CLUSTER OF EXCELLENCE QUANTUM UNIVERSE

DESY THEORY WORKSHOP

WHISPERS FROM THE DARK UNIVERSE – PARTICLES & FIELDS IN THE GRAVITATIONAL WAVE ERA

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Supercooled phase transition reconciles (stepped) dark radiation solutions to the Hubble tension with BBN

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We propose a simple model that can alleviate the H_0 tension while remaining consistent with big bang nucleosynthesis (BBN). It is based on a dark sector described by a standard Lagrangian featuring a $SU(N)$ gauge symmetry with $N \geq 3$ and a massive scalar field with a quartic coupling. The scalar acts as a dark Higgs leading to spontaneous symmetry breaking $SU(N) \to SU(N-1)$ via a first-order phase transition \'a la Coleman-Weinberg. This set-up naturally realizes previously proposed scenarios featuring strongly interacting dark radiation (SIDR) with a mass threshold within hot new early dark energy (NEDE). For a wide range of reasonable model parameters, the phase transition occurs between the BBN and recombination epochs and releases a sufficient amount of latent heat such that the model easily respects bounds on extra radiation during BBN while featuring a sufficient SIDR density around recombination for increasing the value of H_0 inferred from the cosmic microwave background. Our model can be summarized as a natural mechanism providing two successive increases in the effective number of relativistic degrees of freedom after BBN but before recombination $\Delta N_{\mathrm{BBN}} \to \Delta N_{\mathrm{NEDE}} \to \Delta N_{\mathrm{IR}}$ alleviating the Hubble tension. The first step is related to the phase transition and the second to the dark Higgs becoming non-relativistic. This set-up predicts further signatures, including a stochastic gravitational wave background and features in the matter power spectrum that can be searched for with future pulsar timing and Lyman-α forest measurements.

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