



Cosmology

What is Cosmology?

Since the beginning of history, people have looked up into the sky and asked,

- How did the Universe come into existence?
- How are the stars and galaxies formed?
- What will be the ultimate fate of the universe?

Cosmology is the overall study of the universe which primarily aims to address the above questions.

Cosmological Principle

Today, cosmologists have a much grander view of the Universe, extending far beyond our solar system. Modern cosmologists think that the universe has no Center at all. Viewed on a sufficiently large scale, the universe looks much the same from all points (homogeneity) and in all the directions (isotropy).

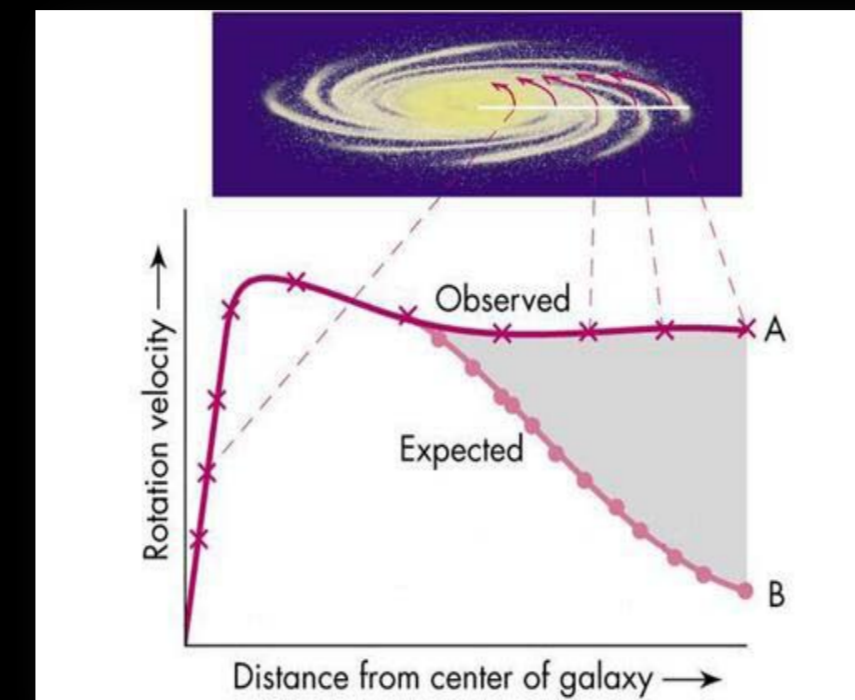
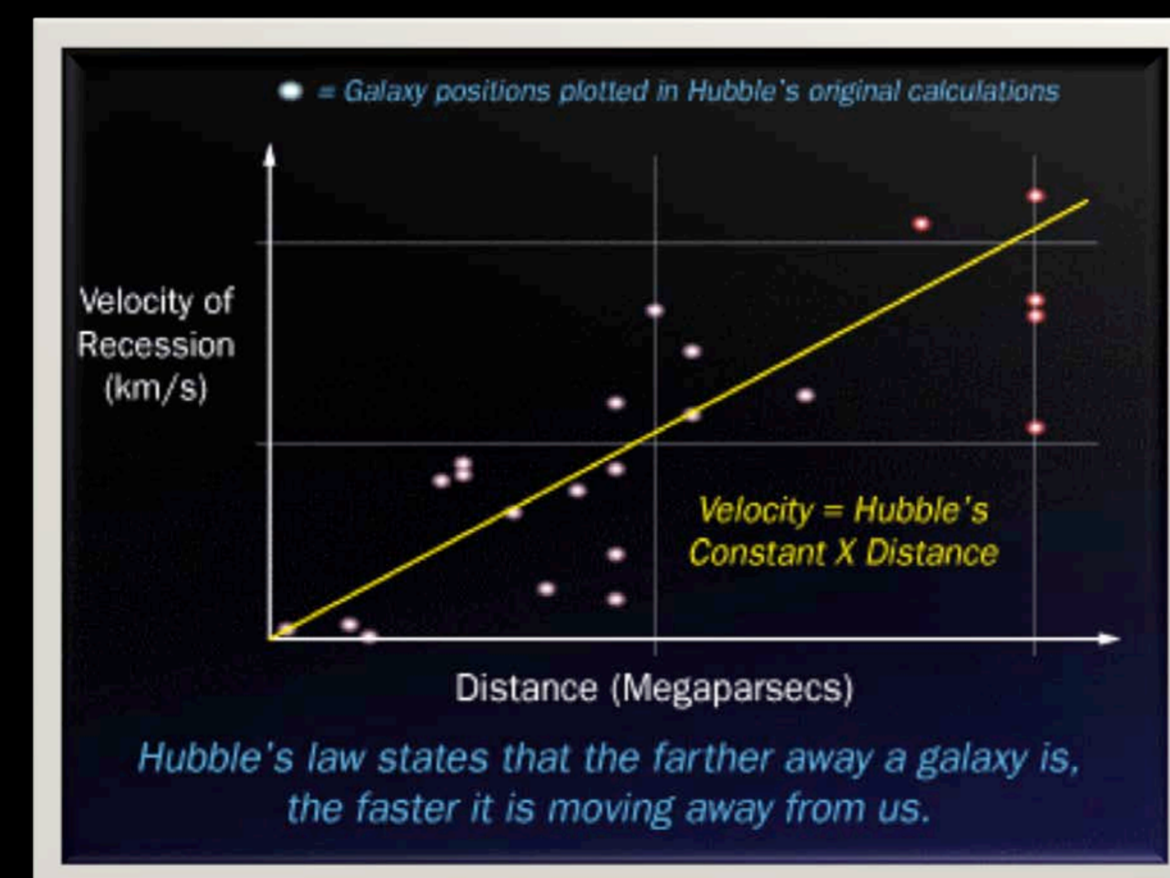
The clusters themselves form superclusters which organize themselves into walls and filaments spanning a few hundred million lightyears. It is believed that at scales of around 100 Mpc, the lumpiness begins to homogenize and isotropize.

