

The Bearable Inhomogeneity of the Baryon Asymmetry

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We study the implications of precision measurements of light-element abundances, in combination with the Cosmic Microwave Background, for scenarios of physics beyond the Standard Model that generate large inhomogeneities in the baryon-to-photon ratio. We show that precision Big Bang Nucleosynthesis (BBN) places strong constraints on any mechanism that produces large-scale inhomogeneities at temperatures around or below the TeV scale. In particular, we find that fluctuations of order 25% on comoving length scales larger than the horizon at ~ 3 TeV are incompatible with the observed light-element abundances. This sensitivity to early-universe physics arises because baryon-number inhomogeneities homogenize primarily through diffusion, a slow process. As a result, BBN serves as a novel probe of baryogenesis below the TeV scale, readily ruling out some proposed scenarios in the literature. We discuss the implications for electroweak baryogenesis, and further show that precision BBN provides a new probe of first-order phase transitions that generate gravitational waves in the pHz-mHz frequency range. This yields constraints on the electroweak phase transition, as well as first-order phase transitions that have been suggested as an explanation of the pulsar timing array signal. Finally, we comment on the future prospects for improving this probe.

Authors: BAGHERIAN, Hengameh; EKHTERACHIAN, Majid (University of Maryland College Park); STELZL, Stefan (EPFL - Ecole Polytechnique Federale Lausanne (CH))

Presenter: BAGHERIAN, Hengameh

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