

Defocusing dark energy: Raychaudhuri diagnostics beyond $w < -1/3$ and the phantom divide

miércoles, 16 de septiembre de 2026 14:25 (25)

In general relativity, cosmic acceleration is a statement about geometry—the timelike defocusing of the comoving congruence—and the field equations source it with mass–energy combinations, not with any equation-of-state ratio. Evolving dark energy is now back at the center of cosmology, and several scenarios under active discussion—sign-switching Λ_s CDM and AdS-to-dS transitions, which simultaneously ease the H_0 and S_8 tensions and restore $\sum m_\nu$ to physical values, as well as modified-gravity backgrounds recast in GR-like form—feature an effective dark-energy density that is negative in the past and crosses zero at some redshift $z_\dagger$. Our standard language quietly assumes this never happens: $w_{\text{de}} < -1/3$ signals repulsion only while $\rho_{\text{de}} > 0$ and the inequality reverses on the negative branch; the phantom divide $w_{\text{de}} = -1$ stops separating anything once the density changes sign; at $\rho_{\text{de}} = 0$ the ratio w_{de} does not exist, though nothing physical is singular there; and sign-preserving parametrizations such as w_0 – w_a cannot represent the crossing at all. In this talk, based on arXiv:2607.18008, we ask what defines dark energy when w cannot, and answer with the two combinations the field equations actually use: the active gravitational mass density $\mathcal{M} = \rho + 3p$, which drives Raychaudhuri defocusing, and the inertial mass density $\mathcal{I} = \rho + p$, whose zero—the null energy condition (NEC) boundary—replaces the phantom divide as the regular separator. Sharp results follow: any smooth sign switch is phantom-like and repulsive at the crossing, with the total NEC intact; the pole in w_{de} is purely kinematic, with universal residue $n(1 + z_\dagger)/3$, so $w_{\text{de}} = -1$ is never attained and the two sides of the divide connect only through the pole; repulsion begins strictly before the switch, at $z_{\text{rep}} > z_\dagger$; an exact window in $\rho'_{\text{de}}(z_\dagger)$ permits acceleration at the crossing itself; and the deceleration parameter admits exactly one or three sign-changing zeros. An analytic Λ_s CDM profile, exponential infrared $f(T)$ gravity, and the minimal phantom brane realize the pattern. The practical moral for reconstructions: across $\rho_{\text{de}} = 0$ the regular targets are $(\rho_{\text{de}}, p_{\text{de}}, \mathcal{I}_{\text{de}}, \mathcal{M}_{\text{de}})$ —kinematic totals need no dark-sector split—and parametrizations should be allowed to change sign.

Primary author(s) : AKARSU, Ozgur (Istanbul Technical University (ITU))

Co-author(s) : DE FELICE, Antonio (Kyoto University); UZUN, Merve (Istanbul Technical University)

Presenter(s) : AKARSU, Ozgur (Istanbul Technical University (ITU))

Clasificación de la sesión : Afternoon Session (Wednesday)