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Vacuum dynamics in the Universe: implications on the cosmological tensions

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The possibility that the vacuum energy density (VED) could be time dependent in the expanding Universe is intuitively more reasonable than just a rigid cosmological constant for the entire cosmic history. The framework of the running vacuum model (RVM) is a remarkable example, in which the VED appears as a power series of the Hubble rate, $H(t)$, and its derivatives. The RVM contributes to alleviate the cosmological tensions with the data, and at a more fundamental level it also helps to smooth out certain hardcore aspects of the cosmological constant problem. Finally, a very recent extension of the RVM, in which the dark energy (DE) is a composite system made of running vacuum energy and an entity X called “phantom matter” (which is radically different from phantom DE, since the former produces positive pressure, like ordinary matter, rather than the negative one produced by the latter) has proven capable to yield an excellent fit to the cosmological data. Such a fit, in addition, is compatible with the observed quintessence-like behavior around our time (as reported by the DESI Collaboration). In my talk, I will discuss some of these theoretical aspects of the VED and also some successful phenomenological implications.

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