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## **Renormalizing the vacuum energy in cosmological spacetime: a new approach to the cosmological constant problem**

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Phenomenological studies in the last few years have provided significant support to the idea that the vacuum energy density (VED) is a running quantity with the cosmological evolution. Such a running actually helps in alleviating the cosmological tensions afflicting the  $\Lambda$ CDM. The theoretical studies backing up this approach go under the name of “running vacuum model” (RVM). Using this framework, based on quantum field theory (QFT) in curved spacetime, one can show that the properly renormalized VED in FLRW spacetime can be freed from fine tuning troubles and the vacuum dynamics proves to be a smooth power series of the Hubble rate  $H$  and its time derivatives. The calculation is performed using a new version of the adiabatic renormalization procedure, which leads to a cosmic evolution with the value of  $H$ , i.e.  $\rho_{\text{vac}}(H)$ . As a result the “cosmological constant”  $\Lambda$  appears here as the nearly sustained value of  $8\pi G(H)\rho_{\text{vac}}(H)$  around (any) given epoch  $H$ , where  $G(H)$  is the gravitational coupling, which runs very mildly (logarithmically). The VED evolution between points  $H$  and  $H_0$  of the cosmic history reads  $\delta\rho_{\text{vac}}(H) \sim v_{\text{eff}} m_{\text{Pl}}^2 (H^2 - H_0^2)$  (where the coefficient  $|v_{\text{eff}}| \ll 1$ ) and  $m_{\text{Pl}}$  is the Planck mass. The effective coefficient  $v_{\text{eff}}$  receives contributions from all the quantized matter fields and can be explicitly computed in QFT. Remarkably, there also exist higher powers of  $H$  which can trigger inflation in the early universe. Finally, the equation of state (EoS) of the running vacuum receives also quantum corrections from bosons and fermion fields, shifting its value from  $-1$ . The striking consequence is that the EoS of the quantum vacuum may nowadays appear as quintessence, as DESI has reported. But the ultimate source of the dynamics stems from the running QFT vacuum, not from fundamental quintessence fields.

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