In [physical cosmology](https://en.wikipedia.org/wiki/Physical_cosmology) and [astronomy](https://en.wikipedia.org/wiki/Astronomy), **dark energy** is an unknown form of [energy](https://en.wikipedia.org/wiki/Energy) which is [hypothesized](https://en.wikipedia.org/wiki/Hypothesis) to permeate all of space, tending to [accelerate](https://en.wikipedia.org/wiki/Accelerating_universe) the [expansion of the universe](https://en.wikipedia.org/wiki/Hubble%27s_law).[[1]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-peebles-1) Dark energy is the most accepted hypothesis to explain the observations since the 1990s indicating that the universe is [expanding](https://en.wikipedia.org/wiki/Metric_expansion_of_space) at an [accelerating rate](https://en.wikipedia.org/wiki/Deceleration_parameter).

Assuming that the [standard model of cosmology](https://en.wikipedia.org/wiki/Lambda-CDM_model) is correct, the [best current measurements](https://en.wikipedia.org/wiki/Planck_%28spacecraft%29#2013_data_release) indicate that dark energy contributes 68.3% of the total energy in the present-day [observable universe](https://en.wikipedia.org/wiki/Observable_universe). The mass–energy of [dark matter](https://en.wikipedia.org/wiki/Dark_matter) and [ordinary (baryonic)](https://en.wikipedia.org/wiki/Baryon#Baryonic_matter) [matter](https://en.wikipedia.org/wiki/Matter) contribute 26.8% and 4.9%, respectively, and other components such as [neutrinos](https://en.wikipedia.org/wiki/Neutrino) and [photons](https://en.wikipedia.org/wiki/Photon) contribute a very small amount.[[2]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-planck_overview-2)[[3]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-planck_overview2-3)[[4]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-wmap7parameters-4)[[5]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-DarkMatter-5) Again, on a mass–energy equivalence basis, the density of dark energy (~ 7 × 10−30 g/cm3) is very low, much less than the density of ordinary matter or dark matter within galaxies. However, it comes to dominate the mass–energy of the universe because it is uniform across space.[[6]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-6)[[7]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-7)[[8]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-8)

Two proposed forms for dark energy are the [cosmological constant](https://en.wikipedia.org/wiki/Cosmological_constant),[[9]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-9) a constant energy density filling space homogeneously,[[10]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-carroll-10) and [scalar fields](https://en.wikipedia.org/wiki/Scalar_field_theory) such as [quintessence](https://en.wikipedia.org/wiki/Quintessence_%28physics%29) or [moduli](https://en.wikipedia.org/wiki/Moduli_%28physics%29), dynamic quantities whose energy density can vary in time and space. Contributions from scalar fields that are constant in space are usually also included in the cosmological constant. The cosmological constant can be formulated to be equivalent to the [zero-point radiation](https://en.wikipedia.org/wiki/Zero-point_energy) of space i.e. the [vacuum energy](https://en.wikipedia.org/wiki/Vacuum_energy).[[11]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-11) Scalar fields that do change in space can be difficult to distinguish from a cosmological constant because the change may be extremely slow.

High-precision measurements of the [expansion of the universe](https://en.wikipedia.org/wiki/Metric_expansion_of_space) are required to understand how the expansion rate changes over time and space. In [general relativity](https://en.wikipedia.org/wiki/General_relativity), the evolution of the expansion rate is parameterized by the cosmological [equation of state](https://en.wikipedia.org/wiki/Equation_of_state_%28cosmology%29) (the relationship between temperature, pressure, and combined matter, energy, and vacuum energy density for any region of space). Measuring the equation of state for dark energy is one of the biggest efforts in observational cosmology today. Adding the cosmological constant to cosmology's standard [FLRW metric](https://en.wikipedia.org/wiki/Friedmann%E2%80%93Lema%C3%AEtre%E2%80%93Robertson%E2%80%93Walker_metric) leads to the [Lambda-CDM model](https://en.wikipedia.org/wiki/Lambda-CDM_model), which has been referred to as the "*standard model of cosmology*" because of its precise agreement with observations. Dark energy has been used as a crucial ingredient in a recent attempt to formulate a [cyclic model](https://en.wikipedia.org/wiki/Cyclic_model) for the universe

Many things about the nature of dark energy remain matters of speculation.[[13]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-13) The evidence for dark energy is indirect but comes from three independent sources:

* Distance measurements and their relation to redshift, which suggest the universe has expanded more in the last half of its life.[[14]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-Durrer-14)
* The theoretical need for a type of additional energy that is not matter or dark matter to form the [observationally flat universe](https://en.wikipedia.org/wiki/Observationally_flat_universe) (absence of any detectable global curvature).
* It can be inferred from measures of large scale wave-patterns of mass density in the universe.

Dark energy is thought to be very [homogeneous](https://en.wiktionary.org/wiki/Homogeneous), not very [dense](https://en.wikipedia.org/wiki/Density) and is not known to interact through any of the [fundamental forces](https://en.wikipedia.org/wiki/Fundamental_forces) other than [gravity](https://en.wikipedia.org/wiki/Gravity). Since it is quite rarefied — roughly 10−27 kg/m3 — it is unlikely to be detectable in laboratory experiments. Dark energy can have such a profound effect on the universe, making up 68% of universal density, only because it uniformly fills otherwise empty space. The two leading models are a [cosmological constant](https://en.wikipedia.org/wiki/Cosmological_constant) and [quintessence](https://en.wikipedia.org/wiki/Quintessence_%28physics%29). Both models include the common characteristic that dark energy must have negative pressure.

**Effects**

Independently of its actual nature, dark energy would need to have a strong negative pressure (acting repulsively) like [radiation pressure](https://en.wikipedia.org/wiki/Radiation_pressure) in a [metamaterial](https://en.wikipedia.org/wiki/Metamaterial)[[15]](https://en.wikipedia.org/wiki/Dark_energy#cite_note-15) to explain the observed [acceleration](https://en.wikipedia.org/wiki/Accelerating_universe) of the [expansion of the universe](https://en.wikipedia.org/wiki/Metric_expansion_of_space). According to general relativity, the pressure within a substance contributes to its gravitational attraction for other things just as its mass density does. This happens because the physical quantity that causes matter to generate gravitational effects is the [stress–energy tensor](https://en.wikipedia.org/wiki/Stress%E2%80%93energy_tensor), which contains both the energy (or matter) density of a substance and its pressure and viscosity. In the [Friedmann–Lemaître–Robertson–Walker metric](https://en.wikipedia.org/wiki/Friedmann%E2%80%93Lema%C3%AEtre%E2%80%93Robertson%E2%80%93Walker_metric), it can be shown that a strong constant negative pressure in all the universe causes an acceleration in universe expansion if the universe is already expanding, or a deceleration in universe contraction if the universe is already contracting. This accelerating expansion effect is sometimes labeled "gravitational repulsion", which is a colorful but possibly confusing expression. In fact, a negative pressure does not influence the gravitational interaction between masses—which remains attractive—but rather alters the overall evolution of the universe at the cosmological scale, typically resulting in the accelerating expansion of the universe despite the attraction among the masses present in the universe. The acceleration is simply a function of dark energy density. Dark energy is persistent: its density remains constant (experimentally, within a factor of 1:10), i.e. it does not get diluted when space expands.