Hubble's Law



In 1929, after nearly a decade of observations from the telescope at Mt. Wilson, Edwin Hubble discovered that the galaxies were moving away from us. He determined the nature of the galaxies receding and gave us the Hubble's law : $v = H \cdot d$

- v = velocity of the galaxy.
- H = Hubble's constant.
- d = distance to the galaxy.

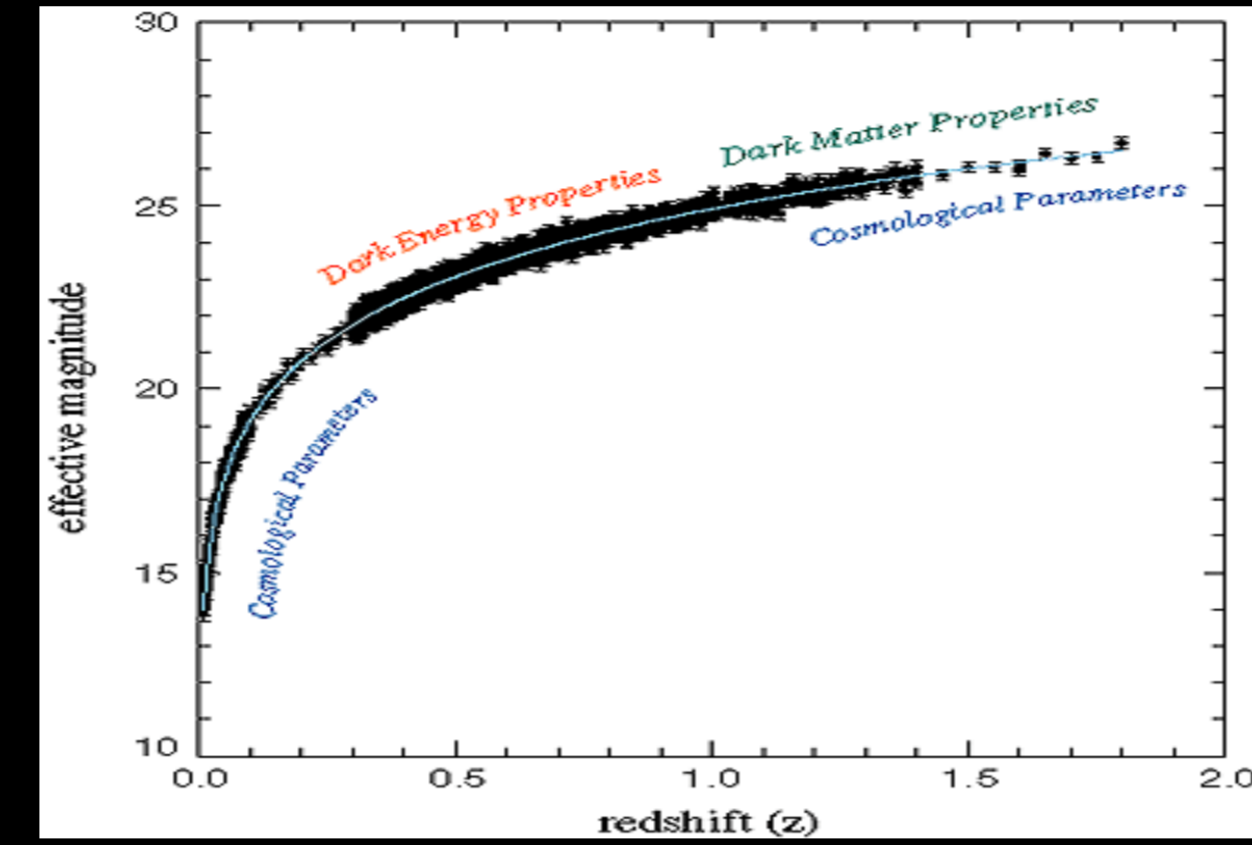


Dark Matter

From the Newton's law one would expect the velocity with which a star revolve around a given galaxy beyond its centre bulge to fall as $R^{-1/2}$. However, observations unveiled that it is actually constant. This discrepancy in the galaxy rotation curve indicate the presence of a substantial amount of matter far from the center of the galaxy that is not emitting light known as Dark Matter.

