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Gauss-Bonnet Cosmology: WIMP phenomenology, large–temperature behaviour and bounds from Gravitational Waves

The Weakly Interacting Massive Particle (WIMP) thermal decoupling scenario can be used to probe modified Cosmologies. We apply this idea to the specific example of dilatonic Einstein Gauss-Bonnet (dEGB) gravity, where the Gauss–Bonnet term is non–minimally coupled to a scalar field with vanishing potential. We show that when the WIMP relic density is constrained to match the observed DM abundance in the Universe the ensuing modified cosmological scenario can drive the required WIMP annihilation cross section to Standard Model particles beyond the present bounds from DM indirect detection searches, allowing to constrain the model parameters. Moreover, at temperatures much higher than those relevant for WIMP decoupling, dEGB exhibits only very few asymptotic behaviors, characterized by a few values of the equation of state w. We provide a transparent explanation of this peculiar behaviour in terms of only three attractors (stable critical points) of the set of autonomous differential equations that describe the evolution of the Friedmann equations. Compared to standard Cosmology dEGB can show a strong enhancement of the expected Gravitational Wave stochastic background produced by the primordial plasma of relativistic particles of the Standard Model. This is due to the very peculiar fact that dEGB allows to have an epoch when the energy density of the relativistic plasma dominates the energy of the Universe while at the same time the rate of dilution with the temperature of the total energy density is slower than what usually expected during radiation dominance. The ensuing bounds are complementary to late-time constraints from compact binary mergers.

Presenter: Prof. SCOPEL, Stefano (Sogang U)

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