

How Does a Thermal Medium Affect Primordial Gravitational Waves?

Sunday, 8 November 2026 17:00 (30)

A thermal medium modifies the propagation of gauge fields, producing collective excitations with a plasmon gap. Does it affect primordial gravitational waves in the same way? For gravity, the thermal soft scale coincides with the Hubble rate, making cosmic expansion essential to answering this question. In this talk, I compute the linear response of thermal radiation, modeled by a conformal scalar, to metric perturbations on a spatially flat FLRW background. The calculation retains both retarded and contact contributions and satisfies the diffeomorphism Ward identities. Although the adiabatic dispersion relation exhibits a gap, $\omega_p^2 = 8\mathcal{H}^2/5$, with $\mathcal{H}$ the conformal Hubble rate, superhorizon tensor modes remain conserved when the initial-time boundary of the retarded response is retained. The real-time evolution reproduces Weinberg's gravitational-wave damping, with amplitude suppression accumulating around horizon reentry. I also explain how the superhorizon growth found in our earlier analyses arose from discarding the response history and adopting a state prescription incompatible with the Ward identities. These results clarify how a thermal collective gap coexists with conserved primordial perturbations and why cosmological evolution requires a real-time treatment.

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Session Classification : Parallel-Cosmology