At sufficiently large radii dark energy modifies the behavior of bound orbits around a galaxy and virialized gas in a cluster of galaxies.

Dark energy necessitates the use of the generalized Virial Theorem to describe gas at the outskirts of a cluster. As a result, gas at a radius of 5 Mpc or above can readily escape, and a decreasing fraction towards the inner radii can do likewise:

$$2\tilde{K} = -\tilde{V}_1 + 2\tilde{V}_2$$

There exists a maximum circular orbit beyond which periodic motion is no longer possible, and the evolution of orbits near critical binding is analytically calculable using an adiabatic invariant integral.

$$I = \int_{R_{per}}^{R_{aph}} \sqrt{E - V(R)} \, dR$$

$$V(R, t) = \frac{J^2}{2R^2} - \frac{GM}{R} + \frac{1}{2} qH_0^2 R^2$$

Reasons why the boundary radius is important:

*Mass and spatial extent of dark halos
*Location and quantity of baryons in a bound structure
*Large scale dynamics of structures in an ΛCDM cosmology

Impact to community:

*Dynamical test for the existence of dark energy
*Furthers understanding of inter and intra-cluster medium
*Theory for continued precision in astrodynamics

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