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Plenary — Ryo Saito: Probing the Early Universe with Gravitational-Wave Background Anisotropies: Universal Structures at Large Angles

Wednesday, 18 November 2026 11:00 (1 hour)

The stochastic gravitational-wave background (SGWB) offers a new window onto the early Universe. While its sky-averaged spectrum is the primary target of current searches, distinct primordial and astrophysical mechanisms can produce similar spectra over a finite observational band. Angular anisotropies provide complementary information that may help identify the origin of a signal.

The importance of such information is familiar from the cosmic microwave background (CMB). In particular, large-angle CMB anisotropies trace primordial perturbations that were superhorizon at recombination and therefore provide a relatively direct window into inflationary initial conditions. SGWB anisotropies may offer a similar probe, potentially retaining information from epochs far earlier than recombination. At the same time, important differences exist between CMB and SGWB observations. I will discuss how these similarities and differences determine which angular information can be extracted from SGWB observables and how it should be interpreted.

To organize primordial SGWB anisotropies, I will introduce the Cosmological Form Factor (CFF), a model-independent framework describing their response to cosmological long-wavelength perturbations. The CFF characterizes how long modes modulate local short-scale GW statistics and connects observable anisotropies to cosmological correlation functions. This connection allows general principles, including statistical isotropy and locality, to determine the angular and polarization structures, while amplitudes, frequency dependence, and source-time dependence retain information about the underlying mechanism. Both propagation and fossil effects arise as representative realizations of this common framework. As an application, I will show that nearly scale-invariant scalar long modes yield a universal Sachs–Wolfe-like large-angle scaling.