Programme and Abstracts

Stockholm University
KTH
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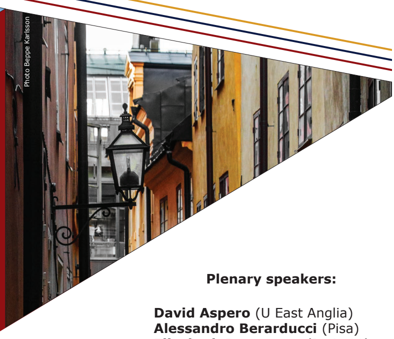
ASL European Summer Meeting

Logic Colloquium 2017

Stockholm University
14 – 20 August
http://logic.math.su.se/lc-2017

LOGIC in Stockholm 2017



Special sessions:

Joint session of CSL2017 and LC2017 (Aug 20)

Category theory and type theory
in honor of Per Martin-Löf on his 75th birthday

History of logic

Model theory

Philosophical logic

Proof theory

Set theory

Plenary speakers:

David Aspero (U East Anglia)
Alessandro Berarducci (Pisa)
Elisabeth Bouscaren (Paris 11)
Christina Brech (Sao Paulo)
Sakae Fuchino (Kobe U)
Denis Hirschfeldt (U Chicago)
Wilfrid Hodges (British Academy)
Emil Jeřábek (Prague)
Per Martin-Löf (Stockholm U)
Dag Prawitz (Stockholm U)
Sonja Smets (U Amsterdam)

Tutorial speakers:

Patricia Bouyer-Decitre (LSV ENS Cachan)
Mai Gehrke (Paris 7)

LC2017 highlight speakers for the LC-CSL session:

Veronica Becher (Buenos Aires)
Pierre Simon (UC Berkeley)

Programme committee

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Fernando Ferreira (U of Lisbon)
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Sara Negri (U Helsinki)
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Logic Colloquium 2017

Stockholm, August 14-20, 2017

Programme and abstracts

Contents

Preface

The Logic Colloquium 2017 is the 2017 annual European summer meeting of the Association of Symbolic Logic (ASL) and is held during August 14–20, 2017, at the main campus of Stockholm University.

The Logic Colloquium 2017 (LC 2017) is organised and hosted jointly by the Departments of Mathematics and Philosophy at Stockholm University and also supported by the Department of Theoretical Computer Science at KTH Royal Institute of Technology.

LC 2017 is colocated with the Nordic Logic Summer School of the Scandinavian Logic Society, held during August 7–11, and the 26th annual EACSL conference Computer Science Logic (CSL 2017) held during August 20–24, 2017, both at Stockholm University.

As a special feature of the LC 2017 conference includes a joint special session with CSL 2017, held in the morning of August 20 at Stockholm University and featuring two invited highlight speakers from each of LC 2017 and CSL 2017, presenting the highlights of their subject and aimed at the broader community represented by the two conferences.

The scientific programme of LC 2017 consists of:

- 11 plenary lectures, given by
  - David Aspero (University of East Anglia)
  - Alessandro Berarducci (University of Pisa)
  - Elisabeth Bouscaren (University of Paris Sud (Paris XI))
  - Christina Brech (University of São Paulo)
  - Sakae Fuchino (Kobe University)
  - Denis Hirschfeldt (University of Chicago)
  - Wilfrid Hodges (British Academy)
  - Emil Jeřábek (Czech Academy of Sciences)
  - Per Martin-Löf (Stockholm University)
  - Dag Prawitz (Stockholm University)
  - Sonja Smets (University of Amsterdam)
- 2 tutorials, given by

  - Patricia Bouyer-Decitre (LSV, ENS Cachan)
  - Mai Gehrke (University of Paris Diderot (Paris 7))
- 4 highlight lectures at the joint LC-CSL session, with speakers:
  - Verónica Becher (University of Buenos Aires) (LC)
  - Pierre Simon (University of California, Berkeley) (LC)
  - Phokion Kolaitis, University of California Santa Cruz and IBM Research - Almaden (CSL)
  - Wolfgang Thomas, RWTH Aachen University (CSL)
- 7 special sessions with a total of 38 invited talks, as follows:
  - Special session on category theory and type theory in honour of Per Martin-Löf on his 75th birthday, August 17–19, 2017. Speakers:
    - Thierry Coquand (Göteborg University)
    - Richard Garner (Macquarie University, Sydney)
    - André Joyal (University of Quebec, Montreal)
    - Vladimir Voevodsky (Institute for Advanced Study, Princeton)
  - Special session on computability, with speakers:
    - Emmanuel Jeandel (University of Lorraine, France)
    - Klaus Meer (Brandenburg University of Technology, Cottbus-Senftenberg, Germany)
    - Arno Pauly (University of Cambridge, England)
    - Theodore Slaman (University of California, Berkeley)
    - Mariya Soskova (Sofia University, Bulgaria)
    - Keita Yokoyama (University of California, Berkeley)
  - Special session on history of logic, with speakers:
    - Wilfrid Hodges (British Academy)
    - Peter Øhrstrøm (Aalborg University)

    * Jan von Plato (University of Helsinki)

- Special session on model theory, with speakers:
    * Martin Bays (University of Münster)
    * Zaniar Ghadernezhad (University of Freiburg)
    * Tomás Ibarlucía (University of Paris Diderot (Paris 7))
    * Franziska Jahnke (University of Münster)
    * Vincenzo Mantova (University of Leeds)
    * Ivan Tomašić (Queen Mary University of London)

- Special session on philosophical logic, with speakers:
    * Michele Friend (Gerrge Washington University)
    * Juliette Kennedy (Helsinki University)
    * Benedikt Loewe (University of Amsterdam and Hamburg)
    * Sara Negri (Helsinki University)
    * Davide Rizza (University of East Anglia)
    * Giambattista Formica (Pontifical Urbaniana University, Rome)

- Special session on proof theory, with speakers:
    * Fernando Ferreira (University of Lisbon)
    * Anton Freund (University of Leeds)
    * Annika Kanckos (University of Helsinki)
    * Kentaro Sato (University of Bern)
    * Anton Setzer (Swansea University)
    * Silvia Steila (University of Bern)

- Special session on set theory, with speakers:
    * William Chen (Ben-Gurion University of the Negev, Israel)
    * Brent Cody (Virginia Commonwealth University, USA)

- * Ashutosh Kumar (Hebrew University, Jerusalem)
  * Giorgio Laguzzi (Freiburg University)
  * Yann Pequignot (University of California, Los Angeles)
  * Sandra Uhlenbrock (University of Vienna)
- 138 contributed talks,

We wish to thank first of all the members of the local organising team for the time and efforts they have invested in organising the LC 2017. We also thank the programme committee and the organisers of the special sessions, all invited speakers, as well as all participants.

Lastly, we express our special thanks to the conference sponsors:

- Stockholm University, through its rector, Professor Astrid Söderbergh Widding
- the Departments of Mathematics and Philosophy of Stockholm University
- the Stockholm Mathematics Center
- the Association for Symbolic Logic
- the School of Computer Science and Communication and the Department of Theoretical Computer Science at KTH Royal Institute of Technology
- Stockholm City Hall
- the G.S. Magnusson foundation
- Prover Technology

Valentin Goranko and Erik Palmgren
LC 2017 Organising co-chairs

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- Karl Nygren, Department of Philosophy, Stockholm University
- Peter Pagin, Department of Philosophy, Stockholm University
- Erik Palmgren (OC co-chair), Department of Mathematics, Stockholm University
- Dag Westerståhl, Department of Philosophy, Stockholm University

In addition, Christian Espíndola and Håkon Robbestad Gylterud of the Department of Mathematics, Stockholm University have been working on preparing the schedule and this book of abstracts.

Chapter 1

Invited plenary and tutorial lectures

Invited plenary and tutorial lectures schedule

Time	Monday 14th of August
09:00–09:15	Opening
09:15–10:15	Per Martin-Löf
10:45–11:45	Mai Gehrke
11:45–12:45	David Aspero

Time	Tuesday 15th of August	Wednesday 16th of August
09:00–10:00	Alessandro Berarducci	Elisabeth Bouscaren
10:30–11:30	Mai Gehrke	Patricia Bouyer-Decitre
11:30–12:30	Denis Hirschfeldt	Sonja Smets

Time	Thursday 17th of August	Friday 18th of August
09:00–10:00	Emil Jeřábek	Sakaé Fuchino
10:30–11:30	Mai Gehrke	Patricia Bouyer-Decitre
11:30–12:30	Patricia Bouyer-Decitre	Christina Brech

Time	Saturday 19th of August	Sunday 20th of August
09:00–10:00	Wilfred Hodges	Verónica Becher
10:00–11:00		Wolfgang Thomas
11:20–12:10		Pierre Simon
12:10–13:00		Phokion Kolaitis
16:00–17:00	Dag Prawitz	

▸ MARTIN-LÖF, PER, *Assertion and request.*
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Think of the content of an assertion as something that is to be done: let us call it a task. Peirce's explanation of the speech act of assertion as the assuming of responsibility then takes the form: by making an assertion, you assume the responsibility, or duty, of performing the task which constitutes the content of the assertion, when requested to do so by the hearer. Thus a duty on the part of the speaker appears as a right on the part of the hearer to request the speaker to perform his duty: this is an instance of what is called the correlativity of rights and duties, a fundamental principle of deontological ethics which can be traced back to Bentham. In logic, it appears as the correlativity of assertions and requests. Since nothing but assertions appear in the usual inference rules of logic, there arises the question of what the rules are that govern the correlative requests. In the case of constructive type theory, they turn out to be the rules which bring the meaning explanations for the various forms of assertion to formal expression. Thus, in analogy with Gentzen's dictum that the propositional operations, the connectives and the quantifiers, are defined by their introduction rules, we may say that the forms of assertion are defined by their associated request rules.

▶ MAI GEHRKE, *On Stone duality in logic and computer science.*
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URL Address: `https://www.irif.fr/ mgehrke/`.

Stone duality shows that the category of bounded distributive lattices[1] is dually equivalent to a certain category of topological spaces. This duality underlies many connections between algebra and geometry or topology in mathematics. In logic, it is central to correspondences between syntax and semantics. More recently, it has been realised that Stone duality plays a central role in more algorithmic questions such as the decidability of certain classes of languages in automata theory.

In this three part tutorial, the first lecture will provide an introduction to Stone duality with an overview of its different versions and their applications. The second lecture will focus on applications in semantics and will introduce duals of certain functors, such as the Vietoris functor, which corresponds to classical quantification. The third lecture will concentrate on applications in the theory of formal languages and, in particular, on the notion of ultrafilter equations as a tool for separating complexity classes. The papers [1] and [2], which are gueared to computer scientists rather than logicians, provide a survey on Stone duality and a gentle introduction to the apllications in formal language theory, respectively.

[1] MAI GEHRKE, *Duality in Computer Science*, ***Logic in Computer Science*** (Columbia University, New York City, NY, USA), (Martin Grohe, Eric Koskinen, and Natarajan Shankar, editors), ACM, 2016, pp. 12–26.

[2] MAI GEHRKE AND ANDREAS KREBS, *Stone duality for languages and complexity*, ***Association for Computing Machinery Special Interest Group on Logic (ACM SigLog) and Computation News***, vol. 4, no. 2, pp. 23–53.

[1]The algebras corresponding to the "and", "or", "true", and "false" fragment of classical propositional logic.

▶ DAVID ASPERÓ, *Generic absoluteness for Chang models.*
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E-mail: `d.aspero@uea.ac.uk`.
URL Address: `https://archive.uea.ac.uk/ bfe12ncu/`.

The main focus of the talk will be on extensions of Woodin's classical result that, in the presence of a proper class of Woodin cardinals, $\mathcal{C}_\omega^V$ and $\mathcal{C}_\omega^{V^P}$ are elementally equivalent for every set–forcing P (where $\mathcal{C}_\kappa$ denotes the κ–Chang model).

1. In the first part of the talk I will present joint work with Asaf Karagila in which we derive generic absoluteness for $\mathcal{C}_\omega$ over the base theory ZF + DC.

2. Matteo Viale has defined a strengthening MM^{+++} of Martin's Maximum which, in the presence of a proper class of sufficiently strong large cardinals, completely decides the theory of $\mathcal{C}_{\omega_1}$ modulo forcing in the class Γ of set–forcing notions preserving stationary subsets of ω_1; this means that if MM^{+++} holds, $P \in \Gamma$, and P forces MM^{+++}, then $\mathcal{C}_{\omega_1}^V$ and $\mathcal{C}_{\omega_1}^{V^P}$ are elementarily equivalent. MM^{+++} is the first example of a "category forcing axiom."

In the second part of the talk I will present some recent joint work with Viale in which we extend his machinery to deal with other classes Γ of forcing notions, thereby proving the existence of several mutually incompatible category forcing axioms, each one of which is complete for the theory of $\mathcal{C}_{\omega_1}$, in the appropriate sense, modulo forcing in Γ.

▸ ALESSANDRO BERARDUCCI, *Surreal differential calculus.*
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E-mail: alessandro.berarducci@unipi.it.

I will report on joint surreal work with Vincenzo Mantova. We recall that Conway's ordered field of surreal numbers contains both the real numbers and the ordinal numbers. The surreal sum and product of two ordinals coincide with the Hessenberg sum and product, and Cantor's normal form of ordinals has a natural extension to the surreals. In [1] we proved that there is a meaningful way to take both the derivative and the integral (anti-derivative) of a surreal number, hence in particular on an ordinal number. The derivative of the ordinal number omega is 1, the derivative of a real number is zero, and the derivative of the sum and product of two surreal numbers obeys the expected rules. More difficult is to understand what is the derivative of an ordinal power of omega, for instance the first epsilon-number, but this can be done in a way that reflects the formal properties of the derivation on a Hardy field (germs of non-oscillating real functions). In [2] we showed that many surreal numbers can indeed be interpreted as germs of differentiable functions on the surreals themselves, so that the derivative acquires the usual analytic meaning as a limit. It is still open whether we can interpret all the surreals as differentiable functions, possibly changing the definition of the derivative.

[1] Alessandro Berarducci, Vincenzo Mantova, *Surreal numbers, derivations and transseries*, ***arXiv:1503.00315, pp. 47***, To appear in the Journal of the European Mathematical Society.

[2] ——— *Transseries as germs of surreal functions*, ***arXiv:1703.01995, pp. 44*** .

▸ DENIS HIRSCHFELDT, *Computability theory and asymptotic density.*
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URL Address: www.math.uchicago.edu/~drh.

The notion of generic-case complexity was introduced by Kapovich, Myasnikov, Schupp, and Shpilrain to study problems with high worst-case complexity that are nevertheless easy to solve in most instances. They also introduced the notion of generic computability, which captures the idea of having a partial algorithm that halts for almost all inputs, and correctly computes a decision problem whenever it halts. Jockusch and Schupp began the general computability-theoretic investigation of generic computability and also defined the notion of coarse computability, which captures the idea of having a total algorithm that might make mistakes, but correctly decides the given problem for almost all inputs (although this notion had been studied earlier in Terwijn's dissertation). Two related notions, which allow for both failures to answer and mistakes, have been studied by Astor, Hirschfeldt, and Jockusch (although one of them had been considered in the 1970's by Meyer and by Lynch). All of these notions lead to notions of reducibility and associated degree structures. I will discuss recent and ongoing work in the study of these reducibilities.

▸ ELISABETH BOUSCAREN, *A stroll through some important notions of model theory and their applications in geometry.*
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E-mail: elisabeth.bouscaren@math.u-psud.fr.

In this talk, we will try to explain the use of some important model-theoretic notions, focusing on the model-theory of finite rank groups and on the notion of orthogonality. Their use in applications to algebraic geometry will be gently illustrated by some examples. This talk is partly inspired by a series of recent joint papers with Franck Benoist (Paris-Sud) and Anand Pillay (Notre-Dame), giving new model theoretic proofs of the original results of Ehud Hrushovski on the Mordell-Lang Conjecture for function fields (1994).

▶ PATRICIA BOUYER, *On the verification of timed systems – and beyond.*
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URL Address: http://www.lsv.fr/~bouyer/.

Towards the development of more reliable computerized systems, expressive models are designed, targetting application to automatic verification (model-checking). As part of this effort, timed automata have been proposed in the early nineties [2] as a powerful and suitable model to reason about (the correctness of) real-time computerized systems. Timed automata extend finite-state automata with several clocks, which can be used to enforce timing constraints between various events in the system. They provide a convenient formalism and enjoy reasonably-efficient algorithms (*e.g.* reachability can be decided using polynomial space), which explains the enormous interest that they provoked in the community of formal methods. Timed games [4] extend timed automata with a way of modelling systems interacting with external, uncontrollable components: some transitions of the automaton cannot be forced or prevented to happen. The reachability problem then asks whether there is a strategy (or controller) to reach a given state, whatever the (uncontrollable) environment does. This problem can also be decided, in exponential time.

Timed automata and games are not powerful enough for representing quantities like resources, prices, temperature, etc. The more general model of hybrid automata [14] allows for accurate modelling of such quantities using hybrid variables. The evolution of these variables follow differential equations, depending on the state of the system, and this unfortunately makes the reachability problem undecidable, even in the very restricted case of stopwatches (stopwatches are clocks that can be stopped, and hence, automata with stopwatches only are the simplest hybrid automata one can think of).

Weighted (or priced) timed automata [3, 5] and games [15, 1, 9] have been proposed in the early 2000's as an intermediary model for modelling resource consumption or allocation problems in real-time systems (*e.g.* optimal scheduling [6]). As opposed to (linear) hybrid systems, an execution in a weighted timed model is simply one in the underlying timed model: the extra quantitative information is just an observer of the system, and it does not modify the possible behaviours of the system.

In this tutorial, we will present basic results concerning timed automata and games, and we will further investigate the models of weighted timed automata and games. We will present in particular the important optimal reachability problem: given a target location, we want to compute the optimal (*i.e.* smallest) cost for reaching a target location, and a corresponding strategy. We will survey the main results that have been obtained on that problem, from the primary results of [3, 5, 16, 13, 8, 17, 7] to the most recent developments [11, 10]. We will also mention our new tool TiAMo, which can be downloaded at `https://git.lsv.fr/colange/tiamo`. We will finally show that weighted timed automata and games have applications beyond that of model-checking [12].

[1] Rajeev Alur, Mikhail Bernadsky, and P. Madhusudan, *Optimal reachability in weighted timed games*, ***In Proceedings of the 31st International Colloquium on Automata, Languages and Programming (ICALP'04)*** (Turku, Finland), (Josep Díaz, Juhani Karhumäki, Arto Lepistö, and Donald Sannella, editors), vol. 3142 of Lecture Notes in Computer Science, Springer, 2004, pp. 122–133.

[2] Rajeev Alur and David L. Dill, *A theory of timed automata*, ***Theoretical Computer Science***, vol. 126 (1994), no. 2, pp. 183—235.

[3] Rajeev Alur, Salvatore La Torre, and George J. Pappas, *Optimal paths in weighted timed automata*, ***In Proceedings of the 4th International Workshop on Hybrid Systems: Computation and Control (HSCC'01)*** (Rome, Italy), (Maria Domenica Di Benedetto and Alberto L. Sangiovanni-Vincentelli, editors), vol. 2034 of Lecture Notes in Computer Science, Springer, 2001, pp. 49–62.

[4] Eugene Asarin, Oded Maler, Amir Pnueli, and Joseph Sifakis, *Controller synthesis for timed automata*, ***In Proceedings of the IFAC Symposium on System Structure and Control*** Elsevier Science, 1998, pp. 469–474.

[5] Gerd Behrmann, Ansgar Fehnker, Thomas Hune, Kim G. Larsen, Paul Pettersson, Judi Romijn, and Frits Vaandrager, *Minimum-cost reachability for priced timed automata*, ***In Proceedings of the 4th International Workshop on Hybrid Systems: Computation and Control (HSCC'01)*** (Rome, Italy), (Maria Domenica Di Benedetto and Alberto L. Sangiovanni-Vincentelli, editors), vol. 2034 of Lecture Notes in Computer Science, Springer, 2001, pp. 147–161.

[6] Gerd Behrmann, Kim G. Larsen, and Jacob I. Rasmussen, *Optimal scheduling using priced timed automata*, ***ACM Sigmetrics Performancs Evaluation Review***, vol. 32 (2005), no. 4, pp. 34–40.

[7] Patricia Bouyer, Thomas Brihaye, Véronique Bruyère, and Jean-François Raskin, *On the optimal reachability problem*, ***Formal Methods in System Design***, vol. 31 (2007), no. 2, pp. 135–175.

[8] Patricia Bouyer, Thomas Brihaye, and Nicolas Markey, *Improved undecidability results on weighted timed automata*, ***Information Processing Letters***, vol. 98 (2006), no. 5, pp. 188–194.

[9] Patricia Bouyer, Franck Cassez, Emmanuel Fleury, and Kim G. Larsen, *Optimal strategies in priced timed game automata*, ***In Proceedings of the 24th Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS'04)*** (Chennai, India), (Kamal Lodaya and Meena Mahajan, editors), vol. 3328 of Lecture Notes in Computer Science, Springer, 2001, pp. 148–160.

[10] Patricia Bouyer, Maximilien Colange, and Nicolas Markey, *Symbolic optimal reachability in weighted timed automata*, ***In Proceedings of the 28th International Conference on Computer Aided Verification (CAV'16) – Part I*** (Toronto, Canada), (Swarat Chaudhuri and Azadeh Farzan, editors), vol. 9779 of Lecture Notes in Computer Science, Springer, 2016, pp. 513–530.

[11] Patricia Bouyer, Samy Jaziri, and Nicolas Markey, *On the value problem in weighted timed games*, ***In Proceedings of the 26th International Conference on Concurrency Theory (CONCUR'15)*** (Madrid, Spain), (Luca Aceto and David de Frutos-Escrig, editors), vol. 42 of LIPIcs, Leibniz-Zentrum für Informatik, 2015, pp. 311–324.

[12] Patricia Bouyer, Nicolas Markey, Nicolas Perrin, and Philipp Schlehuber, *Timed automata abstraction of switched dynamical systems using control funnels*, ***In Proceedings of the 13th International Conference on Formal Modeling and Analysis of Timed Systems (FORMATS'15)*** (Madrid, Spain), (Sriram Sankaranarayanan and Enrico Vicario, editors), vol. 9268 of Lecture Notes in Computer Science, Springer, 2015, pp. 60–75.

[13] Thomas Brihaye, Véronique Bruyère, and Jean-François Raskin, *On optimal timed strategies*, ***In Proceedings of the 3rd International Conference on Formal Modeling and Analysis of Timed Systems (FORMATS'05)*** (Uppsala, Sweden), (Paul Pettersson and Wang Yi, editors), vol. 3821 of Lecture Notes in Computer Science, Springer, 2005, pp. 49–64.

[14] Thomas A. Henzinger, Peter W. Kopke, Anuj Puri, and Pravin Varaiya, *What's decidable about hybrid automata?*, ***Journal of Computer and System Sciences***, vol. 57 (1998), no. 1, pp. 94–124.

[15] Salvatore La Torre, Supratik Mukhopadhyay, and Aniello Murano, *Optimal-reachability and control for acyclic weighted timed automata*, ***In Proceedings of the 2nd IFIP International Conference on Theoretical Computer Science (TCS 2002)*** (Montréal, Canada), (Ricardo A. Baeza-Yates, Ugo Montanari and Nicola Santoro, editors), vol. 223 of IFIP Conference Proceedings, Kluwer, 2007, pp. 485–497.

[16] Kim G. Larsen, Gerd Behrmann, Ed Brinksma, Angskar Fehnker, Thomas Hune, Paul Pettersson, and Judi Romijn, *As cheap as possible: Efficient cost-optimal reachability for priced timed automata*, ***In Proceedings of the 13th International Conference on Computer Aided Verification (CAV'01)*** (Paris, France), (Gérard Berry, Hubert Comon and Alain Finkel, editors), vol. 2102 of Lecture Notes in Computer Science, Springer, 2001, pp. 493–505.

[17] Jacob I. Rasmussen, Kim G. Larsen, and K. Subramani, *On using priced timed automata to achieve optimal scheduling*, ***Formal Methods in System Design***, vol. 29 (2006), no. 1, pp. 97–114.

▸ SONJA SMETS, *The logical basis of a formal epistemology for social networks.*

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In this presentation I focus on a logical-philosophical study of group beliefs and collective "knowledge", and their dynamics in communities of interconnected agents capable of reflection, communication, reasoning, argumentation etc. In particular, the aim is to study belief formation and belief diffusion (doxastic influence) in social networks, and to characterize a group's "epistemic potential". This covers cases in which a group's ability to track the truth is higher than that of each of its members (the "wisdom of the crowds": distributed knowledge, epistemic democracy and other beneficial forms of belief aggregation and deliberation), as well as situations in which the group's dynamics leads to informational distortions (the "madness of the crowds": informational cascades, "groupthink", the curse of the committee, pluralistic ignorance, group polarization etc). I look at several logical formalisms that make explicit various factors affecting the epistemic potential of a group: the agents' degree of interconnectedness, their degree of mutual trust, their different epistemic interests (their "questions"), their different attitudes towards the available evidence and its sources etc. In this presentation I refer to a number of recent papers (1,2,3,4,5,6), that make use a variety of formal tools ranging from dynamic epistemic logics and probabilistic logics. I conclude with some philosophical reflections about the nature and meaning of group knowledge, as well as about the epistemic opportunities and dangers posed by informational interdependence.

[1] A. Achimescu, A. Baltag and J. Sack, *The Probabilistic Logic of Communication and Change*, ***The Journal of Logic and Computation***, issue 07 January 2016.

[2] A. Baltag, Z. Christoff, J.U. Hansen and S. Smets, *Logical Models of Informational Cascades*, ***Logic across the University: Foundations and Applications, Proceedings of the Tsinghua Logic Conference*** (Beijing), (J. van Benthem and F. Liu, editors), vol. 47, College Publications, 2013, pp. 405–432.

[3] A. Baltag, Z. Christoff, R.K Rendsvig, S. Smets, *Dynamic epistemic logics of diffusion and prediction in social networks (extended abstract)*, ***Pre-Proceedings of LOFT, 2016.*** (Maastricht), (G. Bonanno, W. van der Hoek, A. Perea, editors), 2016.

[4] A. Baltag, R. Boddy and S. Smets, *Group Knowledge in Interrogative Epistemology.*, ***Forthcoming in the Outstanding Contributions to Logic Series, volume dedicated to J. Hintikka***, Springer 2017.

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▸ EMIL JEŘÁBEK, *Counting in weak theories.*
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In first-order theories of arithmetic, the only "official" objects are natural numbers. However, much of the expressive power of these theories comes from the fact that we may also work with finite sets of numbers by means of bounded definable sets (or even to encode such sets by numbers where possible). In many applications of finite sets in arithmetic, it is crucial that we can count their cardinalities. The most straightforward way to do that requires the totality of the exponentiation function.

In weaker fragments of arithmetic that lack exponentiation (variants of bounded arithmetic), exact counting of bounded definable sets is not possible. Nevertheless, impromptu rough comparison of set sizes could be sometimes achieved by ad hoc use of combinatorial principles available in these theories, most notably variants of the weak pigeonhole principle (WPHP).

By exploiting the power of the weak pigeonhole principle in a systematic way, we can in fact develop a general framework for approximate counting of bounded definable sets in fragments of bounded arithmetic [2, 3, 4].

Approximate counting has various applications within bounded arithmetic. The original motivations were, first, that it can be used to handle randomized algorithms in bounded arithmetic, and to develop the basic theory of probabilistic complexity classes such as BPP; second, to facilitate proofs of combinatorial or number-theoretic statements that rely on counting and probabilistic arguments. Somewhat unexpectedly, approximate counting has been recently employed to show the collapse of the bounded depth proof hierarchy for propositional proof systems using mod-p gates [1].

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▸ SAKAÉ FUCHINO, *Set-theoretic reflection of mathematical properties.*
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If there is an uncountable structure A in a class $\mathcal{C}$ of structures with some (bad) property $\mathcal{P}$ then it seems to be natural to ask whether there is a substructure $B \in \mathcal{C}$ of A of cardinality less than some given cardinality κ which inherits the property $\mathcal{P}$. If there is always such a small substructure for any structure $A \in \mathcal{C}$ with the property $\mathcal{P}$, we shall say that "the reflection of the property $\mathcal{P}$ in $\mathcal{C}$ down to $< \kappa$" holds.

Uncountable coloring number of graphs as property $\mathcal{P}$ in the class $\mathcal{C}$ of graphs shows interesting behavior in terms of the reflection as above. Recall that a graph $G = \langle G, E\rangle$ is of coloring number $\leq \kappa$ if there is a well-ordering $\sqsubset$ on G such that for any $x \in G$ the set $\{y \in G : y \sqsubset x \text{ and } x\ E\ y\}$ is of cardinality $< \kappa$. The coloring number of G is the minimal κ such that G is of coloring number $\leq \kappa$. Fleissner [1] proved that the reflection of uncountable coloring number of graphs down to $< \aleph_2$ follows from the Axiom R which asserts that for a stationary $S \subseteq [\lambda]^{\aleph_0}$ for an uncountable cardinal λ and an ω_1-club $C \subseteq [\lambda]^{<\aleph_2}$ there is $Y \in C$ such that $S \cap [Y]^{\aleph_0}$ is stationary in $[Y]^{\aleph_0}$.

We proved in [2] that the reflection of uncountable coloring number of graphs down to $< \aleph_2$ follows from the so-called Fodor-type Reflection Principle (FRP) which is a combinatorial principle strictly weaker than Axiom R. We then could show that the reflection of uncountable coloring number down to $< \aleph_2$ is actually equivalent to FRP [3]. Since FRP is also a consequence of Rado Conjecture [4] (see also [5]).

These results can be generalized to the assertions about the reflection of the property "of coloring number $> \mu$" of graphs for an uncountable cardinality μ. The straight forward generalization of FRP does not work but we can find an appropriate generalization of FRP for uncountable cardinal μ and prove the equivalence of the reflection of the property "of coloring number $> \mu$" of graphs down to $< \mu^{++}$ with this generalization of FRP for μ. Further, under certain cardinal arithmetical assumptions, we can also prove that this generalized FRP follows from a generalization of Rado's Conjecture [7]. These results and some further generalizations can be recast into a construction of a graph with the non-reflection of the property "of chromatic number $> \mu$" from a graph with the non-reflection of the property "of coloring number $> \mu$" ([6], [7]).

In the talk I will discuss about some more details of these results and the connection of them to some other reflection statements.

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[4] Sakaé Fuchino, Hiroshi Sakai, Victor Torres-Perez and Toshimichi Usuba, *Rado's Conjecture and the Fodor-type Reflection Principle*, in preparation.

[5] Sakaé Fuchino, *Rado's Conjecture implies Fodor-type Reflection Principle*, `http://fuchino.ddo.jp/notes/RCimpliesFRP2.pdf`

[6] Sakaé Fuchino, *On local reflection of the properties of graphs with uncountable characteristics*, RIMS Kôkyôroku, to appear.

[7] Sakaé Fuchino, André Ottenbreit Maschio Rodrigues and Hiroshi Sakai, *Reflection and non-reflection of properties with uncountable characteristics*, in preparation.

▸ CHRISTINA BRECH, *Families on large index sets and applications to Banach spaces.*
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Schreier families on countable index sets have been used in Banach space theory to study asymptotic objects and ranks of compacity. We will present a generalization of these objects to the uncountable setting and some applications to nonseparable Banach spaces, which can be found in the joint work [1] with Jordi Lopez-Abad and Stevo Todorcevic. Our methods to built such families in all cardinals below the first Mahlo cardinal involve Ramsey theory and a deep combinatorial analysis of families on trees.

[1] C. Brech, J. Lopez-Abad, S. Todorcevic, *Homogeneous families on trees and subsymmetric basic sequences*, ***preprint***.

▸ WILFRID HODGES, *Avicenna sets up a modal logic with a Kripke semantics.*

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When Avicenna (11th century Persia) wanted to set up modal logic rigorously, he had available to him a rich but confused body of material from Aristotle and the Aristotelian commentators. Avicenna rearranged and sifted this material into two related formal systems, which we can call Mod and Temp. Mod is a fragment of monadic predicate modal logic; apart from a couple of mishaps on the edges it is a robust system up to modern standards. Temp is equally robust but more mysterious. Mathematically it can be correctly described as an S5 Kripke semantics for Mod, with fixed universe and an existence predicate; Avicenna several times uses Temp to give what in this sense are 'semantic proofs' of inferences in Mod. But Avicenna himself couldn't have described Temp that way, and though everything is formally correct, we have little idea how he justified its use to himself.

▶ DAG PRAWITZ, *Gentzen's justification of inferences and the ecumenical systems.*
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Some of the different proposals for how to make precise Gentzen's way of justifying the introduction and elimination rules of natural deduction are briefly surveyed. A crucial question is whether the justification is applicable only to inferences occurring in intuitionistic logic or can be extended also to inferences occurring in classical logic. I shall argue that it is extendible to classical inference rules but that for some logical constants the introduction rules must vary depending on whether the constant is read classically or intuitionistically - when the constant is read classically the rule must be weaker than when it is read intuitionistically.

Respecting this condition, it is possible to allow classical and intuitionistic logical constants in one and the same system, a system that we may call the ecumenical system. In this system the usual elimination rules for some logical constants do not hold when the constant is read classically. Modus ponens is an example - it is not valid generally when implication is read classically, but remains valid when also all of the constants of the subformulas of the implication are read classically.

▸ VERÓNICA BECHER, *Normal numbers, Logic and Automata.*
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Flip a coin a large number of times and roughly half of the flips will come up heads and half will come up tails. *Normality* makes analogous assertions about the digits in the expansion of a real number. Precisely, let b be an integer greater than or equal to 2. A real number is *normal* to base b if each of the digits $0, 1, \ldots, b-1$ occurs in its expansion with the same asymptotic frequency $1/b$, each of the blocks of two digits occurs with frequency $1/b^2$, each of the blocks of three digits occurs with frequency $1/b^3$, and so on, for every block length. A number is *absolutely normal* if it is normal to every base. Émile Borel [11] defined normality more than one hundred years ago to formalize a basic feature of randomness for real numbers. Many of his questions are still open, such as whether any of π, e or $\sqrt{2}$ is normal in some base, as well as his conjecture that the irrational algebraic numbers are absolutely normal [12].

In this talk I will highlight some theorems on normal numbers proved with tools from *computability theory*, *automata theory* and *descriptive set theory* and I will point out some open questions.

From computability theory: Alan Turing was the first. He gave an effective version of Borel's theorem showing that almost all numbers (in the sense of Lebesgue measure) are absolutely normal. Based on this construction Turing gave the first algorithm to compute an absolutely normal number [23, 3]. A current research line aims to effectivize results in number theory and give algorithms to compute absolutely normal numbers that have also some other mathematical properties [22, 7, 10, 13]. It is an open question whether there exists a fast algorithm that computes an absolutely normal number with fast speed of convergence to normality [18, 20, 8].

From automata theory: To regard normality from the point of view of finite automata we must consider expansions in a single base. So, we fix a base and we speak of normal sequences. V. Agafonov [1] established that a sequence is normal exactly when any subsequence selected by a finite automata is normal (see also [19]). Besides, normal sequences admit characterizations analogous to those for Martin-Löf random sequences [16], but using finite automata instead of Turing machines. C.P. Schnorr and H. Stimm [21] established that a sequence is normal exactly when no martingale defined by a finite automaton can make infinite profit. Dai, Lathrop, Lutz and Mayordomo [15] obtained that a sequence is normal exactly when it can not be compressed by one-to-one finite automata with input and output (finite transducer). This characterization holds for various enrichments of finite automata [6, 14]. An open question is whether normal sequences can be compressed by deterministic push-down automata.

From descriptive set theory. The set of real numbers normal to base 2, as a subset of the set of all real numbers, is complete at the third effective level of the Borel Hierarchy [17]. So is the set of absolutely normal numbers [4]. This gives another proof that the set of absolutely normal real numbers is different from the set of Martin-Löf random numbers, since this is just complete at the second level of the Borel Hierarchy. The set of real numbers that are normal to some base is complete at the fourth level of the Borel Hierarchy, both effective and non-effective [5]. This implies that there is no logical dependence between normality to different bases, other than multiplicative dependence. Recently Airey, Mance and Jackson [2] proved that the subset of real numbers that preserve normality to a given base under addition is complete at the third level of the Borel Hierarchy.

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▶ WOLFGANG THOMAS,
Determinacy of Infinite Games: Perspectives of the Algorithmic Approach.
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Determinacy of infinite two-player games is a topic of descriptive set theory that has triggered intensive research in theoretical computer science since 1957 when A. Church formulated his “synthesis problem” (regarding the construction of circuits with infinite behavior from logical specifications). In the first part of the lecture we review the fascinating development of the algorithmic theory of infinite games that was started by Church’s problem, that enriched automata theory and related fields, and that led to interesting applications in verification and program synthesis. In the second part we turn to the question how to lift this theory from the case of the Cantor space (where a play is a sequence of bits) to the case of the Baire space (where a play is a sequence of natural numbers). While this step does not involve difficulties in classical descriptive set theory, the algorithmic approach raises non-trivial questions since it requires to consider automata that work over infinite alphabets. We present recent results (joint work with B. Brütsch) that provide a solution of Church’s synthesis problem in this context, and we point to numerous questions that are still open.

▸ PIERRE SIMON, *Recent directions in model theory.*
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Model theory studies combinatorial tameness properties of mathematical structures. As such it has an ever growing ambition to offer new tools and new approaches to many different areas of mathematics. In the last few decades, its range of applications has greatly expanded, at times in unexpected directions. So much so that the subject looks nothing like what it was 30 or 40 years ago.

In this talk—meant to be accessible to a wide audience—I will present a couple of themes of present research in model theory and try to give a feel for the area, what has been achieved and what might lie ahead.

▸ PHOKION G. KOLAITIS, *Schema mappings: structural properties and limits.*

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A schema mapping is a high-level specification of the relationship between two database schemas. For the past fifteen years, schema mappings have played an essential role in the modeling and analysis of important data interoperability tasks, such as data exchange and data integration. Syntactically, schema mappings are expressed in some schema-mapping language, which, typically, is a fragment of first-order logic or second-order logic. In the first part of the talk, we will introduce the main schema-mapping languages, will discuss the fundamental structural properties of these languages, and will then use these structural properties to obtain characterizations of various schema-mapping languages in the spirit of abstract model theory. In the second part of the talk, we will examine schema mappings from a dynamic viewpoint by considering sequences of schema mappings and studying the convergence properties of such sequences. To this effect, we will introduce a metric space that is based on a natural notion of distance between sets of database instances and will investigate pointwise limits and uniform limits of sequences of schema mappings. Among other findings, it will turn out that the completion of this metric space can be described in terms of graph limits arising from converging sequences of homomorphism densities.

Chapter 2

Special sessions invited talks

2.1 Special session on category theory and type theory in honour of Per Martin-Löf on his 75th birthday

Thursday,	17th of August
14:00	André Joyal
15:00	Discusssion 30 min

Friday,	18th of August
14:00	Vladimir Voevodsky
15:00	Discusssion 30 min

Saturday,	19th of August
14:00	Richard Garner 45 min talk
14:45	Thierry Coquand 45 min talk

▸ ANDRÉ JOYAL, *Logic Colloquium 2017*.
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Title: On some categorical aspects of homotopy type theory

Abstract: Few things can better illustrate the unity of mathematics than the homotopy interpretation of Martin-Löf type theory (Awodey-Warren, Voevodsky) and the discovery of the univalence axiom (Voevodsky). *Homotopy Type Theory* is the new field of mathematics springing from these discoveries. There are good evidences that Hott can contribute effectively to homotopy theory and to higher topos theory: non-trivial homotopy groups of spheres were computed by Brunerie and a new proof of a fundamental result of homotopy theory (the Blakers-Massey theorem) was discovered (and verified in Agda) by Favonia, Finster, Licata and Lumsdane. The theorem was generalised by Anel, Biedermann, Finster and the author, and applied to Goodwillie's calculus [arxiv/1703.09050/1703.09632]. The [ABFJ] papers are written in *mathematical creole*, a blend of homotopy theory, infty-category theory, category theory and type theory, but a formal verification in Agda by Finster and Licata is on the way. It is clear that category theory serves as an intermediate between type theory and homotopy theory [ALV/arxiv/1705.04310][CCHM/arxiv/1611.02108][LS/arxiv/1705.07088]. The basic aspects of the theory of infty-categories were recently formalised in Hott by Riehl and Shulman. The syntactic category of type theory happens to be a *path category* in the sense of Van den Berg. The notion of *tribe*, introduced independantly by Shulman and the author, is somewhat simpler, but not every path category is a tribe. However, every fibration category is equivalent (in the sense of Dwyer-Kan) to a tribe by a construction of Cisinski and by the work of Szumilo and of Kapulkin. I will sketch the homotopy theory of tribes and of *simplicial tribes*.

▸ VLADIMIR VOEVODSKY, *Models, interpretations and the initiallity conjectures.*

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Work on proving consistency of the intensional Martin-Löf type theory with a sequence of univalent universes (MLTT+UA) led to the understanding that in type theory we do not know how to construct an interpretation of syntax from a model of inference rules. That is, we now have the concept of a model of inference rules and the concept of an interpretation of the syntax and a conjecture that implies that the former always defines the latter. This conjecture, stated as the statement that the term model is an initial object in the category of all models of a given kind, is called the Initiallity Conjecture. In my talk I will outline the various parts of this new vision of the theory of syntax and semantics of dependent type theories.

▸ RICHARD GARNER, *Polynomials and theories.*
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A basic tenet of Martin–Löf type theory [1] is that types are inductively generated by their elements. This idea finds clearest expression in the W-types and the more general *tree types* [2]; categorically, these admit characterisation as initial algebras for certain *polynomial endofunctors* of the category of types over a given context. The calculus of polynomial endofunctors is interesting in its own right, with application in combinatorics, algebraic topology and computer science; a key organising principle is that polynomial functors between the slices of a locally cartesian closed category form into a bicategory whose composition is given by substitution of multivariate polynomials [3].

