1. DARK ENERGY

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1.1. Repulsive Gravity and Cosmic Acceleration

In the late 1990s, supernova surveys by two independent teams provided direct evidence for accelerating cosmic expansion [8,9], establishing the cosmological constant model (with $\Omega_{\rm m} \approx 0.3$, $\Omega_\Lambda \approx 0.7$) as the preferred alternative to the $\Omega_{\rm m} = 1$ scenario. Shortly thereafter, CMB evidence for a spatially flat universe [10,11], and thus for $\Omega_{\rm tot} \approx 1$, cemented the case for cosmic acceleration by firmly eliminating the free-expansion alternative with $\Omega_{\rm m} \ll 1$ and $\Omega_\Lambda = 0$. Today, the accelerating universe is well established by multiple lines of independent evidence from a tight web of precise cosmological measurements.

As discussed in the Big Bang Cosmology article of this *Review* (Sec. 22), the scale factor $R(t)$ of a homogeneous and isotropic universe governed by GR grows at an accelerating rate if the pressure $p < -\frac{1}{3}\rho$. A cosmological constant has $\rho_\Lambda =$ const. and pressure $p_\Lambda = -\rho_\Lambda$ (see Eq. 22.10), so it will drive acceleration if it dominates the total energy density. However, acceleration could arise from a more general form of "dark energy" that has negative pressure, typically specified in terms of the equation-of-state-parameter $w = p/\rho$ ($= -1$ for a cosmological constant). Furthermore, the conclusion that acceleration requires a new energy component beyond matter and radiation relies on the assumption that GR is the correct description of gravity on cosmological scales. The title of this article follows the common but inexact usage of "dark energy" as a catch-all term for the origin of cosmic acceleration, regardless of whether it arises from a new form of energy or a modification of GR.

For further discussion and references, see the full *Review*.