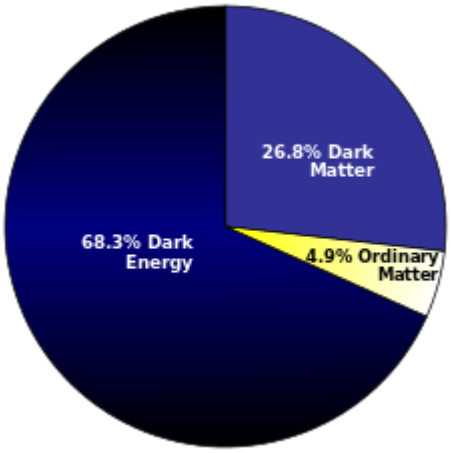
Dark Energy

1. What is dark energy?

Dark energy is a name given to a hypothetical force that accelerates the expansion of the universe. Amazingly only in 1998 astronomers discovered nearly three quarters of the contents of the universe was unknown. This was called dark energy, an unknown form of energy, permeating the whole of the universe, causing the expansion of the universe to accelerate. Dark energy is the hypothesis to explain the observations in the 1990's of the accelerated expansion of the universe. It consists of 68.3 percent of the contents of the universe. See diagram below.

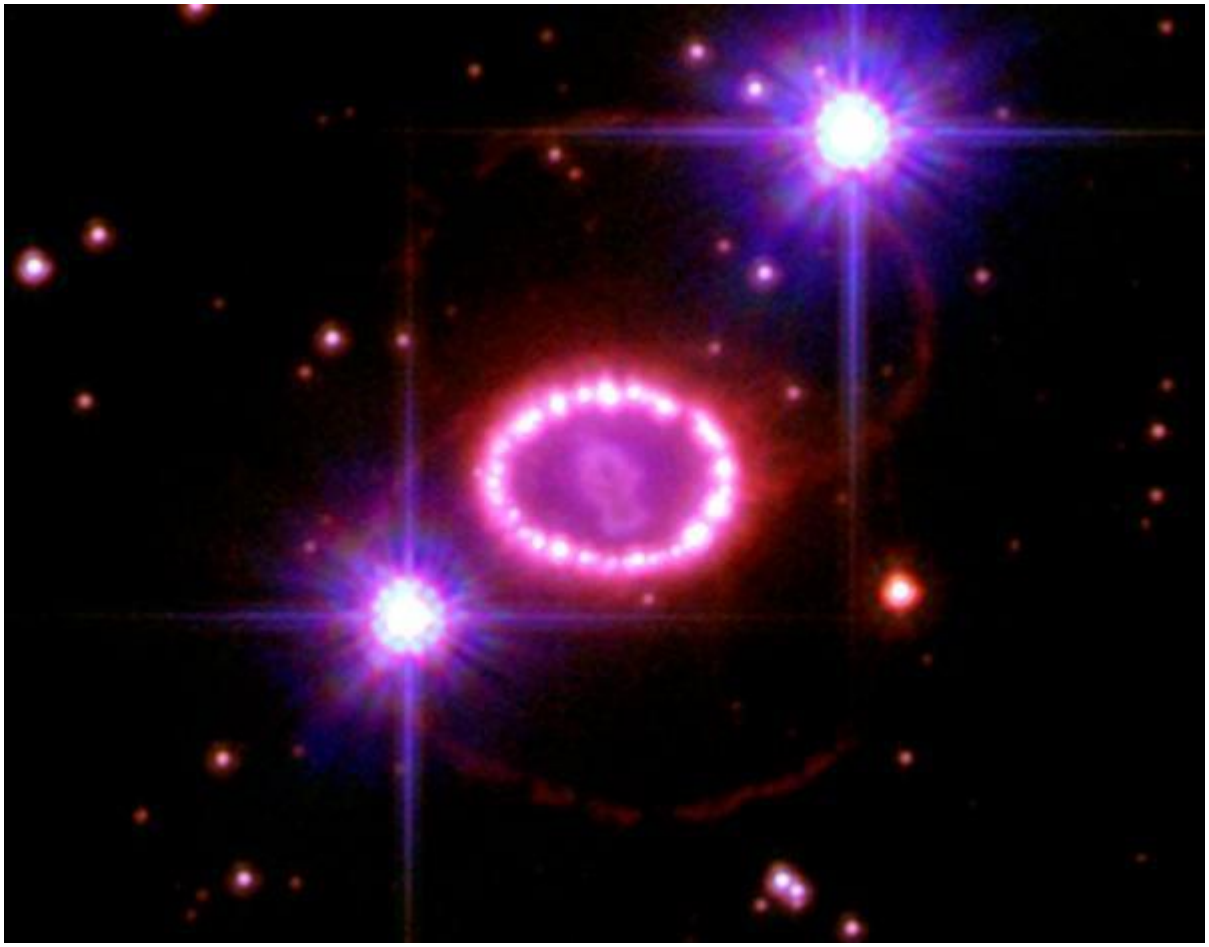


Credit: Wikipedia

2. Evidence for Dark Energy

In the expanding universe galaxies move apart at a speed that depends on the distance between them. How do

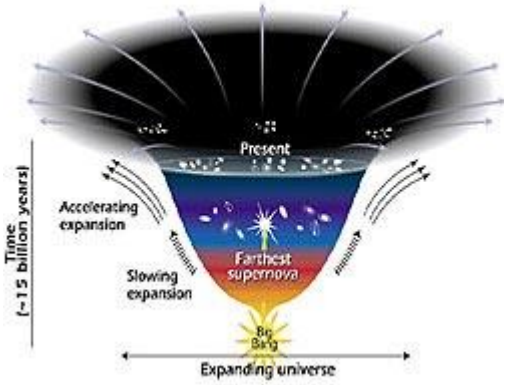
scientists measure this effect? Standard candles whose luminosity is assumed to be known such as type 1a supernovae are the most luminous standard candles used. In an expanding universe galaxies are moving apart at a rate that depends on the distance between them. This effect can be measured using supernovae 1a since their spectral redshift reveals the speed at which the galaxy moved away and their brightness the distance. See photo below of supernova.



Supernova 1987A. Credit NASA.

The Cosmic Microwave Background Radiation contains spots the size of which reveals the overall geometry of space and consequently the density of the universe. This quantity exceeds the amount of matter. It therefore follows that a missing component such as dark energy must reflect the difference. In addition the CMBR has been slightly reworked by gravitational fields of cosmic structures. This reworking reflects how the expansion of the universe has changed and must be a reflection of what dark energy would do.

