A minimal SM/LCDM cosmology

Neil Turok
University of Edinburgh and Perimeter Institute for Theoretical Physics, Canada

Observations of the very large-scale universe are remarkably well-fit by LCDM, a model with only five free parameters. Likewise, on subnuclear scales the Large Hadron Collider sees no deviations from the Standard Model (SM). These findings were not what most theorists expected. According to the dominant paradigm - a combination of string theory and inflation - the universe is expected to be extremely complex on tiny scales and wildly chaotic and unpredictable on very large scales. What should we make of the apparent discrepancy? Perhaps the simplicity of the observed universe is an accident and when observations and experiments reach small or large enough scales, the asserted complexity will be revealed. Alternatively, the universe really is simple and predictable on large and small scales. This second possibility is more interesting, I believe, because we might be closer to understanding nature's basic laws than we imagined. I will review a hypothesis developed recently with Latham Boyle, that the universe respects CPT symmetry. This simple idea turns out to provide new theoretical foundations for LCDM as well as several testable predictions. The dark matter can consist of stable, RH neutrinos: the lightest neutrino is predicted to be massless. The big bang singularity is resolved using conformal symmetry. The observed large-scale geometry (flat, homogeneous, isotropic) is explained by gravitational thermodynamics without any need for inflation. There is no monopole problem. The zero-point vacuum energy divergence and the trace anomalies of the SM are cancelled by a new mechanism which predicts precisely 3 generations of SM fermions. With some assumptions, the same mechanism predicts primordial fluctuations in excellent agreement with cosmological measurements, suggesting an exciting road map for future theoretical and observational work.