The notion of bicategory also crops up in a very deep observation of Walters [4]: namely, that the theory of categories enriched over a monoidal category admits generalisation to a theory of categories enriched over a bicategory. This is closely bound up with what is sometimes called indexed or variable category theory, that is, category theory relative to a base category that acts as a surrogate for the category of sets. In this talk, we consider the natural question: what are categories enriched over the bicategory of polynomials? The answer turns out to be quite interesting: they encode notions of Lawvere theory and PROP appropriate to the indexed setting.

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▸ THIERRY COQUAND, *Univalent Type Theory.*
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The notion of sheaf models, which can be traced back to the works of Beth and Kripke, is an important tool for metamathematical analysis of higher order logic. The problem for the generalization of such interpretations to dependent types is for the interpretation of universes, and this is precisely for this reason, in another context, that the notion of stacks was introduced. I will present a possible generalization for models of univalent type theory, i.e. dependent type theory where the univalence axiom holds, and where we have an operation of propositional truncation. This can be used in particular to show that such a type theory is compatible with continuity principles, and that it does not prove the principle of countable choice.

CAHLMERS TEKNISKA HÖGSKOLA, DATA- OCH INFORMATIONSTEKNIK, RÄNNVÄGEN 6, 41296 GÖTEBORG

2.2 Special session on computability

Monday,	14th of August
14:00	Ted Slaman
14:30	Mariya Soskova
15:00	Keita Yokoyama

Tuesday,	15th of August
14:00	Klaus Meer
14:30	Emmanuel Jeandel
15:00	Arno Pauly

▸ VERÓNICA BECHER, JAN REIMANN AND THEODORE A. SLAMAN, *Irrationality Exponents and Effective Hausdorff Dimension.*
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We generalize the classical theorem by Jarník and Besicovitch on the irrationality exponents of real numbers and Hausdorff dimension. Let a be any real number greater than or equal to 2 and let b be any non-negative real less than or equal to 2/a. We show that there is a Cantor-like set with Hausdorff dimension equal to b such that, with respect to its uniform measure, almost all real numbers have irrationality exponent equal to a. We give an analogous result relating the irrationality exponent and the effective Hausdorff dimension of individual real numbers. We prove that there is a Cantor-like set such that, with respect to its uniform measure, almost all elements in the set have effective Hausdorff dimension equal to b and irrationality exponent equal to a. In each case, we obtain the desired set as a distinguished path in a tree of Cantor sets.

▸ MARIYA I. SOSKOVA, *Characterizing the continuous degrees.*
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The continuous degrees were introduced by J. Miller [3] as a way to capture the effective content of elements of computable metric spaces. They properly extend the Turing degrees and naturally embed into the enumeration degrees. Although nontotal (i.e., non-Turing) continuous degrees exist, they are difficult to construct: every proof we know invokes a nontrivial topological theorem.

In 2014 Cai, Lempp, Miller and Soskova discovered an unusual structural property of the continuous degrees: if we join a continuous degree with a total degree that is not below it then the result is always a total degree. We call degrees with this curious property *almost total.* We prove that the almost total degrees coincide with the continuous degrees. Since the total degrees are definable in the partial order of the enumeration degrees [1], this implies that the continuous degrees are also definable. Applying earlier work of J. Miller [3] on the continuous degrees, this shows that the relation "PA above" on the total degrees is definable in the enumeration degrees.

In order to prove that every almost total degree is continuous, we pass through another characterization of the continuous degrees that slightly simplifies one of Kihara and Pauly [2]. Like them, we identify our almost total degree as the degree of a point in a computably regular space with a computable dense sequence, and then we apply the effective version of Urysohn's metrization theorem (Schröder [4]) to reveal our space as a computable metric space.

This is joint work with Uri Andrews, Greg Igusa, and Joseph Miller.

[1] Mingzhong Cai, Hristo A. Ganchev, Steffen Lempp, Joseph S. Miller, and Mariya I. Soskova. Defining totality in the enumeration degrees. *Journal of the American Mathematical Society*, 29(4):1051–1067, 2016.

[2] Takayuki Kihara and Arno Pauly. Point degree spectra of represented spaces. Submitted.

[3] Joseph S. Miller. Degrees of unsolvability of continuous functions. *Journal of Symbolic Logic*, 69(2):555–584, 2004.

[4] Mathias Schröder. Effective metrization of regular spaces. In J. Wiedermann, K.-I. Ko, A. Nerode, M. B. Pour-El, and K. Weihrauch, editors, *Computability and Complexity in Analysis*, volume 235 of *Informatik Berichte*, pages 63–80, 1998.

▶ KEITA YOKOYAMA, *On the first-order strength of Ramsey's theorem in reverse mathematics.*

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Deciding the first-order part of Ramsey's theorem for pairs is one of the important problems in reverse mathematics. In this talk, I will overview the recent developments of this study. To decide the first-order part, a standard approach is proving Π^1_1-conservation over some induction or bounding axiom by showing ω-extension property. In [1], Cholak/Jockusch/Slaman showed $\mathsf{WKL}_0 + \mathrm{RT}^2_2 + \mathrm{I}\Sigma^0_2$ is a Π^1_1-conservative extension of $\mathrm{I}\Sigma^0_2$ and $\mathsf{WKL}_0 + \mathrm{RT}^2 + \mathrm{I}\Sigma^0_3$ is a Π^1_1-conservative extension of $\mathrm{I}\Sigma^0_3$, and they posed whether they are Π^1_1-conservative over $\mathrm{B}\Sigma^0_2$ and $\mathrm{B}\Sigma^0_3$ respectively. For RT^2, the answer is yes, which is shown by sharpening the argument in [1] (see [4]). For RT^2_2, the question is more difficult. Chong/Slaman/Yang[2] showed that a slightly weaker principle CAC is Π^1_1-conservative over $\mathrm{B}\Sigma^0_2$ by using ω-extension property. On the other hand, it is now known that $\mathsf{WKL}_0 + \mathrm{RT}^2_2$ is actually Π^0_3-conservative over $\mathrm{B}\Sigma^0_2$ by using the indicator argument [3]. In fact, one can characterize the first-order part of $\mathsf{WKL}_0 + \mathrm{RT}^2_2$ by generalizing the indicator argument used in [3].

[1] Peter A. Cholak, Carl G. Jockusch and Theodore A. Slaman, *On the strength of Ramsey's theorem for pairs*, ***Journal of Symbolic Logic***, vol. 66 (2001), no. 1, pp. 1–55.

[2] Chi-Tat Chong, Theodore A. Slaman and Yue Yang, Π^1_1-*conservation of combinatorial principles weaker than Ramseys Theorem for pairs*, ***Advances in Matheamtics***, vol. 230 (2012), pp. 1060–1077.

[3] Ludovic Patey and Keita Yokoyama, *The proof-theoretic strength of Ramsey's theorem for pairs and two colors*, submitted.

[4] Theodore A. Slaman and Keita Yokoyama, *The strength of Ramsey's theorem for pairs and arbitrary many colors*, draft.

▸ KLAUS MEER, *Generalized Finite Automata over the Real Numbers.*
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Gandhi, Khoussainov, and Liu introduced and studied a generalized model of finite automata able to work over arbitrary structures. The model mimics finite automata over finite structures, but has an additional ability to perform in a restricted way operations attached to the structure under consideration. As one relevant area of investigations for this model Gandhi et al. identified studying the new automata over uncountable structures such as the real and complex numbers.

In the talk we pick up this suggestion and consider their automata model as a finite automata variant in the BSS model of real number computation. We study structural properties as well as (un-)decidability results for several questions inspired by the classical finite automata model. This is joint work with A. Naif.

▸ EMMANUEL JEANDEL, *Reducibilities and Higman-like theorems in symbolic dynamics.*

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Symbolic Dynamics is the study of subshifts, sets of infinite words given by local constraints. Subshifts constitute a shift-invariant version of Π^0_1 classes of sets and are intimately linked to automata theory in dimension one and tiling theory in higher dimensions.

One of its distinguished feature is that subshifts of finite type, which are equivalent to tilings of the discrete space by Wang tiles, already exhibit a large range of uncomputable behaviours, as evidence by Berger in the 60s and popularized by Robinson and his so-called Robinson tiling in the 70s.

While these results could be deemed negative, a recent approach due to Hochman show that various quantities and invariants defined for subshifts [1, 3, 4, 6] can be completely understood and characterized using various concepts from computability theory.

The goal of this talk is to show a striking resemblance between these recent results and the embedding theorems pioneered by Higman in the 60s for combinatorial group theory. To do this, I will present a framework in which these theorems can be written using the exact same vocabulary, and show how the easy part of the theorems follow from the exact same proof.

[1] Nathalie Aubrun and Mathieu Sablik. An order on sets of tilings corresponding to an order on languages. In *26th International Symposium on Theoretical Aspects of Computer Science, STACS 2009*, pages 99–110, 2009.

[2] Graham Higman. Subgroups of Finitely Presented Groups. *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*, 262(1311):455–475, August 1961

[3] Michael Hochman. On the dynamics and recursive properties of multidimensional symbolic systems. *Inventiones Mathematicae*, 176(1):2009, April 2009.

[4] Michael Hochman and Tom Meyerovitch. A characterization of the entropies of multidimensional shifts of finite type. *Annals of Mathematics*, 171(3):2011–2038, May 2010.

[5] Emmanuel Jeandel. Enumeration Reducibility in Closure Spaces with Applications to Logic and Algebra. In *ACM/IEEE Symposium on Logic in Computer Science (LICS)*, 2017.

[6] Emmanuel Jeandel and Pascal Vanier. Characterizations of periods of multidimensional shifts. *Ergodic Theory and Dynamical Systems*, 35(2):431–460, April 2015.

[7] Richard J. Thompson. Embeddings into finitely generated simple groups which preserve the word problem. In *Word Problems II, volume 95 of Studies in Logic and the Foundations of Mathematics*, pages 401–441. North Holland, 1980

▶ ARNO PAULY, *Applications of computability theory in topology.*
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The notion of the *point degree spectrum* links σ-homeomorphism types of second-countable spaces to substructures of the enumeration degrees. Using the framework of computable analysis, we can extend Turing reducibility from Cantor space to represented spaces:

Definition 1. We say that $x \in \mathbf{X}$ is reducible to $y \in \mathbf{Y}$ (denoted $x^{\mathbf{X}} \leq_{\mathrm{T}} y^{\mathbf{Y}}$), iff there exists a partial computable function $f :\subseteq \mathbf{Y} \to \mathbf{X}$ with $f(y) = x$.

If $\mathbf{X}$ is second-countable, then the degrees of its points form a substructure of the enumeration degrees, and this substructure (up to products with $\mathbb{N}$ and relativization) characterizes the σ-homeomorphism type of $\mathbf{X}$:

Definition 2. We say that $\mathbf{X}$ and $\mathbf{Y}$ are σ-homeomorphic, if there are partitions $\mathbf{X} = \bigcup_{i \in \mathbb{N}} \mathbf{X}_i$ and $\mathbf{Y} = \bigcup_{i \in \mathbb{N}} \mathbf{Y}_i$ such that $\mathbf{X}_i$ and $\mathbf{Y}_i$ are homeomorphic for all $i \in \mathbb{N}$.

Motivated by a connection to Banach space theory, Jayne had raised the question how many σ-homeomorphism types of uncountable Polish spaces there are. Arguments from dimension theory establish that Cantor space 2^ω and the Hilbert cube $[0,1]^\omega$ are not σ-homeomorphic, and all other well-known uncountable Polish spaces are σ-homeomorphic to one of these. Whether there are more σ-homeomorphism types has been illusive for a long time. Using recursion-theoretic arguments and the point degree spectrum connection, we can establish:

Theorem 3. *There are uncountably many σ-homeomorphism types of uncountable Polish spaces.*

The framework of point degree spectra enables further applications of computability theory to topology, and also applications in the reverse direction.

This is joint work with Takayuki Kihara. A preprint is available as [2]. A precursor of this approach is found in [3] by Joseph S. Miller.

[1] J. E. Jayne, *The space of class a Baire functions*, ***Bull. Amer. Math. Soc.***, vol. 80 (1974), pp. 11511156.

[2] T. Kihara & A. Pauly, ***Point degree spectra of represented spaces***, arXiv:1405.6866, 2014.

[3] J. S. Miller, *Degrees of Unsolvability of Continuous Functions*, ***JSL.***, vol. 69-2 (2004), pp. 555 – 584.

2.3 Special session on history of logic

Saturday,	19th of August
10:30	Wilfrid Hodges
11:00	Peter Øhstrøm
11:30	Jan von Plato

▸ WILFRID HODGES, *How far did Avicenna get with propositional logic?*.

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Late in his career Avicenna (11th c. Persia) made a fresh approach to propositional logic, basing it on his temporal logic. This has to be seen as work in progress - there are awkwardnesses and some outright mistakes. But overall it comes remarkably close to Boole (19th c.).

▸ PETER ØHRSTRØM,
The Rise of Temporal Logic.
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A.N. Prior (1914-69) was the founder of modern temporal logic. In the 1950s and 1960s he showed that tense-logic can be used in order to keep track of the past and of the future possibilities in a way which makes it possible to reason systematically on temporal matters. From the early 1930s Prior had been an active member of the Presbyterian community in New Zealand. He became a specialist in the debates regarding the logical tension between the doctrine of divine foreknowledge and the doctrine of human freedom. He demonstrated how this logical problem can be formalized and analysed in terms of his tense-logic. He found great inspiration in the works of Aristotle, Diodorus, Thomas Aquinas, William of Ockham, C.S. Peirce, Jan Łukasiewicz, Saul Kripke and several others. He argued that in the discussion concerning divine foreknowledge and human freedom there are just a few reasonable positions. In general Prior demonstrated that temporal logic can be used to analyze the notion of time itself as well as fundamental existential problems, such as the problem of determinism versus freedom of choice.

▸ JAN VON PLATO, *Gödel's reading of Gentzen's first consistency proof for arithmetic.*
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A shorthand notebook of Gödel's from late 1935 shows that he read Gentzen's original, unpublished consistency proof for arithmetic. By 1941, many such notebooks were filled with various formulations of the result, one with explicit use of choice sequences, and a generalization based on an induction principle for functionals of finite type over Baire space. Gödel's main aim was to extend Gentzen's result into a consistency proof for analysis. In the lecture, an overview of these so far unknown results about consistency proofs for arithmetic will be presented.

2.4 Special session on model theory

Tuesday,	15th of August
14:00	Ivan Tomašić
14:30	Zaniar Ghadernezhad
15:00	Tomás Ibarlucía

Thursday,	17th of August
14:00	Martin Bays
14:30	Vincenzo Mantova
15:00	Franziska Jahnke

▶ IVAN TOMAŠIĆ, *Enriching our view of model theory of fields with operators.*
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A naïve approach to developing the methods of homological algebra for difference and differential fields, rings and modules quickly encounters numerous obstacles, such as the failure of the hom-tensor duality.

We will describe a categorical framework that overcomes these difficulties, allowing us to transfer most classical techniques over to the difference/differential context.

We will conclude by applying these techniques to study the cohomology of difference algebraic groups and discuss potential model-theoretic consequences.

▸ ZANIAR GHADERNEZHAD, *Non-amenablility of automorphism groups of generic structures.*

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A group G is amenable if every G-flow has an invariant Borel probability measure. Well-known examples of amenable groups are finite groups, solvable groups and locally compact abelian groups. Kechris, Pestov, and Todorcevic established a very general correspondence which equates a stronger form of amenability, called extreme amenability, of the automorphism group of an ordered Fraïssé structure with the Ramsey property of its finite substructures. In the same spirit Moore showed a correspondence between the automorphism groups of countable structure and a a structural Ramsey property, which englobes Følner's existing treatment. In this talk we will consider automorphism groups of certain Hrushovski's generic structures. We will show that they are not amenable by exhibiting a combinatorial/geometrical criterion which forbids amenability.

▸ TOMÁS IBARLUCÍA, *Model theory of strongly ergodic actions.*
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I will discuss novel applications of continuous logic to ergodic theory, particularly to the study of rigidity phenomena associated with strongly ergodic actions of countable groups. This is joint work in progress with François Le Maître and Todor Tsankov.

▸ MARTIN BAYS, *Pseudofiniteness in fields, modularity, and groups.*
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Part of a project with Emmanuel Breuillard and Hong Wang. Hrushovski has pointed to intriguing connections between ideas of geometric stability theory and phenomena in the combinatorics of (pseudo)finite sets in fields. In particular, Szemeredi-Trotter results can, in certain situations, be interpreted as a kind of modularity, and results of Elekes-Szabo on groups arising from pseudofinite configurations can be seen as arising from the same source as the groups which arise in non-trivial modular minimal sets. I will discuss some further observations along these lines.

▸ VINCENZO MANTOVA, *Transseries as surreal analytic functions.*
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Transseries such as LE series arise when dealing with certain asymptotic expansions of real analytic function. Most transseries, though, are not convergent, and cannot represent real analytic functions, if only just for cardinality reasons.

On the other hand, we can show that LE series do induce germs of nonstandard analytic functions on the *surreal line*. More generally, call "omega-series" the surreal numbers that can be generated from the real numbers and the ordinal omega by closing under exponentiation, logarithm and infinite sum. Then omega-series form a proper class of transseries including LE series.

It turns out that all omega-series induce (germs of) surreal analytic functions. Moreover, they can be composed and differentiated in a way that is consistent with their interpretation as functions, extending the already known composition and derivation of LE series, and the derivation coincides with the simplest one on surreal numbers.

This is joint work with A. Berarducci.

▸ FRANZISKA JAHNKE, *NIP fields and henselianity*.
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NIP is a model-theoretic dividing line which was introduced in Shelah's classification theory programme. As with any combinatorial property, it is a natural question to ask whether it corresponds to some well-known algebraic notion when one considers the class of NIP fields. An open conjecture by Shelah states that every NIP field is either real closed or separably closed or 'like the p-adic numbers'. In this talk, I will explain the conjecture and discuss some recent developments around it.

2.5 Special session on philosophical logic

Tuesday,	15th of August
14:00	Juliette Kennedy
14:30	Davide Rizza
15:00	Giambattista Formica

Friday,	18th of August
14:00	Michele Friend
14:30	Sara Negri
15:00	Benedikt Loewe

▸ JULIETTE KENNEDY, *Squeezing arguments and strong logics.*
Department of Mathematics and Statistics, University of Helsinki, P.O. Box 68 (Gustaf Hllstrmin katu 2b) FI-00014 University of Helsinki, Finland.
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G. Kreisel has suggested that squeezing arguments, originally formulated for the informal concept of first order validity, should be extendable to second order logic, although he points out obvious obstacles. We develop this idea in the light of more recent advances and delineate the difficulties across the spectrum of extensions of first order logics by generalised quantifiers and infinitary logics. In particular we argue that if the relevant informal concept is read as informal in the precise sense of being untethered to a particular semantics, then the squeezing argument goes through in the second order case. Consideration of weak forms of Kreisel's squeezing argument leads naturally to reflection principles of set theory. This is joint work with Jouko Väänänen.

▸ DAVIDE RIZZA, *How to make an infinite decision.*
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Infinite exchange problems arise when certain computable features of finite iterations of decisions are studied over an actual (usually countable) infinity of acts. In presence of standard sequential reasoning, as familiar from real analysis, it looks as if infinite iterations lead to the loss of features typical of finite iterations. This conclusion, however, depends on the lack of a proper, computationally amenable, approach to actually infinite iterations of decisions. Once it is possible to offer a numerical specification of the infinitely large number of iterations concerned, it becomes possible to compute features that sequential reasoning could not represent. This gives rise to a uniform, elementary resolution of puzzles concerning infinite decisions (notably those in [2]). In this paper I present a fruitful approach that achieves this goal, due to Yaroslav Sergeyev, informally presented in [3] and axiomatised in the context of second order predicative arithmetic in [1].

[1] Lolli, G., *Metamathematical Investigations on the Theory of Grossone*, ***Applied Mathematics and Computation***, vol. 255 (2015), pp. 3–14.

[2] Scott, M. and A. Scott, *Infinite exchange problems*, ***Theory and Decision***, vol.57 (2005), no.4, pp. 397–406.

[3] Sergeyev, Ya.D., *A new applied approach for executing computations with infinite and infinitesimal quantities*, ***Informatica***, vol.19 (2008), no.4, pp. 567–596.

▶ GIAMBATTISTA FORMICA, *On Hilbert's axiomatic method.*
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Hilbert's methodological reflection certainly shaped a new image of the axiomatic method. However, the discussion on the nature of this method is still open. There are (1) those who have seen it as a synthetic method, i.e., a method to derive theorems from axioms already and arbitrarily established; (2) others have counter-argued in favor of its analytical nature, i.e., given a particular scientific field the method is useful to reach the conditions (axioms) for the known results of the field (theorems) and to rightly place both in a well-structured theory; (3) still others underlined the metatheoretical nature of the axiomatic reflection, i.e., the axiomatic method is the method to verify whether axioms already identified satisfy properties such as completeness, independence and consistency.

Each of these views has highlighted aspects of the way Hilbert conceived and practiced the axiomatic method, so they can be harmonized into an image better suited to the function the method was called to fulfill: i.e., deepening the foundations of given scientific fields, to recall one of his well-known expressions. Considering some textual evidence from early and late writings, I shall argue that the axiomatic method is in Hilbert's hands a very flexible tool of inquiry and that to lead analytically to an axiomatic well-structured theory it needs to include dynamically both synthetic procedures and metatheoretical reflections. Therefore, in Hilbert's concern the expression "deepening the foundations" denotes the whole set of considerations, permitted by the axiomatic method, that allow the theoretician first to identify and then to present systems of axioms for given scientific fields.

▸ MICHÈLE FRIEND, *Reasoning abhorrently.*
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We reason in different ways on different occasions. Sometimes it is suitable to reason classically, sometimes constructively and sometimes paraconsistently. We might insist on, prefer, be trained in, or find familiar, some forms of reasoning. Each form will enjoy its own suite of formal representations. Some formal representations are clearly extensions of others, for example, we can add modal operators to classical propositional logic. But sometimes we are called upon to reason in a way that is to-our-lights: incorrect, unfamiliar, disagreeable or perverse; call these 'abhorrent' for short. At such times, to allay the threat of incorrectness, triviality, or absurdity, we reason hypothetically, or "in quotation marks". We compartmentalise the reasoning in some way. The tractable technical question is how to formally represent how we do this in such a way as to ultimately fend from whatever we find abhorrent. The deeper, philosophical question is how to understand what it is that we are doing when in the process of orchestrating such reasoning and carrying out such reasoning. After all, it is only later that we model such reasoning using a formal or semi-formal representation that re-constructs the reasoning to show that it was legitimate.

▸ SARA NEGRI, *Reasoning with counterfactual scenarios: from models to proofs.*

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Ever since the sophisticated analysis provided by David Lewis, counterfactuals have been a challenge to logicians, because they were shown to escape both the traditional truth-valued semantics and the standard possible worlds semantics. Lewis' semantics will be here generalized and shown capable of covering, in a modular way, all the systems for counterfactuals presented in [1]. On its basis, and along the methodology of [3], proof systems are developed that feature a transparent justification of their rules [2], good structural properties, analyticity, direct completeness and decidability proofs [4, 5].

[1] D. Lewis, ***Counterfactuals***, Blackwell, 1973.

[2] S. Negri, *Non-normal modal logics: a challenge to proof theory*, ***The Logica Yearbook 2016*** (P. Arazim and T. Lavička, editors), College Publications, 2017, in press.

[3] S. Negri, *Proof theory for non-normal modal logics: The neighbourhood formalism and basic results*, ***IfCoLog Journal of Logics and their Applications***, in press.

[4] S. Negri and G. Sbardolini, *Proof analysis for Lewis counterfactuals*, ***The Review of Symbolic Logic***, vol. 9 (2016), no. 1, pp. 44–75.

[5] S. Negri and N. Olivetti, *A sequent calculus for preferential conditional logic based on neighbourhood semantics*, ***Automated Reasoning with Analytic Tableaux and Related Methods*** (H. De Nivelle, editor), Lecture Notes in Computer Science, vol. 9323, Springer, 2015, pp. 115–134.

▸ ALEXANDER C. BLOCK, LUCA INCURVATI, & BENEDIKT LÖWE, *Maddian interpretations and their derived notions of restrictiveness*.
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Penelope Maddy's naturalistic approach to philosophy of mathematics aims to explain why the research community embraces some candidates for axiomatic foundations of mathematics and rejects others. In [5], she argued that since set theory aims to be a foundation for mathematics, it should conform to the methodological maxim MAXIMIZE and therefore, axiomatic set theories that are *restrictive* ought to be rejected. She then went on to define a formal notion of restrictiveness, based on a fixed class of interpretations. In [3, 4, 1], this notion was discussed and a number of technical and substantial issues were raised. Following [2], this talk will present the general framework for interpretations and their derived notions of restrictiveness and then go on to discuss a *symmetrised* version of Maddy's original notion that takes both inner model and outer model constructions into account and can deal with the substantial issues raised in [4].

[1] JOEL D. HAMKINS, *A multiverse perspective on the axiom of constructibility*, ***Infinity and Truth*** (Chitat Chong, Qi Feng, Theodore A. Slaman, and W. Hugh Woodin, editors), Lecture Notes Series, Institute for Mathematical Sciences, National University of Singapore, Vol. 25, World Scientific, Singapore, 2013, pp. 25–45.

[2] LUCA INCURVATI, BENEDIKT LÖWE, *Restrictiveness relative to notions of interpretation*, ***Review of Symbolic Logic***, vol. 9 (2016), no. 2, pp. 238-250.

[3] BENEDIKT LÖWE, *A first glance at non-restrictiveness*, ***Philosophia Mathematica***, vol. 9 (2001), pp. 347–354.

[4] BENEDIKT LÖWE, *A second glance at non-restrictiveness*, ***Philosophia Mathematica***, vol. 11 (2003), pp. 323–331.

[5] PENELOPE MADDY, ***Naturalism in Mathematics***, Clarendon Press, 1997.

2.6 Special session on proof theory

Monday,	14th of August
14:00	Fernando Ferreira
14:30	Annika Kanckos
15:00	Anton Setzer

Friday,	18th of August
14:00	Silvia Steila
14:30	Kentaro Sato
15:00	Anton Freund

▸ FERNANDO FERREIRA, *A herbrandized functional interpretation of classical first-order logic.*
Departamento de Matemática, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Ed. C6, Piso 2, 1749-016 Lisboa, Portugal.
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We define a (cumulative) functional interpretation of first-order classical logic and show that each theorem of first-order logic is naturally associated with a certain scheme of tautologies. Herbrand's theorem is obtained as a special case. The schemes are given through formulas of a language of finite-type logic defined with the help of an extended typed combinatory calculus that associates to each given type the type of its nonempty finite subsets. New combinators and reductions are defined, the properties of strong normalization and confluence still hold and, in reality, they play a crucial role in defining the above mentioned schemes. The functional interpretation is dubbed "cumulative" because it enjoys a monotonicity property now so characteristic of many recently defined functional interpretations.

(Joint work with Gilda Ferreira in [1].)

[1] Fernando Ferreira and Gilda Ferreira, *A herbrandized functional interpretation of classical first-order logic*, ***Archive for Mathematical Logic***, published online on 19 May 2017.

▸ ANNIKA KANCKOS, *Strong Normalization for Simply Typed Lambda Calculus.*
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A solution is proposed to Gödel's Koan as the problem is stated in the TLCA list of open problems. As the problem is formulated it contains an element of vagueness as it is presented as the problem of finding a simple or easy ordinal assignment for strong normalization of the beta-reduction of simply typed lambda calculus. Whether a proof is sufficiently easy to cathegorize as a solution is thus a matter of opinion.

The solution is based on (Howard, 1970) and its improved notation in (Schütte, 1977). These normalization proofs also work for a system with a recursor. However, when the recursor is absent, as in our case, a further simplification is possible. The delta-operation becomes redundant (or at least highly simplified), as does the use of ordinal and vector variables, while the crucial Howard's permutation lemma 2.6 is preserved with some alterations in the vector assigned to the abstracted term.

The proof also gives a unique ordinal assignment for strong normalization as opposed to the non-unique assignment of Howard. The limit ordinal of the assignment is ε_0. That this is possible is more or less noted by Howard when he explains that the delta-operation is the point where the strong normalization proof breaks down for his unique assignment. The reason being that the division into cases in the definition of the delta-operation makes some vectors incomparable and it becomes impossible to prove that the inequalities are preserved when the delta-operator is applied. Therefore, Howard's unique assignment is limited to a weak normalization (however with the recursor included). As mentioned the presented result gives a unique assignment for strong normalization though the recursor is not included in order to fit the problem description of the Koan that was first proposed by Gödel.

▸ ANTON SETZER, *The extended predicative Mahlo Universe in Explicit Mathematics – model construction*.

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URL Address: http://www.cs.swan.ac.uk/~csetzer/.

This is joint work with Reinhard Kahle, Lisbon. In [3] Setzer introduced the Mahlo universe V in type theory and determined its proof theoretic strength. This universe has a constructor, which depends on the totality of functions from families of sets in the universe into itself. Essentially for every such function f a subuniverse U_f of V was introduced, which is closed under f and represented in V. Because of the dependency on the totality of functions, not all type theoretists agree that this is a valid principle, if one takes Martin-Löf Type Theory as a foundation of mathematics.

Feferman's theory of Explicit Mathematics [1] is a different framework for constructive mathematics, in which we have direct access to the set of partial functions. In such a setting, we can avoid the reference to the totality of functions on V. Instead, we can take arbitrary partial functions f, and try to form a subuniverse U_f closed under f. If f is total on U_f, then we add a code for it to V. In [2] we developed a universe based on this idea (using m as a name for V and sub as a name for U), and showed that we can embed the axiomatic Mahlo universe, an adaption of the Mahlo construction as in [3] to Explicit Mathematics, into this universe. We added as well an induction principle, expressing that the Mahlo universe is the least one. Since the addition of U_f to V depends only on elements of V present before U_f was added to V, it can be regarded as being predicative, and we called it therefore the extended predicative Mahlo universe.

In this talk we construct a model of the extended predicative Mahlo universe in a suitable extension of Kripke-Platek set theory, in order to determine an upper bound for its proof theoretic strength. The model construction adds only elements to the Mahlo universe which are justified by its introduction rules. The model makes use of a new monotonicity condition on family sets, the notion of a monotone operator for defining universes, and a special condition for closure operators. This is an alternative to Richter's $[\Gamma, \Gamma']$ operator for defining closure operators.

[1] SOLOMON FEFERMAN ***Algebra and Logic***, (John Crossley, editor), Springer, 1975, pp. 87–139.

[2] REINHARD KAHLE AND ANTON SETZER, *An extended predicative definition of the Mahlo universe*, ***Ways of proof theory***, (Ralf Schindler, editor), Ontos Series in Mathematical Logic, Ontos Verlag, Frankfurt (Main), Germany, 2010, pp. 315–340.

[3] ANTON SETZER, *Extending Martin-Löf Type Theory by one Mahlo-Universe*, ***Archive for Mathematical Logic***, vol. 39 (2000), pp. 155–181.

▸ GERHARD JÄGER, SILVIA STEILA, *On some fixed point statements over Kripke Platek*.
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E-mail: {`jaeger, steila`}`@inf.unibe.ch`.

In Kripke Platek Set Theory (KP), every monotone, set-bounded Σ_1-operator has a Σ_1-definable least fixed point. Hence Σ_1-separation is strong enough to prove that the least fixed point is actually a set. To the aim of understanding the relation between these two principles, we perform an analysis of some distinct fixed-points-statements over KP.

▸ KENTARO SATO, *Inductive Dichotomy and Determinacy of Difference Hierarchy.*
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In the context of second order arithmetic, as well as second order set theory and higher order arithmetic (as in the previous works [2, 3] of the speaker), a new weak variant of inductive definition, called inductive dichotomy, is introduced. Intuitively, this asserts that, for any x, either there is a witness that x is in the least fixed point or there is a witness that x is outside of the least fixed point, without claiming the existence of the least fixed point itself. This is combined with axioms of iterated inductive definition in various ways. Though some of them do not seem natural, they are motivated by the equivalences with determinacy axioms. Actually, such equivalences will be used to show the determinacy axioms associated with Hausdorff-Kuratowski hierarchy of differences of opens form a strict hierarchy in the sense of consistency, with only one exception: between clopen and open determinacy in second order arithmetic. In particular, in the other frameworks, open determinacy is consistency-wise strictly stronger than clopen one. This is among dissimilarities between second order arithmetic and the other frameworks which have been discovered in the previous works, and enhances Hachtman's [1] separation of clopen and open determinacies to a consistency-wise separation.

[1] S. Hachtman, *Determinacy separations for class games*, manuscript, arXiv:1607.05515, 2016.

[2] K. Sato, Relative predicativity and dependent recursion in second-order set theory and higher-order theories, *Journal of Symbolic Logic* 79(3), 712–732 (2014).

[3] K. Sato, Full and hat inductive definitions are equivalent in **NBG**, *Archive for Mathematical Logic* 54, 75–112 (2015).

▶ ANTON FREUND, *Type-Two Well-Ordering Principles and* Π^1_1*-Comprehension*.
Department of Pure Mathematics, University of Leeds, Leeds LS2 9JT, England.
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A well-ordering principle of type one consists of a construction which transforms linear orders into linear orders, together with the assertion that well-foundedness is preserved. It is known that many second order axioms of complexity Π^1_2 (e.g. arithmetical comprehension, arithmetical transfinite recursion) are equivalent to natural well-ordering principles of type one. Montalbán [1, Section 4.5] and Rathjen [2, Section 6] have conjectured that Π^1_1-comprehension, which is a Π^1_3-statement, corresponds to a well-ordering principle of type two: one that transforms each well-ordering principle of type one into a well-order. I will present recent progress [3] towards this conjecture.

[1] Antonio Montalbán, *Open questions in Reverse Mathematics*, ***Bulletin of Symbolic Logic***, vol. 17 (2013), pp. 431-454.

[2] Michael Rathjen, *Omega-models and well-ordering principles*, ***Foundational Adventures: Essays in Honor of Harvey M. Friedman*** (Neil Tennant, editor), College Publications, London, 2014, pp. 179–212.

[3] Anton Freund, *A Higher Bachmann-Howard Principle*, arXiv:1704.01662 (preprint).

2.7 Special session on set theory

Monday.	14th of August
14:00	Sandra Uhlenbrock
14:30	Ashutosh Kumar
15:00	Giorgio Laguzzi

Thursday,	17th of August
14:00	Brent Cody
14:30	William Chen
15:00	Yann Pequignot

▸ SANDRA UHLENBROCK, *The hereditarily ordinal definable sets in inner models with finitely many Woodin cardinals.*
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E-mail: sandra.uhlenbrock@univie.ac.at.

An essential question regarding the theory of inner models is the analysis of the class of all hereditarily ordinal definable sets HOD inside various inner models M of the set theoretic universe V under appropriate determinacy hypotheses. Examples for such inner models M are $L(\mathbb{R})$, $L[x]$ and $M_n(x)$. Woodin showed that under determinacy hypotheses these models of the form HOD^M contain large cardinals, which motivates the question whether they are fine-structural as for example the models $L(\mathbb{R})$, $L[x]$ and $M_n(x)$ are. A positive answer to this question would yield that they are models of CH, $\diamond$, and other combinatorial principles.

The first model which was analyzed in this sense was $\mathrm{HOD}^{L(\mathbb{R})}$ under the assumption that every set of reals in $L(\mathbb{R})$ is determined. In the 1990's Steel and Woodin were able to show that $\mathrm{HOD}^{L(\mathbb{R})} = L[M_\infty, \Lambda]$, where M_∞ is a direct limit of iterates of the canonical mouse M_ω and Λ is a partial iteration strategy for M_∞. Moreover Woodin obtained a similar result for the model $\mathrm{HOD}^{L[x,G]}$ assuming Δ^1_2 determinacy, where x is a real of sufficiently high Turing degree, G is $\mathrm{Col}(\omega, {<}\kappa_x)$-generic over $L[x]$ and κ_x is the least inaccessible cardinal in $L[x]$.

In this talk I will give an overview of these results and outline how they can be extended to the model $\mathrm{HOD}^{M_n(x,g)}$ assuming $\mathbf{\Pi}^1_{n+2}$ determinacy, where x again is a real of sufficiently high Turing degree, g is $\mathrm{Col}(\omega, {<}\kappa_x)$-generic over $M_n(x)$ and κ_x is the least inaccessible cutpoint in $M_n(x)$ which is a limit of cutpoints in $M_n(x)$.

This is joint work with Grigor Sargsyan.

▶ ASHUTOSH KUMAR, *Transversal of full outer measure.*
Hebrew University of Jerusalem.
E-mail: akumar@math.huji.ac.il.

For every partition of a set of reals into countable sets there is a transversal of full outer measure. Joint work with S. Shelah.

[1] A. Kumar, S, Shelah, *A transversal of full outer measure*, ***Preprint***

▸ GIORGIO LAGUZZI, *Infinite utility streams and irregular sets.*
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Utility streams for infinite horizon have been widely investigated in economical theory in the last decades. From the set-theoretical view point, infinite utility streams are nothing more than infinite sequences on certain topological spaces, and so they can be analyzed and studied with the usual methods coming from forcing and descriptive set theory. In particular, Zame [3] and Lauwers [2] showed that the existence of Paretian social welfare relations satisfying intergenerational equity imply the existence of non-constructible objects, such as non-Ramsey and non-measurable sets.

In this talk I prove some connection also with another well-known regularity property, namely the Baire property, and I use Shelah's amalgamation ([1] for a very detailed and complete introduction) in order to show that the two above implications do not reverse. Moreover I also investigate other types of egalitarian pre-orders, such as pre-orders satisfying Pigou-Dalton's principle and Hammond's principle.

I thank Adrian Mathias to suggest me the reading of [2] and more generally to show me this connection between set theory and theoretical economics.

[1] Haim Judah, Andrej Roslanowsky, *On Shelah's amalgamation*, ***Israel Mathematical Conference Proceedings***, Vol. 6 (1993), pp. 385-414.

[2] Luc Lauwers, *Ordering infinite utility streams comes at the cost of a non-Ramsey set*, ***Journal of Mathematical Economics***, Vol. 46 (2009), pp 32-37.

[3] William R. Zame, *Can intergenerational equity be operationalized?*, ***Theoretical Economics***, Vol. 2 (2007), pp 187-202.

▸ BRENT CODY, *Adding a non-reflecting weakly compact set.*
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There is is a strong analogy between stationary sets and weakly compact sets. However, by a theorem of Kunen there are models in which non-weakly compact sets can become weakly compact after forcing, whereas nonstationary sets can never be forced to become stationary. Thus, proofs about the ideal of non-weakly compact sets often require a finer analysis than their counterparts for the nonstationary ideal. Many questions whose analogues have been answered for the nonstationary ideal remain open for the weakly compact ideal, and higher order Π^1_n-indescribability ideals. This talk will survey what is known in this area and will include a discussion of some recent results on the weakly compact reflection principle, which is a generalization of a certain stationary reflection principle. We say that the weakly compact reflection principle holds at κ and write $\mathrm{Refl}_{\mathrm{wc}}(\kappa)$ if and only if κ is a weakly compact cardinal and every weakly compact subset of κ has a weakly compact proper initial segment. The weakly compact reflection principle at κ implies that κ is ω-weakly compact, and in this talk we will discuss a proof that the converse of this statement can be false. Moreover, if κ is $(\alpha+1)$-weakly compact where $\alpha < \kappa^+$ then there is a forcing extension in which there is a weakly compact set $W \subseteq \kappa$ having no weakly compact proper initial segment, the class of weakly compact cardinals is preserved and κ remains $(\alpha+1)$-weakly compact.

▶ WILLIAM CHEN, *Negative partition relations from cardinal invariants.*
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Classically, many partition relations involving ω_1 and countable ordinals were shown to fail from CH. In joint work with Shimon Garti and Thilo Weinert, we prove that having certain cardinal characteristics equal to $\aleph_1$ causes the failure of partition relations such as $\omega_1 \to (\omega_1, \omega{+}2)^2_2$ and $\omega_1^2 \to (\omega_1\omega, 4)^2_2$. Most often, we use the hypothesis $\mathfrak{d} = \aleph_1$, but this seems quite strong. In an effort to use weaker hypotheses, we consider how partition relations behave under the stick principle, and with certain values of invariants for category, evasion and prediction.

Chapter 3

Contributed talks

▸ BAHAREH AFSHARI, *Interpolation for modal mu-calculus.*
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Modal logics are known to widely enjoy interpolation and so does modal μ-calculus, the extension of modal logic by propositional fixed point quantifiers. D'Agostino and Hollenberg [2] utilise automata theory to show that bisimulation quantifiers are expressible in modal μ-calculus and can be used to define interpolants. I will present a constructive and purely syntactic proof of Lyndon (and hence also Craig) interpolation via a finitary sequent calculus of circular proofs introduced in [1].

[1] Bahareh Afshari and Graham E. Leigh, *Cut-free completeness for modal mu-calculus*, ***Proceeding of Thirty-Second Annual ACM/IEEE Symposium on Logic in Computer Science*** (Reykjavik, Iceland), 2017, to appear.

[2] Giovanna D'Agostino and Marco Hollenberg, *Logical questions concerning the μ-calculus*, ***Journal of Symbolic Logic***, vol. 65 (2000), no. 1, pp. 310–332.

▸ BAHAREH AFSHARI, AND GRAHAM E. LEIGH, *Cut-free completeness for modal mu-calculus.*
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Modal μ-calculus is the extension of propositional modal logic by constructors for fixed points of inductive and co-inductive definitions. Kozen [1] proposed an axiomatisation for the logic which was proved to be complete by Walukiewicz [2]. Kozen's system contains cut and Walukiewicz' proof makes essential use of this rule. We present a cut-free sequent calculus for the logic that features a strengthening of the standard induction rule for greatest fixed point. The system is readily seen to be sound and its completeness is established by utilising a novel calculus of circular proofs. As a corollary we obtain a new, constructive, proof of completeness for Kozen's axiomatisation which avoids the usual detour through automata and games.

[1] Dexter Kozen, *Results on the propositional μ-calculus*, ***Theoretical Computer Science***, vol. 27 (1983), pp. 333–354.

