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[colloquium] A new theory of the universe

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Observations of the universe have revealed a surprising economy in its basic laws and structure. In this light, Latham Boyle and I have reconsidered cosmology's central puzzles, aiming to find simpler, more principled and more predictive solutions. From an improved understanding of the big bang singularity, we were able to explain the dark matter as consisting of a stable, massive RH neutrino. Forthcoming large scale galaxy surveys including EUCLID and LSST will closely test this hypothesis. The baryon asymmetry can likewise be accounted for by the standard model including RH neutrinos (leptogenesis). By calculating the gravitational entropy for realistic cosmologies, we have found a new explanation for the large scale geometry of the cosmos which does not require inflation. These thermodynamic arguments address the arrow of time and provide a clue to the role of the cosmological constant. We recently found a new cure for the leading order divergences of the standard model coupled to gravity, requiring no new particles or forces and explaining why there are three generations of standard model fermions (including RH neutrinos). As a byproduct of this change in the properties in the quantum vacuum of the standard model, we show how approximately scale-invariant, primordial curvature perturbations, responsible for the formation of galaxies and large scale structure, are generated. The perturbation amplitude, statistical properties and character are predicted in terms of standard model parameters. If time allows, I'll discuss a new and potentially observable signature on very large scales.

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