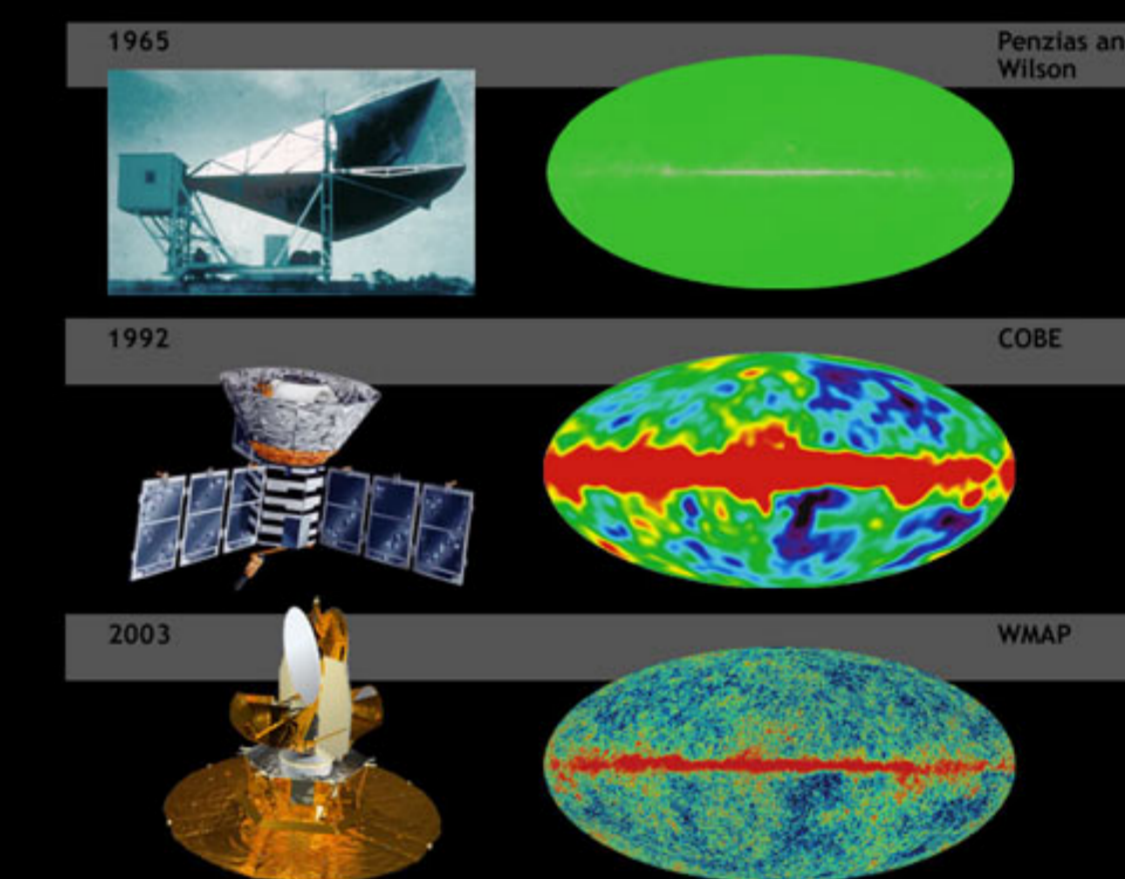
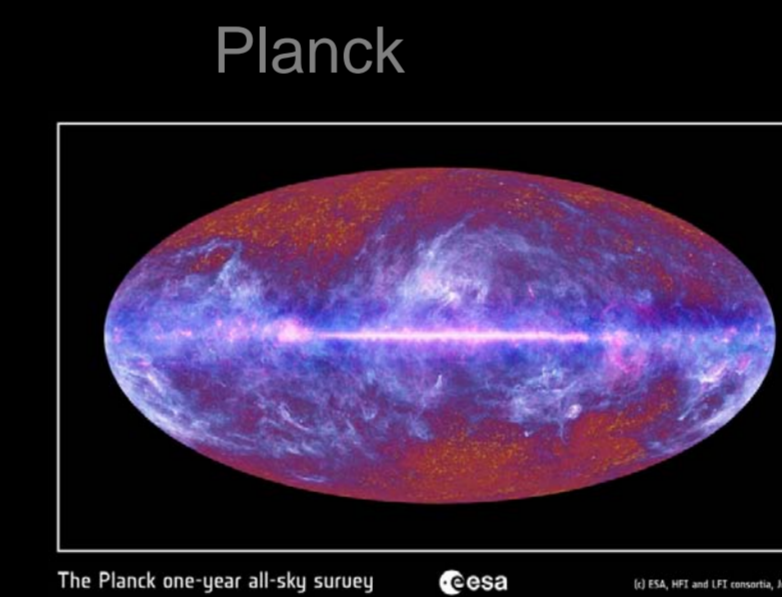
The Accelerating Universe

The presence of Dark Energy was revealed through a 10-year study of the spectacular astronomical events known as supernovae (extremely bright exploding stars). Light coming from far beyond Earth must cross expanding space. This shifts the colour of light waves towards the red end of the spectrum. If the expansion of the Universe were now slowing under the influence of gravity, supernovae in distant galaxies would appear brighter. Instead, the most distant supernovae seem to be dimmer. This means that the expansion rate of the Universe is accelerating due to some invisible, unidentified energy with negative pressure offsetting gravity. The Nobel Prize in Physics 2011 was awarded to Saul Perlmutter, Brian P. Schmidt and Adam G. Riess "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae"



Observational cosmology

Cosmic Microwave Background Radiation carries the frozen imprint of the density fluctuation in the early universe. Therefore several ground based and space based experiments are carried out for measuring the CMBR upto a higher degree of accuracy. Some of the satellite for measuring CMBR are : COBE, WMAP, Planck