[2] Igor Walukiewicz, *Completeness of Kozen's axiomatisation of the propositional μ-calculus*, ***Information and Computation***, vol. 157 (2000), pp. 142–182.

▸ OVE AHLMAN, *Easy and hard homogenizable structures.*
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For any natural number k, a structure $\mathcal{M}$ is called $>k-$homogeneous if for any $\mathcal{A} \subseteq \mathcal{M}$ with $|A| > k$ if $f : \mathcal{A} \to \mathcal{M}$ is an embedding, then f may be extended into an automorphism of $\mathcal{M}$. A structure is called homogeneous (sometimes called ultrahomogeneous) if it is both $>k-$homogeneous and $\leq k-$homogeneous. The random graph is a typical example of a homogeneous structure while the random $t-$partite graph is not. However the random $t-$partite graph can be forced into being homogeneous by adding a definable binary predicate ξ as a new relational symbol such that $\xi(a, b)$ hold if and only if a and b are in the same part. We say that a structure is homogenizable if there exists a finite amount of definable new relations which may be added to the signature in order to make the structure homogeneous.

Since the homogeneous structures have many nice properties, it is a natural question to ask which structures are the closest to being homogeneous. In this talk I will give you a tour of the homogenizable structures, pointing out especially how close (or not) the structures are to being homogeneous. We will take special care with the $>k-$homogeneous graphs for which I will also provide an explicit classification.

► OĞUZ AKÇELİK, AZİZ F. ZAMBAK, *A Decision Procedure Model for Finding the Missing Premise in Automated Reasoning.*

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Missing premise is an unstated premise that is required to make an incomplete argument valid. Discovering a missing premise in an argument is crucial for both commonsense reasoning and scientific reasoning [2, 1]. In natural sciences, there are lots of data sets used for supporting scientific hypotheses. There may be some cases in which these data sets cannot support the hypotheses. The technique, which is developed to discover the missing premise, can help to find the required information in order to build a bridge between the data set and hypotheses. Our method aims to provide a decision procedure in order to reason with uncertainty and inconsistency, which will ease formal reasoning.

We build a proof theoretical model to provide a decision procedure for finding the missing premise. A model for decision procedure consists of finite number of steps for proving the validity of arguments [4, 3]. For this purpose, we construe a decision procedure by means of formal techniques, i.e. definitions and set of rules, including an automated reasoning computer program, to find the missing premise in the domain of first order monadic predicate logic without identity. In our study we are running a modified version of "Tree Proof Generator" developed by Wolfgang Schwarz which is based on analytic tableaux method [6]. We use eligible problems from [5] for testing the decision procedure model. We first introduce a notation then using this notation we formulate the basic rules that will be used in our project.

[1] Besnard, P. and Hunter, A., *A logic-based theory of deductive arguments*, ***Artificial Intelligence***, vol. 128 (2001), no. 1-2, pp. 203–235.

[2] Chesnevar, C.; Marguitman, A, *Logical models of argument*, ***ACM Computing Surveys***, vol. 32 (2000), pp. 337–383.

[3] Dupin de Saint-Cry, F., *Handling Enthymemes in Time-Limited Persuasion Dialogs*, ***Scalable Uncertainty Management*** (S. Benferhat and J. Grant, editors), Springer, 2011, pp. 149–162.

[4] Macagno F. and Walton D., *Enthymemes, argumentation schemes, and topics*, ***Logique et Analyse***, vol. 205 (2009), pp. 39–56.

[5] Pelletier, F. J., *Seventy-five problems for testing automatic theorem provers*, ***Journal of Automated Reasoning***, vol. 205 (1986), no. 2, pp. 191–216.

[6] Schwarz, W., ***Tree Proof Generator***, v2.09 (2015-03-04) http://www.umsu.de/logik/trees/

▸ SVETLANA ALEKSANDROVA, *On computability in hereditarily finite superstructures and computable analysis.*
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One of the widely known ways to extend computability theory on the objects of mathematical analysis is computable analysis [1]. On the other hand, to describe computability in an uncountable structure we can use an approach via definability by $\Sigma-$formulas in hereditarily finite superstructure over that structure, which was introduced by Yu.L. Ershov in [2].

In this talk we will compare expressive powers of $\Sigma-$definability in hereditarily finite superstructures and computable analysis. In particular, we show that there exists a computable real function, which is not $\Sigma-$definable in hereditarily finite superstructure over the real exponential field.

[1] WEIHRAUCH, K., ***Computable analysis.***, Texts in Theoretical Computer Science, An EATCS Series, Springer-Verlag, Berlin 2000.

[2] ERSHOV, YU. L., ***Definability and Computability***, Consultants Bureau, New York-London-Moscow, 1996.

▸ PAVEL ARAZIM, *Logical dynamism as a way of understanding plurality of logics.*
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The very presence of multiple mathematical systems each of which is called *logic* raises the questions what these systems really have in common and whether we have in fact discovered that we can have many different logics. One extreme reaction to this situation is logical monism (maintained, for instance, by Leech), an alternative is logical pluralism (defended, for example, by Beall and Restall), which can vary as to its breadth as well as to its exact nature. I think both the pluralist and the monist intuitions are sound and a way of combining the seemingly incompatible insights should be found. I will present a view which edeavours to achieve as much, namely *logical dynamism*, as it emphasizes logic's ability to develop. Based on the general tenets of inferentialism and logical expressivism (as presented by Brandom and Peregrin), it asserts that any concept can develop by the change of our normative stances and the logical notions, such as that of conjunction, negation, conditional etc. are no exceptions to this. Nevertheless, as the logical expressivism has it that logic is here to make the inferential rules which constitute our concepts explicit, it is difficult to make the logical notions themselves explicit because that would be close to circular. Yet lacking the possiblity to develop each logical concept explicitly on its own, we have the various logical systems each of which points to the possibility of how the whole logical activity of making rules explicit could develop. We thus share one common logic but this can develop in multifarious ways, as is shown by the multifarious logical systems. Both monism and pluralism were thus right but did not tell us the whole story.

[1] Beall, J. & Restall, ***Logical pluralism***, Oxford University Press, 2006.

[2] Robert Brandom, ***Making it explicit***, Cambridge: Harvard University Press, 1994.

[3] Jessica Leech, *Logic and the laws of thought*, ***Philosopher's imprint***, vol. 15 (2015), no. 12, pp. 1–27.

[4] Jaroslav Peregrin, ***Inferentialism: Why rules matter***, Palgrave Macmillan, 2014.

▸ MICHAEL ARNDT, *Tomographs for substructural display logic.*
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The central feature of Belnap's Display Logic [1] is the possibility of displaying every formula occuring in any given sequent as the only formula in either the antecedent or succedent. This is accomplished by means of structural connectives that retain the positional information of the contextual formulae as they are moved aside. Goré [2] accomodates substructural, intuitionistic and dual intuitionistic logic families by building upon a basic display calculus for Bi-Lambek logic. His version uses two nullary, two unary, and three binary structural connectives. The meaning of each of these varies depending on whether it occurs in an antecendent part or in a succedent part of a sequent. Since the structural connectives are not independent of one another, display equivalences are required to mediate between the binary structural connectives.

I propose an alternative approach in which two graph-like ternary structural connectives express one set of three structural connectives each. Each of these new connectives represents all three sequents making up one of the two display equivalences. The notion of sequent disappears and is replaced by that of a structure graph consisting of systems of ternary connectives in which occurrence variables or nodes mark the linking of the connectives and of formulae to those connectives. This manner of linking yields tomographs, graphs that have the property that disconnecting a structure graph at an occurrence variable yields two unconnected subgraphs. The turnstile of a sequent is represented by the highlighting of a single one of the occurrence variables linking connectives.

I will demonstrate that the highlight can be moved freely within the tomograph in accordance to the display equivalences. Specifically, every outmost occurrence variable can be highlighted, and this corresponds to displaying the formula connected to that occurrence. Furthermore, one of the two nullary connectives can be shown to arise as a special case for empty positions of the ternary connective, and the unary negation connectives can be shown to be definable through the ternary ones with the help of that nullary connective. The result is a tomographical framework for Gor's Substructural Display Logic.

[1] Nuel D. Belnap, *Display logic*, ***Journal of Philosophical Logic***, vol. 11 (1982), pp. 375–417.

[2] Rajeev Goré, *Substructural logics on display*, ***Logic Journal of the Interest Group in Pure and Applied Logics***, vol. 6 (1998), no. 3, pp. 451–504.

▸ SERGEI ARTEMOV, ELENA NOGINA, *On completeness of epistemic theories.*
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Semantic formalizations of epistemic situations as Kripke models produce complete descriptions: for each sentence F, they specify which of F or $\neg F$ holds. This renders semantic formalizations inadequate for incomplete scenarios. To represent all epistemic situations, complete and incomplete, we need *epistemic theories*, i.e., sets of epistemic formulas (cf. [1]), analogous to *mathematical theories*, many of which are incomplete (group theory, Peano Arithmetic, etc.).

We consider epistemic theories of card dealing and establish their completeness. One should not expect epistemic completeness to be maintained throughout the game: players could use private communications to learn facts which do not follow from the game description. For such situations, epistemic theories become essential.

Assume a deck of cards dealt to n players. Consider epistemic logic $\mathsf{S5}^n$ with atomic propositions *'player i is dealt card j'*; for a given property P, let $\ulcorner P \urcorner$ denote its representation by a formula. Let Γ be set of formulas $\mathsf{S5}^n + \ulcorner$*rules of dealing*$\urcorner +$
$\ulcorner$*each player knows her hand and deems possible any dealing consistent with it*$\urcorner$. For each combination α of cards dealt, define theory

$$\Delta_\alpha = \ulcorner \textit{common knowledge of } \Gamma \urcorner + \ulcorner \alpha \urcorner.$$

The standard model of card dealing (cf. [2]) has all possible dealings as worlds, indistinguishability as accessibility relations, and the natural evaluation of atomic propositions.

Completeness Theorem: $\Delta_\alpha \vdash F$ *iff* $\alpha \Vdash F$ *in the standard model.*

[1] S. Artemov, *Syntactic Epistemic Logic*, ***Book of abstracts. 15th Congress of Logic, Methodology and Philosophy of Science*** University of Helsinki, 2015, pp. 109–110.

[2] R. Fagin, J. Halpern, *et al.*, ***Reasoning about knowledge***, MIT Press, 1995.

▸ ASHOT BAGHDASARYAN, HOVHANNES BOLIBEKYAN, *On Some Systems of Minimal Propositional Logic with History Mechanism.*
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Backwards proof search and theorem proving with a standard cut-free calculus for the propositional fragment of minimal logic is insufficient because of three problems. Firstly, the proof search is not in general terminating caused by the possibility of looping. Secondly, it might generate proofs which are permutations of each other and represent the same natural deduction. Finally, during the proof some choice should be made to decide which rules to apply and where to use them. Several proof systems of I.Johansson's minimal logic of predicates were introduced in [1]. Looping is the main issue in the propositional fragment of the system GM^- developed in [1]. Looping may easily be removed by checking if a sequent has already occurred in the branch. Though this is insufficient as it requires much information to be stored. Some looping mechanisms have been considered earlier in [2,3]. One way to detect loops is adding history to each sequent.

We introduce two systems for propositional fragment of minimal logic (SwMin and ScMin) which are slightly different. Both systems are based on the idea of adding context to the sequents. In one system, SwMin, the history is kept smaller, but ScMin detects loops more quickly. The heart of the difference between the two systems is that in the SwMin loop checking is done when a formula leaves the goal, whereas in the ScMin it is done when it becomes the goal.

Theorem

1. The systems GM^- and SwMin are equivalent.
2. The systems GM^- and ScMin are equivalent.

[1] Bolibekyan H. R., Chubaryan A. A., *On some proof systems for I.Johansson's minimal logic of predicates*, ***Proceedings of the Logic Colloquium***, 2003, p. 56.

[2] Gabbay D., *Algorithmic proof with diminishing resources*, ***Springer Lecture Notes in Computer Science*** 1991, 533, Part 1, pp. 156-173.

[3] Bolibekyan H., Muradyan T., *On some loop detection strategies for minimal propositional logic*, ***Proceedings of the Logic Colloquium*** 2011 , p. 45-46.

▸ NIKOLAY BAZHENOV, EKATERINA FOKINA, DINO ROSSEGGER, AND LUCA SAN MAURO, *Computable bi-embeddable categoricity of equivalence relations.*
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We study the algorithmic complexity of embeddings between bi-embeddable equivalence structures. To do this, we use the notions of Δ^0_α *bi-embeddable categoricity* and *relative* Δ^0_α *bi-embeddable categoricity* defined analogously to the standard concepts of Δ^0_α categoricity and relative Δ^0_α categoricity.

We give a characterization of Δ^0_1 bi-embeddably categorical equivalence structures, completely characterize Δ^0_2 bi-embeddably categorical and relatively Δ^0_2 bi-embeddably categorical equivalence structures, and show that all equivalence structures are relatively Δ^0_3 bi-embeddably categorical.

Furthermore, let the *degree of bi-embeddable categoricity* of a computable structure $\mathcal{A}$ be the least Turing degree that, if it exists, computes embeddings between any computable bi-embeddable copies of $\mathcal{A}$. Then every computable equivalence structure has a degree of bi-embeddable categoricity, and the only possible degrees of bi-embeddable categoricity for equivalence structures are $\mathbf{0}, \mathbf{0}'$ and $\mathbf{0}''$.

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In standard Propositional Dynamic Logic (PDL) literature [1], the semantics is given by Labeled Transition Systems, where for each program π we associate a binary relation R_π. Process Algebras also give semantics to process (terms) by means of Labeled Transition Systems. In both formalisms, PDL and Process Algebra, the key notion to compare processes is bisimulation. In PDL, we also have the notion of logic equivalence, that can be used to prove that two programs π_1 and π_2 are logically equivalent $\vdash \langle\pi_1\rangle\varphi \leftrightarrow \langle\pi_2\rangle\varphi$. Unfortunately, logic equivalence and bisimulation do not match in PDL. Bisimilar programs are logic equivalent but the converse does not hold.

This paper proposes a semantics and an axiomatization for PDL that makes logically equivalent programs also bisimilar. This allows for developing Dynamic Logics to reasoning process algebras about specification, in particular about CCS (Calculus for Communicating Systems) [2]. As in CCS the bisimulation is the main tool to establish equivalence of programs, it is very important that these two relations coincide. We propose a new Propositional Dynamic Logic with a new non-deterministic choice operator, PDL+. We prove its soundness, completeness, finite model property and EXPTIME-completeness for the satisfiability problem.

We also add to PDL+ the parallel composition operator (PPDL+) and prove its soundness and completeness. We establish that the satisfiability problem for PPDL+ is in 2-EXPTIME. Finally, we define some fragments of PPDL+ and prove its EXPTIME-completeness.

In [3, 4] we do not deal with test operator. In this work we discuss some issues concerning test and point out some direction on how it can be handle.

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One of the virtues of Voevodsky's celebrated univalence axiom is that it offers a formal justification for the common practice among mathematicians of identifying objects just in case they are isomorphic. Since in general there may be different isomorphisms between any two objects, it follows that a thing can be recognized as the same again in more than one way. Equipped with this axiom and other powerful features, homotopy type theory (The Univalent Foundations Program 2013) provides a novel notion of equality with a subtle structure that takes account of the different reasons a thing can be the same.

Over one hundred years ago, Frege (1982) drew attention to a puzzle concerning the slippery and multifaceted nature of equality. In a sense, he also arrived at the conclusion that there should be different ways for two objects to be identified — and he explained this by saying that two objects expressing a different sense denote the same referent. Now, a natural question is "can the homotopy-type theoretic notion of equality shed new light on Frege's puzzle?"

In this work-in-progress talk, I shall propose a constructive solution for Frege's puzzle based on elementary insights from homotopy type theory. I claim that, from the viewpoint of constructive semantics, Frege's solution is unable to explain adequately the informative content of identity statements, since, as I shall argue, not only identity statements of the form "$a = b$", but also "$a = a$" may contribute to extensions of our knowledge. More precisely, I hold that my approach can be seen as an extension of Frege's ideas to account for constructive reasoning.

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One of the main reasons for introducing a formal language is to remove ambiguity, the possibility of assigning several meanings to a linguistic expression. Typically, this is achieved through ensuring unique readability of formulas by using brackets (or another convention, such as Polish notation). Unique readability implies meaning uniqueness, exactly one valuation of a sentence given an interpretation of basic formulas and recursive truth conditions. Obviously, in natural language this one-to-one correspondence between syntax and semantics is absent, the unique readability assumption does not hold true universally. Whereas e.g. scope ambiguities in natural languages have been studied extensively, ambiguous formal languages have not been the focus of in depth research. Here, we lift the assumption of unique readability by omitting the brackets from propositional logic, making it possible to formally distinguish between syntactic and semantic ambiguity. A valuation then amounts to a semantic disambiguation, and rather than a unique valuation (truth value), there is a set of valuations corresponding to ways a formula could have been constructed. We show what happens to familiar concepts of logic such as definability, satisfiability and validity. Here follows two simple examples illustrating the relation between syntactic and semantic ambiguity. In some cases unique readability can be regained through careful construction of formulas. E.g., although an attempt to define $p \to q$ as $\neg p \vee q$ would be syntactically and semantically ambiguous, one may define it as $q \vee \neg p$, which can be read only one way (but obviously this construction is not stable under substitution). Syntactic ambiguity does not imply semantic ambiguity, although it is typically the case. For instance, although the formula $p \wedge \neg p \wedge p$ can be read in three ways, it has only one possible meaning (a contradiction).

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This paper performs a constructivist, qualitative evaluation of different ontological, epistemic approaches to intentionality. Primarily, the paper will consider Brentano's theory of intentionality and Husserl's development of intentional inexistence. I will use Husserl's exploration of noesis and noema (as a direct extraction from Brentano's intentional object) to highlight the importance of Frege's judgement stroke and how this logical symbol bridges the gap between analytic and continental philosophy.

Brentano's theory of intentionality suggests two processes: we must have a mode of existence of an object (e.g. judgement) as well as our mental act directed toward the object. The object is not a physical or purely mental object, but rather a refiguration of an object as an intentional object. This paper will explore the similarities between Husserl's noesis and noema, Brentano's intentional inexistence and Frege's sense and reference. For Husserl, noema is the thought or intentional thoughts. However, Husserl uses it in his phenomenological analysis to mean the object of the thought and this is similar to Brentano's intentional inexistence. After Ideas, Husserl supplements the terms noesis and noema for intentional acts and contents which implies a tacit agreement with Brentano.

As part of the theory of intentionality, we make judgements that the object exists in a particular context. Frege includes the human (intentional) act of judging: the judgement stroke. This assertion/judgement is necessary for the intentional experience to occur in the lebenswelt. In this paper I will highlight the similarities with Brentano's intentional inexistence and the need for Frege's judgement stroke within a phenomenological analysis.

It is important to readdress intentionality with Brentano and Frege in mind, as this could shed light on other aspects of intentionality and develop cohesion in the varying theories of intentionality.

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Gödel's second incompleteness theorem is commonly accepted as a decisive argument against realizability of Hilbert's program of finitary grounding of mathematics in its original setting. We show that this widespread belief is wrong.

According to Gödel's second incompleteness theorem, if the formal Dedekind–Peano arithmetic (PA) is consistent and the formula $\mathrm{Prov}(x, y)$ that numeralwise expresses the provability predicate satisfies Hilbert–Bernays–Löb conditions, then the formula

$$\exists x \forall y \neg \mathrm{Prov}(x, y) \qquad \text{(Consis)}$$

that numeralwise expresses the consistency of PA is unprovable in PA. This readily implies that, for any formula A, the formula

$$\forall y \neg \mathrm{Prov}(\ulcorner A \urcorner, y) \qquad (*_A)$$

that expresses the unprovability of A is unprovable in PA.

The argument against realizability of Hilbert's program based on the second theorem is generally built as follows. Let PA be consistent. Suppose that there is an informal finitary consistency proof of PA. By von Neumann's thesis (every finitary informal proof is formalizable in PA), such a proof would be formalizable in PA. As a result, a formula that expresses the consistency of PA would turn out to be provable, which would contradict the second incompleteness theorem (see, e.g., [1]).

We will show that such reasoning is incorrect. We know that the PA may be either consistent or inconsistent. Tertium non datur.

Let PA be inconsistent. In this case the second theorem cannot be applied, because its formulation contains a presupposition of PA being consistent.

Let PA be consistent. Consider a formula $\neg(\mathbf{0} = \mathbf{0})$ and repeat von Neumann's reasoning in relation to this formula. Suppose that there is an informal finitary proof that $\neg(\mathbf{0} = \mathbf{0})$ is unprovable in PA. Such a proof could be Gödel-style formalizable in PA. As a result, being an instance of $(*_A)$, the formula $\forall y \neg \mathrm{Prov}(\ulcorner \neg(\mathbf{0} = \mathbf{0}) \urcorner, y)$ that expresses the unprovability of $\neg(\mathbf{0} = \mathbf{0})$ would turn out to be provable, which would contradict the second incompleteness theorem. Thus we can conclude that an informal finitary proof of the unprovability of $\neg(\mathbf{0} = \mathbf{0})$ does not exist.

However, if PA is consistent, then such a finitary proof exists! Here is the proof: Suppose $\vdash_{\mathrm{PA}} \neg(\mathbf{0} = \mathbf{0})$. In view of $\vdash_{\mathrm{PA}} (\mathbf{0} = \mathbf{0})$, it would follow that $\vdash_{\mathrm{PA}} (\mathbf{0} = \mathbf{0}) \,\&\, \neg(\mathbf{0} = \mathbf{0})$, and hence PA would be inconsistent, which contradicts our assumption. And this trivial proof is obviously finitary! We have thus arrived at a contradiction with von Neumann's reasoning.

Thus the argument against realizability of Hilbert's program based on the second theorem is incorrect from the outset.

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► FRODE ALFSON BJØRDAL, *Volutionary deliberations.*
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As a continuation of divulgations at *Trends in Logic XVI* and after in seminaries and at *Encontro Brasileiro de Lógica XVIII* I relate the *volutionary* point of view ₽ ("ruble") which shifts attention to the set Ⅎ ("eet") of sentences whose negation are not theses of the presupposed formal arithmetic **T** as traditionally conceived; we assume **T** is axiomatized so only *sentences* are derivable and only modus ponens is a primitive inference rule; for details on how only modus ponens is needed see [5] and [4], and [8] is useful also for historical matters. Volutionism alters how we think about fundamental matters e.g. in that the standard Gödel sentence of **T** is taken as a textbook liar sentence, and gives occasion to reinterpret issues concerning decidability and computability as other sentences independent of **T** are treated similarly. Volutionary systems are not like traditional paraconsistent approaches as classical logical theses are included and not contradicted even in the presence opf comprehension; nevertheless: if γ is the standard Gödel sentence for **T** both γ and $\neg\gamma$ are theses of Ⅎ so *modus ponens* does not, but exotic induced inferential principles hold for Ⅎ. The volutionary resolution of paradoxes has similarities with that of the author's *librationist* set theory and theory of truth £ developed in some former publications such as [1], [3] and [2]. A deviant volutionary truth predicate $\mathrm{Tr}_{Ⅎ}\ulcorner\phi\urcorner$ for Ⅎ defined as $\neg\mathrm{Pr}_{\mathbf{T}}\ulcorner\neg\phi\urcorner$ is introduced. Let formula ϕx with free variable indicated be Δ_1-*limited* in **T** just if Σ_1 and **T** proves $(\forall n)(\phi^x_n \leftrightarrow \psi^x_n)$ for some Π_1 formula ψx with just x free. Recall predicate sub in [7] p. 837 which functions so that $\mathrm{sub}(\ulcorner\phi(v_i)\urcorner, i, \ulcorner t\urcorner) = \ulcorner\phi(t)\urcorner$. Let $\textsc{sub}(x,y,z)$ =sub(x,i,z) if $y = \ulcorner v_i\urcorner$, else 0. Let PAIR be Cantor's pairing function and the projections of a natural number $m = \textsc{pair}(m_0, m_1)$. $\{x|\phi\}$ is short for $\textsc{pair}(\ulcorner\phi\urcorner, \ulcorner x\urcorner)$. $s \in t$ is short for $\mathrm{Tr}_{Ⅎ}\textsc{sub}(t_0, t_1, \ulcorner s\urcorner)$. A thesis of Ⅎ is maximally justified if also a thesis of **T**, and else just minimally justified. We have a minimal justification for $(\forall x)(x \in \{y|\phi\} \leftrightarrow \phi(x))$ if $\phi(x)$ is Δ_1-limited, and thence of a volutionary style recursive comprehension $(\exists y)(x)(x \in y \leftrightarrow \phi(x))$. The last may be useful combined with the *weak completeness theorem* of RCA_0 in [6] p. 93 and other weak assumptions to secure volutionary aritmetical models for stronger theories of interest.

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A monotonic function on a set $\mathcal{S}$ is a $\subseteq$-preserving mapping on $2^{\mathcal{S}}$, that is, a function C such that $\mathsf{C}(A) \subseteq \mathsf{C}(A \cup B)$, for every $A, B \subseteq \mathcal{S}$. Tarski's fixpoint theorem guarantees the existence of the least and of the greatest fixpoints for monotonic functions. The latter have a variety of applications, in particular in providing a foundation for inductive and co-inductive definitions, and the proof methods associated therewith. A Tarskian closure operator on $\mathcal{S}$ is a monotonic function on $\mathcal{S}$ that is also inflationary (i.e. $A \subseteq \mathsf{C}(A)$) and idempotent (i.e. $\mathsf{C}(\mathsf{C}(A)) = \mathsf{C}(A)$); it is a generalization of the notion of topological closure, axiomatized by Kuratowski. A closure operator on $\mathcal{S}$ is called structural when it commutes with endomorphisms on $\mathcal{S}$. (Structural) Tarskian closure operators are known [3] to be characterizable by a family of so-called logical matrices, viz. structures containing sets of 'algebraic' truth-values, some of which are distinguished. Their inflationary and idempotent character also guarantees that they may be characterized by (at most) two 'logical' values (cf. Chap. 4 of [4]). In the present contribution we will show how a generalized notion of closure and a two-dimensional notion of logical matrix (resp. B-closure and B-matrix) may be used to characterize any given monotonic function on a set $\mathcal{S}$, recovering a theme earlier explored at [2] in the context of symmetrical consequence relations involving two potentially distinct languages. We will also show that any B-matrix may be alternatively characterized by (at most) four logical values [1]. A brief discussion of inferential many-valuedness and its connections with bilattice-based reasoning, from a metalogical perspective, will ensue.

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In this paper, we will develop a plausibility model by defining a new notion of rationality and provide an epistemic characterization for the Iterated Regret Minimization (IRM) algorithm. Especially, we show that the interactive epistemic outcomes from the common knowledge of this type of rationality are in line with the solutions of the IRM algorithm. So, we state that one can achieve characterizing the algorithm in the light of common knowledge of some weakened definition of rationality. A benefit of our characterization is that it provides the epistemic foundation to IRM algorithm. Meanwhile, we also link solutions of the algorithm to modal μ-calculus to deepen our understanding of the epistemic characterization.

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In functional analysis, there are different notions of limit for a bounded sequence of L^p functions. Besides the pointwise limit, that does not always exists, the behaviour of a bounded sequence of L^p functions can be described in terms of its weak (weak-$\star$ if $p = 1$ or $p = \infty$) limit, or by introducing a measure-valued notion of limit in the sense of Young measures. By using nonstandard analysis, we will show that for every bounded sequence $\{z_n\}_{n\in\mathbb{N}}$ of L^p functions there exists a function of a hyperfinite domain that simultaneously generalizes the weak, weak-$\star$ and Young measure limits of the sequence. Let ${}^*\mathbb{R}$ be a set of hyperreals of nonstandard analysis, let $\varepsilon \in {}^*\mathbb{R}$ be a positive infinitesimal, and let $\mathbb{X} = \{n\varepsilon : n \in {}^*\mathbb{Z}\}$. For all open $\Omega \subseteq \mathbb{R}^k$, let $\mathbb{G}(\Omega)$ be the vector space of ${}^*\mathbb{R}$-valued functions defined on $\Omega_{\mathbb{X}} = {}^*\Omega \cap \mathbb{X}^k$. We will prove that, for every bounded sequence $\{z_n\}_{n\in\mathbb{N}}$ in $L^p(\Omega)$, there exists a (non unique) function $u \in \mathbb{G}(\Omega)$ such that

- u represents the weak (weak-$\star$ if $p = 1$ or $p = \infty$) limit of the sequence $\{z_n\}_{n\in\mathbb{N}}$ in the sense that for all $g \in C^0(\Omega)$ it holds

$$^\circ\left(\varepsilon^k \sum_{x\in{}^*\Omega\cap\mathbb{X}^k} u(x)\,{}^*g(x)\right) = \lim_{n\to\infty}\int_\Omega z_n(x)g(x)dx;$$

- u represents the Young measure limit of the sequence $\{z_n\}_{n\in\mathbb{N}}$ in the sense that for all $f \in C^0(\mathbb{R})$ with $\lim_{|x|\to\infty} f(x) = 0$ and for all $g \in C^0(\Omega)$ it holds

$$^\circ\left(\varepsilon^k \sideset{}{^*}\sum_{x\in{}^*\Omega\cap\mathbb{X}^k} f(u(x))\,{}^*g(x)\right) = \lim_{n\to\infty}\int_\Omega f(z_n(x))g(x)dx.$$

Thus, functions of $\mathbb{G}(\Omega)$ can be used to simultaneously describe very different behaviours of bounded sequences of L^p functions; moreover, we believe that the study of functions in $\mathbb{G}(\Omega)$ will allow to define new notions of standard limits that could be successfully applied to the study of ill-posed problems from functional analysis.

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We work in the context of second order arithmetic and consider formal systems centered around the axiom schema (ATR) of arithmetical transfinite recursion and the fixed point schema (FP). Starting from arithmetical comprehension we introduce several schemas that turn out to be equivalent to (ATR) and (FP). More precisely, we consider transfinite recursions and fixed point principles for syntactically richer classes of formulas and a form of transfinite dependent choice. The results are obtained by adapting methods from [1].

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▶ LORENZO CARLUCCI, *Weak yet strong restrictions of Hindman's Theorem.*

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Hindman's Finite Sums Theorem [7] is a celebrated result in Ramsey's Theory stating that any finite colouring of the positive integers admits an infinite set such that all non-empty finite sums of distinct elements from that set have the same colour.

The strength of Hindman's Theorem is known to be between the $(\omega+1)$-th Turing Jump and the Halting Set, by seminal results of Blass, Hirst, and Simpson from some thirty years ago [1]. In terms of reverse mathematics, the theorem is provable from ACA_0^+ and implies ACA_0. Recently Dzhafarov et al. [5] proved that the lower bound on the full theorem is already true for its restriction to sums of at most 3 distinct terms. Yet no proof of the latter restriction is known that does not also prove the full Finite Sums Theorem. Whether such a proof exists is indeed an open problem in combinatorics [8]. Consequently, no better upper bound is known to hold for that restriction other than the ACA_0^+ upper bound on the full Finite Sums Theorem itself.

We introduce natural restrictions of Hindman's Theorem for which both a non-trivial lower bound and a better upper bound can be established. We call them "weak yet strong" restrictions (see [2, 3]). First we present an infinite family of restrictions of Hindman's Theorem that are equivalent to ACA_0. Second we introduce a restriction of Hindman's Theorem in which monochromaticity is required only for sums of adjacent elements in the solution set and prove it to be between Ramsey's Theorem for pairs and the Increasing Polarized Ramsey's Theorem for pairs of Dzhafarov and Hirst [6].

Further related results have been obtained in collaboration with Kołodziejczyk, Lepore and Zdanowski [4] and will not be discussed in this talk.

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▸ ENRIQUE CASANOVAS, SAHARON SHELAH, *Universal theories and compactly expandable models.*

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A model M of countable vocabulary τ and cardinality κ is *expandable* if for every vocabulary $\tau' \supseteq \tau$ of cardinality $\leq \kappa$, if Σ is a first-order set of sentences of vocabulary τ' consistent with the first-order theory $\mathrm{Th}(M)$ of M, then there is some expansion M' of M to τ' such that $M' \models \Sigma$. Call a set of first-order sentences Σ of vocabulary $\tau' \supseteq \tau$ *finitely satisfiable in* M if for every finite subset $\Sigma_0 \subseteq \Sigma$ there is an expansion of M that satisfies Σ_0. M is *compactly expandable* if for every vocabulary $\tau' \supseteq \tau$ of cardinality $\leq \kappa$, if Σ is a first-order set of sentences of vocabulary τ' finitely satisfiable in M, then there is some expansion M' of M to τ' such that $M' \models \Sigma$. We present the result proved in [2], which shows that there are compactly expandable models which are not expandable, solving an open problem of [1]. The proof depends on some new result we have obtained on the logic $L(Q^{\mathrm{cf}}_{\aleph_0})$ (see [3]), first-order logic with the additional quantifier $Q^{\mathrm{cf}}_{\aleph_0}$ of cofinality $\aleph_0$, namely the existence of κ-universal theories of $L(Q^{\mathrm{cf}}_{\aleph_0})$ for any cardinal $\kappa = 2^{<\kappa} > \aleph_0$.

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▸ ANAHIT CHUBARYAN, ARTUR KHAMISYAN, *Application of Kalmar's proof of deducibility in two valued propositional logic for many valued logic.*
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We focus on the problem of constructing of some standard Hilbert style proof systems for any version of many valued propositional logic. The generalization of well-known Kalmar's proof of deducibility for two valued tautologies inside classical propositional logic [1] gives us a possibility to suggest some method for defining of two types axiomatic systems for any version of 3-valued logic, completeness of which is easy proved direct, without of loading into two valued logic.

First of constructed system bases on the logic with one designated value and *conjunction, disjunction, implication*, defined by Gödel, and *negation*, defined by permuting of truth values cyclically. For every formula A, B, C of 3-valued logic, each σ_1, σ_2 from the set $\{0, 1/2, 1\}$ and $* \in \{\&, \vee, \supset\}$, the following formulas are axioms schemes

1. $A \supset (B \supset A)$
2. $(A \supset B) \supset ((A \supset (B \supset C)) \supset (A \supset C))$
3. $A^{\sigma_1} \supset (B^{\sigma_2} \supset (A * B)^{\varphi_*(A,B,\sigma_1,\sigma_2)})$
4. $A^{\sigma} \supset (\neg A)^{\bar{\sigma}}$
5. $(A \supset B) \supset ((\bar{A} \supset B) \supset ((\bar{\bar{A}} \supset B) \supset B))$, where

$$\varphi_{\supset}(A, B, \sigma_1, \sigma_2) = (\sigma_1 \supset \sigma_2)\&(\neg(A \vee \bar{A}) \vee (\bar{\bar{B}} \supset B)) \vee (\neg(A \vee \bar{\bar{A}})\&\neg(B \vee \bar{\bar{B}})),$$

$$\varphi_{\vee}(A, B, \sigma_1, \sigma_2) = (\sigma_1 \vee \sigma_2) \vee (A \supset \bar{A})\&\neg(\bar{B} \vee \bar{\bar{B}})) \vee (\neg(\bar{A} \vee \bar{\bar{A}})\&(B \supset \bar{B})),$$

$$\varphi_{\&}(A, B, \sigma_1, \sigma_2) = (\sigma_1\&\sigma_2) \vee ((A\&\bar{\bar{A}}) \vee (B\&\bar{B})) \vee ((A\&\bar{A}) \vee (B\&\bar{\bar{B}})$$

and for $\delta = \frac{i}{2}$ $(0 \leqslant i \leqslant 2)$ A^{δ} is A with $2 - i$ negations. Inference rule is *modus ponens*.

Note that axioms 3.-4. are generalizations of formulas, using in Kalmar's proof of deducibility for two valued tautologies, therefore the completeness of this system is proved very easy. This method i) can be base for direct proving of completeness for all well-known axiomatic systems of k-valued $(k \geqslant 3)$ logics and may be for fuzzy logic also, ii) can be base for constructing of new Hilbert-style axiomatic systems for all mentioned logics.

Second system obtained from first one by some restrictions, which allow to obtain the same by order bounds of main proof complexity characteristics for large sets of k-tautologies.

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▶ ANAHIT CHUBARYAN, HAKOB NALBANDYAN, ARMAN KARABAKHTSYAN, GARIK PETROSYAN, *Propositional sequent systems of two valued classical logic and many valued logics are no monotonous.*
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The minimal tautologies, i.e. tautologies, which are not a substitution of a shorter tautology, play main role in proof complexity area. Really all propositional formulaes, proof complexities of which are investigated in many well known papers, are minimal tautologies. There is traditional assumption that minimal tautology must be no harder than any substitution in it. This idea was revised at first by Anikeev in [1]. He has introduced the notion of monotonous proof system and has given two types of no complete propositional proof systems: monotonous system, in which the proof lines of all minimal tautologies are no more, than the proof lines for results of a substitutions in them, and no monotonous system, the proof lines of substituted formulas in which can be less than the proof lines of corresponding minimal tautologies. For the first time it was proved in [2] that Frege systems are no monotonous neither by lines nor by size.

We introduce the analogous notion of minimal sequent (two or many valued) and show that well known propositional sequent systems of two valued classical logic (with and without cat rule) as well as the sequent systems, which are constructed by us for some versions of many valued logic are also no monotonous neither by lines nor by size of proofs.

Acknowledgments. This work arose in the context of propositional proof complexity research supported by the Russian-Armenian University from founds of MESRF.

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▸ ANAHIT CHUBARYAN, GARIK PETROSYAN, *On proof complexities for some classes of tautologies in Frege systems.*
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One of the most fundamental problems of the proof complexity theory is to find for classical propositional calculus a proof system, which has a polynomial size $p(n)$ proof for every tautology of size n. Cook and Reckhow named such a system a *super system* and showed in [1] that $NP = coNP$ iff a super system exists. Lately it is proved in [2] that $NP = coNP = PSPACE$, hence a super system must be. It is well known that many systems are not super. This question about Frege system, the most natural calculi for propositional logic, is still open.

Some results about Frege proof complexities are presented here. We introduce the notion of *specific* tautologies A in the form: $A = p \supset (A_1 \vee A_2 \vee \cdots \vee A_k)$ $(k \geqslant 1)$, where p is a literal (variable or negation of variable), neither $A_1 \vee A_2 \vee \cdots \vee A_k$ nor every $A_i (1 \leqslant i \leqslant k)$ are tautology or contradiction and $|A_i| \leqslant \frac{|A_1|}{2^{i-1}}$, and show that Frege systems are super systems iff there is a polynomial $p()$ such that all specific tautologies of size n have a proofs, size of which are bounded by $p(n)$. Then we show, that all *balanced* tautologies (every variable of which has only one positive and one negative occurrences), given in disjunctive normal form, also have Frege proofs with polynomial bounded sizes. Lastly we give some notes about relations between the proof complexities of tautologies A_n and B_n and proof complexities of the tautologies in a form $A_n * B_n$, where $*$ is $\wedge$, $\vee$, $\supset$. In particular we show that for some tautologies A_n and B_n proofs of formulas $A_n \vee B_n$ can be more easier than proofs every of A_n and B_n.

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▸ ANDRÉS CORDÓN–FRANCO AND F. FÉLIX LARA–MARTÍN, *On local induction rules: collapse and conservation properties.*
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Local induction schemes are variations of the classical induction schemes axiomatizing Peano arithmetic (Σ_n–induction or Π_n–induction). These local schemes are obtained by restricting the conclusion of the induction axioms to some class of definable elements. Given $n, m \geq 1$, the scheme $I(\Sigma_n, \mathcal{K}_m)$ is defined in this way, when the conclusion of the classical Σ_n–induction scheme is restricted to Σ_m–definable elements.

For $m = n$, the schemes $I(\Sigma_n, \mathcal{K}_n)$ and the corresponding induction rules associated to them, $(\Sigma_n, \mathcal{K}_n)$–IR, have showed to be useful tools in the analysis of the conservation properties of parameter free Π_n–induction schemes and local reflection principles (see [1] and [2]). An especially interesting feature of $(\Sigma_n, \mathcal{K}_n)$–IR is the "collapse" property (i.e. reduction of nested applications of the rule to unnested applications) that distinguishes this rule from the classical Σ_n–IR.

In this work we extend our previous work in [1] and focus on collapse and conservation properties of the rules $(\Sigma_n, \mathcal{K}_m)$–IR and their parameter free counterparts. Namely:

1. For $n = m$, we discuss general collapse results for $(\Sigma_n, \mathcal{K}_n)$–IR.
2. For $n > m \geq 1$, we discuss results á la Kreisel–Levy relating (parameter free) local induction rules and local reflection principles.
3. For $1 \leq n < m$ we discuss non-collapse and conservation results among rules $(\Sigma_n, \mathcal{K}_m)$–IR.

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▸ VALERIA DE PAIVA AND GISELLE REIS, *Benchmarking linear logic.*
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Benchmarking automated theorem proving (ATP) systems using standardised problem sets is a well-established method for measuring their performance, especially in the case of classical logical systems. However, the availability of such libraries for *non-classical* logics is very limited. For intuitionistic logic several small collections of formulas have been published and used for testing ATP systems and Raths, Otten and Kreitz [2] consolidated and extended these small sets to provide the ILTP Library http://www.cs.uni-potsdam.de/ti/iltp/. For quantified modal systems we have both Wisniewski, Steen and Benzmüller's as well as the Raths and Otten libraries of problems.

In this work we seek to provide a similar benchmark for Girard's Linear Logic [1] and some of its variants. For quick bootstrapping of the collection of problems we use Girard's translation of the collection of intuitionistic theorems discussed in the ILTP library. Eventually we hope to compare different Linear Logic provers over an augmented collection of problems.

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▸ LONGYUN DING, *On decomposing Borel functions.*
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The study of decomposing Borel functions originated by a question asked by Luzin: is every Borel function decomposable into countably many continuous functions? This question was answered negatively. So we turn to focus on: what kind of Borel functions is decomposable into countably many continuous functions?

