School of "Physics of atoms and molecules"

Kazan scientific-pedagogical school "Physics of atoms and molecules" has its origins from the formation of the specialization "Optics and Spectroscopy" at KSU in 1947. In the period from 1950 to 1990 scientific research work was conducted in the field of atomic and molecular spectroscopy, atomic absorption spectroscopy, and crystals. Atomic spectroscopy work was done under the guidance and supervision of **Professor I.S.Fishman.** There has been a number of areas and the first of them is - a spectroscopy of optically dense plasma. Scientific area is - an atomic absorption and fluorescence was developed in 1969. It was carried out works on creation of the absolute methods of analysis based on the numerical account the major factors affecting the absorption signal. Scientific research in molecular spectroscopy was carried out under the supervision of **Professor I.S.Pominova**, research laid the foundation for the wide application of spectroscopic methods for the study of ion and intermolecular interactions in liquids and solutions in a wide range of temperatures. Spectroscopy of laser crystals appeared at Kazan University shortly after it became aware of the creation of the first laser generator.

Since 1988, this scientific school explores the molecular and spin dynamics in the photochemical and photophysical processes, explores the nanostructures and spin clusters, develops methods of magnetic resonance tomography. Under the guidance of **K.M.Salikhova** it was created Laboratory of Chemical Physics, Russian Academy of Sciences, and in KPhTI Department of Chemical Physics, Faculty of Physics of KSU.

School has established a good experimental base.

- Solid-state femtosecond laser impulse with a duration of 70 fs

- A spectrometer of electron paramagnetic resonance (EPR) with a time resolution of 50-100 ns,

- A unique EPR spectrometer of tunable submillimeter range in the range of 60-500 GHz

- Atomic force and magnetic force scanning microscope,

- Installation of EPR tomography.

Available equipment corresponds to the world level and provides an opportunity to carry out fundamental scientific research of the structure and properties of of condensed matter to study the molecular and spin dynamics of photochemical and

photophysical processes with time resolution, a resolution by frequency and resolution in the coordinate space.

A distinctive feature of this school is that the focus of its research interests is the study of fast processes, study of the effects of the spin quantum coherence, research spectroscopic manifestations of spin coherence and coherence transfer, learning new mechanisms of spin polarization, creation of new methods of investigation of photochemical and photophysical processes based on the use of the spin coherence effects, the study of coherence effects of vibrational and rotational motion of the molecules, coherent control of photochemical and photophysical processes.

Currently, scientific and pedagogical school "Physics of atoms and molecules," is headed by Doctor of Science in Physics and Mathematics, Professor, Head of the Department of Optics and Spectroscopy, academician of Science of the Republic of Tatarstan, KSU Rector **M.H.Salahov** and Doctor of Science in Physics and Mathematics, Professor, Head of Department of Chemical Physics, Corresponding Member of RAS **K.M.Salihov.**

This scientific school has the results that have been recognized by the world scientific community and stimulated world science development in specific areas. It has been created the theory of time-resolved of EPR spectra of separated charges in the initial stages of photosynthesis. Narrow lines of two-quantum transitions in the EPR spectra of spin-correlated radical pairs were predicted. For the first time using the ESR tomography the skin layer was visualized.

Methods of spectroscopic diagnostics of low-temperature plasma asymmetric spectral emission and absorption lines have been developed. A set of algorithms and software for processing and interpretation of physical experiments based on the solution of ill-posed inverse problems have been created. The optical and transport properties of plasma-dust structures and computer modeling of collective processes in low-temperature turbulent plasma have been studied. The results were obtained for the further development of scaling theory, the theory of kinetic equations with self-similar fluctuations, the theory of relaxation in a turbulent plasma and it was developed a set of software for solving ill-posed inverse problems in plasma spectroscopy and modeling of plasma gas and dust structures.

It have been elaborated the physical principles of optical phase memory based on the long-lived photon echo; optimal regimes of laser cooling in solids; four-dimensional optical holography, the development of femtosecond optics. It have been developed optimal superradiant generation modes of “compressed” light.

It has been developed a formalism of generalized quantum dynamics, which allows to describe the evolution of a quantum system, the interaction of which is non-local in time. This formalism opens up new possibilities for solving many problems of atomic physics, quantum optics, and the theory of the broadening of the spectral lines of atoms.

Methods of coherent anti-Stokes scattering of light in conformational analysis have been developed. It has been developed a method of studying the local mobility and distribution of free volume in polymers for optical spectra of conformational probes.

It has been predicted and experimentally observed muon spin echo. A new type of single-photon light echo has been predicted, experimental discovery which opens up prospects for the realization of quantum optical memory and single-photon technologies.

New methods of atomic force microscopy have been developed for studying insitu chemical and photochemical processes at the interface between a liquid and a solid, used in technological processes of micro- and nanoelectronics. Methods of magnetic force microscopy have been determined by single-domain magnetic reversal characteristics of multidomain ferromagnetic micro- and nanoparticles.

It have been developed and introduced the theoretical methods of quantum chemistry and molecular dynamics for studying the potential energy surfaces basic and excited states of the molecules for further interpretation of the experimental data on the femtosecond spectroscopy.

Within the framework of scientific and pedagogical school there is training for engineer-physicists, bachelors and masters in physics in the area of Physics "Physics of atoms and molecules."