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Puzzling Puzzles in the Standard Model of Cosmology

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The standard model of cosmology, known as ΛCDM, successfully explains a wide variety of observations spanning different epochs of cosmic evolution. However, its most abundant components—dark energy and dark matter—still lack a fundamental theoretical explanation. In addition, the past decade has highlighted several tensions between the model and observational data, potentially pointing to new physics. In this talk, I will first summarize the key tensions affecting the ΛCDM model, with a focus on the Hubble and growth tensions. The discussion of the Hubble tension, currently the most statistically significant discrepancy in cosmology, relies heavily on baryon acoustic oscillation (BAO) data, which play a pivotal role in constructing the inverse distance ladder. I will discuss the existing tension between angular (2D) and anisotropic (3D) BAO observations and examine how these datasets point to different late-time solutions to the H_0 tension. Finally, I will comment on the importance of unbiased large-scale structure estimators like σ12 for comparing theoretical predictions and observational data from various surveys. I will also evaluate the current status of several models proposed in the literature to address the H_0 and growth tensions, analyzing their strengths and limitations.

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