Dark Energy at Redshift Z=1

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Tuesday, 05 December 2006

Dark energy, the unidentified force that's pushing the universe to expand at ever faster rates, was already at work as early as nine billion years ago, scientists reported last week. New Hubble Space Telescope sightings of distant supernova explosions support the explanation of dark energy as energy of the vacuum whose density has stayed constant throughout the universe's history, the scientists said.

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This cosmic acceleration was first revealed in 1998 by two separate teams of astrophysicists. By measuring the brightness of supernova explosions from up to seven billion light years ago, the scientists discovered an unexpected discrepancy. The supernovae appeared dimmer, and thus farther, than expected from their measured red shifts. Put another way, supernovae at a given distance were less redshifted than expected. Because red shift measures how much light waves stretch as the universe expands, the lower red shift meant that, early on, the light from these distant supernovae had traveled in a universe that was expanding at a slower rate than the current universe (whose rate of expansion is known by other means). The then-widely accepted model of cosmology required instead that the universe be slowing down in its expansion, owing to the mutual gravitational tug of all of the matter and energy contained in it.

Using the Hubble, a team led by Adam Riess, an astrophysicist at the Space Telescope Science Institute and at Johns Hopkins University has now observed 23 new supernovae dating back to 8 to 10 billion years ago, he said in a Nov. 16 NASA press conference. That was an era of intense star formation, when galaxies were three times as bright as they are today. Until now, astronomers had only seen seven supernovae from that period, Riess said, too few to measure the properties of dark energy. The data show that the repulsive action of dark energy was already active at that time, and are consistent with a constant energy density -- in other words, with an energy of the vacuum that does not dilute itself as the universe expands, eventually fueling an exponential growth of the universe.

More
complicated models with non-constant energy density -- including a class known as quintessence models -- are not completely ruled out, Riess said during the press conference: the new data still allows for variations of up to 45 percent from constant density. "It's still pretty crude," Riess said. For more recent ages, dark energy is known to have been constant up to a 10 percent variation. Mario Livio, another STScI astronomer who also was at hand at the press conference, said, "The results only rule out certain variants of quintessence models," but not all of them.

Lawrence Berkeley Lab astrophysicists Saul Perlmutter, who leads another supernova search, says that this is a step in the right direction, but that only a new, dedicated space telescope will be able to constrain the variation enough to convince scientists that dark energy is constant. "We expect that the differences will be much more subtle between the various models of dark energy," he says. Perlmutter says his team is also looking at supernovae from the distant past, focusing on ones from dust-free regions of the universe, in order to estimate the statistical and systematic uncertainties of the measurements.

The new data also confirm the reliability of supernovae as signposts of the universe's expansion, Riess said. The particular kind of supernova used for this kind of measurement, called type Ia, takes place when a white dwarf star becomes heavier by accreting matter from a companion star, until -- at a critical mass of about 1.4 times the mass of our sun -- it undergoes a thermonuclear explosion. Virtually all type Ia supernovae have very standard characteristics -- they all follow the same cycle, have roughly the same brightness and relative abundances of elements, as seen from their spectra. This makes astrophysicists believe that type Ia's have a predictable intrinsic brightness, making their distances easy to estimate. It now appears that the same is true for the oldest supernovae, even though the elemental composition of the universe as a whole was different back then.

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To appear in Astrophysical Journal, 10 February 2007

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