Jayne-Rogers' theorem shows that, a function of Baire class 1 is decomposable into countably many continuous functions with closed domains iff the preimage of any F_σ set is still F_σ. The generalization of Jayne-Rogers' theorem is named The Decomposability Conjecture.

In this talk, we will introduce the recent developments on the decomposability conjecture.

► SERGEY DROBYSHEVICH, *Investigating some effects of display property.*
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The investigation concerns display calculi — a generalization of sequent calculi due to Nuel Belnap [1]. The generalization is obtained by replacing comma in sequents with a number of formal structural connectives. Sequents are then pairs of *structures*, which are built from formulas using structural connectives. Display framework provides several advantages over traditional sequent calculi, including a general cut-elimination result, which holds for all display calculi satisfying a number of conditions. Another advantage is that display calculi can be applied to study classes of logics by making the notion of extension more precise.

A display calculus is built around some structural rules called *display equivalences*, which postulate basic relations between structural connectives. It is assumed that display equivalences should allow one to obtain the *display property*, which says that any structure in a sequent can be *displayed* by providing an equivalent sequent, in which this structure is the entire antecedent or the entire consequent. Display property has an important philosophical value related to the proof-theoretic semantics.

In this work we investigate some technical aspects of display property, using Rajeev Goré's display calculus $\delta\mathsf{H}$ for intuitionistic logic to illustrate our ideas [2]. We show that while display property allows us to characterize naturally the class of logics given by extensions of a display calculus, weakening it can give us more expressive power. The investigation also raises questions on the way structural connectives are involved in formulating introduction rules.

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▶ PHILIP EHRLICH, *Are points (necessarily) unextended?*.
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Ever since Euclid defined a point as that which has no part it has been widely assumed that points are necessarily unextended. It has also been assumed that, analytically speaking, this is equivalent to saying that points or, more properly speaking, degenerate segments–i.e. segments containing a single point–have length zero. In our talk we will challenge these assumptions. We will argue that neither degenerate segments having null lengths nor points satisfying the axioms of Euclidean geometry implies that points lack extension. To make our case, we will provide models of ordinary Euclidean geometry where the points are extended despite the fact that the corresponding degenerate segments have null lengths, as is required by the geometric axioms. The first model will be used to illustrate the fact that points can be quite large–indeed, as large as all of Newtonian space–and the other models will be used to draw attention to other philosophically pregnant mathematical facts that have heretofore been little appreciated.

▸ DMITRY EMELYANOV, BEIBUT KULPESHOV, SERGEY SUDOPLATOV, *On algebras of distributions for binary formulas of quite o-minimal theories with non-maximum many countable models.*
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We apply a general approach for distributions of binary formulas [1] to the class of quite o-minimal theories with non-maximum many countable models [2]. Using Cayley tables for countably categorical weakly o-minimal theories [3] we explicitly define the classes of commutative monoids $\mathfrak{A}_n$, respectively, $\mathfrak{A}_n^{\mathrm{QR}}$, $\mathfrak{A}_n^{\mathrm{QL}}$, $\mathfrak{A}_n^{I}$, of isolating formulas for isolated, respectively, quasirational to the right, quasirational to the left, irrational, 1-types p of quite o-minimal theories with non-maximum many countable models, with convexity rank $\mathrm{RC}(p) = n$. For an algebra $\mathfrak{P}_{\nu(p)}$ of binary isolating formulas of 1-type p, we have

Theorem 1. *Let T be a quite o-minimal theory with non-maximum many countable models, $p \in S_1(\emptyset)$ be a non-algebraic type. Then there exists $n < \omega$ such that:*

(1) *if p is isolated then $\mathfrak{P}_{\nu(p)} \simeq \mathfrak{A}_n$;*

(2) *if p is quasirational to the right (left) then $\mathfrak{P}_{\nu(p)} \simeq \mathfrak{A}_n^{\mathrm{QR}}$ ($\mathfrak{P}_{\nu(p)} \simeq \mathfrak{A}_n^{\mathrm{QL}}$);*

(3) *if p is irrational then $\mathfrak{P}_{\nu(p)} \simeq \mathfrak{A}_n^{I}$.*

Corollary 2. *Let T be a quite o-minimal theory with non-maximum many countable models, $p, q \in S_1(\emptyset)$ be non-algebraic types. Then $\mathfrak{P}_{\nu(p)} \simeq \mathfrak{P}_{\nu(q)}$ if and only if $\mathrm{RC}(p) = \mathrm{RC}(q)$ and the types p and q are simultaneously either isolated, or quasirational, or irrational.*

Definition 3. [3] We say that an algebra $\mathfrak{P}_{\nu(\{p,q\})}$ is *generalized commutative* if there is a bijection π: $\rho_{\nu(p)} \to \rho_{\nu(q)}$ witnessing that the algebras $\mathfrak{P}_{\nu(p)}$ and $\mathfrak{P}_{\nu(q)}$ are isomorphic (i.e., that their Cayley tables are equal up to π) and for any labels $l \in \rho_{\nu(p,q)}$, $m \in \rho_{\nu(q,p)}$, we have $\pi(l \cdot m) = m \cdot l$.

Theorem 4. *Let T be a quite o-minimal theory with non-maximum many countable models, $p, q \in S_1(\emptyset)$ be non-algebraic non-weakly orthogonal types. Then the algebra $\mathfrak{P}_{\nu(\{p,q\})}$ is a generalized commutative monoid.*

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▶ CHRISTIAN ESPINDOLA, *Stone duality for infinitary first-order logic.*
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Makkai's reconstruction result [6] allows to recover a first-order theory $\mathbb{T}$, up to pretopos completion, from its category of models $Mod(\mathbb{T})$ by equipping it with appropriate structure and considering set-valued functors preserving this structure. One of the difficulties in extending this result to the infinitary case is that the Keisler-Shelah isomorphism theorem, which asserts that elementarily equivalent models have isomorphic ultrapowers, does not hold for infinitary logic. However, we will see that the theory of accessible categories can provide extra structure, under appropriate large cardinal assumptions, to recover the theory from its category of models up to a notion of infinitary pretopos-completion. More precisely, the plan of Makkai of endowing the categories of models with extra structure coming from ultraproducts can be readily generalized to the infinitary case in the presence of a compact cardinal, by means of which an infinitary version of Łoś theorem is possible. Makkai's use of Keisler-Shelah theorem allows him to regulate the behaviour of subfunctors of functors $Mod(\mathbb{T}) \to \mathcal{S}et$, while the use of Vopěnka's principle in our case, in the form "every subfunctor of an accessible functor is accessible" will provide the desired effect. For the reconstruction result, one more large cardinal axiom needs to be assumed, namely that the class of ordinals Ord is weakly compact. With these assumptions, a duality theory arises for the infinitary case that generalizes the one explained in [6].

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▸ LUIS ESTRADA-GONZÁLEZ AND JOSÉ DAVID GARCÍA-CRUZ, *Connectives as relative modalities.*
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Local operators (also known as Lawvere-Tierney topologies in the context of topos theory, or modal operators in other categorial contexts) have been useful in proving independence results in categorial set theory and more recently in providing categorial interpretations for quantum predicates. Our aim here is to use local operators and their duals to highlight a neglected feature of the usual logical connectives, namely their modal character. Disjunction and conditional have already been recognized as species of possibility; our contribution is the use of dual local operators to show that conjunction and subtraction are species of necessity. More exactly, disjunction is a possibility connective, conditional is a contingency connective, conjunction is a necessity connective and subtraction is an impossibility connective. The modal characters of unary and zero-ary connectives are also discussed.

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The concept of names as studied in the theory of nominal sets has been proven useful in various parts of mathematical logic and computer science. A notable instance is the work presented in [1], which exposes cubical sets as nominal sets equipped with nominal restriction operations. As is well-known, this underlying name-dependending structure has been incorporated into subsequent formulations of cubical type theory.

Following a suggestion of Pitts, the author observed that there are many more examples of toposes, including simplicial sets, that admit a representation as categories of finitely supported M-sets, for a 'monoid of substitutions' M, which is to be taken quite generally. We study these toposes as such and compare them using the theory of classifying toposes. Our findings feed back into this theory by allowing for a nominal presentation of syntactic categories that does not rely on α-equivalence. More examples show how this nominal viewpoint offers a useful paradigm for studying aspects of topos theory. Potential applications include not only the semantics of names in type theory, but also categorical formulations of models of intuitionistic set theory.

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▸ TUAN-FANG FAN, CHURN-JUNG LIAU, *Dynamic Belief Logic Based on Evidential Observation.*
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Reasoning about autonomous agents' informational attitudes, such as knowledge and belief, has been a long-standing area in the research of AI and intelligent agents [2, 3]. The typical perception-action cycle for intelligent agents assumes that an agent forms her beliefs about the environment and acts or makes decisions in accordance with such belief and her preference. Hence, reasoning about belief and knowledge plays a central role in the operational process of agent systems. In the multi-agent environment, an agent generally forms her beliefs by receiving information from different sources. Therefore, it is crucially important to keep track of the information sources and the derivation process that can be regarded as justifications of the agent's belief. However, belief formation from perceptions is actually a dynamic process. In recent years, modeling the dynamic change of belief has been extensively studied in the dynamic epistemic logic (DEL) paradigm with a lot of applications to AI, computer science, multi-agent systems, philosophy, and cognitive science [4, 5]. In this paper, we present a logic for reasoning about evidence and belief. Our framework not only takes advantage of the source-tracking capability of justification logic [1], but also allows the distinction between the actual observation and simply potential admissibility of evidence. We present the axiomatization for the basic logic and its dynamic extension, and investigate its properties and applications.

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▸ DAVID FERNÁNDEZ-DUQUE, PAUL SHAFER, HENRY TOWSNER AND KEITA YOKOYAMA,

Caristi's fixed point theorem and strong systems of arithmetic.

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A *Caristi system* is a triple (X, f, V), where X is a complete metric space, $V\colon X \to (0,\infty)$ is a lower semi-continuous function, and $f\colon X \to X$ is an arbitrary function such that, for all $x \in X$,

$$d(x, f(x)) \leq V(x) - V(f(x)).$$

Caristi's fixed point theorem states that any Caristi system has a fixed point; that is, there is $x_* \in X$ such that $f(x_*) = x_*$. This has been proven in the literature using the *critical point theorem,* which states that V has a pseudo-minimal point, and using *Caristi sequences,* which are transfinite sequences $(x_\xi)_{\xi<\Omega} \subseteq X$ such that $x_{\xi+1} = f(x_\xi)$ for all ξ, the sequence converges at limit ordinals, and $\Omega \leq \omega_1$ is a large enough ordinal.

We analyze Caristi's theorem and its known proofs in the context of reverse mathematics, where metric spaces are assumed separable and coded in the standard way. Among the results obtained, we have that, over RCA_0:

- WKL_0 is equivalent to Caristi's theorem restricted to compact spaces with continuous V.
- ACA_0 is equivalent to Caristi's theorem restricted to compact spaces with lower semi-continuous V.
- TLPP_0 (the Σ_α-relative leftmost path principle for every well-ordering α) is equivalent to Caristi's theorem for Baire or Borel f.
- $\Pi^1_1\mathsf{-CA}_0$ is equivalent to the critical point theorem for lower semi-continuous functions.
- $\Pi^0_\omega\mathsf{-IFP}_0$ (the arithmetical inflationary fixed point scheme) is equivalent to the statement that if f is arithmetically defined, any point $x_0 \in X$ can be extended to a Caristi sequence $(x_\xi)_{\xi<\Omega} \subseteq X$ containing a fixed point of f.

These theories are all defined over the language of second-order arithmetic and we mention them in strictly increasing order of strength. In order to

formalize these results, we also develop techniques for coding lower semi-continuous functions in this setting.

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An *exact truthmaker* for A is a state which, as well as guaranteeing A's truth, is wholly relevant to it. States with parts irrelevant to whether A is true do not count as exact truthmakers for A. Giving semantics in this way produces a very unusual consequence relation, *exact entailment*, understood in terms of preservation of exact truthmakers from premises to conclusion. On this understanding, conjunctions do not exactly entail their conjuncts. This feature makes the resulting logic highly unusual.

In this paper, we set out formal semantics for exact entailment in terms of mereological structures on a domain of states. The main result of the paper is a characterisation theorem, which establishes the syntactic form premises and conclusions must take in an exact entailment. This gives us a conceptual handle on when an exact entailment holds. In intuitive terms, it holds when some ground for the conclusion lies 'in between' a ground for one premise and a ground for all premises taken together. Using this theorem, we show that exact entailment is compact and decidable.

We then investigate the effect of various restrictions on the semantics. The first is to *non-vacuous* models, wherein every atomic sentence letter has a truthmaker and a falsemaker somewhere in the model. The second is to *convex* models, whereby states lying in-between two truthmakers for some A must also be truthmakers for A. We show that neither restriction, in isolation, affects the entailment relation. But their combination produces a stronger logic, for which we provide a further characterisation theorem.

Finally, we formulate a sequent-style proof system for exact entailment and give soundness and completeness results.

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Hilbert's methodological reflection certainly shaped a new image of the axiomatic method. However, the discussion on the nature of this method is still open. There are (1) those who have seen it as a synthetic method, i.e., a method to derive theorems from axioms already and arbitrarily established; (2) others have counter-argued in favor of its analytical nature, i.e., given a particular scientific field the method is useful to reach the conditions (axioms) for the known results of the field (theorems) and to rightly place both in a well-structured theory; (3) still others underlined the metatheoretical nature of the axiomatic reflection, i.e., the axiomatic method is the method to verify whether axioms already identified satisfy properties such as completeness, independence and consistency.

Each of these views has highlighted aspects of the way Hilbert conceived and practiced the axiomatic method, so they can be harmonized into an image better suited to the function the method was called to fulfill: i.e., deepening the foundations of given scientific fields, to recall one of his well-known expressions. Considering some textual evidence from early and late writings, I shall argue that the axiomatic method is in Hilbert's hands a very flexible tool of inquiry and that to lead analytically to an axiomatic well-structured theory it needs to include dynamically both synthetic procedures and metatheoretical reflections. Therefore, in Hilbert's concern the expression “deepening the foundations” denotes the whole set of considerations, permitted by the axiomatic method, that allow the theoretician first to identify and then to present systems of axioms for given scientific fields.

▸ CEDRIC E. GINESTET, *Truth-value semantics generalized to three-valued logics, with applications to elementary arithmetic and to the principle of induction.*

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In truth-value semantics, one interprets quantifiers in terms of the individual truth-values of their component predicates. This approach to semantics, originally advocated by Barcan Marcus [1], is sometimes referred to as the substitution interpretation of quantifiers [2]. We here consider truth-value semantics in the context of three-valued logics. The resulting logic bears some similarity with Kleene's strong logic of indeterminacy and Priest's logic of paradox. Our proposed three-valued logic, however, substantially differs from these two systems, inasmuch the truth tables obtained under truth-value semantics do not directly correspond to the truth tables of either Kleene's or Priest's three-valued logics. Our proposed logic is applied to elementary statements in arithmetic, and we will show how the principle of induction can be naturally expressed in this formal system.

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▸ JANA GLIVICKÁ,*Nonstandard methods and construction of models of arithmetics.*
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We show how to use nonstandard methods of set theory to obtain various models of weak arithmetics. The nonstandard methodology provides us with class mapping * defined on $\mathbf{V}$, the class of all sets. To construct models of arithmetics, we start with the structure $(^{\cdot}\mathbb{N}, ^{\cdot}+, ^{\cdot}\cdot)$, which is obtained as the limit of the elementary chain $(\mathbb{N}, +, \cdot) \preccurlyeq (^*\mathbb{N}, ^*+, ^*\cdot) \preccurlyeq (^{**}\mathbb{N}, ^{**}+, ^{**}\cdot) \preccurlyeq \cdots \preccurlyeq (^{n*}\mathbb{N}, ^{n*}+, ^{n*}\cdot) \preccurlyeq \cdots$. The structure $(^{\cdot}\mathbb{N}, ^{\cdot}+, ^{\cdot}\cdot)$ and its basic properties are due to work by Josef Mlček and Petr Glivický. For every $a \in {^{\cdot}\mathbb{N}}$, its rank is defined by $r(a) = \min\{n \in \mathbb{N}; a \in {^{n*}\mathbb{N}}\}$.

Graded arithmetical structures arise when functions $^{\cdot}+$ and $^{\cdot}\cdot$ are replaced by their so called graded versions. Given g_0, g_1, functions from $\mathbb{N}^2$ to $\mathbb{N}$, the graded version of $f(x, y)$ with respect to g_0, g_1 is defined as $f(^{g_0(r(x),r(y))*}x, {^{g_1(r(x),r(y))*}y})$.

We study basic properties of graded functions and explore how various choices of g_0, g_1 result in very different graded arithmetical structures. An important tool in analyzing the behavior of graded functions is the so called depth function.

We are especially interested in how grading influences prime numbers. By Chen's theorem, there are infinitely many primes p such that $p+2$ is a product of at most two prime numbers. In graded arithmetical structures it is possible to enforce that some composite numbers become primes with respect to the new multiplication (such numbers are called graded primes.) Using Chen's theorem, we show how to obtain a structure that is a model of Robinson (and Presburger) arithmetic and in which the twin prime conjecture holds for graded primes.

▸ MICHAŁ TOMASZ GODZISZEWSKI, *Refuting the 'Converse to Tarski' Conjecture.*
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Roman Kossak formulated in [1] the following 'Converse to Tarski' problem: Let $FS(X)$ be a formula of the language of PA with a additional predicate symbol X expressing that X is a full satisfaction class. $FS(X)$ is an example of a formula $\Phi(X)$ such that:

1. $Con(PA(X) + \Phi(X))$ and:
2. if $(\mathcal{M}, X) \models \Phi(X)$, then X is not definable in $\mathcal{M}$.

Problem: Assume $\Phi(X)$ satisfies 1. and 2. Is it true that for every nonstandard $\mathcal{M} \models PA$ and every $X \subseteq |\mathcal{M}|$, if $(\mathcal{M}, X) \models \Phi(X)$, then there is a nonstandard satisfaction class definable in $(\mathcal{M}, X)$?

We answer the question in the negative, using the seminal result of Harrington, formulated and proved (in the version useful for tackling the 'Converse to Tarski' problem) in unpublished notes In our talk, we present the proof of Harrington's unpublished result and demonstrate how the solution of the 'Converse to Tarski' follows. The interpretation of the result is that, roughly speaking, it is not the case that undefinability of a given set X in a nonstandard model of arithmetic does not always 'come from' Tarski's theorem on undefinability of truth by (arithmetic) reducibility of a satisfaction class to X.

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▸ MICHAŁ TOMASZ GODZISZEWSKI, JOEL DAVID HAMKINS, *Computable quotient presentations of models of arithmetic and set theory.*
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We prove various extensions of the Tennenbaum phenomenon to the case of computable quotient presentations of models of arithmetic and set theory. Specifically, no nonstandard model of arithmetic has a computable quotient presentation by a c.e. equivalence relation. No Σ_1-sound nonstandard model of arithmetic has a computable quotient presentation by a co-c.e. equivalence relation. No nonstandard model of arithmetic in the language $\{+, \cdot, \leq\}$ has a computably enumerable quotient presentation by any equivalence relation of any complexity. No model of ZFC or even much weaker set theories has a computable quotient presentation by any equivalence relation of any complexity. And similarly no nonstandard model of finite set theory has a computable quotient presentation.

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▸ DANNY DE JESÚS GÓMEZ-RAMÍREZ, *Dathematics: a meta-isomorphic version of classic mathematics based on proper classes.*
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An implicit working principle in Von Newmann-Bernays-Gödel Set Theory (NBG) is that small classes (or 'sets') are more suitable objects to start and work with for developing a general foundational framework for standard mathematics. On the other hand, proper classes are just 'too big' and formally 'too dangerous' in order to be able to ground any classic mathematical theory.

In this paper, we will mainly show that these classic quantitative considerations about proper and small classes are just tangential facts regarding the consistency of ZFC set theory. Effectively, we will construct a first-order logic theory D-ZFC (Dual theory of ZFC set theory) strictly based on (a particular sub-collection of) proper classes with a corresponding special membership relation, such that ZFC and D-ZFC are meta-isomorphic frameworks. More specifically, for any standard formal definition, axiom and theorem that can be described and deduced in ZFC set theory, there exists a corresponding 'dual' version in D-ZFC and vice versa. In particular ZFC set theory is consistent if and only if D-ZFC is consistent.

In addition, let us call modern Mathematics for all formal mathematical theories which are grounded in ZFC set theory, for instance, Real and Complex Analysis, Geometry, Algebra, Number theory, Topology and Category Theory. So, we will name *Dathematics* for the family of all dual versions of the (former) modern theories, where all the subsequent concepts and theorems describing properties among them are expressed and grounded by D-ZFC. Finally, we prove the meta-fact that (classic) mathematics and dathematics are meta-isomorphic, i.e., for any concept, theory and conjecture in (classic) mathematics there exists a symmetric d-concept, d-theory and d-conjecture in dathematics with equivalent formal properties, and vice versa; e.g., a mathematical conjecture C is true (resp. provable) if and only if the dual 'dathematical' conjecture C^+ is true (resp. provable). So, (standard) Mathematics and Dathematics are equiconsistent and the last meta-framework has, strictly speaking, proper classes as fundamental objects.

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▸ VALENTIN GORANKO[1], ANTTI KUUSISTO[2], AND RAINE RÖNNHOLM[3],
Game-theoretic semantics for alternating-time temporal Logics.
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The Alternating-Time Temporal Logic ATL is a multi-agent extension of the branching-time temporal logic CTL and one of the most popular logical formalisms for reasoning about strategic abilities of agents in synchronous multi-agent systems. The semantics of ATL is defined over multi-agent transition systems, also known as *concurrent game models*, in which agents take simultaneous actions at the current state and the resulting collective action determines the subsequent transition to a successor state.

We have introduced in [1] versions of game-theoretic semantics (GTS) for ATL. In GTS, truth is defined in terms of existence of a winning strategy in a semantic evaluation game, and thus the game-theoretic perspective appears in the framework of ATL on two semantic levels: on the object level in the standard semantics of the strategic operators, and on the meta-level where game-theoretic logical semantics is applied to ATL. We unify these two perspectives into semantic evaluation games specially designed for ATL. The game-theoretic perspective enables us to identify new variants of the semantics of ATL based on limiting the time resources available to the verifier and falsifier in the semantic evaluation game. We introduce and analyse an *unbounded* and *(ordinal) bounded* GTS and prove these to be equivalent to the standard (Tarski-style) compositional semantics. We show that in both versions of GTS, truth of ATL formulae can always be determined in finite time, i.e., without constructing infinite paths. We also introduce a non-equivalent *finitely bounded* semantics and argue that it is natural from both logical and game-theoretic perspectives. In [2] we extend the GTS for ATL to the richer language ATL^+ and apply it to identify a hierarchy of extensions of ATL with tractable model checking and to obtain some new results on expressiveness and complexity of model checking.

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▸ PAUL GORBOW, *Algebraic new foundations.*
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NF is a set theory obtained by putting a syntactic constraint (stratification) on the comprehension schema; it proves that there is a universal set V. NFU (NF with atoms) is known to be consistent through its close connection with models of conventional set theory that admit automorphisms.

The theory, $\mathrm{ML}_{\mathrm{CAT}}$, in the language of categories is introduced and proved to be equiconsistent to NF (analogous results are obtained for intuitionistic and classical NF with and without atoms) [3]. $\mathrm{ML}_{\mathrm{CAT}}$ is intended to capture the categorical content of the predicative class theory of NF. NF is interpreted in $\mathrm{ML}_{\mathrm{CAT}}$ through the categorical semantics. Thus, the result enables application of category theoretic techniques to meta-mathematical problems about NF-style set theory. For example, an immediate corollary is that NF is equiconsistent to $\mathrm{NFU} + |V| = |\mathcal{P}(V)|$. This is already proved in [2], but becomes intuitively obvious in the categorical setting.

Just like a category of classes has a distinguished subcategory of small morphisms (cf. [1]), a category modelling $\mathrm{ML}_{\mathrm{CAT}}$ has a distinguished subcategory of type-level morphisms. This corresponds to the distinction between sets and proper classes in NF. With this in place, the axiom of power objects familiar from topos theory can be appropriately formulated for NF. It turns out that the subcategory of type-level morphisms contains a topos as a natural subcategory.

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▸ HENSON GRAVES, *Axiomatic toposes for descriptive modeling.*
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Engineers and scientists are reinventing topos constructions for their modeling languages. Modeling languages in the UML family have constructions for products, powers, as well as subtypes. These language constructions are incomplete and do not have any accepted formal semantics. However, together with special purpose sublanguages the engineering modeling languages are used to design and analyze complex systems. With an axiomatic semantics topos based modeling languages can serve as the foundation for a new generation of modeling language tools which integrate automated reasoning with simulation.

Axiomatic topos theory as developed by Lawvere with rule axioms for products and powers goes a long way to providing an axiomatic modeling language suitable for science and engineering. However, subobjects (subtypes) play an extensive role in system modeling. A a constructive axiom for canonical subtypes is given to replaces the traditional subobject classification axiom in the context of axiomatic Cartesian closed categories with powers. The axiom sets which use the language axioms are toposes with canonical subobjects which serves as a replacement for set theory as a modeling language. A descriptive model is one of the an axiom sets which include language axioms.

An aircraft flying over terrain can be modeled in this formalism using maps whose domain is linear time to types representing the aircraft, its components and interconnections. These maps are represented as sheaves on the algebra of subtypes of time. The sheaf maps represent the time evolution of a system with its components. This gives a point free algebraic representation. Time subtypes can be represented as subsets of the spectrum of time type. The interpretations of these models are strict logical functors to *Set*. This provides a formal basis for simulation correctness, as a simulation is an interpretation.

▸ CARLOS ALFONSO RUIZ GUIDO, *Non reduced schemes and Zariski Geometries.*
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I will propose a model theoretic structure which aims to capture the algebra (or geometry) of a non reduced scheme over an algebraically closed field. This structure has quantifier elimination and its picture is similar to Quantum Zariski Geometries and other ones consider by M. Kamenski to prove model theoretic tameness of quasi coherent sheaves, the three of these approaches have a flavor of representation theory. I will talk about relations between definable sets in this structure and arbitrary closed sets in an non reduced scheme.

► LAURI HELLA, MIIKKA VILANDER, *Formula size games for modal logics.*
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Succinctness is an important research topic that has been quite active in modal logic recently. If two logics $\mathcal{L}$ and $\mathcal{L}'$ have equal expressive power, it is natural to ask, whether there are properties that can be expressed in $\mathcal{L}$ by a substantially shorter formula than in $\mathcal{L}'$.

One of the most common methods in the literature for proving lower bounds on the length of formulas expressing given properties is the *Adler-Immerman game* ([1]). We propose (see [2]) another type of formula size game for modal logic. In the Adler-Immerman game the players produce the whole syntax tree of the separating formula. In our game we use parameters m and k referring to the number of modal operators and binary connectives in a formula, thus enabling a game where only a part of the separating formula is constructed in any single play.

We illustrate the use of our game by proving a nonelementary succinctness gap between first-order logic FO and modal logic ML. More precisely, we define a bisimulation invariant property of pointed Kripke models by a first-order formula of size $\mathcal{O}(2^n)$, and show that this property cannot be defined by any ML-formula of size less than the exponential tower of height $n-1$.

We are currently working on an adaptation of our formula size game for the modal μ-calculus. Questions of succinctness and definability for the modal μ-calculus are largely unexplored and none of the other methods mentioned here have been used in this context. We intend to use our new game to investigate these questions.

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▸ ÅSA HIRVONEN, *On Approximations and Eigenvectors - looking at Quantum Physics via Metric Ultraproducts.*
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There is a tradition of using finite dimensional Hilbert spaces to approximate the standard $L_2(\mathbb{R})$ model of quantum mechanics. I present a model theoretic way of looking at such approximations, based on ultraproducts of metric structures.

The ultraproduct allows one to define and calculate the Feynman propagator as the inner product $\langle x_0|K^t|x_1\rangle$, where $|x_i\rangle$ are eigenvectors of the position operator and K^t is the time evolution operator. The calculations use Gauss sums which, however, causes a discretising effect, giving the wrong value at the limit. This can be remedied by instead of the propagator looking at the kernel of the time evolution operator. Mathematically the propagator and the kernel are different things, but they are used the same way in calculating the movement of a particle and thus should have the same value. Calculating the limit of the kernels allows one to avoid the discretising effect and still use the benefits of finite Gauss sums.

The talk is based on joint work with Tapani Hyttinen.

[1] Hirvonen Å. and Hyttinen T., *On Eigenvectors and the Feynman Propagator*, (submitted).

▸ RADEK HONZIK, *The tree property at the double successor of a singular cardinal.*

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We compare several methods for obtaining the tree property at the double successor of a singular strong limit cardinal κ with countable cofinality. We will focus on the case when κ is equal to $\aleph_\omega$, and discuss large cardinal assumptions used for these results. We will also discuss possible values of the continuum function at κ. Some of the results are joint with Sy D. Friedman and Š. Stejskalová.

▸ KOICHIRO IKEDA, *A note on small stable theories.*
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A type $p \in S(T)$ is called special, if there are $a, b \models p$ such that $\mathrm{tp}(b/a)$ is isolated and non-algebraic, and $\mathrm{tp}(a/b)$ is non-isolated. The Lachlan conjecture says that if there is no stable Ehrenfeucht theory. It can be seen that if there is a counterexample of the Lachlan conjecture then the theory has a special type. Modifying Hrushovski's generic pseudoplane [2], Herwig constructed a small stable theory with a type of infinite weight [1]. His example may be close to a counterexample of the Lachlan conjecture, but it does not have a special type. In this talk, I will introduce some result on a relation between generic structures and theories with a special type.

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▶ MIRJANA ILIĆ, *A normalizing system of natural deduction for relevant logic*.
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Several natural deduction calculi are known for relevant logics, see Anderson and Belnap [1], Dunn [5], Brady [3], and Meyer and McRobbie [9]. Some of them are with the explicit distribution rule, such as Anderson–Belnap's and Meyer–McRobbie's, some of them have normalization theorems, such as Brady's, however, all of them, use a kind of relevance numerals in order to keep track of the use of hypotheses.

On the other hand, relevant numerals are not needed in sequent calculi of relevant logics, see e.g. Dunn [4], [5], Minc [10], Bimbo [2]. We formulate a natural deduction calculus, of a particular relevant logic, by defining the translation from its sequent calculus formulation into natural deduction. We consider the contraction–less relevant logic RW_+° and we take its sequent calculus GRW_+°, admitting cut–elimination, presented in [7]. The resulting natural deduction calculus is a normalizing natural deduction system, without explicit distribution rule and free from relevant numerals. Our translations from sequent to natural deduction calculus and vice versa are similar to Negri's translations between those calculi for intintuitionistic linear logic [11], however, due to the presence of two types of multisets of formulae, intensional and extensional ones, needed for the proof of the distribution of conjunction over disjunction in relevant logics, see Dunn [4] and Minc [10], our translations are significantly different from Negri's translations.

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▸ ASSYLBEK ISSAKHOV, FARIZA RAKYMZHANKYZY, *Hyperimmunity and A–computable numberings.*
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Let $\mathcal{F}$ be a family of total functions which is computable by an oracle A, where A is an arbitrary set. A numbering $\alpha : \omega \mapsto \mathcal{F}$ is called A-computable if the binary function $\alpha(n)(x)$ is A-computable, [1].

LEMMA 1. *Let $\mathcal{F}$ be an infinite A-computable family of total functions, where A is an arbitrary set. Then $\mathcal{F}$ has an A-computable Friedberg numbering.*

A degree a is hyperimmune if a contains a hyperimmune set, and a is hyperimmune free otherwise. Every nonzero degree comparable with $0'$ is hyperimmune. Dekker showed that for every non-recursive c.e. set A there is a hyperimmune set B such that $B \equiv_T A$, which means that every non-recursive c.e. degree contains a hyperimmune set.

LEMMA 2. *For every hyperimmune set A there exists a non-recursive A-computable set B.*

It is known [2], that if A is an arbitrary set, $\mathcal{F}$ is an infinite A-computable family of total functions and $\mathcal{F}$ has at least two nonequivalent A-computable Friedberg numberings, then $\mathcal{F}$ has infinitely many pairwise nonequivalent A-computable Friedberg numberings. And also [3], if $\mathcal{F}$ is an infinite A-computable family of total functions, where $\emptyset' \leq_T A$, then $\mathcal{F}$ has infinitely many pairwise nonequivalent A-computable Friedberg numberings.

We extend these results,

THEOREM 3. *Let $\mathcal{F}$ be an infinite A-computable family of total functions, where A is a hyperimmune set. Then $\mathcal{F}$ has infinitely many pairwise nonequivalent A-computable Friedberg numberings.*

Note that, [4], if an A-computable family $\mathcal{F}$ of total functions contains at least two elements, where A is a hyperimmune set, then $\mathcal{F}$ has no A-computable principal numbering.

THEOREM 4. *(Issakhov) Let $\mathcal{F}$ be a finite A-computable family of total functions, where Turing degree of the set A is hyperimmune free. Then $\mathcal{F}$ has an A-computable principal numbering.*

QUESTION. Is it true the formulation of previous theorem for infinite family?

The main talk will be around this question.

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▶ ALEXANDER JONES, *Truth as a logical property.*
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Numerous deflationists claim that truth is a logical property, similar to conjunction or quantification. This claim can be analysed by using Tarski's criterion of logicality - the logical notions are those which are invariant under any permutation of the world [1]. Considering a materially adequate truth property over arithmetic, I prove the existence of permutations π for which the truth property is not invariant. I take this to show that truth is not a logical property.

One can offer a refinement on this thesis: Horsten [2] has argued that truth is not purely logical, but a logico-linguistic property. Can Tarski's criterion be modified to support this claim? I propose suggestions, but show that ultimately they fail, proving that in general it is impossible to have a truth predicate invariant under non-trivial permutation and materially adequate in the permuted model.

McGee's theorem [3] provides an alternative statement of Tarski's criterion: a notion is invariant if and only if it is definable in $L(\infty\infty)$, the infinitary language of first order logic. Whilst a truth predicate is not definable in this language, an arithmetical truth predicate is definable in infinitary arithmetical languages, in particular $L_A(\omega_1\omega)$. This results in interesting formal consequences on the expressive utility of a truth predicate and, I argue, shows one can understand truth as a quasi-logical property.

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▶ DIANA KABYLZHANOVA, *A note on computably enumerable preorders.*
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A preorder is a reflexive and transitive binary relation. We are interested in computably enumerable (c.e.) preorders, in particular, in weakly pre-complete c.e. preorders, [1]. Let P and Q be c.e. preorders. We say that P is computably reducible to Q ($P \leq_c Q$) if there is a computable function f such that xPy iff $f(x)Qf(y)$ for every $x, y \in \omega$. A c.e. preorder P is light if there exists a c.e. preorder Q in which all classes are singletones such that $Q \leq_c P$, and c.e. preorder P is called dark if P is not light and has no computable classes, [2]. A c.e. preorder P is finite if P has a finite number of classes. We say that c.e. preorder P is weakly pre-complete if for every total function φ_e there exist x_e such that $\varphi_e(x_e) \sim_P x_e$.

THEOREM 1. *Let P be a non-universal c.e.preorder. Then there exists a weakly pre-complete, non-universal c.e. preorder Q, such that $P \leq_c Q$*

THEOREM 2. *For every finite c.e. preorder P there are infinitely many minimal dark c.e. preorders P_d such that $P \leq_c P_d$*

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▸ BIRZHAN KALMURZAYEV AND NIKOLAY BAZHENOV, *Weakly precomplete dark computably enumerable equivalence relations.*
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We study computably enumerable equivalence relations (ceers). For the background, we refer the reader to [1].

A ceer E on ω is weakly precomplete if there exists a partial computable function fix such that for all e, if φ_e is total, then $fix(e)\downarrow$ and $\varphi_e(fix(e)) E fix(e)$. We consider ceers relatively to the following well known reduction: a ceer R is said to be reducible to a ceer S (denoted by $R \leq_c S$) if there is a computable function f such that for all x and y, $xRy \Leftrightarrow f(x)Sf(y)$. A ceer E is called dark if it is incomparable with Id under reduction $\leq_c$. We have the following result.

Theorem 1. *For any dark ceer E there is a weakly precomplete dark ceer F such that $E <_c F$.*

Badaev S.A. showed that there is an infinite ω-chain of non-equivalent weakly precomplete ceers. Our result implies that for any dark ceer E, there is an infinite ω-chain of non-equivalent weakly precomplete dark ceers over E.

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▶ VLADIMIR KANOVEI, *The full basis theorem does not imply analytic wellordering.*

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Let *analytically definable* mean lightface Σ^1_n for some n.

THEOREM 1 (with Vassily Lyubetsky, ArXived in [6]). *In a suitable ccc generic extension of L, it is true that every non-empty analytically definable set of reals contains an analytically definable real (the full basis theorem), but there is no analytically definable wellordering of the continuum.*

To prove the theorem, we define, in L, a system of forcing notions $P_{\xi k}$, $\xi < \omega_1$ and $k < \omega$, whose finite-support product $P = \prod_{\xi,k} P_{\xi k}$ adds an array $X = \langle x_{\xi k}\rangle_{\xi<\omega_1 \wedge k<\omega}$ of reals $x_{\xi k} \in 2^\omega$ to L, such that the following holds in $L[X]$:

(1) if $m < \omega$ then the submodel $L[X_m]$ admits a Δ^1_{m+3} wellordering of the reals of length ω_1, where $X_m = \langle x_{\xi k}\rangle_{\xi<\omega_1 \wedge k<m}$;

(2) if $m < \omega$ then $2^\omega \cap L[X_m]$ is a Σ^1_{m+3} set in $L[x]$;

(3) if $m < \omega$ then $L[X_m]$ is an elementary submodel of $L[x]$ with respect to all Σ^1_{m+2} formulas with reals in $L[X_m]$ as parameters;

(4) there is no analytically definable wellordering of 2^ω.

Each factor $P_{\xi k}$ of P is similar to the Jensen minimal Π^1_2 singleton forcing [3] to some extent, but corresponds to a definability level which depends on k (rather than just Π^1_2 for all k and ξ). See [2, 4, 5] on other results by the same method.

Infinite finite-support products of Jensen-type forcing notions were introduced and conjectured to be applicable to studies of definability problems by Ali Enayat [1], whose advise, as well as support of Department of Philosophy, Linguistics and Theory of Science at the University of Gothenburg and the Erwin Schrodinger International Institute for Mathematics and Physics (ESI) at Vienna, are thankfully acknowledged.

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▸ YURII KHOMSKII, *Definable Maximal Independent Families.*
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Maximal independent families are combinatorial objects that have applications in various areas of mathematics. A maximal independent family can be constructed using the Axiom of Choice, and an old result of Arnold Miller shows that there are no analytic maximal independent families. We strengthen this result by showing that in the Cohen model, there are no projective maximal independent families. We also introduce a new cardinal invariant related to maximal independent families and provide some partial results about it. This is joint work with Jörg Brendle (U Kobe, Japan).

▶ YECHIEL M. KIMCHI, *Partition relations equiconsistent with* $o(o(\ldots o(\kappa)\ldots)) = 2$.
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Preamble: We try to associate the consistency strength of statements like $o(\kappa) = \alpha$ (for κ measurable) with various partition relations of the form $\kappa \to (\mu)^{\alpha}_{\lambda}$. Here, we restrict ourselves to partitions of the form $\aleph_1 \to (\omega^{\alpha})^{\omega^{\alpha}}_{\aleph_0}$. Since we work under ZFC, the partition properties are limited to definable functions.

In [1], M. Spector proved that for $\alpha = 1$

$$CON(\exists\kappa(o(\kappa) = \alpha)) \iff CON(\aleph_1 \to (\omega^{\alpha})^{\omega^{\alpha}}_{\aleph_0})$$

In [2] we have shown that it can be generalized to $\alpha = 2$ only (which serves as the basis for the current presentation). In order to resurrect the nice equiconsistency we defined the notion of *weak-homogeneity*, and recently, in [3], we extended the result to

$$CON(\exists\kappa(o(\kappa) = \kappa^{+})) \iff CON(\aleph_1 \xrightarrow{\text{WH}} (\aleph_1)^{\aleph_1}_{\aleph_0})$$

The failure of the original equiconsistency for $\alpha = 3$, lead us in the past to prove

$$CON(\aleph_1 \to (\omega^{3})^{\omega^{3}}_{\aleph_0}) \iff CON(\exists\kappa(o(o(\kappa)) = 2))$$

In this presentation we extend the latter for all $\alpha < \omega$, and for that we need two simple definitions. The first one is just notational: $\kappa \xrightarrow{\text{Cl}} (\mu)^{\alpha}_{\lambda}$ means that both the homogeneous sequence of o.t. μ and the sequences of o.t. α in the domain of the functions, are restricted to closed sequences. The second iterates the $o(\kappa)$ function:

Definition: $o^{n}(\mu)$ is defined by induction on $n \in \omega$ for any ordinal μ:
(i) $o^{0}(\mu) = \mu$ (ii) $o^{n+1}(\mu) = o(o^{n}(\mu))$

We are now able to state the following two related theorems:

Theorem 1: For any $n \in \omega (n \geq 2)$, $CON(\aleph_1 \xrightarrow{\text{Cl}} (\omega^{n})^{\omega^{n}}_{\aleph_0}) \iff CON(\exists\kappa(o^{n}(\kappa) = 2))$

Theorem 2: For $n \in \omega (n \geq 1)$, $CON(\aleph_1 \to (\omega^{n+1})^{\omega^{n+1}}_{\aleph_0}) \iff CON(\exists\kappa(o^{n}(\kappa) = 2))$

Note 1: The new result is the forward direction (from left to right).

Note 2: The exact consistency strength of the statement $\aleph_1 \to (\omega^{\omega})^{\omega^{\omega}}_{\aleph_0}$, is still not known. All we know (cf. [2]) is that it implies the consistency of the statement $\exists\kappa(o(\kappa) > \kappa)$ – witnessing yet another jump in the relationship between partition properties and measurable cardinals.