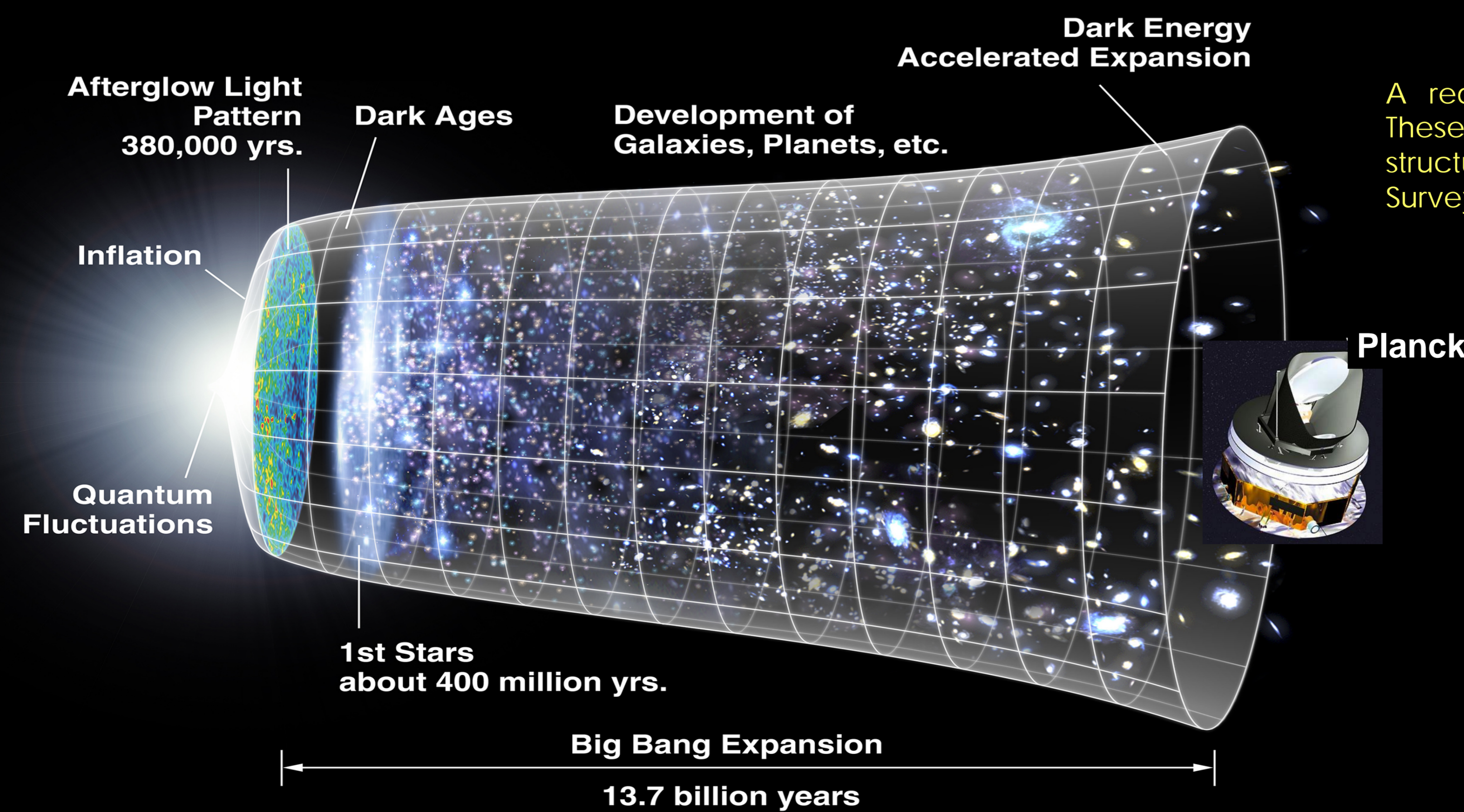
