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Beyond Zero-Temperature: Moduli Fields, Thermal Corrections, and Dark Matter Production

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Early matter-dominated epochs and non-standard cosmological scenarios are frequently motivated by top-down constructions and UV completions of beyond-Standard Model physics. Scalar fields, as natural extensions to the Standard Model of particles, provide a well-studied framework for exploring deviations from the concordance cosmological model and might play a crucial role in dark matter production - whether through direct decays or modifications to the universe's thermal history. Notably, moduli fields, ubiquitous in supergravity and superstring models, develop finite-temperature corrections to their dynamics, leading to significant cosmological imprints despite never reaching thermal equilibrium. In this talk, we review the general dynamics of scalar fields in cosmology, including finite-temperature effects, and present preliminary results derived from modified Boltzmann equations. By implementing numerical solutions for a toy model of direct production, we explicitly contrast the zero-temperature and finite-temperature regimes, highlighting their phenomenological implications.

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