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A Timeless History of Time

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Cosmological observations give us the unique opportunity to probe the fundamental laws of physics at very high energies as well as the perturbative regime of quantum gravity. Unfortunately, due to the creativity of theorists and the paucity of data about the primordial universe, there is a huge number of models compatible with all measurements, featuring a wide variety of mechanisms, symmetries, and spectra of particles.The reason can be traced back to the fact that we don't observe the time evolution during inflation, but only its final outcome.
In this talk I will report on the recent progress in developing a completely new "bootstrap" approach to derive predictions from the very early universe that make no reference to time and the un-observable time evolution. The bootstrap approach builds directly upon the fundamental pillars of physics. In particular, I will present the recent breakthroughs in understanding the consequence of unitarity for cosmological correlators to all orders in perturbation theory, as well as the footprint of (bulk) locality. I will show how these principles can be used to derive many classical and new inflationary predictions associated with primordial non-Gaussianity in a way that is both computationally simpler and conceptually more transparent. This includes a reconstruction formula that relates de Sitter correlators to amplitudes for massless particles, cosmological partial-energy recursion relations and a "timeless" differential representation of the perturbative wavefunction. This approach makes no reference to de Sitter boosts, which are broken by a large amount in models that predict large non-Gaussianity. Finally I speculate on how these results give us a handle on non-perturbative effects in cosmology either from cosmological positivity bounds or from de Sitter holography.

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