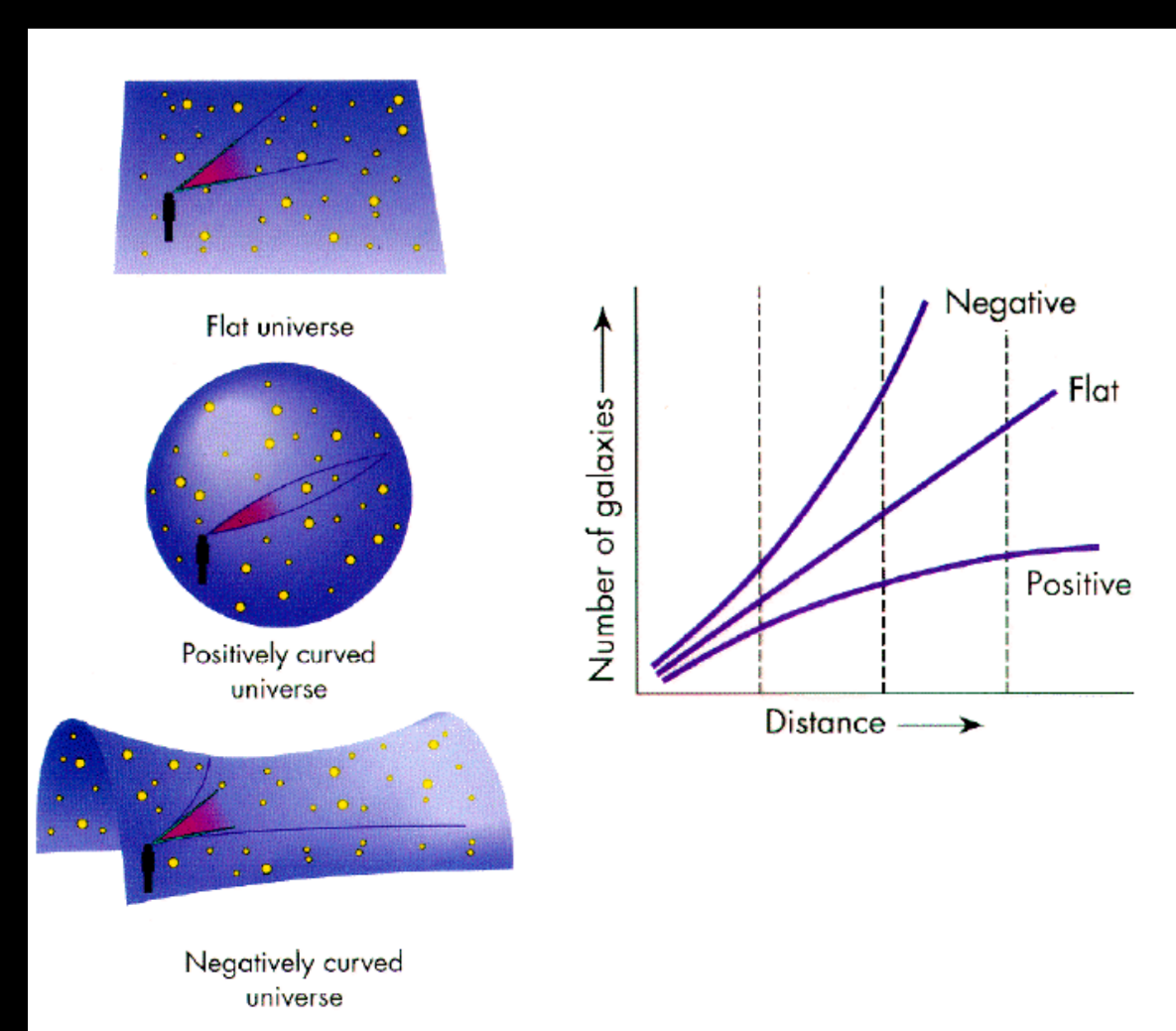