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▸ PAWEŁ KLIMASARA, KRZYSZTOF BIELAS, AND JERZY KRÓL, *Boolean-valued models of ZFC and forcing in geometry and physics.*
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To every complex separable Hilbert space $\mathcal{H}$ of quantum-mechanical (QM) states one can assign orthomodular lattice of projections $\mathbb{L}(\mathcal{H})$. Given a maximal complete Boolean algebra of projections $B \subset \mathbb{L}(\mathcal{H})$, it determines a Boolean-valued ZFC model V^B with real numbers corresponding bijectively to self-adjoint operators with spectral projections in B [1]. We provide the conditions for B to be atomless and the QM-meaning of the non-trivial forcing in V^B. For a generic ultrafilter G in V^B, the change of the real line R in 2-valued model V into $R[G]$ in V^B/G helps to solve some problems in cosmology.

Another change of the real line concerns the level of the formal language, i.e. $R[G] \to \mathbb{R}$ where $R[G]$ is the 1st order set of real numbers and $\mathbb{R}$ is the unique (up to isomorphism) model of the 2nd order theory of Dedekind-complete ordered field. This shift is expected to take place in the cosmological model of expanding Universe [2]. We show that this shift is derivable from $\mathbb{L}(\mathcal{H})$ and leads to a change in smoothness structure of spacetime manifold which must be an exotic R^4. The embedding into the standard smooth $\mathbb{R}^4$ allows prediction of the cosmological constant value purely topologically.

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▸ LESZEK KOŁODZIEJCZYK, *Some new bounds on the strength of restricted versions of Hindman's Theorem.*
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Hindman's Theorem states that for every colouring of $\mathbb{N}$ using finitely many colours, there is an infinite set $H \subseteq \mathbb{N}$ such that all finite sums of distinct elements of H have the same colour. Hindman's Theorem is known to follow from ACA_0^+ and to imply ACA_0; determining its exact logical strength is a significant open problem in reverse mathematics. A related open problem, originally formulated by combinatorialists, is whether there is a proof of the restriction of Hindman's Theorem to sums of length at most 2 that does not establish the full theorem.

Recently, Dzhafarov et al. proved that the restriction of Hindman's Theorem to sums of length at most 3, and 3 colours, already implies ACA_0. By modifying their methods, we show that also the restriction to sums of length at most 2, and 4 colours, implies ACA_0. Thus, the best currently known upper and lower bounds on Hindman's Theorem for sums of length at most 2 are the same as for the full theorem. On the other hand, Carlucci has formulated some versions of Hindman's Theorem which are provably equivalent to ACA_0. We obtain two new simple examples of this kind, as well as some implications between restrictions of Hindman's Theorem and restrictions of Ramsey's Theorem for pairs. Some of our implications can be witnessed by strong computable reductions.

Joint work with Lorenzo Carlucci, Francesco Lepore, and Konrad Zdanowski.

▶ NATALIA KORNEEVA, *On prefix realizability problems of infinite words for natural subsets of context-free languages.*
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In this paper we consider prefix realizability problems of infinite words over an finite alphabet for some classes of languages.

Let $\mathcal{L}_{\mathcal{CFL}}$ be the class of context-free languages, that is, those that are accepted by finite nondeterministic pushdown automata. Let $\mathcal{L}_1(\subseteq \mathcal{L}_{\mathcal{CFL}})$ be the class of languages accepted by finite deterministic pushdown automata by final states and $\mathcal{L}_2(\subseteq \mathcal{L}_{\mathcal{CFL}})$ be the class of languages accepted by finite deterministic pushdown automata by empty stack. Let $\mathcal{L}_{\mathcal{R}}$ be the class of regular languages, that is, those that are accepted by finite automata. Let $\mathcal{L}$ be one of these classes.

Definition. An infinite word x over an finite alphabet Σ is called $\mathcal{L}$-prefix decidable if for any language $L \in \mathcal{L}$ over the alphabet Σ the problem $L \cap Pref(x) \neq \emptyset$ is decidable.

The conception of $\mathcal{L}_{\mathcal{R}}$-prefix decidable infinite words was introduced by M. N. Vyalyi and A. A. Rubtsov [1].

We consider infinite words which are a result of applying finite initial Mealy automaton to some infinite words.

Theorem. Let $(S, \Sigma, \Sigma', \delta, \omega, s_0)$ be a finite initial Mealy automaton, $x \in \Sigma^\infty$ be a $\mathcal{L}$-prefix decidable infinite word. Then $\omega(s_0, x) \in (\Sigma')^\infty$ is a $\mathcal{L}$-prefix decidable infinite word.

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▸ ANGELIKI KOUTSOUKOU-ARGYRAKI, *An invitation to proof mining: two applications in nonlinear operator theory.*
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The revival of Kreisel's program of *unwinding of proofs* by Kohlenbach as *proof mining* has been very fruitful for applications in many mathematical disciplines, especially within analysis. The scope of the program is the extraction of constructive information (e.g. computable bounds) from nonconstructive mathematical proofs. This can be a priori guaranteed by certain logical metatheorems. The quantitative content emerges through the discovery of quantifiers that were implicit in the original proof. The bounds obtained are explicit, highly uniform and of low complexity. We present here: (i) Bounds extracted for the computation of approximate common fixed points of one-parameter nonexpansive semigroups on a subset of a Banach space, obtained via proof mining on a proof by Suzuki. The bounds differ from those that had been obtained in [1] via proof mining on a completely different proof by Suzuki of a generalised version of the studied statement. (ii) Computable rates for the convergence of the resolvents of set-valued operators on a real Banach space that fulfill certain accretivity conditions to the zero of each operator, that were extracted via proof mining on a proof by García-Falset. The above results are, among others, included in [2] and can be of interest for optimization theory.

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▶ BEIBUT KULPESHOV, SERGEY SUDOPLATOV, *On distributions for countable models of quite o-minimal theories with non-maximum many countable models.*
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Quite o-minimal theories (which were introduced in [1]) form a subclass of the class of weakly o-minimal theories preserving a series of properties of o-minimal theories. Using structural results on quite o-minimal Ehrenfeucht theories and solving the Vaught's conjecture [2] similar to [3], a general approach to the classification of countable models of complete theories [4] is applied to the class of quite o-minimal theories with non-maximum many countable models.

We use the following theorem and the general decomposition formula [4] for the number $I(T,\omega)$ of countable models of theory T, the finite Rudin–Keisler preorder $\mathrm{RK}(T)$ of almost prime models of T, and the distribution function IL of limit models with respect to $\mathrm{RK}(T)$:

$$I(T,\omega) = |\mathrm{RK}(T)| + \sum_{i=0}^{|\mathrm{RK}(T)/\sim_{\mathrm{RK}}|-1} \mathrm{IL}(\widetilde{\mathbf{M}}_i). \tag{1}$$

Theorem 1. [2] *Let T be a quite o-minimal theory in a countable language. Then either T has 2^ω countable models or T has exactly $3^k \cdot 6^s$ countable models, where k and s are natural numbers. Moreover, for any $k, s \in \omega$ there is a quite o-minimal theory T with exactly $3^k \cdot 6^s$ countable models.*

The Rudin–Keisler preorders $\mathrm{RK}(T)$ as well as the distribution functions IL are described for quite o-minimal theories T with non-maximum many countable models. The decomposition formula (1) is represented in the following form:

$$3^k \cdot 6^s = 2^k \cdot 3^s + \sum_{t=0}^{k} \sum_{m=0}^{s} 2^{s-m} \cdot (2^t \cdot 4^m - 1) \cdot C_k^t \cdot C_s^m.$$

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▸ TAISHI KURAHASHI, *Two theorems on provability logics.*
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We say that a formula $\tau(v)$ is a numeration of a theory T if $\{n \in \omega : \mathsf{PA} \vdash \tau(\overline{n})\}$ is exactly the set of all Gödel numbers of the axioms of T. For each numeration $\tau(v)$ of T, the provability predicate $\mathsf{Pr}_\tau(x)$ of T is naturally constructed. An arithmetical interpretation f is a mapping from the set of all propositional variables to the set of sentences of arithmetic. Each arithmetical interpretation f is uniquely extended to the mapping f_τ from the set of all modal formulas to the set of sentences of arithmetic so that f_τ commutes with every propositional connective, and $f_\tau(\Box A)$ is $\mathsf{Pr}_\tau(\ulcorner f_\tau(A) \urcorner)$. The provability logic $\mathsf{PL}_\tau(U)$ of $\tau(v)$ relative to a theory U is the set $\{A : U \vdash f_\tau(A)$ for all arithmetical interpretations $f\}$ of modal formulas (see [1, 2]).

We proved the following two theorems.

Theorem 1. *Let U be any recursively axiomatized consistent extension of PA. If L is one of the logics GL_α, D_β, S_β and GL^-_β where $\alpha \subseteq \omega$ is recursively enumerable and $\beta \subseteq \omega$ is cofinite, then there exists a Σ_1 numeration $\tau(v)$ of some extension of $I\Sigma_1$ such that $\mathsf{PL}_\tau(U)$ is exactly L.*

Theorem 2. *Let T be any recursively axiomatized consistent extension of PA. If L is one of the logics K and $\mathsf{K} + \Box(\Box^n p \to p) \to \Box p$ $(n \geq 1)$, then there exists a Σ_2 numeration $\tau(v)$ of T such that $\mathsf{PL}_\tau(T)$ is exactly L.*

The logics $\mathsf{K} + \Box(\Box^n p \to p) \to \Box p$ $(n \geq 1)$ were introduced by Sacchetti [3].

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[3] Sacchetti, Lorenzo, *The fixed point property in modal logic*, ***Notre Dame Journal of Formal Logic***, vol. 42 (2001), no. 2, pp. 65–86.

▸ MATEUSZ ŁEŁYK, *Reflection principles, bounded induction and axiomatic truth theories.*
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An *axiomatic theory of truth* is an extension of PA formulated in a language $\mathcal{L}_{\mathrm{PA}} + T$, where T is a fresh unary predicate (see [5]). The basic classically compositional theory of truth, CT^-, is the extension of PA only with sentences naturally corresponding to inductive Tarski's truth conditions for $\mathcal{L}_{\mathrm{PA}}$ (in particular we do not add induction axioms for sentences with the predicate T), e.g.

$$\text{(NEG)} \qquad \forall \phi \ \big(\mathrm{Sent}_{\mathcal{L}_{\mathrm{PA}}}(\phi) \rightarrow T(\neg\phi) \equiv \neg T(\phi)\big).$$

where $\mathrm{Sent}_{\mathcal{L}_{\mathrm{PA}}}(x)$ is the natural arithmetical formula strongly representing the set of Gödel codes of $\mathcal{L}_{\mathrm{PA}}$ sentences. The starting point of the talk is the theorem on multiple axiomatizations of CT^- extended with a Δ_0 induction for formulae with the T predicate (CT_0): one can show that CT_0 is equivalent to extensions of CT^- with various reflection principles, e.g.

TPA $\forall\phi \ \big(\mathrm{Pr}_{\mathrm{PA}}(\phi) \rightarrow T(\phi)\big)$ ("All theorems of PA are true"),

TL $\forall\phi \ \big(\mathrm{Pr}_{\emptyset}(\phi) \rightarrow T(\phi)\big)$ ("All theorems of first-order logic are true"),

REF $\forall\phi \ \big(\mathrm{Pr}^T_{\emptyset}(\phi) \rightarrow T(\phi)\big)$ ("First-order consequences of true sentences are true").

The theorem is a consequence of results obtained in [1], [2], [4] and our unpublished result, presented during Logic Colloquium 2016. This time we study the role axiom NEG plays in obtaining these equivalences: we investigate extensions of the non-classically compositional truth theory PT^-, in which NEG is replaced with axioms stating how negation behaves with respect to other connectives and quantifiers. For example the following sentences are axioms of PT^-:

$$\forall \phi, \psi \ \Big(\mathrm{Sent}_{\mathcal{L}_{\mathrm{PA}}}(\phi) \wedge \mathrm{Sent}_{\mathcal{L}_{\mathrm{PA}}}(\psi) \rightarrow \big(T(\neg(\phi\vee\psi)) \equiv T(\neg\phi) \wedge T(\neg\psi)\big)\Big)$$

$$\forall \phi \ \Big(\mathrm{Form}^{\leq 1}_{\mathcal{L}_{\mathrm{PA}}}(\phi) \rightarrow \big(T(\neg\exists x\phi) \equiv \forall x T(\neg\phi(\underline{x}))\big)\Big).$$

In other words, PT^- is the natural stratified counterpart of Kripke-Feferman theory KF^- (to our best knowledge PT^- was first introduced in [3]) and its inner logic is modelled after the Strong Kleene Logic. It turns out that adding induction for Δ_0 sentences with the truth predicate to PT^- (PT_0) results in one more axiomatization of CT_0. However in general over PT^-, "completeness" reflection principles (**TPA**, **TL**) are much weaker than the "closure" ones (**REF**). More concretely: PT^- extended with

1. **TL** is conservative over PA,
2. **TPA** is conservative over the uniform reflection scheme over PA, hence

is strictly weaker than CT_0,

3. **REF** is equivalent to CT_0 (and PT_0).

[1] Cezary Cieśliński, *Deflationary Truth and Pathologies*, ***Journal of Philosophical Logic***, vol. 39 (2010), no. 3, pp. 325–337.

[2] Cezary Cieśliński, *Truth, Conservativeness, and Provability*, ***Mind***, vol. 119 (2010), no. 474, pp. 409–422.

[3] Martin Fischer, *Minimal Truth and Interpretability*, ***Review of Symbolic Logic***, vol. 2 (2009), no. 4, pp. 799–815.

[4] Henryk Kotlarski, *Bounded Induction and Satisfaction Classes*, ***Mathematical Logic Quarterly***, vol. 32 (1986), no. 31-34, pp. 531–544.

[5] Volker Halbach, ***Axiomatic Theories of Truth***, Cambridge University Press, 2011.

▶ MICHAEL LIEBERMAN, JIŘÍ ROSICKÝ, SEBASTIEN VASEY, *Set-theoretic pathologies in accessible categories.*
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Recent work in abstract model theory (see [2], [3], and [4]) has highlighted the highly desirable properties of abstract classes under large cardinals axioms, chiefly the assumption of a proper class of strongly (or almost strongly) compact cardinals. There are parallel results for accessible categories (see [5] and [6]), in addition to earlier work of [1] concerning Vopěnka's Principle. We here consider the other end of the spectrum: pathological behavior of accessible categories assuming that there is only a set of measurable cardinals or, indeed, that $V = L$. The pathological examples, which are built directly out of the cumulative set-theoretic hierarchies, include the non-co-well-powered accessible category considered in [1] and [7], as well as an example tucked away in [8], which we have newly adapted to this context.

[1] J. Adámek and J. Rosický, ***Locally presentable and accessible categories***. LMS Lecture Note Series 189, Cambridge UP, 1994.

[2] J. Baldwin and W. Boney, *Hanf numbers and presentation theorems in AECs*, to appear in ***Beyond First Order Model Theory*** (J. Iovino, editor), CRC Press, 2017.

[3] W. Boney, *Tameness from large cardinal axioms*, ***Journal of Symbolic Logic***, vol.163 (2012), pp. 2008–2017.

[4] W. Boney and S. Unger, *Large cardinal axioms from tameness in AECs*, to appear in ***Proceedings of the American Mathematical Society***.

[5] M. Lieberman and J. Rosický, *Classification theory for accessible categories*, ***Journal of Symbolic Logic***, vol. 81 (2016), no. 1, pp. 151–165.

[6] ———, *Hanf numbers via accessible images*, arXiv:1610.07816v4.

[7] M. Makkai and R. Paré, ***Accessible Categories: The Foundations of Categorical Model Theory***, Contemporary Mathematics 104, AMS, 1989.

[8] S. Shelah, *Model theory for a compact cardinal.* ***arXiv:1303.5247v3***.

▶ KRISTINA LIEFKE, SAM SANDERS, *A computable solution to Partee's puzzle.*

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We present an application of computability theory to *formal semantics*, a sub-discipline of *linguistics*. In particular, we discuss the *computable* solution to Partee's temperature puzzle from [1]. Our solution improves upon the standard Montagovian solution to Partee's puzzle (i) by providing *computable* natural language interpretations for this solution, (ii) by lowering the complexity of the types in the puzzle's interpretation, and (iii) by acknowledging the role of linguistic and communicative context in this interpretation. These improvements are made possible by interpreting natural language in a model that is inspired by the Kleene-Kreisel model of countable-continuous functionals ([2]). In this model, continuous functionals are represented by lower-type objects, called the *associates* of these functionals, analogous to the representation via *codes* in *Reverse Mathematics*.

[1] ——— *A computable solution to Partee's temperature puzzle*, ***Proceedings of LACL2016 (Logical Aspects of Computational Linguistics)***, Lecture Notes in Computer Science 10054, Springer, p. 175-190.

[2] John Longley, Dag Normann *Higher-order Computability*, ***Springer, 2015.***

▸ ROUSSANKA LOUKANOVA, *Type Theory of Restricted Algorithms and Neural Networks.*
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Moschovakis [1] introduced a new approach to the mathematical concept of algorithm. In [2], he extended the approach to typed acyclic recursion, by a formal language L^{λ}_{ar} equipped with a reduction calculus. The theory L^{λ}_{ar} represents crucial semantic distinctions in formal and natural languages. We present our development of L^{λ}_{ar} to Type Theory of Restricted Algorithms (TTofRAlg), as a mathematical theory of the notion of algorithm, by adding a restrictor as an operator. The purpose is to model procedural memory and functionality of biological entities, in particular neurons and neural networks.

Like L^{λ}_{ar}, TTofRAlg has two kinds of typed variables: *pure variables*, for λ-abstraction operator; and, *memory (recursion) variables*, for storing information. The terms of TTofRAlg are generated by the rules:

$$\text{(1a)}\quad A :\equiv \mathsf{c}^{\tau} : \tau \mid x^{\tau} : \tau \mid B^{(\sigma\to\tau)}(C^{\sigma}) : \tau \mid \lambda(v^{\sigma})\,(B^{\tau}) : (\sigma \to \tau)$$

$$\text{(1b)}\quad \mid \big(A_0^{\sigma_0} \text{ where } \{p_1^{\sigma_1} := A_1^{\sigma_1}, \ldots, p_n^{\sigma_n} := A_n^{\sigma_n}\}\big) : \sigma_0$$

$$\text{(1c)}\quad \mid \big(\mathsf{A}_0^{\sigma_0} \text{ such that } \{\, \mathsf{C}_1^{\tau_1}, \ldots, \mathsf{C}_m^{\tau_m} \,\}\big) : \sigma_0$$

given that c is a constant, x is a variable of ether kind, and p_i, are recursion variables of respective types, and each τ_i is either the type $\mathtt{t}$ of truth values, or the type $\widetilde{\mathtt{t}}$ of state dependent truth values.

A *recursion term* A of the form (1b) designates a recursor, i.e., an algorithm for computing the denotation of A. A term A of the form (1c) designates a restrictor that constrains the denotation of A with constraints $\mathsf{C}_1^{\tau_1}, \ldots, \mathsf{C}_m^{\tau_m}$.

Reduction Calculus. We introduce a reduction calculus of TTofRAlg, which extends the reduction system of L^{λ}_{ar}. Each term has a unique, up to congruence, canonical form. The recursion terms in canonical forms represent algorithms for mutually recursive computations, which, in addition, can be restricted by constraints of the form (1c). Assignments of terms to memory variables in recursion terms (1b) represent saving objects and outcomes of computations in memory cells. Semantically, the memory variables, which occur in a TTofRAlg term, represent memory cells of a computational entity, which are engaged in algorithmic computations. The subclass of TTofRAlg, which is limited to recursion terms (1b) with acyclic assignments, represents acyclic algorithms that always end their computations.

Neural Networks. Memory cells in specialised assemblies can establish networks of memory cells. A formal language of functional neural nets (NNets) is a specialised version of the language TTofRAlg. We define terms designating *neural nets* as complex units of restricted memory variables and terms. A neural net consists of memory components, which are restricted simultaneously by complex constraints, and can involve recursive computations.

[1] Yiannis N. Moschovakis, *Sense and denotation as algorithm and value*, ***Lecture Notes in Logic, Number 2*** (J. Oikkonen and J. Vaananen, editors), Springer, 1994, pp. 210–249.

[2] Yiannis N. Moschovakis, *A logical calculus of meaning and synonymy*, ***Linguistics and Philosophy***, vol. 29, pp. 27–89.

▸ ROBERT LUBARSKY, *Determinacy of Boolean combinations of Σ^0_3 games.*
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Welch characterized the ordinal at which winning strategies for all Σ^0_3 games appear, via Σ_2 reflection; namely, it is the least ordinal which is the ordinal standard part of a non-standard model which has an infinite nested sequence of pairs of ordinals, the smaller of which is a Σ_2 substructure of the larger. This reflection property is strictly between Σ_2 admissibility and Σ_2 non-projectibility. Montalban and Shore show that this is the beginning of a hierarchy, in that the least ordinal for winning strategies for all games which are alternating differences of m-many Σ^0_3 sets is strictly between the least $m+1$-admissible and $m+1$-non-projectible. Here we show the straightforward generalization of Welch's result, that this ordinal is the least standard part of a model with an infinite nesting of Σ_{m+1}-elementary pairs. This talk will be an introduction to the subject.

[1] Antonio Montalban and Richard Shore, *The limits of determinacy in second order arithmetic*, ***Proceedings of the London Mathematical Society*** v. 104, 2012, pp. 223-252

[2] Antonio Montalban and Richard Shore, *The limits of determinacy in second order arithmetic: consistency and complexity strength*, ***Israel Journal of Mathematics***, v. 204, 2014, pp. 477-508; doi: 10.1007/s11856-014-1117-9

[3] Philip Welch, *Weak systems of determinacy and arithmetical quasi-inductive definitions*, ***The Journal of Symbolic Logic***, v. 76 (2011), pp. 418-436

▶ ERIC JOHANNESSON, ANDERS LUNDSTEDT, *When one must strengthen one's induction hypothesis.*
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Sometimes when trying to prove a fact by induction, one gets "stuck" at the induction step. The solution is often to use a "stronger" induction hypothesis, that is to prove a "stronger" result by induction. But in such cases, can we say that "strengthening the induction hypothesis" is necessary in order to prove the fact?

The general problem of when one must, in order to prove a fact X, first prove another fact Y, seems very hard. Interestingly, the special case of when one must strengthen one's induction hypothesis turns out to be more manageable. We provide the following characterization of when one in fact must strengthen one's induction hypothesis.

Let $\mathsf{Th}(\mathcal{N})$ be the set of sentences of first-order arithmetic that are true in the standard model. Let $T \subseteq \mathsf{Th}(\mathcal{N})$ and let $\varphi(x)$ and $\psi(x)$ be formulas both with at most one free variable x. Say that $\psi(x)$ *witnesses that* T *proves* $\forall x \varphi(x)$ *with and only with strengthened induction hypothesis* if and only if

(1) $T \cup \{\varphi(0) \wedge \forall x(\varphi(x) \to \varphi(x+1)) \to \forall x \varphi(x)\} \nvdash \forall x \varphi(x)$,
(2) $T \vdash \varphi(0)$,
(3) $T \vdash \psi(0)$,
(4) $T \vdash \forall x(\psi(x) \to \psi(x+1))$,
(5) $T \vdash \forall x \psi(x) \to \forall x \varphi(x)$.

We show that this definition applies to a number of natural examples. By reflecting on mathematical practice, we argue that this definition does capture the notion of "proof by strengthened induction hypothesis".

▸ KERKKO LUOSTO, *Logical co-operation in multiplayer games.*
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This work is joint with Raine Rönnholm.

In the context of classical game theory, multiplayer games with a common goal are trivial. In practice, however, finding a strategy is a computational or logical problem. We work with the following framework:

a) The players share a common goal.
b) The players assume no distinct roles.
c) The players are allowed to communicate before the rules of the game are revealed, but not after that.

Note that condition c seems to make the task next to impossible for the players.

Continuing with simplifying conditions:

1) The possible outcomes are reduced to win or loss.
2) Following the standard normalization, each player has only one move in the play. These moves are done simultaneously.
3) Every player has the same set of moves.

We may then describe the game by a *game structure* $\mathfrak{M}$ of the vocabulary $\{W\}$ where $\mathrm{Dom}(\mathfrak{M})$ of the structure is the common set of moves and the predicate $W^{\mathfrak{M}}$ corresponds to what is usually represented as the utility matrix. Conditions b and c entail that the players decide on a *strategy formula* $\alpha(x)$ which is copied to each player i permuting the variables of W appropriately, giving rise to a formula $\alpha_i(x)$. Call the strategy formula $\alpha(x)$ *winning* in $\mathfrak{M}$ if

$$\emptyset \neq \prod_{i=0}^{k} \alpha_i^{\mathfrak{M}} \subseteq W^{\mathfrak{M}}.$$

Some results:

- Any first order strategy formula α loses asymptotically almost surely. This is a natural consequence of extension axioms holding a.a.s in $\mathfrak{M}$.
- In contrast, one may write a asymptotically almost surely winning formula in $\mathrm{FO}(\mathsf{R})$ where R is the Rescher quantifier. The proof uses the method of Babai, Erdős and Selkow to order the set of moves.

▸ ROBERTO MAIELI, *Non-decomposable connectives of Linear Logic.*
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We present the so called generalized connectives of multiplicative linear logic (MLL). These general connectives were formerly introduced by J.-Y. Girard [2] but most of the results known after then are due to V. Danos and L. Regnier [1]. This talk elaborates on these seminal works and brings several innovations.

A multiplicative generalized (or n-ary) connective can be defined by two pointwise orthogonal sets of partitions, P and Q, over the same domain $\{1, ..., n\}$. Actually, we can use partitions according two different points of view (i.e., two syntaxes), *sequential* and *parallel*, preserving the same notion of orthogonality ($P \perp Q$). Anyway, general connectives are more expressive in the parallel syntax since this allows to represent correct proofs, namely *proof-nets*, containing generalized connectives (*n-ary links*) that cannot be defined (decomposed) by means of the basic (binary) multiplicative ones, $\parr$ and $\otimes$. Dislike the standard proof-nets, these ”more liberal“ proof-nets do not correspond (*sequentialize*) to any sequential proof (if we exclude the trivial axioms).

In this talk, we characterize an ”elementary“ class of non-decomposable connectives: the class of *entangled connectives.* Actually, entangled connectives are the “smallest” generalized multiplicative connectives (w.r.t. the number of partitions or, equivalently, w.r.t. the number of rules or switchings), if we exclude, of course, the basic ones. Surprisingly, non-decomposable generalized connectives witness an asymmetry between proof-nets and sequent proofs since the former ones allow to express a kind of parallelism (concurrency) that the latter ones cannot do.

[1] Danos, V. and Regnier, L.: The structure of multiplicatives. Archive for Mathematical Logic, vol. 28, pp.181-203, 1989.

[2] Girard, J.-Y.: Linear Logic, Theoretical Computer Science, London Math. vol. 50(1), pp. 1-102, 1987.

▸ ALBERTO MARCONE,

Strongly surjective linear orders.

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A linear order L is *strongly surjective* if there exists an order preserving surjection from L onto each of its suborders. For example, an ordinal is strongly surjective if and only if it is of the form $\omega^\alpha m$, for some $\alpha < \omega_1$ and $m > 0$.

Our main result is that the set StS of countable strongly surjective linear orders is a $\check{\mathrm{D}}_2(\mathbf{\Pi}^1_1)$-complete set. This means that StS is the union of an analytic and a coanalytic set, and is complete for the class of sets that can be written in this way. More in detail, we show that the countable strongly surjective linear orders which are scattered form a $\mathbf{\Pi}^1_1$-complete set, while the countable strongly surjective linear orders which are not scattered form a $\mathbf{\Sigma}^1_1$-complete set. Our proof of the upper bound for scattered strongly surjective orders makes an essential use of both effective descriptive set theory and the fact that order preserving surjections well quasi-order the countable linear orders ([3, 1]).

Even if the study of the first two levels of the projective hierarchy is a long-standing topic, examples of sets that are true $\mathbf{\Delta}^1_2$ are very rare. In fact, as far as we know, StS is the first concrete example of a "natural" $\check{\mathrm{D}}_2(\mathbf{\Pi}^1_1)$-complete set.

If time permits, I'll also discuss uncountable strongly surjective linear orders. We can prove their existence under either PFA or $\diamondsuit^+$, while the provability in ZFC of the existence of these orders is an interesting open problem.

This is joint work with Riccardo Camerlo and Raphaël Carroy ([2]).

[1] Riccardo Camerlo, Raphaël Carroy, Alberto Marcone, *Epimorphisms between linear orders*, Order **32** (2015), 387–400, arXiv:1403.2158.

[2] Riccardo Camerlo, Raphaël Carroy, Alberto Marcone, *Linear orders: when embeddability and epimorphism agree*, arXiv:1701.02020.

[3] Charles Landraitis, *A combinatorial property of the homomorphism relation between countable order types*, The Journal of Symbolic Logic **44** (1979), 403–411.

▸ JUAN CARLOS MARTÍNEZ, *On pcf spaces which are not Fréchet-Urysohn*.
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An *admissible poset* is a triple $\langle T, \prec, i\rangle$ such that T is a non-empty set, $\prec$ is a well-founded ordering on T and $i : [T]^2 \to [T]^{<\omega}$ satisfying the following two properties:

(1) For all $u, s, t \in T$, $u \preceq s$ and $u \preceq t$ iff $u \preceq v$ for some $v \in i\{s, t\}$.

(2) For all $t \in T$ and all α less than the $\prec$-rank of t, $\{s \in T : s \prec t\} \cap \{s \in T : \text{rank}(s) = \alpha\}$ is infinite.

An admissible poset $\langle T, \prec, i\rangle$ has associated with it a locally compact, Hausdorff and scattered space X of underlying set T whose basic open sets are of the form $b_t \setminus (b_{u_0} \cup \cdots \cup b_{u_n})$, where $b_t = \{s \in T : s \preceq t\}$ for each $t \in T$. If Y is a subset of T, $\overline{Y}$ denotes the closure of Y in X.

A *pcf structure* is an admissible poset $\langle \theta + 1, \prec, i\rangle$ where θ is an infinite ordinal such that the following conditions are satisfied:

(PCF1) If $\nu \prec \mu$ then $\nu \in \mu$.

(PCF2) $\overline{\omega} = \theta + 1$.

(PCF3) If $I \subseteq \theta + 1$ is an interval, then $\overline{I}$ is also an interval.

(PCF4) $\xi \prec \theta$ for every $\xi \in \theta$.

(PCF5) For each $\nu \in \theta$ of uncountable cofinality there is a club C_ν of ν such that $\overline{C_\nu} \subseteq \nu + 1$.

The compact, Hausdorff, scattered space X associated with a pcf structure is called a *pcf space*, whose *height* is defined as the least ordinal α such that the αth Cantor-Bendixson level of X is empty. In [1], it was shown by means of a forcing argument that if CH holds then there is a pcf space of height $\omega_1 + 1$ which is not Fréchet-Urysohn, answering in a partial way a question posed by Todorcevic. Then, we will give here a simpler proof of Pereira's theorem by means of a forcing-free argument and we will extend his result to pcf spaces of any height $\delta + 1$ where $\delta < \omega_2$ with $\text{cf}(\delta) = \omega_1$.

[1] L. Pereira, *Applications of the topological representation of the pcf-structure*, ***Archive for Mathematical Logic***, vol. 47 (2008), no. 5, pp. 517–527.

▸ JOSÉ M. MÉNDEZ, GEMMA ROBLES, SANDRA M. LÓPEZ, MARCOS M. RECIO, *Belnap-Dunn semantics for natural implicative expansions of Kleene's strong three-valued matrix.*
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Belnap-Dunn type bivalent semantics is the semantics originally defined for interpreting Anderson and Belnap's "First Degree Entailment Logic" (cf. [1] and references therein). On the other hand, the notion of a "natural implication" is understood as it is defined in [2]. According to this notion, there are exactly 24 natural implicative expansions of Kleene's strong three-valued matrix with 1 and 1/2 as designated values. Some of these expansions characterize interesting logics such as paraconsistent expansions of the three-valued extensions of the positive fragments of Lewis' S5 and three-valued Gödel logic G3.

The aim of this paper is to define a Belnap-Dunn type bivalent semantics for the logics determined by each one of these 24 implicative expansions.

[1] A. R. Anderson, N. D. Jr. Belnap, ***Entailment. The logic of relevance and Necessity***, vol. 1, Princeton University Press, 1975.

[2] N. Tomova, *A Lattice of implicative extensions of regular Kleene's logics*, ***Reports on Mathematical Logic***, 47 (2012), pp. 173-182.

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▸ JOAN BERTRAN-SAN MILLÁN, *Frege's* Begriffsschrift *and logicism.*
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It is commonly accepted that G. Frege announced his logicist project in *Begriffsschrift* [1]. Disregarding what he achieved in this work, almost all historical studies agree that Frege formulated his goal of justifying that arithmetic is not an autonomous theory, but it is based on logic alone. The formal system developed in *Begriffsschrift*, the concept-script, is thus seen as the first step to realise Frege's logicist program.

I put forward a new interpretation of Frege's use of *Begriffsschrift* concept-script and argue that, according to this use, it is incorrect to claim that he outlined a logicist program in 1879. Two main argumental lines support this claim. First, I show that in 1880–1882 Frege presented the concept-script of *Begriffsschrift* as a tool for arithmetic, and not as a logical theory from which to deduce arithmetical theorems. Arithmetic was presented as an independent theory, with a specific domain of entities. In fact, Frege meant to apply the formal resources of this formal system – in particular, its theory of quantification – to express the logical relations that bind the atomic formulas of arithmetic together. He thus did not want either to replace the proper symbols of arithmetic with logical ones or to modify the interpretation of the letters used in arithmetical expressions; arithmetic provided the semantic content which was related by means of the concept-script. Second, I consider Frege's results in *Begriffsschrift* and conclude that they are incompatible with his later logicist program.

Frege might have had intuitions concerning the logical nature of arithmetical truths in 1879. However, he did not articulate them. Besides, I conclude that he could not defend them as a programmatic goal without contradicting key features of his factual use of the concept-script.

[1] G. Frege, ***Begriffsschrift, eine der arithmetischen nachgebildete Formelsprache des reinen Denkens***, Louis Nebert, 1879.

▸ RUSSELL MILLER, *Topology of isomorphism types of countable structures.*
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Let $\mathfrak{C}$ be a class of countable structures, closed under isomorphism. The collection of all members of $\mathfrak{C}$ with domain ω forms a subspace of Cantor space: the atomic diagram of each space becomes a subset of ω, using a Godel coding of the atomic formulas in the language of $\mathfrak{C}$ with extra constants from ω. We give this space the subspace topology, and then endow the quotient space $I(\mathfrak{C}) = \mathfrak{C}/\cong$, under the relation of isomorphism, with the quotient topology. The result is that we view the isomorphism types of elements of $\mathfrak{C}$ as elements of this topological space $I(\mathfrak{C})$.

The isomorphism relation on $\mathfrak{C}$ often resembles various of the well-known Borel equivalence relations on either Cantor space 2^ω or Baire space ω^ω. Determining which Borel equivalence relations yield spaces homeomorphic to $I(\mathfrak{C})$ requires the use of techniques from computable structure theory, along with reductions of the sort used in Borel reducibility, only stronger. These reductions may be regarded as type-2-computable functions. Often the main goal is to determine which definable relations on the members of $\mathfrak{C}$, if added to the language, turn $I(\mathfrak{C})$ into a recognizable space: when this happens, we may say that the elements of $\mathfrak{C}$ are *classified* up to isomorphism by the members of the recognizable space.

The talk will consist largely of examples of these phenomena, mostly using classes in which isomorphism is an arithmetic relation, such as algebraic fields, finite-valence graphs, torsion-free abelian groups, and equivalence structures.

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In Euclidean Elements in Book IV, Proposition 16, one can find how to inscribe an equilateral and equiangular fifteen-angled figure in a given circle. This construction was used both in theoretical and practical terms by Piero della Francesca. For instance in the setting of his painting *Baptism of Christ* one can find the first part of the construction. In the top side of the rectangle we construct an equilateral triangle, and we find that its apex falls at the point where the central vertical axis passes through the tip of Christs right foot. Then we locate the center of the triangle and find it to be precisely at the fingertips of Christs hands in prayer. In this way it is possible to set the center point of the painting. The result can be combined with Proposition 1.13 of his *De Prospectiva Pingendi*. In the second part of the treatise one can find more geometrical problems and theorems that have obvious relevance to Piero's work as a painter. There are problems of drawing a combination of prisms (Proposition 2.6), a beam of octogonal cross-section, lying on the ground plane (2.8), of drawing a cross-vaulted structure with a square ground plane (2.11).

My goal here is to describe the advanced geometrical exercises presented in the form of propositions. The treatise of Piero della Francesca is manifestation of a union of the fine arts and the mathematical sciences of arithmetic and geometry. The proofs of propositions are presented both in geometrical and mathematical form but from a logical point of view it is proposed by me a method of natural deduction that takes into account the importance of diagrams within formal proofs.

▸ ALIREZA MOFIDI, *Some VC-combinatorial aspects of definable set systems.*
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Several aspects of interactions between combinatorial features of definable set systems and model theoretic properties of them have been explored in different works in recent years such as [1], [2], [3], [4], etc. For example many connections between notions of VC-dimension, VC-density, (p,q)-theorems and compression schemes from combinatorial sides and NIP, forking and UDTFS from model theoretic side has been studied. Also some VC-combinatorial invariants are defined in [5]. We will talk about some further developments in these directions. We consider several new combinatorial assumptions on definable set systems, in particular some properties with an extremal combinatorial nature, and then explore their model theoretic impacts for example on complexities in stability hierarchy, spaces of types, etc. We also give several examples in each case. Meanwhile, we give characterizations of some stability theoretic dividing lines in terms of such combinatorial properties.

[1] M. Aschenbrenner, A. Dolich, D. Haskell, D. Macpherson, and S. Starchenko, *Vapnik-Chervonenkis Density in some Theories without the Independence Property I*, ***Trans. Amer. Math. Soc***, 368 (2016), no. 8, 5889-5949.

[2] A. Chernikov, P. Simon, *Externally definable sets and dependent pairs II*, ***Trans. Amer. Math. Soc***, vol.367 (2015), pp.52175235.

[3] V. Guingona1, C. Hill, *On Vapnik-Chervonenkis density over indiscernible sequences*, ***Math. Log. Quart***, No. 12, (2014), pp.5965.

[4] H. Johnson, *Vapnik-Chervonenkis Density on Indiscernible Sequences, Stability, and the Maximum Property*, ***Notre Dame J. Formal Logic***, vol 56, Number 4 (2015), 583-593.

[5] A. Mofidi, *On some dynamical aspects of NIP theories*, ***Arch. Math. Logic***, to appear.

▸ SEAN MOSS, *The Diller-Nahm model of type theory.*
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Gödel's Dialectica interpretation is a proof interpretation of Heyting arithmetic into a system of computable functionals of finite type. De Paiva [1], Hyland [2] and others have worked on the idea of a semantic version of Dialectica: starting with a category of types and a fibration of predicates over it, a new structured category is built whose morphisms correspond to the Dialectica interpretation of logical implication. Recently, von Glehn [3] has adapted this idea for the original Dialectica interpretation to categorical models of dependent type theory. I will discuss how we can build models of dependent type theory based on other variants of Dialectica, including the Diller-Nahm variant.

[1] V.C.V. de Paiva, *The Dialectica categories*, ***Categories in Computer Science and Logic*** (John W. Gray and Andre Scedrov, editors), American Mathematical Society, Providence, RI, 1989, pp. 47–62.

[2] J.M.E. Hyland, *Proof theory in the abstract*, ***Annals of Pure and Applied Logic***, vol. 114 (2002), pp. 43–78.

[3] T.L. von Glehn, ***Polynomials and Models of Type Theory***, PhD thesis, University of Cambridge, 2014.

▸ JOACHIM MUELLER-THEYS, *On the Provability of Consistency.*
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A *consistency sentence* $\mathrm{Con}^{\sigma}_{\Sigma} := \neg\mathrm{Prov}_{\Sigma}(\ulcorner\sigma\urcorner)$ states in the standard model that the decidable system Σ is consistent, viz. $\mathcal{N} \models \mathrm{Con}^{\sigma}_{\Sigma}$ iff $\Sigma \nvdash \bot$. We showed at [1] that this is the case if $\Sigma \vdash \neg\sigma$ or $\Sigma \nvdash \sigma$. So Gödel's Con_{Σ} is a consistency sentence indeed. By Löb's Theorem, $\Sigma \nvdash \mathrm{Con}^{\bot}_{\Sigma}$ if $\Sigma \vdash \mathrm{PA}$ is consistent.

We have recently found an alternative consistency sentence, the unprovability of which can be shown much more easily and already for consistent $\Sigma \vdash \mathrm{Q}$. The proof exploits that the provability predicate does *not* negatively represent Σ in itself, viz. there are σ_{B} such that $\Sigma \nvdash \sigma_{\mathrm{B}}$, but *non* $\Sigma \vdash \neg\mathrm{Prov}_{\Sigma}(\ulcorner\sigma_{\mathrm{B}}\urcorner)$, whence $\mathrm{Con}'_{\Sigma} := \mathrm{Con}^{\sigma_{\mathrm{B}}}_{\Sigma}$ already does the job. [1]

Specifying a remark of Evgeny I. Gordon during LC '15, such *negative* consistency sentences do not show the unprovability of consistency *in general*; they only show the unprovability of consistency *by them.* Accordingly, there might be *positive* consistency sentences, which would—by the analogous argument—prove the consistency of Σ in Σ. If $\Sigma \nvdash \sigma$ and $\Sigma \vdash \neg\mathrm{Prov}_{\Sigma}(\ulcorner\sigma\urcorner)$, $\mathrm{Con}^{\sigma}_{\Sigma}$ is a positive consistency sentence; and *total* negative self-irrepresentability seems to be unnatural and unlikely.

