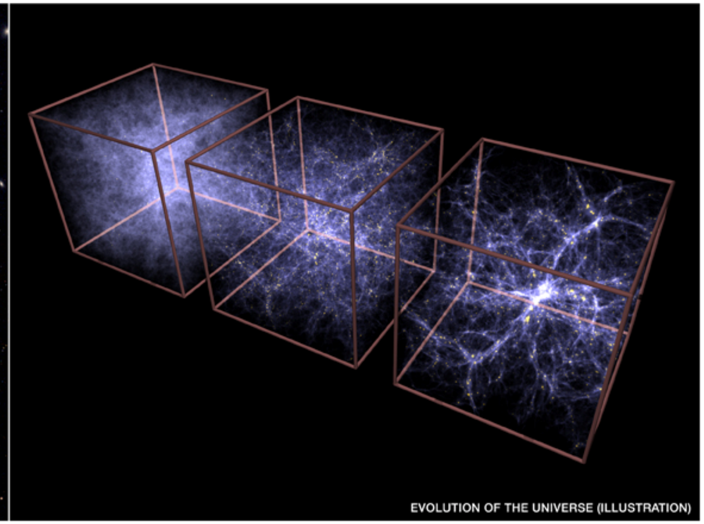
Chandra Science Highlight

Abell 85: Dark Energy Found Stifling Growth in Universe



Scale: Image is 42 arcsec across.

The composite image on the left is of the galaxy cluster Abell 85, located about 740 million light years from Earth. The purple emission is multi-million degree gas detected in X-rays by NASA's Chandra X-ray Observatory and the other colors show galaxies in an optical image from the Sloan Digital Sky Survey. This galaxy cluster is one of 86 observed by Chandra to trace how dark energy has stifled the growth of these massive structures over the last 7 billion years. The illustration on the right shows snapshots from a simulation representing the growth of cosmic structure when the Universe was 0.9 billion, 3.2 billion and 13.7 billion years old (now). This shows how the Universe has evolved from a smooth state to one containing a vast amount of structure. Gas is shown in these snapshots, where the yellow regions are stars and the brightest structures are galaxies and galaxy clusters.

•Constraints on dark energy and dark matter have been derived from a sample of 49 low redshift galaxy clusters and 37 high redshift clusters. The change in the mass function of the clusters allows the presence of dark energy to be detected at a 5-sigma significance level, easily the strongest evidence for dark energy using a growth of structure technique.

•The dark energy equation of state parameter (w) is determined to be w=-1.14 with 20% errors, assuming constant w and a flat universe.

•Constraints on dark energy are significantly improved when combined with other methods, namely the latest supernova, cosmic microwave background and baryonic acoustic oscillation measurements. With this combined approach, w = -0.991 with a 4.5% statistical error, giving the most precise constraint ever on dark energy. There is a factor of 1.5 reduction in statistical uncertainties and a factor of 2 reduction in systematic uncertainties, compared to results that can be obtained without clusters.

•These results provide strong evidence that the cosmological constant, interpreted to be the energy density of the vacuum, is the explanation for dark energy and cosmic acceleration. Crucially, the results also limit deviations from Einstein's General Theory of Relativity, the standard theory of gravity.

Reference: A.Vikhlinin et al. 2008 astro-ph arXiv:0812.2720

Credit: X-ray (NASA/CXC/SAO/A.Vikhlinin et al.); Optical (SDSS); Illustration (MPE/V.Springel)

December 2008

CXC operated for NASA by the Smithsonian Astrophysical Observatory