Composition of the Universe

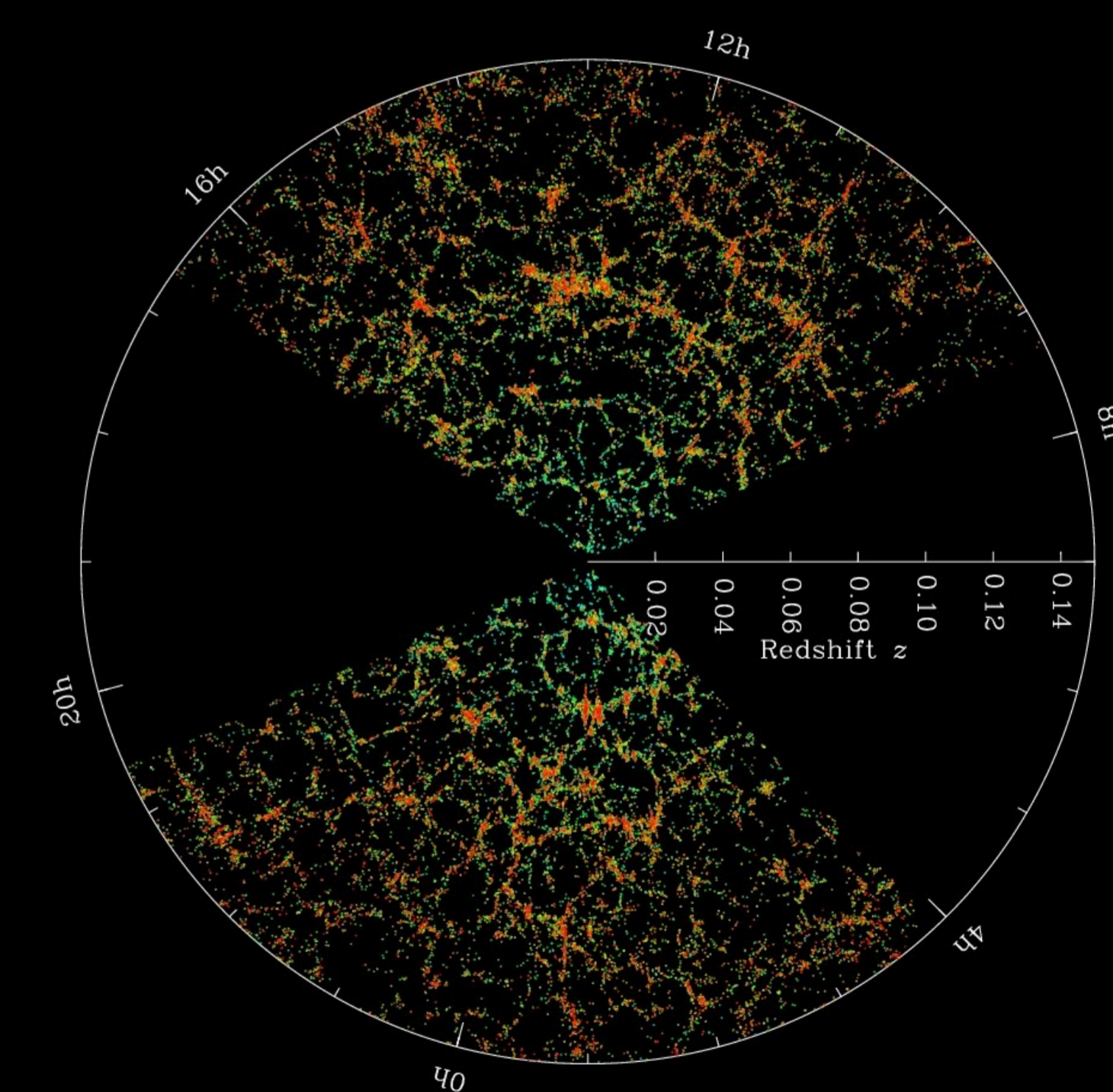


Geometry of the Universe

If we solve the Einstein's equations of General relativity for a homogenous and isotropic Universe, then there are basically three possible geometry to the Universe; a flat Universe (Euclidean or zero curvature), a spherical Universe (positive curvature) or a hyperbolic Universe (negative curvature). Observations from CMBR indicate that the geometry is close to a flat Universe.



A redshift survey maps the 3D distribution of matter within a field of the sky. These observations are used to measure properties of the large scale structure of the universe. The most notable surveys are 2dF Galaxy Redshift Survey, Sloan Digital Sky Survey and 2MASS Redshift Survey.



Supernova is a stellar explosion that is extremely luminous over several weeks or months. It outshines an entire galaxy before fading out. These are used as standard candles and hence can be indicator of astronomical distances. Observations of supernovae also supports the view that the expansion of the universe is accelerating. Some of the surveys observing supernova are CfA, Sloan Digital sky survey etc.