Gravitational lensing is the result of the bending of the light by the intervening matter if the light source is directly behind the object. Studies of this phenomena show how clumps of matter have grown over time which is a reflection of dark energy. See diagram below for a reflection of the influence of dark energy on the expansion of the universe.



Credit NASA.

3. Influence of dark energy on the expansion of the universe.

Studies revealed that the earliest galaxies appear to be merging. As time went on the merger of galaxies became less common. Between two billion and six billion years after the formation of the universe the fraction of galaxies undergoing a merger dropped from half to just under one

percent. 1) Since then the merger of galaxies have become uncommon. Currently the number of massive galaxies in the universe are either elliptical of spiral galaxies, shapes and structures that would be disrupted by a merger. These galaxies consist mostly of old stars telling us they have formed early and their forms remained unchanged. Most of the stars today have been formed in the early part of the universe. This decline of merger of galaxies in the second half of the universe is indicative of the accelerated expansion of the universe and the influence of dark energy.

The influence of dark energy has emerged as the most probable explanation for the decrease in galaxy and black hole formation. The idea is that the decrease in galaxy mergers coincide with the timing when the force of dark energy appeared to have overwhelmed the attractive force of gravity which is a prerequisite for the formation of stars and galaxies. Similarly, dark energy is seen as the force driving galaxies and clusters of galaxies away from each other preventing the merger of galaxies and the formation of new black holes. It seems dark energy will force galaxies and clusters of galaxies further and further away from each other so fast that we will lose sight of them.

1) Christopher J. Conselice quoted in the Special Collectors Edition of Scientific America November 2014.

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