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Investigating inflation and super-high-energy physics with new CMB data

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The measurement of a small deviation of the primordial spectrum of scalar (density) perturbations in the Universe from the exactly flat (Harrison-Zeldovich, $n_s = 1$) one in the WMAP and Planck CMB experiments confirms the general prediction of the early Universe scenario with the de Sitter (inflationary) stage preceding the radiation dominated stage (the hot Big Bang) and strongly restricts the class of viable inflationary models [1].Thus, the status of the inflationary paradigm is changing from "proving" it in general and testing some of its simplest models to applying it for investigation of the actual history of the Universe in the remote past and particle physics at super-high energies using actual observational data. The announced discovery of primordial gravitational wave background through the measurement of the B-mode of the CMB linear polarization in the range of multipoles $\ell = 50 - 150$ in the BISEP2 experiment [2] confirms another general prediction [3] of this scenario, as well as produces the direct evidence for the existence of a very strongly curved space-time with $H \sim 10^{-5} M_{Pl}$ in the past of our Universe and the necessity of quantization of gravitational waves. Still the BISEP2 result is partially contaminated by foregrounds (mainly by polarized galactic dust emission) and requires confirmation of its blackbody character. Moreover, comparison of BISEP2 data with the temperature and E-mode polarization data earlier obtained in the WMAP and Planck experiments shows that the inflationary stage is not so simple and may not be described by a one-parametric model. In particular, the primordial spectrum of scalar perturbations generated during inflation is not of a power-law form [4], mainly due to the $\sim 10\%$ depression of the angular anisotropy power spectrum in the multipole range $\ell = 20 - 40$. A class of models describing this feature which implies existence of some scale (i.e. new physics) during inflation is proposed [5]. Furthermore, account of additional wiggles in the spectrum at $\ell \approx 22$ and $\ell \approx 40$ requires further complication of the inflaton potential [6] by introducing sharp features of the type suggested by previous studies [7]. While viable inflationary models with a smooth potential require the inflaton mass $m \sim 10^{13}$ GeV, it has to increase up to $H \sim 10^{14}$ GeV and may be larger near the feature. Thus, combination of CMB temperature anisotropy and polarization data helps to make a "tomographic" study of inflation and particle physics in this range of energies.

References

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