In search for suchlike sentences, we realised that $\Sigma \nvdash \mathrm{Con}^{\sigma}_{\Sigma}$ for all $\Sigma \vdash \neg\sigma$, and, subsequently, that the required $\Sigma \nvdash \mathrm{Con}^{\bot}_{\Sigma}$ implies $\Sigma \nvdash \mathrm{Con}^{\sigma}_{\Sigma}$ can be proven without any precondition on σ. This has the incredible consequence that $\Sigma \nvdash \neg\mathrm{Prov}_{\Sigma}(\ulcorner\sigma\urcorner)$ *for all* σ. In particular, all consistency sentences are negative. It follows either that there is *no* $\mathrm{Con}^{\sigma}_{\Sigma}$ stating in the theory of Σ that Σ is consistent.

Note. We obtained the theorem first in a more complicated and less general way by $\neg\Box p \notin \mathbf{GL}$ (which we had gained from a lemma for [2]) and Solovay's Theorem.

[1] MUELLER-THEYS, J., *Defining & simplifying Gödel's 2nd Incompleteness Theorem*, ***ASL 2017 Spring Meeting*** (Seattle).

[2] ———, *On Uniform Substitution*, ***The Bulletin of Symbolic Logic***, vol. 20 (2014), pp. 264–5.

▸ RANJAN MUKHOPADHYAY, *Intrinsic harmony and total harmony.*
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When placed within the context of proof-theoretic justification of deduction (Dummett, Prawitz) recent studies on the question of stability of intelim rules reveal the importance of the two distinct notions of intrinsic harmony, and, total harmony (or, what is the same thing: the satisfaction of the requirement of conservative extension (Belnap)) with respect to the intelim rules. The inversion principle of Prawitz captures the notion of intrinsic harmony. But non-substructural weak disharmony (Dicher) can creep in even if the inversion principle is satisfied by a constant, as can be seen in the case of the constant called knot (Dicher) which is the dual of tonk (Belnap). Dichers study hints that lack of non-substructural weak disharmony amounts to stability for intelim rules which are insulated from tinkering with structural rules. For Dummett, harmony along with this sort of stability make a constant self-justifying. So, intrinsic harmony does not entail the satisfaction of the requirement of conservative extension. Does the satisfaction of the requirement of conservative extension entail intrinsic harmony? The present paper attempts to show that the intelim rules for constants of minimal logic (system M of Prawitz) when satisfy the requirement of conservative extension in the context of the language for deducibility-as-such (Belnap, Tonk, plonk and plink) also have intrinsic harmony, i.e., respect the inversion principle. It goes by contrapositively showing that within the specified context, if the inversion principle is violated then conservative extension is also violated. Dummett conjectured that intrinsic harmony implies total harmony in a context where stability prevails (The Logical Basis of Metaphysics, HUP, 1991, p. 290). In such a case, given that total harmony entails intrinsic harmony in a specified context, intrinsic harmony coupled with stability (or, lack of non-substructural weak disharmony), and total harmony would coincide in that context.

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Diagrammatic approaches to deductive and formal reasoning [1, 2] have seen a resurgence in recent years. We propose a diagrammatic method for deciding whether Boolean equations over set-valued variables are tautologies or not. Conventional diagrammatic approaches to the above decision problem work reasonably well when the total number of sets under consideration is rather small. However, conventional approaches become cumbersome, if not completely unusable, while dealing with a large number of sets. We devise an algorithm for the above decision problem, and demonstrate that it scales well when the number of set variables in the equations increases rapidly.

[1] GARDNER M., *Logic Machines and Diagrams*, Second Edition, The University of Chicago Press, 1982.

[2] ROBERTS D.D., *The Existential Graphs of Charles S. Pierce*, Mouton & Co. N.V., Publishers, The Hague, 1973.

▶ VLADISLAV NENCHEV, *Definability between temporal relations in dynamic mereology.*
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This paper explores definability dependencies between temporal and spatio-temporal relations in some dynamic mereological systems. These systems are part of a point-free approach to spatial and temporal theories. The approach in question describes space and time in terms of “regions”, which are tangible and/or regular parts of space or time (“periods” or “epochs” may be used for parts of time). The point-free theories forgo standard Euclidean notions like “point” or “line”, arguing that such objects are abstract and do not exist in reality. Space and time are built, instead, on regions, while points and lines are complex constructs of specific sets of regions (see [1] and [2] for recent works in this area).

The current studies compare three types of systems, which are different types of dynamic spatio-temporal structures. The first two types are mereological reducts of dynamic structures from [2]: *Dynamic Mereological Algebras* (DMAs) are algebraic structures that use products of Boolean algebras to track changes in space and time, while *rich Dynamic Mereological Algebras* are a specific kind of DMAs that include special spatio-temporal regions, called “time representatives”. The third type of structures is the relational variants of DMAs from [1] that have much weaker language and conditions on their domains. All of these systems include the following four dynamic relations: *unstable part-of* (a dynamic region is sometimes part of another dynamic region), *stable overlap* (a dynamic region always overlaps with another), *stable underlap* (a pair of regions always do not exhaust the whole space) and *temporal contact* (a pair of regions exist simultaneously at some point).

The results in this paper show that in rich DMAs all of the four relations are equivalent (each of them can define the other three), in general DMAs the first three are equivalent, while the temporal contact is independent, and in relational DMAs all four relations are completely independent from each other.

[1] ——— *Logics for stable and unstable mereological relations*, ***Central European Journal of Mathematics***, vol. 9 (2011), no. 6, pp. 1354–1379.

[2] Dimiter Vakarelov, *Dynamic Mereotopology. III. Whiteheadian Type of Integrated Point-Free Theories of Space and Time. Part II*, ***Algebra and Logic***, vol. 55 (2016), no. 1, pp. 9–23.

▸ DAG NORMANN, SAM SANDERS, *Nonstandard Analysis, computability theory, and metastability.*
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We present the surprising connections between *computability theory* and *Nonstandard Analysis* initiated in [2]. In particular, we investigate the two following topics *and* show that they are intimately related via Tao's notion of *metastability* ([3]).

(T.1) A basic property of *Cantor space* $2^{\mathbb{N}}$ is *Heine-Borel compactness*: For any open cover of $2^{\mathbb{N}}$, there is a *finite* sub-cover. A natural question is: *How hard is it to compute such a finite sub-cover*? We make this precise by analysing the complexity of functionals that given any $g : 2^{\mathbb{N}} \to \mathbb{N}$, output a finite sequence $\langle f_0, \ldots, f_n \rangle$ in $2^{\mathbb{N}}$ such that the neighbourhoods defined from $\overline{f_i}g(f_i)$ for $i \leq n$ form a cover of Cantor space.

(T.2) A basic property of Cantor space in *Nonstandard Analysis* is Abraham Robinson's *nonstandard compactness*, i.e. that every binary sequence is 'infinitely close' to a *standard* binary sequence. We analyse the strength of this nonstandard compactness property of Cantor space, compared to the other axioms of Nonstandard Analysis and usual mathematics.

Our study of (T.1) yields exotic objects in computability theory, while (T.2) leads to surprising results in *Reverse Mathematics*. Nonetheless, the functionals from (T.1) arise naturally and directly from slight variations of Tao's notion of *metastability*. Furthermore, we show that the functionals from (T.1) completely disrupt the elegant 'Big Five picture' of Reverse Mathematics, and also destroy the complex structure of the Reverse Mathematics 'zoo' ([1]).

[1] Damir Dzhafarov, *Reverse Mathematics Zoo*, http://rmzoo.uconn.edu/

[2] Dag Normann and Sam Sanders, *Computability Theory, Nonstandard Analysis, and their connections*, ***Submitted*** arXiv: https://arxiv.org/abs/1702.06556

[3] Terence Tao, *Structure and randomness*, ***American Mathematical Society, Providence, RI***, 2008, pp. xii+298

▸ ITAY NEEMAN AND ZACH NORWOOD, *Happy and mad families.*
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In 2015, Törnquist [4] answered an old question of Mathias [1] by showing that there are no infinite mad families in the Solovay model. Mathias's original paper explores a connection between mad families and the H-Ramsey property for H a happy family, but Törnquist's proof is purely combinatorial and does not exploit this connection. We prove the following theorem: in the Solovay model, every $X \subseteq [\omega]^\omega$ is H-Ramsey for every happy family H that also belongs to the Solovay model. This gives a new proof of Törnquist's theorem.

Törnquist also asked whether the Axiom of Determinacy (AD) implies that there are no infinite mad families. Using a new generic absoluteness result that builds on the absoluteness results of [3], we show how to give a positive answer under AD^+, a well-studied strengthening of AD. (It is open whether AD and AD^+ are equivalent.) In fact, we show that under AD^+ every $X \subseteq [\omega]^\omega$ is H-Ramsey for every happy family H.

[1] A. R. D. Mathias, *Happy families*, ***Annals of Mathematical Logic***, vol. 12 (1997), no. 1, pp. 59–111.

[2] I. Neeman and Z. Norwood, *Happy and MAD families in $L(\mathbb{R})$*, ***submitted***.

[3] I. Neeman and J. Zapletal, *Proper forcing and $L(\mathbb{R})$*, ***Journal of Symbolic Logic***, vol. 66 (2001), no. 2, pp. 801–810.

[4] A. Törnquist, *Definability and almost disjoint families*, ***submitted***.

▸ SERGI OMS, *The notion of paradox*.
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In this paper I want to show that the traditional characterization of the notion of paradox —an apparently valid argument with apparently true premises and an apparently false conclusion— is too narrow; there are paradoxes that do not satisfy it. After discussing and discarding some alternatives, a paradox is found to be an argument that seems valid —in the sense that rejecting its validity would imply giving up some core intuitions about the notion of logical consequence— but such that the commitment to the conclusion that stems from the acceptance of the premises and the validity of the argument should not be there. Something even stronger can be said to be the case: apparently, there is no commitment at all. In the last sections, some consequences and some objections are discussed.

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There is well-known result, that for any natural $m > n + 1$ nontrivial Rogers semilattices from level Σ^0_m are nonisomorphic to Rogers semilattices from level Σ^0_n (Badaev, Goncharov, Sorbi [1] and then improved in Podzorov [2]). It is still an open question, whether it is possible to remove this gap between levels. Here we concentrate our interest in similar properties for analytical hierarchy. In work are proven

Theorem. *For any constructive ordinal α Rogers semilattices from level Σ^0_α are nonisomorphic to nontrivial Rogers semilattices from level Π^1_1*

Theorem. *For any natural $m > n$ Rogers semilattices from level Π^1_m are nonisomorphic to nontrivial Rogers semilattices from level Π^1_n.*

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[1] S.A. Badaev, S.S. Goncharov, A. Sorbi, *Isomorphism types of Rogers semilattices for families from different levels of the arithmetical hierarchy*, ***Algebra Logika***, vol. 45 (2006), no. 6, pp. 637–654.

[2] S.Yu. Podzorov, *Arithmetical D-degrees*, ***Siberian Mathematical Journal***, vol. 49 (2008), no. 6, pp. 1391–1410.

▸ FEDOR PAKHOMOV, *Gödel's second incompleteness theorem from scratch.*
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We introduce a new approach to Gödel's second incompleteness theorem that covers some theories that were not covered by earlier approaches and gives the result that is more close to the informal statement "any formal theory that could formulate its own consistency couldn't prove it". For each first-order theory T we formulate a natural first-order theory $\mathsf{Syn}(\mathsf{T})$ that works with syntactical objects from the formal language of T. We consider the theories T with finite signature that interpret the respective theories $\mathsf{Syn}(\mathsf{T})$. We prove Gödel's second incompleteness theorem for all the theories T from this class: for any provability predicate for T that satisfies Hilbert-Bernays-Löb derivability conditions, T couldn't prove its own consistency with respect to the predicate. Note that unlike more standard approaches, our class of theories contains some theories that aren't able to represent arbitrary computations. In particular, the class contains the complete and decidable elementary theory $\mathsf{Th}(\mathbb{N}, C)$ of natural numbers with Cantor pairing function, $C(n, m) = (n+m)(n+m+1)/2+m$ [CGR00]. We prove Diagonal Lemma for all the theories from the class. Also, we show that existence of a "reasonable" (in certain sense) provability predicate for a consistent theory T implies undecidability of T.

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[CGR00]Patrick Cégielski, Serge Grigorieff, and Denis Richard. La théorie élémentaire de la fonction de couplage de Cantor des entiers naturels est décidable. *Comptes Rendus de l'Académie des Sciences - Series I - Mathematics*, 331(2):107–110, 2000.

▸ FRANCESCO PARENTE, *Keisler's order via Boolean ultrapowers.*
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In this talk, we shall present some applications of the Boolean ultrapower construction [2] to Keisler's order.

Over the last decade, Malliaris and Shelah proved a striking sequence of results in the intersection between model theory and set theory, solved a long-lasting problem [1], and developed surprising connections between classification theory and cardinal characteristics of the continuum. The main motivation of their work is the study of Keisler's order, introduced originally in 1967 as a device to compare the complexity of complete theories by looking at saturated ultrapowers of their models.

Although the definition of Keisler's order makes use of regular ultrafilters on power-set algebras, recently there has been a shift towards building ultrafilters on complete Boolean algebras. In particular, moral ultrafilters have emerged as the main tool to find dividing lines among unstable theories.

Motivated by this new Boolean-algebraic framework, in this talk we shall address the following question: what kind of classification can arise when we compare theories according to the saturation of Boolean ultrapowers of their models?

We shall show that most model-theoretic properties of κ-regular ultrafilters can be generalized smoothly to the context of κ-distributive Boolean algebras. On the other hand, we shall prove the existence of regular ultrafilters on the Cohen algebra $\mathbb{C}_\kappa$ with unexpected model-theoretic features.

[1] Maryanthe Malliaris and Saharon Shelah, *Cofinality spectrum theorems in model theory, set theory, and general topology*, ***Journal of the American Mathematical Society***, vol. 29 (2016), no. 1, pp. 237–297.

[2] Richard Mansfield, *The theory of Boolean ultrapowers*, ***Annals of Mathematical Logic***, vol. 2 (1971), no. 3, pp. 297–323.

▶ FRANCO PARLAMENTO, FLAVIO PREVIALE, *On the Admissibility of the Structural Rules in Kanger's Sequent Calculus with Restricted Equality Rules.*

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Kanger's sequent calculus for first order logic with equality, introduced in the classic [1], is a sequent calculus for classical first order logic with equality, free of structural rules, based on the following equality rules:

$$\frac{\Gamma_1\{v/r\}, s = r, \Gamma\{v/r\} \Rightarrow \Delta\{v/r\}}{\Gamma_1\{v/s\}, s = r, \Gamma\{v/s\} \Rightarrow \Delta\{v/s\}} \; P_3 \qquad \frac{\Gamma_1\{v/r\}, r = s, \Gamma\{v/r\} \Rightarrow \Delta\{v/r\}}{\Gamma_1\{v/s\}, r = s, \Gamma\{v/s\} \Rightarrow \Delta\{v/s\}} \; P_4$$

where $\Gamma_1, \Gamma_2, \Delta$ are sequences of formulas and $\Gamma\{v/t\}$ denotes the result of substituting all the free occurrences of v in Γ by t. [1] restricts the applications of P_3 by the requirement that $rank(r) \leq rank(s)$ and those of P_4 by the requirement that $rank(r) < rank(s)$, and the applications of the γ-rules:

$$\frac{\Gamma_1, F\{x/t\}, \forall x F, \Gamma_2 \Rightarrow \Delta}{\Gamma_1, \forall x F, \Gamma_2 \Rightarrow \Delta} \qquad \frac{\Gamma \Rightarrow \Delta_1, F\{x/t\}, \exists x F \Delta_2}{\Gamma \Rightarrow \Delta_1, \exists x F \Delta_2}$$

by the requirement that the term t be present free in the endsequent or be a fresh variable in case there are no free terms in the endsequent. If such restrictions on the equality and γ-rules are dropped, a syntactic proof of the admissibility of all the structural rules, including the cut rule, over the resulting calculus, as well as over its intuitionistic version, is known from [2]. We address that admissibility issue in case the restriction on the equality rules is maintained, and give a syntactic proof that the unrestricted equality rules are admissible over the restricted ones, from which it follows that cut elimination still holds. The proof is based on the admissibility of the contraction rule for equalities in the restricted calculus, for which a syntactic proof remains to be given. The result is obtained through a strengthening of Orevkov's claim in [4] concerning the existence of nonlentghening derivations, that by itself would fall short of establishing the desired result, since nonlengthening in the specific case ensures only that we have the same restriction $rank(r) \leq rank(s)$ in both P_3 and P_4 (see also [3]).

[1] S. Kanger, *A Simplified Proof Method for Elementary Logic*, *In: P. Braffort, D. Hirshberg (eds)*, *Computer Programming and Formal Systems, pp. 87-94*, North-Holland, Amsterdam (1963)

[2] F. Munini, F.Parlamento, *Admissibility of the Structural Rules in Kanger's Sequent Calculus for First Order Logic with Equality*, Logic Colloquium 2015- Abstract of Contributed Talks, ***The Bulletin of Symbolic Logic*** , vol. 22(2016), no. 3, p.414

[3] F.Parlamento, F.Previale, *The Cut Elimination and Nonlengthening Property for the Sequent Calculus with Equality.*, Logic Colloquium 2016- Contributed Talk ***ArXiv 1705.00693***

[4] V. P. Orevkov, On Nonlengthening Applications of Equality Rules (in Russian) ***Zapiski Nauchnyh Seminarov LOMI***, 16:152-156, 1969
English translation in: A.O. Slisenko (ed) Studies in Constructive Logic*, Seminars in Mathematics: Steklov Math. Inst. 16, Consultants Bureau, NY-London 77-79 (1971)*

▸ MICHAL PELIŠ, PAWEŁ ŁUPKOWSKI, ONDREJ MAJER, MARIUSZ URBAŃSKI, *(Dynamic) epistemic interpretation for erotetic search scenarios.*
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In this paper we take the ideas from Inferential Erotetic Logic (IEL, [2]), however we relay on *epistemic erotetic logic* proposed and discussed in details in [1]. Such an approach allows us to discuss problem-solving and strategic questioning in the context of agents' interaction. We do this by the means of providing an epistemic interpretation of *erotetic search scenarios* (a tool from IEL).

We take S5 epistemic logic supplemented with questions and we introduce central concepts of *askability* and *epistemic erotetic implication* (e-e-implication). The intuitions behind the askability are the following. Asking (publicly) the question $?_i\{\alpha, \beta\}$ the addressee obtains the following information: (i) the agent i does not know whether α or β; (ii) the agent i considers α and β as her epistemic possibilities; (iii) the agent i expects a complete answer leading to α or to β. The notion of askability allows us to say that question Q_1 e-e-implies question Q_2. We can also consider the situation when Q_1 e-e-implies Q_2 *on the basis of* a finite set of declaratives Γ.

Erotetic search scenarios are tree-like structures that form strategies for asking and answering questions. The notion of e-e-implication allows us to grasp the rationale behind queries (i.e., questions on the branching points) of epistemic erotetic search scenarios. Each query appearing in e-e-scenario is e-e-implied by the question that precedes it in the tree (possibly with respect to the set of declarative premises). This requirement guarantees that scenario will lead to the solution of the initial question through auxiliary questions.

The idea of epistemic erotetic search scenarios will be demonstrated on the single-agent version of *public announcement logic.* We will also propose the extension to multi-agent settings where scenarios serve as a questioning strategy in revealing of distributed (implicit) knowledge.

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▸ LUIZ CARLOS PEREIRA, RICARDO OSCAR RODRIGUEZ, *Ecumenism: a new perspective on the relation between logics.*
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Eclecticism is not a position available to an intuitionist mathematician/logician of faith. The classical mathematician/logician may even consider the intuitionist position quite interesting, since constructive proofs, although usually longer, are more informative than indirect classical proofs, since they have an algorithmic nature and satisfy interesting informative properties such as the disjunction property and the property of the existential quantifier. To the intuitionist mathematician/logician however, there seems to be no alternative but to revise and revoke the universal validity of certain classical principles of reasoning; for the intuitionist, mathematics must be constructed exclusively on constructively valid forms of argument. From the point of view of the classical mathematician, the intuitionist proposition, if taken seriously, would imply a mutilation of the mathematical corpus; for the intuitionist it is simply the only correct way of doing mathematics. In 2015 Dag Prawitz (see [2]) proposed the idea of an ecumenical system, a codification where the classical and the intuitionist could coexist in peace. The main idea behind this codification is that the classical and the intuitionist share the constants for conjunction and negation, but each have their own disjunction and implication. Similar ideas were present in Dowek [1] and Krauss [3], but without Prawitz philosophical motivations. The aims of the present paper are: [1] to investigate the proof theory for Prawitz' Ecumenical system, [2] to propose a truth-theoretical semantics for which Prawitz' system is sound and complete, [3] to compare Prawitz system with other ecumenical approaches, and [4] to propose a generalization of the ecumenical idea.

[1] Dowek, Gilles, *On the definitions of the classical connective and quantifiers*, ***Why is this a proof*** (Eward Haeusler, Wagner Sanz and Bruno Lopes, editors), College Books, UK, 2015, pp. 228 - 238.

[2] Prawitz, Dag, *Classical versus intuitionistic logic*, ***Why is this a proof*** (Eward Haeusler, Wagner Sanz and Bruno Lopes, editors), College Books, UK, 2015, pp. 15 - 32.

[3] Peter H. Krauss, *A constructive interpretation of classical mathematics*, ***Mathematische Schriften Kassel, preprint No. 5/92 (1992)***

▸ THOMAS PIECHA, PETER SCHROEDER-HEISTER, *Intuitionistic logic is not complete for standard proof-theoretic semantics.*
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Prawitz conjectured that intuitionistic first-order logic is complete with respect to a notion of proof-theoretic validity [1, 2, 3]. We show that this conjecture is false. The notion of validity obeys the following standard conditions, where S refers to atomic bases (systems of production rules):

1. $\vDash_S A \land B \iff \vDash_S A$ and $\vDash_S B$.
2. $\vDash_S A \lor B \iff \vDash_S A$ or $\vDash_S B$.
3. $\vDash_S A \to B \iff A \vDash_S B$.
4. $\Gamma \vDash A \iff$ For all S: $(\vDash_S \Gamma \Longrightarrow \vDash_S A)$.
5. If $\Gamma \vDash A$ and $\Gamma, A \vDash_S B$, then $\Gamma \vDash_S B$.

Any semantics obeying these conditions satisfies the generalized disjunction property:

> For every S: if $\Gamma \vDash_S A \lor B$, where $\lor$ does not occur positively in Γ, then either $\Gamma \vDash_S A$ or $\Gamma \vDash_S B$.

This implies the validity ($\vDash$) of Harrop's rule $\neg A \to (B \lor C)/(\neg A \to B) \lor (\neg A \to C)$, which is admissible but not derivable in intuitionistic logic.

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[3] Peter Schroeder-Heister, *Validity concepts in proof-theoretic semantics*, ***Synthese***, vol. 148 (2006), pp. 525–571.

► PEDRO PINTO, *A quantitative analysis of a theorem by F.E.Browder guided by the bounded functional interpretation.*
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In [2], Kohlenbach did an analysis of the proof of Browder's theorem (in [1]) via the monotone functional interpretation. I will be following the same outline but guided by the bounded functional interpretation ([3], [4]). Although the bounds obtained are the same, this example provides a first look at how the bounded functional interpretation works in practice.

[1] Browder, Felix E, *Convergence of approximants to fixed points of nonexpansive nonlinear mappings in Banach spaces*, ***Archive for Rational Mechanics and Analysis***, vol. 24 (1967), no. 1, pp. 82–90.

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[3] Ferreira, Fernando and Oliva, Paulo, *Bounded functional interpretation*, ***Annals of Pure and Applied Logic***, vol. 135 (2005), no. 1-3, pp. 73–112.

[4] Ferreira, Fernando, *Injecting uniformities into Peano arithmetic*, ***Annals of Pure and Applied Logic***, vol. 157 (2009), no. 2, pp. 122–129.

▶ PAOLO PISTONE, *Balanced polymorphism and quantifiers in Linear Logic.*
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Linear Logic was discovered in 1987 ([2]) through investigations on the semantics of polymorphism. Its most well-known contributions are: (*i.*) the decomposition $A \Rightarrow B = !A \multimap B$ of implication into a non linear connective, the exponential !, and a linear connective, the multiplicative $\multimap$ (the so-called *pons asinorum* in [2]); (*ii.*) the introduction of proof-nets, a graphical syntax for proofs in which rule permutations become geometrical invariants.

Maybe surprisingly, the connections of Linear Logic with polymorphism haven't received a comparable attention in the literature. While proof-nets for quantifiers have been investigated since [4], the extension of (*i.*) to quantification has not received considerable attention. Yet, a *pons asinorum* for quantifiers would be expectable, as polymorphic quantifiers are usually presented in type theory as products over the type of all propositions.

In this paper we present a decomposition of quantifiers in multiplicative linear logic, by introducing multiplicative quantifiers $(⅋X)A$ and $(\otimes X)A$, corresponding to *balanced polymorphism* ([6, 5, 7]). The latter is a restricted form of polymorphism, in which one demands that the polymorphic variable occurs exactly twice in the sequent, once positively and once negatively. It was investigated in the context of the simply typed λ-calculus, in connection with Milner's notion of *principal typing* (any linear lambda term has a principal type which is balanced [6]).

To investigate balanced polymorphism in the context of proof-nets, we will consider generalized MLL proof-structures ([1]). The resulting proof-nets enjoy cut-elimination and are adequate and sequentializable with respect to sequent calculus. Moreover, standard quantifiers can be defined by means of balanced quantifiers plus exponentials (according to (*i.*)), and the resulting proof-nets turn out to be equivalent to the usual ones with jumps ([4]).

The treatment of quantifiers as special multiplicative connectives suggests to look for a definition of *generalized* MLL^2 *connectives*, where partitions are replaced by *vehicules* in the sense of *Geometry of Interaction* ([3]). In particular, new (possibly non sequentializable) balanced quantifiers might be investigated in such a frame.

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[2] Girard, Jean-Yves, *Linear Logic*, ***Theoretical Computer Science***, vol. 50 (1987), no. 1, pp. 1–102.

[3] ——— *Geometry of Interaction I: Interpretation of System F*, ***Logic Colloquium '88*** (R. Ferro et al., eds), North-Holland, 1989, pp. 221–260.

[4] ——— *Quantifiers in Linear Logic II*, ***Atti del congresso "Nuovi problemi della logica e della filosofia della scienza" 1990*** (Viareggio),

CLUEB, 1991, pp. 79–90.

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▸ SERGEY POTEMKIN, *Expressing natural language semantics in PROLOG.*
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Our purpose is to obtain the sense or the meaning of some text. This goal is quite opposite to the Melchuks approach which goes from the meaning to the text. Obviously, the former is more important for solving most NLP problems.

Lambda-expressions can easily be encoded in Prolog [1].

λ x[boy(x)] = (Prolog) = lbd(x,boy(x))

Consider the sentence Every boy loves some girl.

det(lbd(q, lbd(p, exists(x, (q@x & p@x))))) −− > [some].

det(lbd(q,lbd(p, forall(x,(q@x -¿ p@x))))) −− > [every].

v(lbd(s,lbd(x,s@lbd(y, (loves(x,y)))))) −− > [loves].

English loves takes a GQ object but interprets it as quantified in, with a metalanguage version of loves in the translation that takes an e-type object. This is similar to what Montague did [2].

n(lbd(x,boy(x)))−− > [boy].

n(lbd(x,girl(x)))−− > [girl].

If we ask: ?- s(SSem,[every,boy,loves,some,girl],[]), pp(SSem).

Well obtain the result of the Prolog program executed:

(x11)(boy(x11) =¿ (Ex2)(girl(x2) & loves(x11, x2)))

which, when we change the fonts a bit, becomes

∀ x11(boy(x11) ? ?x2(girl(x2) ⋀ loves(x11, x2)))

Similarly: ?- s(SSem, [some, girl, loves, some, girl],[]), pp(SSem).

Result: (Ex41)(girl(x41) & (Ex5)(girl(x5) & loves(x41, x5)))

or: ∃ x41(girl(x41) ⋀ ?x5(girl(x5) ⋀ loves(x41, x5)))

The syntax could be farcified using X-bar theory [3].

ip(SSem) −− > np(NPSem), ibar(IbarSem), var replace(NPSem, NPSem1), beta(NPSem1@IbarSem, SSem).

ibar(VPSem)−− > i(MvdVbL), vp(VPSem, MvdVbL).

i([])−− > [Aux],isAux(Aux).

i([Verb])−− > [InflVerb], pastInfl(Verb, InflVerb),isVerb(Verb)

Examples in Russian:

?- ip([odin, student, podaril, vse, tsvety]).

Result: (Ex141)(student(x141) & (x15)(tsvety(x15) − > podarit(x141,x15)))

?- ip(['Ivan', zastrelil, odin, buntovshik]).

Result: (Ex20)(buntovshik(x20) & zastrelit(Ivan,x20))

?- ip([odin, student, vyuchil, vse, pravila]).

Result: (Ex441)(student(x441) & (x45)(pravila(x45) − > vyuchit(x441,x45)))

In Russian the word order is mere free, so for the other word order:

?- ip([vse, pravila, vyuchil, odin, student]).

The result is different: (x411)(pravila(x411) − > (Ex42)(student(x42) & vyuchit(x411,x42)))

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Representation and inference for natural language, Publisher, CSLI (Center for the Study of Language and Information) Year, 2005.

[2] Barbara Partee,
Teaching formal semantics, ***Teaching Linguistics: Reflections on Practice*** (Koenraad Kuiper, editors), Equinox Publishing London:, 2011, pp. 40–50.

[3] Andras Kornai and Geoffrey Pullum,
The X-bar theory of phrase structure, ***Language***, vol. 66 (1990), no. 1, pp. 24–50.

▶ VÍT PUNČOCHÁŘ, *Uniform substitution and replacement of equivalents.*
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The goal of my paper is to present a formal semantics that deals with some peculiar phenomena that have been rather neglected in logical literature. In particular, these phenomena concern the surprising fact that on the level of natural language, logical connectives seem to be sensitive to the syntactic structure of the sentences they connect. One consequence of this fact is the failure of two basic principles that are respected by most logical theories: *Uniform Substitution* and *Replacement of Equivalents*. For an illustration, let us consider a counterexample to the second principle. We regard the following two sentences as equivalent in the sense that they are mutually inferable (even though they might differ in pragmatic implicatures):

(1) If A is not the murderer, then B is.
(2) A or B is the murderer.

However, the first of the following two arguments seems to be valid but the second, which is obtained by replacement of equivalents, not:

(1) It is not the case that A or B is the murderer. Therefore, neither A nor B is the murderer.
(2) It is not the case that if A is not the murderer then B is. Therefore, neither A nor B is the murderer.

To see that (2) is not valid, consider the situation in which A is among the suspects but B is not.

In the talk, we will provide a precise formal semantics and a corresponding deductive calculus that deals with these kinds of phenomena. The semantics is a modification of the theory developed originally in [1]. It builds on but goes beyond the work contained in [2].

[1] Christopher Gauker, ***Conditionals in Context***, MIT Press, 2005.

[2] Vít Punčochář, *Semantics of assertibility and deniability*, ***Epistemology, Knowledge and the Impact of Interaction*** (J. Redmond, O. Pombo Martins and Á. Nepomuceno Fernández, editors), Springer, 2016, pp. 343–362.

▸ PAULA QUINON, *Predicates as second-order variables: a possible way towards intensionality in the model-theoretical framework.*
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I discuss explicative power of axiomatic systems understood as implicit definitions. The question whether these systems can be considered as full-blooded definitions goes back to Gergonne (1818 [3]), it appears in various contexts in Russell, Hilbert and Bernays, Carnap, Quine and many others. After Benacerraf (1965 [1]) and "the structuralist turn" in philosophy of mathematics implicit definitions started to play a central role in discussions relating ontology and epistemology of natural numbers. Today, the structural approach to mathematical entities is widely accepted. What remains problematic is whether we shall still account for intensional differences between various isomorphic models. If yes, which conceptual tools should we use.

As an illustration I will recall the idea of using Tennenbaum's theorem (1959 [9]): any enumerable model of Peano Arithmetic, where arithmetical functions are interpreted as computable functions, is isomorphic to the standard model of arithmetic. The mathematical perspective will focus on assessing consequences of this conditional result. The philosophical perspective will search for ways to reconsider model-theoretical framework with the intuition that natural numbers serve to enumerate and to compute. Dean (2014 [2]) claims that there is no reason to favour one model over another. Others claim that the Church-Turing thesis supports the idea that the "recursive" is strictly bound to intuitive understanding of computability, which should be prioritised (Halbach-Horsten 2005 [4], Quinon-Zdanowski 2007 [10]). Most recently discussions on conceptual fixed points show that none analysis of "computability" is possible.

In this paper, I propose to provide an additional insight into the structure of implicit definitions based on the result from Ramsey (1929 [8]). Ramsey proposed formalised treatment of empirical theories: non-logical first-order predicates shall be replaced by second-order variables bounded by existential quantifiers. The intended meaning of theories is encoded in a "dictionary". I translate Ramsey's idea to formal mathematical theories, in particular to the first-order Peano's Arithmetic. I investigate philosophical standpoints that are compatible with this apprehension of formal theories.

[1] Paul Benacerraf, *What Numbers Could Not Be*, ***Philosophical Review***, vol. 74 (1965), no. 1, pp. 47–73.

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[3] Jose Diez Gergonne, *Essai sur la theorie des definitions*, ***Annales***

de mathematique pure et appliquee, vol. 9 (1818-19): pp. 1–35.

[4] Volker Halbach & Leon Horsten, *Computational Structuralism*, ***Philosophia Mathematica***, vol. 13 (2005), no. 2, pp. 174–186.

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[7] Willard Van Orman Quine, *Implicit Definitions Sustained*, ***Journal of Philosophy***, vol. LXI (1964), no. 2, pp. 71–74.

[8] Frank Plumpton Ramsey, *Theories*, ***Foundations of Mathematics*** (R.B. Braithwaite, editors), Routledge and Kegan Paul, 1929.

[9] Stanley Tennenbaum, *Non-Archimedian Models for Arithmetic*, ***Notices of the American Mathematical Society***, vol. 6 (1959), pp. 270.

[10] Paula Qunon & Konrad Zdanowski, *The Standard Model of Arithmetic. The Argument from Tennenbaums Theorem*, ***CiE Proceedings*** 2007

► EDOARDO RIVELLO, *On extending the general recursion theorem to non-wellfounded relations.*
Department of Mathematics, University of Torino, Via Carlo Alberto 10, Italy.
E-mail: `rivello.edoardo@gmail.com`. The principle of definition by recursion on a wellfounded relation [1], can be stated as follows: Let A be any set and let P be the set of all partial functions from A to some set B. Let $G : A \times P \to B$ be any function and let $R \subseteq A \times A$ be any binary relation.

Fact 1 (Montague): If R is wellfounded on A then there exists a unique function $f : A \to B$ such that

$$\forall x \in A\,(f(x) = G(x, f \restriction x^R)), \tag{1}$$

where $x^R = \{y \in A \mid y\,R\,x\}$.

If R is not wellfounded on the entire domain A, an obvious way of extending this method of definition is to identify a proper subset W of A on which R is wellfounded and to apply the principle to this set. The usual choice for W is the *wellfounded part* of R, defined as the set of all R-wellfounded points of A.

In my talk, after examining several different strategies to prove Fact 1, I will present a new approach to extend this method of definition to all kinds of binary relations. We look at subsets X of A on which R is not necessarily wellfounded, yet there exists a unique function $g : X \to B$ which satisfies (1) for all $x \in X$. Lets call such subsets *determined*. Then we can prove

Theorem: There exists a unique subset U of A such that a) U is R-closed, i.e., $\forall x \in U, x^R \subseteq U$; b) U is determined and all R-closed subsets of U are determined; c) U is the largest subset of A satisfying (a) and (b). This theorem ensures, for any relation R, the existence and uniqueness of a function $g : U \to B$ which satisfies (1) on its domain and is defined on a domain U which extends the wellfounded part W of R.

[1] Richard Montague, *Well-founded relations: generalizations of principles of induction and recursion*, ***Bulletin American Mathematical Society***, vol. 61, p. 442.

▸ GEMMA ROBLES, FRANCISCO SALTO, JOSÉ M. BLANCO, *Routley-Meyer semantics for natural implicative expansions of Kleene's strong three-valued matrix.*
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Routley-Meyer semantics, originally introduced for interpreting relevance logic, is a highly malleable semantics capable of modelling families of non-classical logics very different from each other. Let us now understand the notion of a "natural implication" following [2]. Then, there are exactly six natural implicative expansions of Kleene's strong three-valued matrix with 1 as the sole designated value.

The aim of this paper is to endow each one of the logics characterized by these six expansions with a Routley-Meyer type ternary relational semantics. There are well-known logics among those determined by these six expansions. Łukasiewicz three-valued logic Ł3 is an example.

[1] R. Routley, R. K. Meyer, R. K., V. Plumwood, R. T. Brady, ***Relevant Logics and their Rivals***, vol. 1, Atascadero, CA: Ridgeview Publishing Co., 1982.

[2] N. Tomova, *A Lattice of implicative extensions of regular Kleene's logics*, ***Reports on Mathematical Logic***, 47 (2012), pp. 173-182.

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▸ ANDREI RODIN, *Two "Styles" of Axiomatization: Rules versus Axioms. A Modern Perspective..*

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In a Hilbert-style non-logical axiomatic theory the semantics of logical symbols is rigidly fixed, while the interpretation of non-logical symbols usually varies giving rise to different models of the given theory. All non-logical content of such a theory is comprised in its non-logical axioms (e.g. axioms of ZF) while rules, which generate from these axioms new theorems, belong to the logical part of the theory (aka underlying logic).

An alternative approach to axiomatization due to Gentzen amounts to a presentation of formal calculi in the form of systems of rules without axioms. Gentzen did not try to extend his approach to non-logical theories by considering specific non-logical rules as a replacement for non-logical axioms. However the more recent work in Univalent Foundations of Mathematics [2] suggests that the Gentzen-style rule-based approach to formal presentation of theories may have important applications also outside the pure logic.

A reason why one may prefer a rule-based formal representation is that it is more computer-friendly. This, in particular, motivates the recent work on the constructive justification of the Univalence Axiom via the introduction of new operations on types and contexts [1]. However this pragmatic argument does not meet the related epistemological worries. What kind of knowledge may represent a theory having the form of a bare system of rules ? Is such a form of a theory appropriate for representing a knowledge of objective human-independent reality? How exactly truth features in rule-based non-logical theories?

Using HoTT as a motivating example I provide some answers to these questions and show that the Gentzen-style rule-based approach provides a viable alternative to the standard axiomatic approach not only in logic but also in science more generally.

[1] C. Cohen, Th. Coquand, S. Huber, A. Mörtberg, Cubical Type Theory: a constructive interpretation of the univalence axiom, arXiv:1611.02108

[2] The Univalent Foundations Program, Homotopy Type Theory, IAS, 2013

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This talk is an introduction to the problems concerning certain relevant logics and relation algebras.

[1] has shown how to obtain sound and complete semantics for RM, *i. e.* the implicational fragment $R \rightarrow$ of R with the axiom mingle $A \rightarrow (A \rightarrow A)$. He also demonstrated how one can obtain a sound but not complete interpretation of R by replacing sets with commuting dense binary relations. But RM does not have a variable-sharing property (VSP) which R has. A modal restriction of RM in case of which the VSP is preserved was given in [2] together with the argument that from an intuitive semantical point of view, this modal restriction of RM is an alternative to Anderson and Belnap's logic of entailment E ([3]).

[4] has studied a version of positive minimal relevant logic B and [5] demonstrated that B is fully interpretable in the variety of weakly-associative relation algebras which are not representable. [6] went on to show that if representability is dropped, one can obtain a complete interpretation of certain relevant logics in the language of relation algebras.

We will examine the mentioned results in order to clarify the connection between certain relation algebras and relevant logics like R and RM and see (i.) whether such connection entails full interpretability of relevant logics in terms of relation algebras and (ii.) what are the consequences of achieving this interpretability for representability and completeness.

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editors), vol. 25, EasyChair, 2014, pp. 125–128.

▸ DENIS I. SAVELIEV, *Systems of propositions referring to each other: a model-theoretic view.*
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We investigate arbitrary sets of propositions such that some of them state that some of them (possibly, themselves) are wrong, and criterions of paradoxicality or non-paradoxicality of such systems. For this, we propose a finitely axiomatized first-order theory with one unary and one binary predicates, T and U. An heuristic meaning of the theory is as follows: variables mean propositions, Tx means that x is true, Uxy means that x states that y is wrong, and the axioms express natural relationships of propositions and their truth values. A model (X, U) is called non-paradoxical iff it can be enriched to some model (X, T, U) of this theory, and paradoxical otherwise. E.g. a model corresponding to the Liar paradox consists of one reflexive point, a model for the Yablo paradox is isomorphic to natural numbers with their usual ordering, and both these models are paradoxical.

We show that the theory belongs to the class Π^0_2 but not Σ^0_2. We propose a natural classification of models of the theory based on a concept of a collapse of models. Further, we show that the theory of non-paradoxical models, and hence, the theory of paradoxical models, belongs to the class Δ^1_1 but is not elementary. We consider also various special classes of models and establish their paradoxicality or non-paradoxicality. In particular, we show that models with reflexive relations, as well as models with transitive relations without maximal elements, are paradoxical; this general observation includes the instances of Liar and Yablo. On the other hand, models with well-founded relations, and more generally, models with relations that are winning in sense of a certain membership game are non-paradoxical. Finally, we propose a natural classification of non-paradoxical models based on the above-mentioned classification of models of our theory.
This work was supported by grant 16-11-10252 of the Russian Science Foundation.

