Search for quantum-gravitational effects in the early and present Universe

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The quantum effect of creation of particles-antiparticles and corresponding field fluctuations including space-time metric ones in strongly curved space-time is one of the cornerstones of present viable inflationary models, as well as of some alternative scenarios. It includes the purely quantum-gravitational effect of generation of gravitational waves during inflation. It leads to definite and falsifiable predictions for primordial metric perturbation spectra, and some of them have been confirmed by observations. However, this does not mean that we can exclude a possibility of some other purely deterministic process leading to the same spectra completely. I discuss perspectives of detection of the primordial GW background predicted by the simplest viable inflationary models including the $R+R^2$ one, and of gravitational quantum corrections to the background behavior expected in these models and their effect on the measured spectrum of primordial scalar perturbations. None of these corrections has been observed by now, and only upper bounds on their free parameters are obtained. This has been expected since their relative smallness is caused by the anomalously large value of the dimensionless coefficient in front of the R^2 term that finally follows from the actual amount of present large-scale inhomogeneity of the Universe. Another case there quantum-gravitational effects may show themselves is the possibility that the present dark energy in the Universe is a very light, non-minimally coupled scalar field which fluctuations were generated during inflation when this field was a spectator one. Dark energy in this model has a rather specific effective equation of state parameter as a function of redshift. This allows for testing the model using cosmological observational data on the Universe background evolution.