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Analyzing the Hubble tension through hidden sector dynamics in the early universe

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We propose a particle physics model that can alleviate the observed Hubble tension via an out-of-equilibrium hidden sector coupled to the visible sector. The particles that populate the dark sector consist of a dark fermion, which acts as dark matter, a dark photon, a massive scalar and a massless pseudo-scalar. Assuming no initial population of particles in the dark sector, feeble couplings between the visible and the hidden sectors via kinetic mixing populate the dark sector even though the number densities of hidden sector particles never reach their equilibrium distribution and the two sectors remain at different temperatures. A cosmologically consistent analysis is presented where a correlated evolution of the visible and the hidden sectors with coupled Boltzmann equations involving two temperatures, one for the visible sector and the other for the hidden sector, is carried out. The relic density of the dark matter constituted of dark fermions is computed in this two-temperature formalism. As a consequence, BBN predictions are upheld with a minimal contribution to ΔNeff. However, the out-of-equilibrium decay of the massive scalar to the massless pseudo-scalar close to the recombination time causes an increase in ΔNeff that can help weaken the Hubble tension.

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