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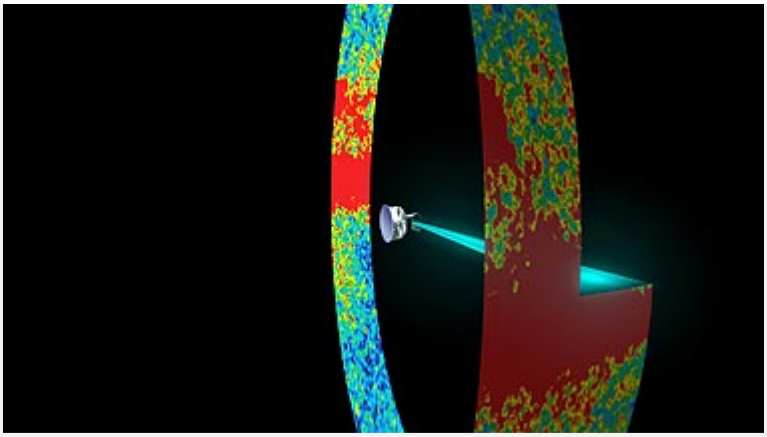
What is dark energy?

Week 39

Exactly what is dark energy? Astrophysicists would also like to know the answer to this question – it determines how the Universe will develop. Cosmologists are fairly sure that it has been expanding since the Big Bang. (For more on this topic, see the astronomy question from week 38: How quickly is the Universe expanding?) What is still uncertain is whether this expansion will continue forever or whether the Universe will one day begin to collapse again, and also how much mass is present in the Universe – or would have to be present – to prevent one or other of these two scenarios from occurring.

When Albert Einstein formulated the general theory of relativity at the beginning of the 20th century, he assumed that the Universe is static. He therefore had to include an additional expression in his equations, referred to as the cosmological constant. In 1929, Edwin Hubble discovered that the rate at which distant galaxies move away from Earth increases the further away they are; this observation indicated that the Universe is expanding. In an expanding Universe, the cosmological constant is no longer crucial and its necessity was hotly debated in the decades that followed.

Accelerating expansion of the Universe



The Planck space telescope also has its sights on dark energy

In 1998, this abruptly changed. Two research groups used exploding stars – type 1a supernovae – to show that the cosmic expansion is not being slowed down as expected by gravitational attraction between the matter in the Universe. In fact, the Universe is expanding increasingly quickly. However, an accelerating expansion in a Universe with a cosmological constant is to be expected. The cosmological constant might correspond to a special form of energy that counteracts the mutual attraction of matter. The term 'dark energy' has established itself as a generic name for the various attempts made by astronomers to explain the observations. The existence of dark energy has been confirmed and quantified as a result of various studies – for example, on microwave background radiation, the large-scale distribution of matter in space and using gravitational lenses. Around 70 percent of the Universe (and its density of electromagnetic energy) consists of dark energy!

However, astronomers are still speculating as to the nature of dark energy. It is often interpreted as being a characteristic of a vacuum –'vacuum energy'. In what are known as quintessence models, dark energy is a time-dependent variable. Perhaps it is a natural constant that depicts a curvature of space that is unrelated to the presence of matter? Some theories avoid the concept of dark energy and attempt to explain the observations by an inhomogeneous distribution of matter throughout the Universe. Numerous experiments are currently being planned in order to test these and other ideas.

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