▸ DENIS I. SAVELIEV, ILYA B. SHAPIROVSKY, *Defining modal logics of relations between models*.
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Let $\mathcal{C}$ be a class of models in a fixed signature and $\mathcal{R}$ a relation on $\mathcal{C}$; e.g. $\mathfrak{A}\,\mathcal{R}\,\mathfrak{B}$ may mean "$\mathfrak{B}$ is a submodel of $\mathfrak{A}$", "$\mathfrak{B}$ is a homomorphic image of $\mathfrak{A}$", "$\mathfrak{B}$ is an extension (for models of arithmetic or set theory: an end-extension, a generic extension) of $\mathfrak{A}$", "$\mathfrak{B}$ is an existential closure of $\mathfrak{A}$", etc. We interpret modal formulas by sentences of a model-theoretic language $\mathcal{L}$ such that $\Diamond\varphi$ is true at a model $\mathfrak{A}$ ("φ is possible at $\mathfrak{A}$") iff φ is true at some model $\mathfrak{B}$ with $\mathfrak{A}\,\mathcal{R}\,\mathfrak{B}$. A few recent instances of a similar approach deal with models of PA ([1], [2]) and ZF ([3], [4], [5]). In these cases, the first-order languages are powerful enough to put the interpretation inside them. This is not true for arbitrary models: $\Diamond\varphi$ may be not first-order expressible. However, once $\mathcal{L}$ is chosen strong enough to overcome this, truth and validity of modal formulas can be defined in terms of general frame semantics, and the modal theory of $(\mathcal{C},\mathcal{R})$ defined as the set of all valid modal formulas turns out to be a normal modal logic. This provides a general framework for defining and studying modal logics of model-theoretic relations.

We apply this approach to the case where $\mathfrak{A}\,\mathcal{R}\,\mathfrak{B}$ means "$\mathfrak{B}$ is a submodel of $\mathfrak{A}$". In general, even infinitary first-order languages are not powerful enough to express the satisfiability in submodels. However, for any signature with $< \kappa$ functional symbols (and arbitrarily many predicate symbols), the monadic fragment of the second-order language $\mathcal{L}^2_{\kappa,\omega}$ expresses the satisfiability of its own sentences in submodels. We prove that whenever the signature contains at least one functional symbol of arity ≥ 2 and $\mathcal{C}$ is the class of all models in this signature, then the modal theory of $(\mathcal{C},\mathcal{R})$ is S4 if the signature does not have constant symbols, and S4.1.2 otherwise.

The work is supported by grant 16-11-10252 of the Russian Science Foundation. A preliminary report can be found in [6].

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▸ GIORGIO SBARDOLINI, *The semanticist's guide to ramification.*
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I outline an account of intensional paradoxes in Ramified Higher Order Logic (RHOL). These paradoxes are intensional counterparts of the paradoxes derived by a syntactic truth predicate. One reason why the intensional paradoxes are especially interesting is that they arise from reasoning about domains of propositions. Thus, they are especially relevant for our understanding of the foundations of Semantic Theory.

In his work on intensional paradoxes, Kaplan (1995) sketches a version of RHOL. Ramification is one way of articulating a consistent metalanguage for Semantic Theory in which the rules for the logical operators are classical. Thus the resulting theory is compatible with standard Montague Grammar.

There are several different ways of ramifying, and there are different interpretations of the metaphysical underpinnings of ramification. Here I discuss a simple and user-friendly version of RHOL (in fact, so simple that it could be taught in undergraduate textbooks) in which predicative restrictions on the level of formulas are introduced only by generalization over propositional domains. In effect, on my favorite version, a Ramified Logic is one in which the inference from $\forall pSp$ to Sq sometimes fails. I argue that this version of RHOL is preferable to Kaplan's form the standpoint of the foundations of Semantics. A crucial premise for this argument is that on the former version, but not on Kaplan's, ramification allows enough impredicativity over the domain of propositions and attitude operators for the definition of a Stalnakerian Common Ground for arbitrary classes of propositions.

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► DAVID SCHRITTESSER, *Compactness of eventually different families*.
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We show that there is an effectively closed maximal eventually different family of functions in spaces of the form $\prod_n F(n)$ for $F\colon \mathbb{N} \to \mathbb{N} \cup \{\mathbb{N}\}$ and give an exact criterion for when there exists an effectively compact such family. The proof generalizes and simplifies the argument due to Horowitz and Shelah that there is a Borel maximal eventually different family.

▸ IBRAHIM SENTURK, TAHSIN ONER, *An Analysis of Peterson's Intermediate Syllogisms with Caroll's Diagrammatic Method.*
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In this work, our purpose is to analyze the Peterson's Intermediate Syllogisms by means of Caroll's diagrammatic method. For this aim, we firstly construct a formal system PISLCD (Peterson's Intermediate Syllogistic Logic with Caroll Diagrams), which gives us a formal approach to logical reasoning with diagrams, for representations of the fundamental Intermediate propositions and show that they are closed under the intermediate syllogistic criterion of inference which is the deletion of middle term. Therefore, it is implemented to let the formalism comprise synchronically bilateral and trilateral diagrammatical appearance and a naive algorithmic nature. And also, there is no specific knowledge or exclusive ability is needed in order to understand it and use it.

In other respects, we examine algebraic properties of Peterson's intermediate syllogisms in PISLCD. To this end, we explain quantitative relation between two terms by means of bilateral diagrams. Thereupon, we enter the data, which are taken from bilateral diagrams, on the trilateral diagram. With the help of elemination method, we obtain a conclusion which is transformed from trilateral to bilateral diagram. A Peterson's intermediate syllogistic system consists of 4000 syllogistic moods. 105 of them are valid forms.

Finally, we show that syllogism is valid if and only if it is provable in PISLCD. This means that PISLCD is sound and complete.

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Kyiv-Ukraine), 2015, pp. 14–21.

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▸ MICHAEL SHENEFELT AND HEIDI WHITE,

Why does formal deductive logic start with the classical Greeks.

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Many ancient peoples studied logic in the broad sense of argumentation, but the study of formal deductive validity starts with the classical Greeks. For some reason, the only person to invent a study of validity in virtue of form was Aristotle, and all other logicians have had his example to follow. Why?

We contend that formal logic emerged as a result of two factors–one geographical, the other political.

First, unlike other regions of the ancient world, classical Greece had a geography that favored small states, dominated by urban crowds. The ease of navigating the Mediterranean caused the commercial classes to grow, and the small size of these states meant that these same commercial crowds dominated the politics of the classical age. As a result, political questions were settled, not by kings or small groups of nobles, but in mass meetings like the Athenian Assembly. The mechanics of these meetings put special emphasis on public argumentation.

Second, these same crowds, when called to make political decisions, often behaved irrationally. Such crowds had dominated the Athenian Assembly, but when Athens lost its war against Sparta, and then followed with the execution of Socrates, a reaction among intellectuals led to the development of formal logic. Philosophers focused increasingly on the difference between rational argumentation and irrational, and this theme, developed by Plato but later expanded by Aristotle, culminated in the first known system of formal logic.

We attribute the Greek relish for logical demonstration, even in mathematics, to an argumentative political environment, and we draw our argument from our book *If A, Then B: How the World Discovered Logic* (Columbia University Press).

▸ ANDREI SIPOŞ, *Proof mining in convex optimization.*
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Proof mining is a research program introduced by U. Kohlenbach in the 1990s ([2] is a comprehensive reference, while [3] is a survey of recent results), which aims to obtain explicit quantitative information (witnesses and bounds) from proofs of an apparently ineffective nature. This offshoot of interpretative proof theory has successfully led so far to obtaining some previously unknown effective bounds, primarily in nonlinear analysis and ergodic theory. A large number of these are guaranteed to exist by a series of logical metatheorems which cover general classes of bounded or unbounded metric structures.

For the first time, this paradigm is applied to the field of convex optimization (for an introduction, see [1]). We focus our efforts on one of its central results, the proximal point algorithm. This algorithm, or more properly said this class of algorithms, consists, roughly, of an iterative procedure that converges (weakly or strongly) to a fixed point of a mapping, a zero of a maximally monotone operator or a minimizer of a convex function. Similarly to other cases previously considered in nonlinear analysis, we may obtain rates of metastability or rates of asymptotic regularity. What is interesting here, however, is that for a relevant subclass of inputs to the algorithm – "uniform" ones, like uniformly convex functions or uniformly monotone operators – we may obtain an effective rate of convergence. The notion of convergence, being represented by a Π_3-sentence, has been usually excluded from the prospect of being quantitatively tractable, unless its proof exhibits a significant isolation of the use of reductio ad absurdum (see [4, 5]). Here, however, a peculiarity of the input, namely its uniformity, translates into a logical form that makes possible this sort of extraction.

These results are joint work with Laurenţiu Leuştean and Adriana Nicolae.

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[3] U. Kohlenbach, *Recent progress in proof mining in nonlinear analysis*, to appear in forthcoming special issue of ***IFCoLog Journal of Logic and its Applications*** with invited articles by recipients of a Gödel Centenary Research Prize Fellowship, 2016.

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Annals of Pure and Applied Logic, vol. 165 (2014), pp. 1484–1500.

[5] A. Sipoş, *Effective results on a fixed point algorithm for families of nonlinear mappings*, ***Annals of Pure and Applied Logic***, vol. 168 (2017), pp. 112–128.

▸ ALEJANDRO SOLARES-ROJAS AND LUIS ESTRADA-GONZÁLEZ, *How could a logician help solving the* $P \stackrel{?}{=} NP$ *problem?*.
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As Terence Tao has recalled several times, mathematics can benefit not only from correct proofs, or proofs that require some changes to be correct, but also from outlines of strategies for a proof, whether for opening lines of research or closing them definitely. Here, we discuss how a certain kind of logician could argue for P = NP following a translation between logics approach. As P = NP amounts to FOL(LFPO) = SOL, one could argue for the latter by providing a suitable translation between those logics. Though we do not provide any such a translation, we show that such an approach regarding those logics is not *a priori* ruled out. Thus, the broad strategy is:

1. Follow the identities provided by descriptive complexity theory (see Immerman 1998).
2. Compare the expressive powers of FOL(LFPO) and SOL via logical translations (see Manzano 1996).
3. Give reassurance of three kinds: a) Conceptual: the corresponding translations do not distort the studied phenomena. b) Mathematical: the translations do not imply any obvious contradiction with well-established mathematical results. c) Philosophical: the translations do not imply any gratuitous counterintuitive claim regarding logic, mathematics or human nature (cf. Aaronson 2016).

[1] S. Aaronson, $P \stackrel{?}{=} NP$, ***Open Problems in Mathematics*** (J. F. Nash, Jr. and M. Th. Rassias, editors), Springer International Publishing Switzerland, 2016, pp. 1–121.

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▸ ALEXANDRA SOSKOVA, *Structural properties of the cototal enumeration degrees.*

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This is joint work with Uri Andrews, Hristo Ganchev, Rutger Kuyper, Steffen Lempp, Joseph Miller and Mariya Soskova. The talk will be an overview on the structural properties of the cototal enumeration degrees which form a proper substructure of the enumeration degrees. The cototal enumeration degrees properly extend the substructure of the total enumeration degrees. The skip is a monotone operator on enumeration degrees.

We study cototality, using the skip operator and give some examples of classes of enumeration degrees that either guarantee or prohibit cototality. The skip has many of the nice properties of the Turing jump, but not every e-degree is reducible to its skip. The e-degrees reducible to their skip are exactly the cototal degrees. The cototal enumeration degrees are characterized [1] as the enumeration degrees of complements of maximal independent sets for infinite computable graphs on the natural numbers. The image of the continuous degrees, introduced by Joseph Miller [5], is contained in the cototal enumeration degrees [1]. Further characterizations are given by Ethan McCarthy [4], Takayuki Kihara, Arno Pauly [2] and Takayuki Kihara by private conversation.

Recently Joseph Miller and Mariya Soskova [6] prove that the cototal enumeration degrees form a dense substructure of the enumeration degrees. Moreover they show that these are exactly the enumeration degrees which contain sets with good approximations in the sense of Alistair Lachlan and Richard Shore [3].

[1] Uri Andrews, Hristo Ganchev, Rutger Kuyper, Steffen Lempp, Joseph Miller, Alexandra Soskova and Mariya Soskova, *On cototality and the skip operator in the enumeration degrees*, submitted.

[2] Takayuki Kihara and Arno Pauly, *Point degree spectra of represented spaces*, submitted.

[3] Alistair Lachlan and Richard Shore, *The n-rea enumeration degrees are dense*, ***Archive for Mathematical Logic***, vol. 31 (1992), no. 4, pp. 277–285.

[4] Ethan McCarthy, *Cototal enumeration degrees and the Turing degree spectra of minimal subshifts*, to appear in the ***Proceedings of the American Mathematical Society***.

[5] Joseph Miller, *Degrees of unsolvability of continuous functions*, ***Journal of Symbolic Logic***, vol. 69 (2004), no. 2, pp. 555–584.

[6] Joseph Miller and Mariya Soskova, *Density of the cototal enumeration degrees*, submitted.

▶ LUCA SPADA, *Łukasiewicz logic, with coefficients.*
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This talk is based on joint work with A. Di Nola, G. Lenzi, and V. Marra.

The study of the algebraic semantics of Łukasiewicz logic, also known as MV-algebras, has shown deep connections with piece-wise linear geometry: finite theories correspond to rational polyhedra and formulas correspond to piece-wise linear functions with *integer coefficients* [2, 3, 4]. The Diophantine restriction on the coefficients gives rise to complex and interesting phenomena. This talk is about an extension of Łukasiewicz logic by scalars taking values in the unit interval of any ring R such that $\mathbb{Z} \subseteq R \subseteq \mathbb{R}$. The main results are a completeness theorem in the style of C. C. Chang [1] and a characterisation in the style of R. McNaughton of the formulas in this logic. Together, these results leads to a geometric interpretation of this logic similar to the aforementioned one, but where the coefficients are bound to take values in R, rather than in $\mathbb{Z}$.

[1] C. C. Chang, *A new proof of the completeness of the Łukasiewicz axioms*, ***Transaction of the American Mathematical Society***, vol. 93 (1959), pp. 74–80.

[2] V. Marra and L. Spada, *Duality, projectivity, and unification in Łukasiewicz logic and MV-algebras*, ***Annals of Pure and Applied Logic***, vol. 164 (2013), no. 3, pp. 192–210.

[3] R. McNaughton, *A theorem about infinite-valued sentential logic*, ***Journal of Symbolic Logic***, vol. 16 (1951) pp. 1–13.

[4] D. Mundici, ***Advanced Łukasiewicz Calculus and MV-algebras***, Trends in Logic — Studia Logica Library. Springer, 2011.

► WILLIAM STAFFORD, *Genus of proofs as a measure of complexity.*
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Carbone (2009,2010) has proposed the genus of the logical flow graph of a proof as a new measure of its complexity. This proposal is interesting as it measures how interconnected part of the proof are, unlike traditional measures which give some measure of the size of the proof (Buss, 1998, p.13). This makes it implausible that this measure could be used to say whether or not a proof is feasible, a traditional goal of such complexity measures. Rather, Carbone (2009, p.139) claims that her proposal may be a better measure of the difficulty of a proof than the more common measures of number of steps or symbols used. This paper intends to assess Carbone's claim. In particular it will assess whether the method she proposes should be preferred to the more traditional measures. For example, whether Carbone's method is sensitive to whether or not a symbol is taken as primitive, or if it offers a way of distinguishing pure from unpure proofs (Arana (2009) identifies these as important roles for a measure of complexity of proofs).

[1] ARANA, ANDREW, *On Formally Measuring and Eliminating Extraneous Notions of Proofs*, ***Philosophia Mathematica***, vol. 17 (2009), no. 2, pp. 189–207.

[2] BUSS, SAMUEL, *Introduction to Proof Theory*, ***Handbook of Proof Theory*** (Samuel Buss, editor), Elsevier Science, Amsterdam, 1998, pp. 1–78.

[3] CARBONE, ALESSANDRA, *Logical Structures and Genus of Proofs*, ***Annals of Pure and Applied Logic***, vol. 161 (2009), no. 2, pp. 139–149.

[4] ——— *A New Mapping between Combinatorial Proofs and Sequent Calculus Proofs Read Out from Logical Flow Graphs*, ***Information and Computation***, vol. 208 (2010), no. 5, pp. 500–509.

▸ ŠÁRKA STEJSKALOVÁ, *The tree property at $\aleph_{\omega+2}$ with a finite gap.*
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Starting with modest large cardinal assumptions (a hypermeasurable cardinal of a sufficient degree) we construct a model where $\aleph_\omega$ is a strong limit cardinal, the tree property holds at $\aleph_{\omega+2}$, and $2^{\aleph_\omega} = \aleph_{\omega+n}$ for any fixed $2 \leq n < \omega$. The proof uses a variant of the Mitchell forcing and is based on a product-style analysis reminiscent of the original construction in [1]. The results are joint with Sy D. Friedman and R. Honzik.

[1] J. Cummings, M. Foreman, *The tree property*, ***Advances in Mathematics***, vol. 133 (1998), no. 1, pp. 1–32.

▶ VLADIMIR STEPANOV, *Revealing the 4D vector space within disquotational truth theory for self-reference statements.*
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In [2] it is described the dynamic model for the semantics of self-referential statements for $\leftrightarrow, \neg$ language. In this model, the truth table positive estimates for connection of biconditional ($\leftrightarrow$) represents the Cayley table for the Klein four group:

$\leftrightarrow$	**T**	**V**	**A**	**K**
T	**T**	**V**	**A**	**K**
V	**V**	**T**	**K**	**A**
A	**A**	**K**	**T**	**V**
K	**K**	**A**	**V**	**T**

Here **T**=True, **V**=TruthTeller, **A**=Liar, **K**=(**V**$\leftrightarrow$**A**). $\mathbf{V^2} = \mathbf{A^2} = \mathbf{K^2} = \mathbf{VAK} = \mathbf{T}$. Elements of Klein group remind properties of vector product. Example: (**V**$\leftrightarrow$**A**)=**K**, etc. It allows to formulate the following hypothesis:

The Hypercomplex Hypothesis: We postulate that truth space of self-reference statements is a hypercomplex structure, so that the units { **V**, **A**, **K** } represent dimensions of truth space of properly self-reference statements, while the **T** represents a classical statements.

This property we try to use for recording estimates of logical formulas in the form of a hypercomplex numbers: $\mathbb{T} = a_0\mathbf{T} + a_1\mathbf{V} + a_2\mathbf{A} + a_3\mathbf{K}$. Here $a_0 \div a_3$ take the values 1, $\sim$, 0, which means that the component may be positive or negative occurrence, or may not have it all. Graphically as vector on 4D vector space, (like quaternions). As the multiplication table for components of hypercomplex numbers the Cayley table for the Klein four group is used. The logical matrix of such logic is 8-valued fragment of the 4 direct product of classical matrix M_2^c (for $\leftrightarrow, \neg$) on itself:

$$M_{16}^c = (M_2^c)^4 =< \{\mathbf{T}, \mathbf{A}, \mathbf{V}, \mathbf{K}, \neg\mathbf{K}, \neg\mathbf{V}, \neg\mathbf{A}, \neg\mathbf{T}\}, \neg, \leftrightarrow, \{\mathbf{T}\} >$$

Calculus: We formalize the specified matrix as the partial systems of propositional calculus based on equivalence and negation by [Church, 1956] of P^{EN}, or $P^{\leftrightarrow\neg}$:
1) $(p \leftrightarrow q) \leftrightarrow (q \leftrightarrow p)$; 2) $(p \leftrightarrow (q \leftrightarrow r)) \leftrightarrow ((p \leftrightarrow q) \leftrightarrow r)$; 3) $(\neg p \leftrightarrow \neg q) \leftrightarrow (p \leftrightarrow q)$.
The rules of inference being substitution and the rule: from $p \leftrightarrow q$ and p to infer q.

Lemma: The sets of tautologies (T) for M_2^c and M_{16}^c coincide [Jaskovski, [1], 1936].

[1] Jaskovski, S., *Investigations into the system of intuitionist logic.*, ***Studia logica***, vol. 34(1975), no.2, pp. 117-120 (original 1936) .

[2] STEPANOV, V., *Truth theory for logic of self-reference statements as a quaternion structure.*, ***The Bulletin of Symbolic Logic***, vol. 21(2015), no.1, pp. 92-93.

▸ DARIUSZ SUROWIK, *Intuitionistic tense logic. Some remarks.*
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In the talk we would like to consider some system of intuitionistic tense logic. We will propose an axiomatization and Kripke-style semantics for this system. The crucial difference between Kripkes models for intuitionistic tense logic and Kripke models for tense logic constructed over classical propositional logic is in the fact that in the case of tense logic constructed over classical propositional logic the relation R is used only to interpret tense operators; for intuitionistic logic, this relation is used not only to interpret tense operators but also to interpret intuitionistic connectives: negation and implication. We will show the basic properties and compare it to other intuitionistic tense logic systems.

▸ DOROTTYA SZIRÁKI, *Open colorings on generalized Baire spaces.*
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We study the uncountable version of a natural variant of the Open Coloring Axiom. More concretely, suppose that κ is an uncountable regular cardinal and X is a subset of the generalized Baire space ${}^{\kappa}\kappa$ (the space of functions $\kappa \to \kappa$ equipped with the bounded topology). Then $\mathrm{OCA}^*_\kappa(X)$ denotes the following statement: for every partition $[X]^2 = R_0 \cup R_1$ such that R_0 is an open subset of $[X]^2$, either X is a union of κ many R_1-homogeneous sets, or there exists a κ-perfect R_0-homogeneous set. We show that after Lévy-collapsing an inaccessible $\lambda > \kappa$ to κ^+, $\mathrm{OCA}^*_\kappa(X)$ holds for all κ-analytic subsets X of ${}^{\kappa}\kappa$. Furthermore, the Silver dichotomy for $\Sigma^0_2(\kappa)$-equivalence relations on κ-analytic subsets also holds in this model. Thus, both of the above statements are equiconsistent with the existence of an inaccessible $\lambda > \kappa$. We also examine games characterizing the above partition property.

► YUTA TAKAHASHI, *A Proof-Theoretic Semantics for Disjunction.*
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Okada and Takemura ([1]) introduced phase semantics for λ-terms of Laird's dual affine/intuitionistic λ-calculus, whose types are composed from intuitionistic implication $\to$, linear implication $\multimap$ and linear additive product $\&$. The validity in this semantics has several key features of the validity in proof-theoretic semantics (PTS), which was introduced by Prawitz ([2]) and analyzed by Schroeder-Heister ([4]), so one can provide Okada-Takemura's semantics with a PTS-style foundation. This poses the following question: Can one supply Okada-Takemura's semantics with an interpretation of disjunction, keeping the connection to PTS?

First, we introduce a Okada-Takemura-style semantics for the term-calculus $\mathsf{M}_{\to\wedge\vee}$ of minimal propositional logic with the connectives $\to, \wedge$ and $\vee$. Our interpretation of disjunction $\vee$ is inspired by Sandqvist's ([3]) and keeps the connection to PTS. Next, we prove the completeness of $\mathsf{M}_{\to\wedge\vee}$ in the following sense: Every valid term in our semantics is typable. Finally, we note that strong normalization of $\mathsf{M}_{\to\wedge\vee}$ follows from our proof for its completeness.

This is a joint work with Ryo Takemura. The author is supported by KAKENHI (Grant-in-Aid for JSPS Fellows) 16J04925.

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▶ MANUEL TAPIA-NAVARRO AND LUIS ESTRADA-GONZÁLEZ, *When Curry met Abel.*
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Curry's paradox represents a problem for uniform approaches to self-referential paradoxes, as seemingly no negation is involved in it and triviality is reached without the explosion principle, unlike most of the other paradoxes. In particular, purely paraconsistent approaches will not serve to block or solve the paradox. Using some ideas from abstract algebra and Abelian logic, in this paper we argue that the strategy of blocking Curry's paradox by rejecting Detachment can be seen as a generalization of the rejection of the explosion principle, and thus of the paraconsistent strategy. This would imply that a uniform approach to all the self-referential paradoxes, at least those where object-language connectives are involved, is possible.

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▸ HSING-CHIEN TSAI, *On the Decidability of Mereological Theories with Local Complementation.*
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The signature of the formal language of mereology has only one binary predicate P whose intended meaning is 'being a part of'. In the literature, quite a few mereological axioms have been formulated and mereological theories can be generated by using those axioms. The so-called axiom of local complementation, which has been formulated by the present writer recently, says that if x is not the greatest member, then for any proper part y of x, there is another proper part z of x such that y does not overlap z and x is composed of y and z. It has been shown that any first-order mereological theory generated by using the traditional axioms must be undecidable if that theory has atomic models but cannot prove the axiom of local complementation. On the other hand, some first-order mereological theories each of which has the axiom of local complementation have been proven to be decidable. This talk will look into the decidability issue of mereological theories with local complementation in a more systematic way. More precisely, we will try to extend each first-order mereological theory known to be undecidable by adding the axiom of local complementation and see whether such an extension is decidable or not.

Keywords: AMS classification 03B25, mereology, complementation, parthood, partial ordering, decidability, undecidability

▶ MATTHIAS UNTERHUBER, *Negative properties in first-degree entailment with constructible negation and an extensional semantics.*
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Classical logic assumes for arbitrary properties F and individuals c that c has F, exactly if c does not have the negative property non-F. Based on the definition of truth and falsehood in classical logic, this implies that any characterization in terms of positive properties can be expressed in terms of negative properties, and vice versa. There is, however, ample evidence that a characterization in terms of positive in contrast to negative properties matters. Positive properties are often more homogenous (e.g., 'x is a bird' as opposed to 'x is not a bird') and are argued to be privileged from a metaphysical perspective [1].

In non-classical logics a number of semantics have been developed that allow for the differential treatment of positive and negative properties. This paper uses such a semantics and provides a soundness and completeness proof with respect to an extension of first-order Hilbert axiomatization of first-degree entailment. The axiomatization is paraconsistent and extends previous accounts of first degree entailments, based on constructible negation and an extensional four-valued semantics, by allowing for Boolean combinations of entailments. In contrast to [2], both modus ponens and modus tollens inferences with entailments are characterized by valid rules rather than rules which are only admissible. In the semantics, an entailment $A > B$ true iff (a) given A is true, so is B and (b) given B is false, so is A. In contrast, semantic consequence is defined to be only truth preserving.

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▸ BENNO VAN DEN BERG, *Models of set theory in path categories.*
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A classical result by Peter Aczel from 1978 [1] shows how one can interpret the constructive set theory **CZF** in Martin-Löf's constructive type theory, by regarding sets as well-founded trees modulo bisimulation. Moerdijk and Palmgren [4] showed that the same sets-as-trees idea can be used to build models of **CZF** in suitable "predicative toposes". We revisit the work by Aczel, Moerdijk and Palmgren in the light of recent developments in homotopy type theory. The claim is that the sets-as-trees interpretation never uses any definitional equalities and up-to-homotopy versions of the various type constructors suffice to interpret **CZF**. The main challenge is to avoid subtle mistakes involving universes and our main categorical tools are the notion of a path category and the theory of fibred categories. (This is joint work with Ieke Moerdijk and based on the preprints [2, 3].)

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▸ ALEXEY VLADIMIROV,
On effectivity properties of intuitionistic set theory with priciple of double complement of sets and some additional principles.
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Intuitionistic Zermelo–Fraenkel set theory with Collection, $ZFI2C$, is a two-sorted variant of a standard reference theory that relates to set-theoretic explicit mathematics as usual ZF relates to classical set theory.

The paper is concerned with some effectivity properties of $ZFI2C$ plus an additional intuitionistic principles, such that priciple of double complement of sets (DCS), M,UP, etc.

Specifically, let T be $ZFI2C$ or an extension of the theory $ZFI2C$ by addition of each combinations of principles DCS, M, ECT, UP, UZ.

In the paper we prove that the theory T has the following properties:

1. Disjunctive property (DP): if $T \vdash \varphi \vee \psi$, then $T \vdash \varphi$ or $T \vdash \psi$

2. Numerical existence property (EP_ω): If $T \vdash \exists a \varphi(a)$ then there is a number n, such that $T \vdash \varphi(n)$.

3. Markov rule (MR): if $T \vdash \forall a(\varphi(a) \vee \neg\varphi(a))$ and $T \vdash \neg\neg\exists a\varphi(a)$, then $T \vdash \exists a\varphi(a)$.

4. Church rule (CR): if $T \vdash \forall a \exists b \varphi(a; b)$ then there is a natural number such that $T \vdash \forall a \varphi(a; \{e\}(a))$.

5. Uniformization rule UR: if $T \vdash \forall x \exists a \varphi(x; a)$ then $T \vdash \exists a \forall x \varphi(x; a)$.

In each of these rules each formula can contain only set parameters, but no number parameters.

For each of these rules the proof of conclusion can be built effectively by proofs of antecedents.

To obtain these results we use some formalized recursive realizability.

Finally, we remark that DP for $ZFI2C+DCS+M$ together with classical results of Gödel and Cohen implyies that $ZFI2C+DCS+M$ does not prove $CH \vee \neg CH$, where CH is the Continuum Hypothesis.

Keywords: Intuitionistic Zermelo–Fraenkel theory, relative consistency, recursive realizability, disjunction property, numerical existence property.

▸ ANTONIO MONTALBAN, JAMES WALSH, *Canonical aspects of reflection principles.*

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It is a well known empirical phenomenon that natural axiomatic theories are well-ordered by their consistency strength. One expression of this phenomenon comes from ordinal analysis, a research program whereby recursive ordinals are assigned to theories as a measurement of their consistency strength. One method for calculating the proof-theoretic ordinal of a theory T involves demonstrating that T can be approximated over a weak base theory by reflection principles, such as consistency statements and their generalizations [1, 2]. Why are natural theories amenable to such analysis? Fixing a base theory T that interprets elementary arithmetic, we study recursive monotonic functions on the Lindenbaum algebra of T. In this talk we discuss some results that demonstrate that consistency and other reflection principles are canonical among such functions. We also discuss how these results address our motivating questions.

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▸ WEI WANG, *On the computability of perfect subsets of sets with positive measure.*
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It is well-known that every set of reals with positive measure contains a perfect subset. In a joint project of Chong, Li, Yang and Wei Wang, we study the computability of such perfect subsets. We show that every effectively closed set C with positive measure contains a low perfect subset. Moreover, the Turing degrees of perfect subsets of C contain all degrees above the halting problem. We also prove that every set with positive measure contains a perfect subset not computing any given non-computable set.

▸ BARTOSZ WCISŁO, *Remarks on satisfaction classes and recursive saturation.*

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Our talk concerns satisfaction classes in models of Peano Arithmetic. A *full satisfaction class* in a model M of PA is a subset $S \subset M$ such that the expanded structure (M, S) satisfies a certain version of Tarski's compositional clauses for the satisfaction predicate for (the codes of) arithmetical formulae. It is not at all trivial for a model of PA to admit a full satisfaction class. A surprising theorem by Lachlan states that any model M of PA which admits a full satisfactions class S is recursively saturated. However, Lachlan's argument, although very clever, seemed to be based on a rather *ad hoc* trick. We would like to show a modification of the proof which makes the presentation substantially more principled, although it doesn't change the essence of Lachlan's argument.

If time allows, we will show how this modified proof allows to show a stronger result after slight adjustments. The result states that every model M of PA which has a partial satisfaction class also has a partial inductive satisfaction class. A *partial satisfaction class* is a subset $S \subset M$ such that in the expanded structure (M, S), the compositional clauses are satisfied for all (codes of) formulae with complexity at most Σ_c for some nonstandard c. A partial satisfaction class is *inductive* if the expanded structure satisfies all induction axioms in the language extended with a new predicate for S. So any model that has a partial satisfaction class also has one which satisfies induction. This result actually implies Lachlan's Theorem and an earlier result by Stuart Smith that any model which has a full satisfaction class also has a nondefinable class piecewise coded in the model. The discussed theorem on partial satisfaction classes has already appeared in a joint paper by Mateusz Łełyk and the author but with a more complicated proof.

▸ ANDREAS WEIERMANN, *On Generalized Goodstein Sequences.*
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We define generalized Goodstein sequences with respect to the Schwichtenberg-Wainer hierarchy of fast growing functions. The resulting Goodstein principles will then not be provable in the usual theory for non iterated inductive definitions. The results are partly in joint work with T. Arai and S. Wainer.

▸ FELIX Q. WEITKMPER, *Constructing and classifying stability-preserving substructures.*

Algebraic Stability Theory is the branch of Model Theory that applies concepts from stability theory to concrete mathematical structures. Its most fundamental problems are of the form "Given a mathematically interesting class of structures, which of them stand at a certain level of the stability hierarchy?"

Paradigms for results of this sort are Macintyre's theorem that all ω-stable fields are algebraically closed on the one hand and Hrushovski and Itai's theorem that there are many non-differentially-closed ω-stable differential fields on the other hand. Tackling these problems at any level of generality seems unfeasible, however, if one takes "(ω-)stable structure" to mean "structure with an (ω-)stable first-order theory". This is because the existence of an ω-stable theory of differential fields, for example, requires the existence of a well-behaved saturated differential field, and determining saturated models will usually require a discussion of axiomatisability issues. Such issues, though, are highly dependent on the concrete algebraic properties of the class in which one is working. We argue that the more general context of Homogeneous Model Theory provides a more appropriate interpretation for questions of this type, in which "stable structure" is taken to mean "stable homogeneous structure" instead. In this framework, we provide a general construction scheme for substructures preserving degree of stability and discuss how understanding the close connection between these derived structures and their parent structure could help us ask more meaningful questions in this fundamental area of Algebraic Model Theory.

▸ ROMAN WENCEL, *Definable connectedness and definable compactness in the weakly o-minimal context.*
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A first-order structure equipped with a dense linear ordering without endpoints is said to be weakly o-minimal if all its subsets definable in dimension one are finite unions of convex sets. Unlike o-minimality, weak o-minimality is not preserved under elementary equivalences. The strong cell decomposition property is a feature of certain weakly o-minimal structures (ex. weakly o-minimal expansions of real closed fields without non-trivial definable valuations) guaranteeing the existence of a certain canonical o-minimal extension. The latter is constructed using completions of so called strong cells, the building blocks of definable sets.

It is well known that for models of weakly o-minimal theories, a weaker version of cell decomposition theorem holds. For sets definable in models of weakly o-minimal theories, I am proposing a notion of completion together with variants of definable connectedness and definable compactness, and discuss some of their fundamental properties. This generalizes similar concepts recently developed by S. Tari in the setting of weakly o-minimal structures admitting the strong cell decomposition property.

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We formulate *multirole logic* [1] as a new form of logic and naturally generalize Gentzen's celebrated result of cut-elimination between two sequents into one between n sequents for any $n \geq 1$.

While the first and foremost inspiration for multirole logic came to us during a study on multiparty session types in distributed programming [2], it seems natural in retrospective to introduce multirole logic by exploring the well-known duality between conjunction and disjunction in classical logic. Let $\overline{\emptyset}$ be a (possibly infinite) underlying set of integers, where each integer is referred to as a role. In multirole logic, each formula A can be annotated with a set R of roles to form the i-formula $[A]_R$. For each *ultrafilter* $\mathscr{U}$ on the power set of $\overline{\emptyset}$, there is a (binary) logical connective $\land_{\mathscr{U}}$ such that $[A_1 \land_{\mathscr{U}} A_2]_R$ is interpreted as the conjunction (disjunction) of $[A_1]_R$ and $[A_2]_R$ if $R \in \mathscr{U}$ ($R \notin \mathscr{U}$) holds. Furthermore, the notion of negation is generalized to *endomorphisms* on $\overline{\emptyset}$. We formulate both multirole logic (MRL) and linear multirole logic (LMRL) as natural generalizations of classical logic (CL) and classical linear logic (CLL), respectively. Among various meta-properties established for MRL and LMRL, we obtain one named *multiparty cut-elimination* stating that every cut involving one or more sequents can be eliminated. For instance, the cut-rule in CL is generalized to the following one:

$$\frac{\Gamma_1, [A]_{R_1} \quad \ldots \quad \Gamma_n, [A]_{R_n}}{\Gamma_1, \ldots, \Gamma_n}$$

where $\overline{R}_1 \uplus \cdots \uplus \overline{R}_n = \overline{\emptyset}$ is assumed. Note that Gentzen's cut-elimination is the special case where $n = 2$.

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[2] Hongwei Xi and Hanwen Wu, *Propositions in Linear Multirole Logic as Multiparty Session Types*, ***arXiv***, arXiv:1611.08888 [cs.PL], 2016.

▸ SUSUMU YAMASAKI, *A modal operator in multi-modal mu-calculus and induced semiring structure*.
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The meanings of formulas in multi-modal mu-calculus (as an extended version of action logic [1]) are presented by the author, where the states for interactive communication and function application are monitored (conditioned) by formulas. The syntax of the formulas is give in BNF: $\varphi ::= \mathrm{tt} \mid p \mid \neg\varphi \mid {\sim}\varphi \mid \varphi \vee \varphi \mid \langle c\rangle\varphi \mid \mu x.\varphi \mid \varphi\rangle t\rangle$, with the truth tt, propositions p, two kinds of negation $\neg$ and $\sim$, the disjunction operator $\vee$, the least fixed point operator μ, and prefix/postfix modal operators $\langle c\rangle$ (for communications) and $\rangle t\rangle$ (for terms).

This contribution is concerned with the case that the postfix modal operator $\rangle t\rangle$ (in the above logic) is provided with (another type of) logical formulas. The modal operator might be related to and motivated by decralative programming, originating from: (i) propositional formulas of the expression $\wedge_j(l_1^j \wedge \ldots \wedge l_{n_j}^j \to l^j)$ (where l_i^j and l^j are literals), and (ii) their models (by taking correspondence with a Heyting algebra on $\{0, 1/2, 1\}$). Regarding the model, an extended version of fixed point theory (in [2]) is available so that the pair form (P-set, N-set) may be constructed, where P-set and N-set are positive and negative sets of propositions assigned to 1 and to 0, respectively.

As a next step to the modal operator, the model pair is abstracted into the form for sequential and alternative effects, because the meaning of modal operator is involved in a transition system and thus contains state-transition effects of sequence and alternation. In this contribution, the sequential effect is restricted only to the positive set "P-set", such that a form (P-seq, N-set) is aimed at, where P-seq is a subset of the set containing all the finite proposition sequences (formed by *concatenation*) from the set of propositions. Taking the *alternation* (for concatenation formation) into consideration, the form $\Sigma_i(P\text{-seq}_i, N\text{-set}_i)$ (where Σ_i is a direct sum) would be defined.

The set of the forms $\Sigma_i(P\text{-seq}_i, N\text{-set}_i)$ might be finally constructed into a *semiring*, with the operations *addition* and *multiplication* in accordance to *alternation* and *concatenation*, respectively. This construction is well managed with the effects of the negative sets (N-set's).

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[2] A. Van Gelder, K. A. Ross and J. S. Schlipf, *The well-founded semantics for general logic programs*, ***Journal of the ACM***, vol. 38 (1991), no. 3, pp. 619–649.

▸ AIBAT YESHKEYEV, *Some properties of central types for EPSCJ theories.*
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This abstract is associated with the concepts of convexity theory in the class Existentially Prime Jonsson theories. We denote such theories as Existentially Prime Strongy Convex Jonsson(EPSCJ).

Also we have concentrating our attention to not arbitrary subsets but use have deal with Jonsson subsets [1,2] of some semantic model for fixing Jonsson theory.

First of all, we are interested in describing models of central types of Jonsson fragments [3] with respect to stability topics.

Definition 1. Let T is an arbitrary Jonsson theory in the language of the first order signature σ. Let C is a semantic model of theory T. Let $A \subseteq C$ is a Jonsson set of theory T. Let $\sigma_\Gamma(A) = \sigma \cup \{c_a | a \in A\} \cup \Gamma$, $\Gamma = \{P\} \cup \{c\}$. Let $T_A^C = T \cup Th_{\forall\exists}(C, a)_{a \in A} \cup \{P(c_a) | a \in A\} \cup \{P(c)\} \cup \{''P \subseteq''\}$ where $\{''P \subseteq''\}$ is an infinite set of sentences expressing the fact that the interpretation of symbol P is existentially closed submodel in the language of the signatures $\sigma_\Gamma(A)$ and this model is a definable closure of the set A. It is understood that the consideration the set of sentences is Jonsson theory and this theory generally is not complete. Let T^* is the center of the Jonsson theory T_A^C and $T^* = Th(C')$ where C' is a semantic model of the theory T_A^C. By restriction theory T_A^C to signatures $\sigma_\Gamma(A) \backslash \{c\}$ the theory T^* becomes a complete type. This type we call as the central type of the theory T relatively the Jonsson set A and denoted by P_A^C.

Let L be an arbitrary language. Let T be perfect Jonsson theory, complete for existential sentences in the language L, and its semantic model is C. We say that two Jonsson (algebraically) sets (equivalent, cosemantic, categorical), if there are respectively, (Jonsson equivalent, cosemantic, categorical, syntactically similar, semantically similar, etc.) the models obtained by the corresponding closure of these sets. Consider, for example, cosemantic. Two Jonsson sets are cosemantic, if their respective closures are cosemantic, etc. [1].

Let us consider the stability for fragments of Jonsson sets.

Let X Jonsson set and M is existentially closed model, where $dcl(X) = M$.

Consider the fragment of Jonsson set X as the theory $Th_{\forall\exists}(M) = T_M$. And we consider T_M instead of theory T in the definition 1. We have the following results:

Lemma 1. T_M will Jonsson theory in the enrichment of above signature.

Theorem 1. Let T_M, as described above an existentially complete perfect EPSCJ theory. If $\lambda \geq \omega$, then the following conditions are equivalent:

(1) T^* is λ - stable, where T^* is the center of T.

(2) T_A^C is $J - \lambda$ - stable [1];

Theorem 2. Let T_M existentially complete EPSCJ theory. Then the following conditions are equivalent:

(1) $T_M^* - \omega$ - categorical;

(2) $T_A^C - \omega$ - categorical.

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▸ BYEONG-UK YI, *Plural categoricals and squares of opposition.*
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This paper studies the logic of plural categoricals: (a) 'Any unicorns are animals', (a*) 'Any of the unicorns are animals', etc. To do so, it is important to distinguish between two groups thereof:

Group 1 (G1)	**A**: Any Ps are Qs.	**E**: No Ps are Qs.
	I: Some Ps are Qs.	**O**: Some Ps are not Qs.

Group 2 (G2)	**A***: Any of the Ps are Qs.	**E***: None of the Ps are Qs.
	I*: Some of the Ps are Qs.	**I***: Some of the Ps are not Qs.

G1 categoricals (e.g., (a)) are not logically equivalent to matching G2 categoricals (e.g., (a*)) (see [6]). Modern logic gives essentially correct accounts of G1 categoricals. Regarding G2 categoricals, however, traditional logic arguably yields correct accounts. Assume, following Strawson [4]–[5], that G2 categoricals presuppose that the plural terms replacing 'the Ps' (e.g., 'the horses') refer to some things (see [1]). Then all the theses in the traditional square of opposition (see [2]) hold. But **E*** and **I***, unlike **E** and **I**, are not convertible (see [3]).

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[4] Strawson, P., *On referring*, ***Mind***, vol. 59 (1950), no. 235, pp. 320-344.

[5] ——— ***Introduction to logical theory***, Mathuen, 1952.

[6] Yi, B.-U., *Quantifiers, determiners, and plural constructions*, ***Unity and plurality: logic, philosophy, and linguistics*** (Massimiliano Carrara, Friederike Moltmann and Alexandra Arapinis, editors), Oxford University Press, Oxford, 2016, pp. 121–170.

▸ DAMIR ZAINETDINOV, *Limitwise monotonic reducibility between sequences of sets and Σ-definability of abelian groups.*

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In my talk I will consider limitwise monotonic reducibility (lm-reducibility for short) sequences of sets via Σ-definability of abelian groups. The notion of lm-reducibility sequences of sets via the limitwise monotonic operator was introduced in [1]. The basic results on limitwise monotonic functions, sets and sequences can be found in [2, 3].

Definition. Let $\mathcal{A} = \{A_m\}_{m\in\mathbb{N}}$ and $\mathcal{B} = \{B_n\}_{n\in\mathbb{N}}$ arbitrary sequences of sets. Define the following families of initial segments:

$$\mathcal{S}(\mathcal{A}) = \{\{m\} \oplus \mathbb{N} \restriction a : a \in A_m,\ m \in \mathbb{N}\}.$$

Then $\mathcal{A} \leq_{lm} \mathcal{B} \iff \mathcal{S}(\mathcal{A}) \sqsubseteq_{\Sigma} \mathcal{S}(\mathcal{B})$, where definition of Σ-reducibility on the families can be found in [4].

Let abelian group G is of the form $G(\mathcal{A}) = \bigoplus\limits_{m\in\mathbb{N}} \left(\bigoplus\limits_{k\in A_m} \mathbb{Z}_{p_m^k} \right)$, where $\mathbb{Z}_{p^k}$ – cyclic group of order p^k and p is prime.

The main result of my talk is to obtain a description of the lm-reducibility between sequences of sets on the language of Σ-definability of abelian groups.

Theorem 1. *The family $\mathcal{S}(\mathcal{A})$ is Σ-definable in $\mathbb{HF}(G(\mathcal{A}))$.*

Theorem 2. *$\mathcal{A} \leq_{lm} \mathcal{B}$ if and only if abelian group $G(\mathcal{A})$ is Σ-definable in $\mathbb{HF}(G(\mathcal{B}))$.*

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University, and by Russian Foundation for Basic Research (projects 15-01-08252, 15-41-02507).

[1] Zainetdinov D., *Σ-reducibility and lm-reducibility of sets and sequences of sets*, ***Uchenye Zapiski Kazanskogo Universiteta. Seriya Fiziko-Matematicheskie Nauki***, vol. 158 (2016), no. 1, pp. 51–65. (In Russian)

[2] Downey R., Kach A., Turetsky D., *Limitwise monotonic functions and their applications*, ***Proceedings of the 11th Asian Logic Conference. World Scientific***, (2011), pp. 59–85.

[3] Kalimullin I., Khoussainov B., Melnikov A., *Limitwise monotonic sequences and degree spectra of structures*, ***Proceedings of the American Mathematical Society***, vol. 141 (2013), no. 9, pp. 3275–3289.

[4] Kalimullin I., Puzarenko V., *Reducibility on families*, ***Algebra and Logic***, vol. 48 (2009), no. 1, pp. 20–32.

▸ JING ZHANG, *A polarized partition theorem for large saturated linear orders.*
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Fix κ inaccessible or $\kappa = \omega$. A linear order $(X, <)$ is κ-saturated if for any $A, B \subset X$ such that $|A|, |B| < \kappa$ and $A < B$, there exists $c \in X$ with $A < c < B$. There exists a unique, up to ismorphism, κ-saturated linear order of size κ. Let $\mathbb{Q}_\kappa$ denote the order and η_κ denote the order type.

We generalized a partition theorem due to Laver and Galvin [1] to larger cardinals. More precisely, we will discuss the following:

THEOREM 1. *Let $d \in \omega$, κ inaccessible and λ infinite cardinals satisfying that $\lambda \to (\kappa)^{2d}_{2^\kappa}$ be given ($\lambda = (2^\kappa)^+$ suffices when $d = 1$), then* $\begin{pmatrix}\eta_\kappa \\ \vdots \\ \eta_\kappa\end{pmatrix} \to \begin{pmatrix}\eta_\kappa \\ \vdots \\ \eta_\kappa\end{pmatrix}^{\overbrace{1,\cdots,1}^{d+1}}_{<\kappa,(d+1)!}$*, namely for any $\delta < \kappa$ and $f : \mathbb{Q}_\kappa^{d+1} \to \delta$, there exist $\{X_j \subset \mathbb{Q}_\kappa : j \leq d\}$ with type$(X_j) = \eta_\kappa$ such that $|f''\Pi_{j\leq d}X_j| \leq (d+1)!$. When $\kappa = \omega$, it is the Laver/Galvin's theorem.*

This work builds on S.Shelah [2] and M. Džamonja, J. Larson and W. Mitchell [3]. The latter generalized Devlin's theorem on a partition theorem of the rationals [5] to larger saturated linear orders. We isolate a combinatorial principle that we call the *tail cone* version of the Halpern-Läuchli theorem, which powers the "dimension boost", namely under the hypothesis for d, we will be able to get the results up to dimension $d + 1$. It also has some applications to polychromatic Ramsey theory (also known as rainbow Ramsey theory).

We will also mention some development regarding the Halpern-Läuchli theorem at a large cardinal, continuing the study in Dobrinen and Hathaway [4].

THEOREM 2. *The 1-dimensional Halpern-Läuchli theorem at a weakly compact cardinal κ holds for fewer than κ many colors.*

THEOREM 3. *It is relative consistent that the Halpern-Läuchli theorem holds at inaccessible κ yet κ is not weakly compact.*

[1] RICHARD LAVER, *Products of infinitely many perfect trees*, ***Journal of the London Mathematical Society, Second Series***, vol. 29 (1984), no. 3, pp. 385–396.

[2] SAHARON SHELAH, *Strong partition relations below the power set: consistency; was Sierpiński right? II*, ***Sets, graphs and numbers (Budapest, 1991)***, vol. 60 (1992), pp. 637–668.

[3] DŽAMONJA, M. AND LARSON, J. A. AND MITCHELL, W. J., *A partition theorem for a large dense linear order*, ***Israel Journal of Mathematics***, vol. 171 (2009), pp. 237–284.

[4] NATASHA DOBRINEN AND DANIEL HATHAWAY, *The Halpern-Läuchli Theorem at a Measurable Cardinal*, ***Preprint***, (2016), https://arxiv.org/abs/1608.00592.

[5] DENIS DEVLIN, *Some partition theorems and ultrafilters on* ω, ***PhD Thesis***.

▸ MAXIM ZUBKOV, *On the Kierstead's conjecture.*
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E-mail: maxim.zubkov@kpfu.ru.

According to H. Kierstead in paper [1], an automorphism f is fairly trivial if for all $x \in L$, there are only finitely many elements between x and $f(x)$. A nontrivial automorphism is called strongly nontrivial, if it is not fairly trivial. H. Kierstead's paper [1] concluded with 3 conjectures, with the main one as follows.

Conjecture. (H. Kierstead [1]) Every computable copy of a linear order $\mathcal{L}$ has a strongly nontrivial Π^0_1 automorphism if and only if $\mathcal{L}$ contains an interval of order type η.

R. Downey and M. Moses proved that H. Kierstead's conjecture holds for discrete linear orders. C. Harris, K. Lee, S. B. Cooper proved that Kierstead's conjecture holds for $\mathcal{L} \cong \sum_{q\in\mathbb{Q}} F(q)$, where $F : \mathbb{Q} \to \mathbb{N}$ is $\mathbf{0}'$-limitwise monotonic. We generalize previous result to a bigger class of linear orders, in which $\mathcal{L}$ can contain both finite blocks and infinite blocks simultaneously.

THEOREM 1 (G. Wu, M. Zubkov). *The Kierstead's conjecture holds for all linear orders $\mathcal{L}$ of the form $\sum_{q\in\mathbb{Q}} F(q)$, where $F : \mathbb{Q} \to \mathbb{N} \cup \{\zeta\}$ is extended $\mathbf{0}'$-limitwise monotonic function.*

The Kierstead's conjecture has been verified for a large class of linear orders. For this reason, it has remained open for so long. The following theorem is a negative solution to Kierstead's conjecture:

THEOREM 2 (K.M. Ng, M. Zubkov). *There exists a $0'$-limitwise monotonic relative to the Kleene's Ordinal Notation System O function $G : \mathbb{Q} \to \mathbb{N} \cup \{\zeta\}$ such that the linear order $\mathcal{L} \cong \sum_{q\in\mathbb{Q}} (G(q))$ has no subinterval of type η and every computable copy of $\mathcal{L}$ has a strictly nontrivial Π^0_1-automorphism.*

For computable η-like linear orders we have the following partial result.

THEOREM 3 (K.M. Ng, M. Zubkov). *There exists an η-like computable linear order $\mathcal{L}$ win no η subinterval such that every Δ^0_2 isomorphic to $\mathcal{L}$ computable linear order $\mathcal{L}'$ has a strictly nontrivial Π^0_1-automorphism.*

[1] H. A. Kierstead, On Π^0_1-Automorphisms of Recursive Linear Orders, *Journal of Symbolic Logic* **52**(1987), 681-688.

Chapter 4

Programme

4.1 Programme at a glance

	Mon Aug 14	Tue Aug 15	Wed Aug 16	Thu Aug 17	Fri Aug 18	Sat Aug 19	Sun Aug 20
09:00	09:00–10:15 Opening + Per Martin-Löf	09:00–10:00 Alessandro Berarducci	09:00–10:00 Elisabeth Bouscaren	09:00–10:00 Emil Jeřábek	09:00–10:00 Sakaé Fuchino	09:00–10:00 Wilfrid Hodges	09:00–13:00 Joint session with CSL (in G-salen)
10:00		coffee	coffee	coffee	coffee	coffee	
10:15	coffee						
10:30		10:30–11:30 Mai Gehrke	10:30–11:30 Patricia Bouyer-Decitre	10:30–11:30 Mai Gehrke	10:30–11:30 Patricia Bouyer-Decitre	10:30–12:00 History of logic session	
10:45	10:45–11:45 Mai Gehrke						
11:30		11:30–12:30 Denis Hirschfeldt	11:30–12:30 Sonja Smets	11:30–12:30 Patricia Bouyer-Decitre	11:30–12:30 Christina Brech		
11:45	11:45–12:45 David Aspero						
12:30		lunch	lunch	12:30–13:00 Group photo	lunch	lunch	
12:45	lunch						
13:00				lunch			
14:00	14:00–15:30 Special sessions	14:00–15:30 Special sessions	14:00–17:00 Excursions	14:00–15:30 Special sessions	14:00–15:30 Special sessions	14:00-15:30 Category theory and type theory session	
15:30	coffee	coffee		coffee	coffee	coffee	
16:00	16:00–18:00 Contributed talks	16:00–17:00 Contributed talks		16:00–18:00 Contributed talks	16:00–18:00 Contributed talks	16:00–17:00 Dag Prawitz	
17:00							
18:00							
19:00	19:00–21:00 Welcome reception at the City Hall, hosted by Stockholm City			19:00– Dinner			
20:00							
20:30			20:30– ASL council meeting				
21:00							

4.2 Detailed programme

The following pages is based on a print out of the online programme as of July 20, 2017:

`http://easychair.org/smart-program/LC2017/`

See this link or the conference webpages for possible changes in the programme.

LC 2017: LOGIC COLLOQUIUM 2017

PROGRAM   INDEXES

PROGRAM

Days: Monday, August 14th   Tuesday, August 15th
Wednesday, August 16th   Thursday, August 17th
Friday, August 18th   Saturday, August 19th
Sunday, August 20th

Monday, August 14th

View this program: with abstracts   session overview   talk overview

09:00-09:15 Session 1: Opening

LOCATION: Hörsal 2 (A2)

09:15-10:15 Session 2: Plenary talk

CHAIR: *Erik Palmgren*
LOCATION: Hörsal 2 (A2)

09:15 *Per Martin-Löf*
Assertion and request (abstract)

10:15-10:45 Coffee

10:45-11:45 Session 3: Plenary talk

CHAIR: *Erik Palmgren*
LOCATION: Hörsal 2 (A2)

10:45 *Mai Gehrke*
Stone duality and applications in computer science (1/3) (abstract)

11:45-12:45 Session 4: Plenary talk

CHAIR: *Erik Palmgren*
LOCATION: Hörsal 2 (A2)

11:45 *David Aspero*
Generic absoluteness for Chang models (abstract)

12:45-14:00 Lunch

14:00-15:30 Session 5A: Computability

CHAIR: *Denis Hirschfeldt*
LOCATION: Hörsal 11 (F11)

14:00 *Veronica Becher*, *Jan Reimann* and *Theodore Slaman*
Irrationality Exponents and Effective Hausdorff Dimension (abstract)

14:30 *Mariya Soskova*
Characterizing the continuous degrees (abstract)

15:00 *Keita Yokoyama*
On the first-order strength of Ramsey's theorem in reverse mathematics (abstract)

14:00-15:30 Session 5B: Proof theory

CHAIR: *Jan von Plato*
LOCATION: Hörsal 4 (B4)

14:00 *Fernando Ferreira*
A herbrandized functional interpretation of classical first-order logic (abstract)

14:30 *Annika Kanckos*
Strong Normalization for Simply Typed Lambda Calculus (abstract)

15:00 *Anton Setzer*
The extended predicative Mahlo Universe in Explicit Mathematics - model construction (abstract)

14:00-15:30 Session 5C: Set theory

CHAIR: *David Aspero*
LOCATION: Hörsal 8 (D8)

14:00 *Sandra Uhlenbrock*
The hereditarily ordinal definable sets in inner models with finitely many Woodin cardinals (abstract)

14:30 *Ashutosh Kumar*
Transversal of full outer measure (abstract)

15:00 *Giorgio Laguzzi*
Infinite utility streams and irregular sets (abstract)

15:30-16:00 Coffee

16:00-17:40 Session 6A: Contributed talks

LOCATION: D289

16:00 *Anahit Chubaryan*, *Hakob Nalbandyan*, *Arman Karabakhtyan* and *Garik Petrosyan*
Propositional sequent systems of two valued classical logic and many valued logics are no monotonous. (abstract)

16:20 *Cedric Ginestet*
Truth-value semantics generalized to three-valued logics, with applications to elementary arithmetic and to the principle of induction. (abstract)

16:40 *Michael Arndt*
Tomographs for Substructural Display Logic (abstract)

17:00 *Michal Pelis*, *Pawel Lupkowski*, *Ondrej Majer* and *Mariusz Urbanski*
(Dynamic) epistemic interpretation for erotetic search scenarios (abstract)

17:20 *Oğuz Akçelik* and *Aziz Fevzi Zambak*
A Decision Procedure Model for Finding the

Missing Premise in Automated Reasoning (abstract **)**

16:00-18:00 Session 6B: Contributed talks

LOCATION: D299

16:00 *Dmitry Emelyanov*, *Beibut Kulpeshov* and *Sergey Sudoplatov*
On algebras of distributions for binary formulas of quite o-minimal theories with non-maximum many countable models (abstract **)**

16:20 *Sayan Baizhanov* and *Beibut Kulpeshov*
On preserving properties under expanding models of quite o-minimal theories (abstract **)**

16:40 *Ove Ahlman*
Easy and hard homogenizable structures (abstract **)**

17:00 *Enrique Casanovas* and *Saharon Shelah*
Universal theories and compactly expandable models (abstract **)**

17:20 *Beibut Kulpeshov* and *Sergey Sudoplatov*
On distributions for countable models of quite o-minimal theories with non-maximum many countable models (abstract **)**

17:40 *Alireza Mofidi*
Some VC-combinatorial aspects of definable set systems (abstract **)**

16:00-18:00 Session 6C: Contributed talks

LOCATION: E306

16:00 *Vladimir Kanovei*
The full basis theorem does not imply analytic wellordering (abstract **)**

16:20 *David Fernández-Duque*, *Paul Shafer*, *Henry Towsner* and *Keita Yokoyama*
Caristi's fixed point theorem and strong systems of arithmetic (abstract **)**

16:40 *Andrés Cordón-Franco* and *F. Félix Lara-Martín*
On local induction rules: collapse and conservation properties (abstract **)**

17:00 *Jana Glivická*
Nonstandard methods and construction of models of arithmetics (abstract **)**

17:20 *Felix Q. Weitkämper*
Constructing and classifying stability-preserving substructures (abstract **)**

17:40 *Mateusz Łełyk*
Reflection principles, bounded induction and axiomatic truth theories. (abstract **)**

16:00-17:40 Session 6D: Contributed talks

LOCATION: E497

16:00 *Denis I. Saveliev*

Systems of propositions referring to each other: a model-theoretic view (abstract)

16:20 *Vladimir Stepanov*
Revealing the 4D vector space within disquotational truth theory for self-reference statements (abstract)

16:40 *Kristina Liefke* and *Sam Sanders*
A computable solution to Partee's puzzle (abstract)

17:00 *Martin Mose Bentzen*
Logic without unique readability - a study of semantic and syntactic ambiguity (abstract)

17:20 *Alexandr Bessonov*
G\"odel's second incompleteness theorem cannot be used as an argument against Hilbert's program (abstract)

16:00-18:00 Session 6E: Contributed talks

LOCATION: F289

16:00 *Vladislav Nenchev*
Definability between temporal relations in dynamic mereology (abstract)

16:20 *John Corcoran* and *Hassan Masoud*
Teaching universalized-conditionals and Hazen's Theorem. (abstract)

16:40 *Susumu Yamasaki*
A modal operator in multi-modal mu-calculus and induced semiring structure (abstract)

17:00 *Bahareh Afshari*
Interpolation for modal mu-calculus (abstract)

17:20 *Hsing-Chien Tsai*
On the Decidability of Mereological Theories with Local Complementation (abstract)

17:40 *Franco Parlamento* and *Flavio Previale*
On the Admissibility of the Structural Rules in Kanger's Calculus with Restricted Equality Rules (abstract)

16:00-17:40 Session 6F: Contributed talks

LOCATION: F299

16:00 *Paweł Klimasara*, *Jerzy Król* and *Krzysztof Bielas*
Boolean-valued models of ZFC and forcing in geometry and physics (abstract)

16:20 *Francesco Parente*
Keisler's order via Boolean ultrapowers (abstract)

16:40 *Åsa Hirvonen*
On Approximations and Eigenvectors - looking at Quantum Physics via Metric Ultraproducts (abstract)

17:00 *Federico Bobbio* and *Jianying Cui*
A plausibility model for regret games (

abstract)

17:20 *Danny De Jesus Gomez-Ramirez*
Dathematics: a meta-isomorphic version of classic mathematics based on proper classes (abstract)

16:00-18:00 Session 6G: Contributed talks

LOCATION: E487

16:00 *Giorgio Sbardolini*
The Semanticist's Guide to Ramification (abstract)

16:20 *Matthias Unterhuber*
Negative Properties in First-Degree Entailment with Constructible Negation and an Extensional Semantics (abstract)

16:40 *Frode A. Bjørdal*
Volutionary deliberations (abstract)

17:00 *Byeong-Uk Yi*
Plural Categoricals and Squares of Opposition (abstract)

17:20 *John Corcoran* and *George Boger*
Meanings of contradicts. (abstract)

17:40 *Alexander Jones*
Truth as a Logical Property (abstract)

19:00-21:00 Session : City Hall reception

Welcome reception in the City Hall, hosted by Stockholm City

Tuesday, August 15th

View this program: with abstracts session overview talk overview

09:00-10:00 Session 7: Plenary talk

CHAIR: *Vera Koponen*

LOCATION: Hörsal 2 (A2)

09:00 *Alessandro Berarducci*
Surreal differential calculus (abstract)

10:00-10:30 Coffee

10:30-11:30 Session 8: Plenary talk

CHAIR: *Vera Koponen*

LOCATION: Hörsal 2 (A2)

10:30 *Mai Gherke*
Stone duality and applications in computer science (2/3) (abstract)

11:30-12:30 Session 9: Plenary talk

CHAIR: *Vera Koponen*

LOCATION: Hörsal 2 (A2)

11:30 *Denis Hirschfeldt*
Computability theory and asymptotic density (

abstract)

12:30-14:00 Lunch

14:00-15:30 Session 10A: Computability

CHAIR: *Veronica Becher*
LOCATION: Hörsal 11 (F11)

14:00 *Klaus Meer* and *Ameen Naif*
Generalized Finite Automata over the Real Numbers (abstract **)**

14:30 *Emmanuel Jeandel*
Reducibilities and Higman-like theorems in symbolic dynamics (abstract **)**

15:00 *Arno Pauly*
Applications of computability theory in topology (abstract **)**

14:00-15:30 Session 10B: Model theory

CHAIR: *Enrique Casanovas*
LOCATION: Hörsal 4 (B4)

14:00 *Ivan Tomasic*
Enriching our view of model theory of fields with operators (abstract **)**

14:30 *Zaniar Ghadernezhad*
Non-amenablility of automorphism groups of generic structures (abstract **)**

15:00 *Tomás Ibarlucía*
Model theory of strongly ergodic actions (abstract **)**

14:00-15:30 Session 10C: Philosophy

CHAIR: *Peter Pagin*
LOCATION: Hörsal 8 (D8)

14:00 *Juliette Kennedy*
Squeezing arguments and strong logics (abstract **)**

14:30 *Davide Rizza*
How to make an infinite decision (abstract **)**

15:00 *Giambattista Formica*
On Hilbert's Axiomatic Method (abstract **)**

15:30-16:00 Coffee

16:00-17:00 Session 11A: Contributed talks

LOCATION: D289

16:00 *Anahit Chubaryan* and *Garik Petrosyan*
On proof complexities for some classes of tautologies in Frege systems (abstract **)**

16:20 *William Stafford*
Genus of proofs as a measure of complexity (abstract **)**

16:40 *Mario Benevides*
Propositional Dynamic Logic for Bisimilar programs with Parallel Operator and Test (

abstract)

16:00-17:00 Session 11B: Contributed talks

LOCATION: D299

16:00 *Michael Bärtschi*
Arithmetical transfinite Recursion and Relatives (abstract)

16:20 *Raja Natarajan*
Diagrammatic Reasoning for Boolean Equations (abstract)

16:40 *Roussanka Loukanova*
Type Theory of Restricted Algorithms and Neural Networks (abstract)

16:00-17:00 Session 11C: Contributed talks

LOCATION: F289

16:00 *Emanuele Bottazzi*
Describing limits of bounded sequences of measurable functions via nonstandard analysis. (abstract)

16:20 *Dag Normann* and *Sam Sanders*
Nonstandard Analysis, Computability Theory, and metastbility (abstract)

16:40 *Ranjan Mukhopadhyay*
Intrinsic harmony and total harmony (abstract)

16:00-17:00 Session 11D: Contributed talks

LOCATION: E487

16:00 *Maxim Zubkov*
On the Kierstead's conjecture (abstract)

16:20 *Carlos Alfonso Ruiz Guido*
Non reduced schemes and model theory (abstract)

16:40 *Lorenzo Carlucci*
Some Weak Yet Strong restrictions of Hindman's Theorem (abstract)

16:00-17:00 Session 11E: Contributed talks

LOCATION: E497

16:00 *Hannah Berry*
Brentano and Frege: The tunnel between analytic and continental theories of language with intentional inexistence and the judgement stroke. (abstract)

16:20 *Philip Ehrlich*
Are points (necessarily) unextended? (abstract)

16:40 *Michael Shenefelt* and *Heidi White*
Why Does Formal Deductive Logic Start With the Classical Greeks? (abstract)

16:00-17:00 Session 11F: Contributed talks

LOCATION: F299

16:00 *Robert Lubarsky*
Determinacy of Boolean combinations of Σ^0_3 games (abstract **)**

16:20 *Sarka Stejskalova*
The tree property at $\aleph_{\omega+2}$ with a finite gap (abstract **)**

16:40 *Paul Gorbow*
Algebraic new foundations (abstract **)**

Wednesday, August 16th

View this program: with abstracts session overview talk overview

09:00-10:00 Session 12: Plenary talk

LOCATION: Hörsal 2 (A2)

09:00 *Elisabeth Bouscaren*
A stroll through some important notions of model theory and their applications in geometry (abstract **)**

10:00-10:30 Coffee

10:30-11:30 Session 13: Plenary talk

LOCATION: Hörsal 2 (A2)

10:30 *Patricia Bouyer*
On the verification of timed systems – and beyond (1/3) (abstract **)**

11:30-12:30 Session 14: Plenary talk

LOCATION: Hörsal 2 (A2)

11:30 *Sonja Smets*
The Logical basis of a formal epistemology for social networks (abstract **)**

12:30-14:00 Lunch

14:00-17:00 Session : Excursion

Excursion

20:30-23:00 Session 15: ASL Council Meeting

LOCATION: D320

Thursday, August 17th

View this program: with abstracts session overview talk overview

09:00-10:00 Session 16: Plenary talk

LOCATION: Hörsal 2 (A2)

09:00 *Emil Jeřábek*
Counting in weak theories (abstract **)**

10:00-10:30 Coffee

10:30-11:30 Session 17: Plenary talk

LOCATION: Hörsal 2 (A2)

10:30 *Mai Gherke*
Stone duality and applications in computer science (3/3) (abstract)

11:30-12:30 Session 18: Plenary talk

LOCATION: Hörsal 2 (A2)

11:30 *Patricia Bouyer*
On the verification of timed systems – and beyond (2/3) (abstract)

12:30-13:00 Session : Group photo

13:00-14:00 Lunch

14:00-15:30 Session 19A: Model theory

CHAIR: *Charles Steinhorn*
LOCATION: Hörsal 4 (B4)

14:00 *Martin Bays*
Pseudofiniteness in fields, modularity, and groups (abstract)

14:30 *Vincenzo Mantova*
Transseries as surreal analytic functions (abstract)

15:00 *Franziska Jahnke*
NIP fields and henselianity (abstract)

14:00-15:30 Session 19B: Set theory

CHAIR: *Sakaé Fuchino*
LOCATION: Hörsal 8 (D8)

14:00 *Brent Cody*
Adding a non-reflecting weakly compact set (abstract)

14:30 *William Chen*
Negative partition relations from cardinal invariants (abstract)

15:00 *Yann Pequignot*
Countable Borel chromatic numbers and Sigma^1_2 sets (abstract)

14:00-15:30 Session 19C: Category theory and type theory

CHAIR: *Thierry Coquand*
LOCATION: Hörsal 11 (F11)

14:00 *André Joyal*
On some categorical aspects of homotopy type theory (abstract)

15:00 *Peter Lefanu Lumsdaine*
Discussions following the Category theory and type theory session (abstract)

15:30-16:00 Coffee

16:00-18:00 Session 20A: Contributed talks

LOCATION: E319

16:00 *Henson Graves*
Topos Theory For Descriptive Modeling (abstract **)**

16:20 *Eric Faber*
Names in Topos Theory (abstract **)**

16:40 *Benno van den Berg*
Models of set theory in path categories (abstract **)**

17:00 *Christian Espindola*
Stone duality for infinitary first-order logic (abstract **)**

17:20 *Michael Lieberman*, *Jiri Rosicky* and *Sebastien Vasey*
Set-theoretic pathologies in accessible categories (abstract **)**

17:40 *Sergi Oms*
The Notion of Paradox (abstract **)**

16:00-18:00 Session 20B: Contributed talks

LOCATION: D289

16:00 *Anahit Chubaryan* and *Artur Khamisyan*
Application of Kalmar's proof of deducibility in two valued propositional logic for many valued logic. (abstract **)**

16:20 *Carolina Blasio*, *Joao Marcos* and *Heinrich Wansing*
Monotonic functions are logically four-valued (abstract **)**

16:40 *José M. Méndez*, *Gemma Robles*, *Sandra M. López* and *Marcos M. Recio*
Belnap-Dunn semantics for natural implicative expansions of Kleene's strong three-valued matrix (abstract **)**

17:00 *Gemma Robles*, *Francisco Salto* and *José M. Blanco*
Routley-Meyer semantics for natural implicative expansions of Kleene's strong three-valued matrix (abstract **)**

17:20 *Luca Spada*
Łukasiewicz logic, with coefficients (abstract **)**

17:40 *Yuta Takahashi*
A Proof-Theoretic Semantics for Disjunction (abstract **)**

16:00-18:00 Session 20C: Contributed talks

LOCATION: D299

16:00 *Taishi Kurahashi*
Two theorems on provability logics (abstract **)**

16:20 *Andrei Sipos*
Proof mining in convex optimization (abstract **)**

16:40 *Luis Estrada-González* and *José David García-Cruz*

Connectives as relative modalities (abstract)

17:00 *Dariusz Surowik*
Intuitionistic tense logic. Some remarks. (abstract)

17:20 *Joachim Mueller-Theys*
On the Provability of Consistency (abstract)

17:40 *Sergei Artemov* and *Elena Nogina*
On completeness of epistemic theories (abstract)

16:00-18:00 Session 20D: Contributed talks

LOCATION: E487

16:00 *Damir Zainetdinov*
Limitwise monotonic reducibility between sequences of sets and Sigma-definability of abelian groups (abstract)

16:20 *Sergey Ospichev*, *Nikolay Bazhenov* and *Mars M. Yamaleev*
Rogers semilattices in analytical hierarchy (abstract)

16:40 *Fedor Pakhomov*
Gödel's second incompleteness theorem from scratch (abstract)

17:00 *Ashot Baghdasaryan* and *Hovhannes Bolibekyan*
On Some Systems of Minimal Propositional Logic with History Mechanism (abstract)

17:20 *Vit Puncochar*
Uniform Substitution and Replacement of Equivalents (abstract)

17:40 *İbrahim Şentürk* and *Tahsin Oner*
An Analysis of Peterson's Intermediate Syllogisms with Caroll's Diagrammatic Method (abstract)

16:00-18:00 Session 20E: Contributed talks

LOCATION: E497

16:00 *Tuan-Fang Fan* and *Churn-Jung Liau*
Dynamic Belief Logic Based on Evidential Observation (abstract)

16:20 *Bruno Bentzen*
A solution to Frege's puzzle in Homotopy Type Theory (abstract)

16:40 *Joan Bertran-San Millán*
Frege's Begriffsschrift and logicism (abstract)

17:00 *Valentin Goranko*, *Antti Kuusisto* and *Raine Rönnholm*
Compositional vs game-theoretic semantics for alternating-time temporal Logics (abstract)

17:20 *Pavel Arazim*
Logical dynamism as a way of understanding plurality of logics (abstract)

17:40 *Andrei Rodin*
Two "Styles" of axiomatization: Rules versus Axioms. A Modern Perspective. (abstract)

16:00-18:00 Session 20F: Contributed talks

LOCATION: F299

16:00 *Jing Zhang*
A polarized partition theorem for large saturated linear orders (abstract)

16:20 *Juan Carlos Martínez*
On pcf spaces which are not Fréchet-Urysohn (abstract)

16:40 *Zach Norwood* and *Itay Neeman*
Happy and mad families (abstract)

17:00 *Yurii Khomskii*
Definable Maximal Independent Families (abstract)

17:20 *Yechiel M. Kimchi*
Partition relations equiconsistent with $o(o(\ldots o(\kappa)\ldots)) = 2$ (abstract)

17:40 *Radek Honzik*
The tree property at the double successor of a singular cardinal (abstract)

16:00-18:00 Session 20G: Contributed talks

LOCATION: F289

16:00 *Natalia Korneeva*
On prefix realizability problems of infinite words for natural subsets of context-free languages (abstract)

16:20 *Wei Wang*
On the computability of perfect subsets of sets with positive measure (abstract)

16:40 *Assylbek Issakhov* and *Fariza Rakymzhankyzy*
Hyperimmunity and A--computable numberings (abstract)

17:00 *Michał Tomasz Godziszewski*
Refuting 'Converse to Tarski' Conjecture (abstract)

17:20 *Aibat Yeshkeev*
Some properties of central types for EPSCJ theories (abstract)

17:40 *David Schrittesser*
Compactness of maximal eventually different families (abstract)

Friday, August 18th

View this program: with abstracts session overview talk overview

09:00-10:00 Session 21: Plenary talk

CHAIR: *Theodore Slaman*

LOCATION: Hörsal 2 (A2)

09:00 *Sakaé Fuchino*
Set-theoretic reflection of mathematical properties (abstract **)**

10:00-10:30 Coffee

10:30-11:30 Session 22: Plenary talk

CHAIR: *Theodore Slaman*
LOCATION: Hörsal 2 (A2)

10:30 *Patricia Bouyer*
On the verification of timed systems – and beyond (3/3) (abstract **)**

11:30-12:30 Session 23: Plenary talk

CHAIR: *Theodore Slaman*
LOCATION: Hörsal 2 (A2)

11:30 *Christina Brech*
Families on large index sets and applications to Banach spaces (abstract **)**

12:30-14:00 Lunch

14:00-15:30 Session 24A: Proof theory

CHAIR: *Andreas Weiermann*
LOCATION: Hörsal 4 (B4)

14:00 *Gerhard Jäger* and *Silvia Steila*
On some fixed point statements over Kripke Platek (abstract **)**

14:30 *Kentaro Sato*
Inductive Dichotomy and Determinacy of Difference Hierarchya (abstract **)**

15:00 *Anton Freund*
Type-Two Well-Ordering Principles and Pi^1_1-Comprehension (abstract **)**

14:00-15:30 Session 24B: Philosophy

LOCATION: Hörsal 8 (D8)

14:00 *Michèle Friend*
Reasoning abhorrently (abstract **)**

14:30 *Sara Negri*
Reasoning with counterfactual scenarios: from models to proofs (abstract **)**

15:00 *Alexander C. Block*, *Luca Incurvati* and *Benedikt Löwe*
Maddian interpretations and their derived notions of restrictiveness (abstract **)**

14:00-15:30 Session 24C: Category theory and type theory

CHAIR: *Richard Garner*
LOCATION: Hörsal 11 (F11)

14:00 *Vladimir Voevodsky*
Models, Interpretations and the Initiallity

Conjectures. (abstract)

15:00 *Erik Palmgren*
Discussions following the Category theory and type theory session (abstract)

15:30-16:00 Coffee

16:00-18:00 Session 25A: Contributed talks

LOCATION: D289

16:00 *Roberto Maieli*
Non-decomposable connectives of Linear Logic (abstract)

16:20 *Paolo Pistone*
Balanced polymorphism and quantifiers in Linear Logic (abstract)

16:40 *Valeria de Paiva* and *Giselle Reis*
Benchmarking Linear Logic (abstract)

17:00 *Kerkko Luosto*
Logical co-operation in multiplayer games (abstract)

17:20 *Denis I. Saveliev* and *Ilya Shapirovsky*
Defining modal logics of relations between models (abstract)

17:40 *Paula Quinon*
Predicates as second-order variables: a possible way towards intensionality in the model-theoretical framework (abstract)

16:00-18:00 Session 25B: Contributed talks

LOCATION: D299

16:00 *Birzhan Kalmurzayev* and *Nikolay Bazhenov*
Weakly precomplete dark computably enumerable equivalence relations (abstract)

16:20 *Nikolay Bazhenov*, *Ekaterina Fokina*, *Dino Rossegger* and *Luca San Mauro*
Computable bi-embeddable categoricity of equivalence relations (abstract)

16:40 *Diana Kabylzhanova*
A note on computably enumerable preorders (abstract)

17:00 *Svetlana Aleksandrova*
On computability in hereditarily finite superstructures and computable analysis (abstract)

17:20 *Alexandra Soskova*
Structural properties of the cototal enumeration degrees (abstract)

17:40 *Lauri Hella* and *Miikka Vilander*
Formula size games for modal logics (abstract)

16:00-18:00 Session 25C: Contributed talks

LOCATION: E487

16:00 *Kit Fine* and *Mark Jago*

Semantics for Exact Entailment (abstract)

16:20 *Hongwei Xi* and *Hanwen Wu*
Multirole Logic (abstract)

16:40 *Aleksandra Samonek*
Relation algebras, representability and relevant logics (abstract)

17:00 *Bahareh Afshari* and *Graham Leigh*
Cut-free completeness for modal mu-calculus (abstract)

17:20 *Sergey Drobyshevich*
Investigating some effects of display property (abstract)

17:40 *Mirjana Ilic*
A normalizing system of natural deduction for relevant logic (abstract)

16:00-18:00 Session 25D: Contributed talks

LOCATION: E497

16:00 *Pedro Pinto*
A quantitative analysis of a theorem by F.E.Browder guided by the bounded functional interpretation (abstract)

16:20 *Alexey Vladimirov*
Effectivity proprties of Intuitionistic Zermelo-Fraenkel Set Theory with DCS principle. (abstract)

16:40 *Thomas Piecha* and *Peter Schroeder-Heister*
Intuitionistic logic is not complete for standard proof-theoretic semantics (abstract)

17:00 *Sean Moss*
The Diller-Nahm model of type theory (abstract)

17:20 *Angeliki Koutsoukou-Argyraki*
An invitation to proof mining: two applications in nonlinear operator theory (abstract)

17:40 *Serge Potemkin*
EXPRESSING NATURAL LANGUAGE SEMANTICS IN PROLOG (abstract)

16:00-18:00 Session 25E: Contributed talks

LOCATION: F289

16:00 *John Corcoran*
Meanings of statement, proposition, and sentence. (abstract)

16:20 *Anders Lundstedt* and *Eric Johannesson*
When one must strengthen one's induction hypothesis (abstract)

16:40 *Luiz Carlos Pereira* and *Ricardo Rodriguez*
Ecumenism: a new perspective on the relation between logics. (abstract)

17:00 *Alejandro Solares-Rojas* and *Luis Estrada-González*

How could a logician help solving the P =? NP problem? (abstract)

17:20 *Ryszard Mirek*
Euclidean Geometry in Renaissance (abstract)

17:40 *Manuel Tapia* and *Luis Estrada-González*
When Curry met Abel (abstract)

16:00-18:00 Session 25F: Contributed talks

LOCATION: F299

16:00 *Longyun Ding*
On decomposing Borel functions (abstract)

16:20 *Alberto Marcone*
Strongly surjective linear orders (abstract)

16:40 *Russell Miller*
Topology of isomorphism types of countable structures (abstract)

17:00 *Roman Wencel*
Definable connectedness and definable compactness in the weakly o-minimal context (abstract)

17:20 *Bartosz Wcisło*
Remarks on satisfaction classes and recursive saturation (abstract)

17:40 *Koichiro Ikeda*
A note on small stable theories (abstract)

16:00-18:00 Session 25G: Contributed talks

LOCATION: E306

16:00 *Andreas Weiermann*
On generalized Goodstein sequences (abstract)

16:20 *Edoardo Rivello*
On extending the general recursion theorem to non-wellfounded relations (abstract)

16:40 *Leszek Kolodziejczyk*
Some new bounds on the strength of restricted versions of Hindman's Theorem (abstract)

17:00 *Dorottya Sziraki*
Open colorings on generalized Baire spaces (abstract)

17:20 *Michał Tomasz Godziszewski* and *Joel David Hamkins*
Computable quotient presentations of models of arithmetic and set theory (abstract)

17:40 *James Walsh* and *Antonio Montalbán*
Canonical aspects of reflection principles (abstract)

Saturday, August 19th

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overview talk overview

09:00-10:00 Session 26: Plenary talk

CHAIR: *Mirna Dzamonja*

LOCATION: Hörsal 2 (A2)

09:00 *Wilfrid Hodges*

Avicenna sets up a modal logic with a Kripke semantics (abstract **)**

10:00-10:30 Coffee

10:30-12:00 Session 27: History of logic

CHAIR: *Valentin Goranko*

LOCATION: Hörsal 2 (A2)

10:30 *Wilfrid Hodges*

How far did Avicenna get with propositional logic? (abstract **)**

11:00 *Peter Øhrstrøm*

The Rise of Temporal Logic (abstract **)**

11:30 *Jan von Plato*

Gödel's reading of Gentzen's first consistency proof for arithmetic (abstract **)**

12:30-14:00 Lunch

14:00-15:30 Session 28: Category theory and type theory

CHAIR: *Peter Dybjer*

LOCATION: Hörsal 2 (A2)

14:00 *Thierry Coquand*

Sheaf models of type theory (abstract **)**

14:45 *Richard Garner*

Polynomials and theories (abstract **)**

15:30-16:00 Coffee

16:00-17:00 Session 29: Plenary talk

CHAIR: *Vladimir Voevodsky*

LOCATION: Hörsal 2 (A2)

16:00 *Dag Prawitz*

Gentzen's justification of inferences and the ecumenical systems (abstract **)**

Sunday, August 20th

View this program: with abstracts session overview talk overview

09:00-09:10 Session 30: LC+CSL joint session opening

LOCATION: G-salen

09:10-10:50 Session 31: LC+CSL joint session

LOCATION: G-salen

09:10 *Verónica Becher*

Normal Numbers, Logic and Automata (

abstract)

10:00 *Wolfgang Thomas*
Determinacy of Infinite Games: Perspectives of the Algorithmic Approach (abstract **)**

10:50-11:20 Coffee

11:20-13:00 Session 32: LC+CSL joint session

LOCATION: G-salen

11:20 *Pierre Simon*
Recent directions in model theory (abstract **)**

12:10 *Phokion Kolaitis*
Schema mappings: structural properties and limits (abstract **)**

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