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DISTANT EXPLODING STARS FORETELL FATE OF THE UNIVERSE

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BERKELEY, CA--New studies of exploding stars in the farthest reaches of deep space indicate that the universe will expand forever, according to findings of the Supernova Cosmology Project, an international team of astrophysicists based at the Department of Energy's Ernest Orlando Lawrence Berkeley National Laboratory.

The research, utilizing data obtained with the world's most powerful optical telescopes, including NASA's Hubble Space Telescope, is being presented today at the meeting of the American Astronomical Society in Washington, D.C.

"Distant supernovae provide natural mile-markers which can be used to measure trends in the cosmic expansion," says Berkeley Lab's Saul Perlmutter, leader of the Supernova Cosmology Project. "All the indications from our observations of supernovae spanning a large range of distances are that we live in a universe that will expand forever. Apparently there isn't enough mass in the universe for its gravity to slow the expansion, which started with the Big Bang, to a halt."

This result rests on analysis of 40 of the roughly 65 supernovae so far discovered by the Supernova Cosmology Project. Exploding stars known as supernovae are so intrinsically bright that their light is visible half-way across the observable universe. By the time the light of the most distant supernova explosions so far discovered by the team reached telescopes on earth, some 7 billion years had past since the stars exploded.

After such a journey the starlight is feeble, and its wavelengths have been stretched by the expansion of the universe over time (a phenomenon known as redshift). By comparing the faint light of distant supernovae to that of bright nearby supernovae, the astrophysicists were able to determine how far the supernova light had traveled.

Distances combined with redshifts of the supernovae give the rate of expansion of the universe over its history, allowing a determination of how much the expansion rate is speeding up or slowing down.

The supernova-based measurement of the deceleration depends on the remarkable predictability of one particular kind of supernova explosions, called "Type Ia", These explosion are triggered when a dying white dwarf star pulls too much gas off a neighboring red giant star, igniting a thermonuclear explosion that rips the white dwarf apart.

"A Type Ia supernova can shine brighter than an entire galaxy, but only for a month or so before it becomes too faint for even the largest telescopes to observe at these distances," says Gerson Goldhaber, a professor at the Berkeley Lab and the University of California at Berkeley. Although not all Type Ia supernova have the same brightness, their intrinsic brightness can be determined by examining how quickly each supernova fades away.

In fact, Type Ia supernovae seen in nearby galaxies are so predictable that, as Peter Nugent of the Berkeley Lab explained at the Washington meeting, "the time at which the supernova explosion started can be determined just from looking at a spectrum. When we studied even the most distant of our supernovae, we found they had just the right spectrum on just the right day of the explosion. This tells us that Type Ia supernovae which exploded when the universe was half its present age behave essentially the same as they do today."

This result, reported in the Jan 1 issue of the science journal, Nature, is crucial since using supernovae as milestones rests on the comparison of nearby supernovae to distant ones. If the properties of supernovae were different when the universe was young it would confuse the measurement of changes in the expansion of the universe.

Because the most distant supernova explosions appear so faint from earth, occur at unpredictable times, and last for such a short time, the Supernova Cosmology Project team had to develop and perform a tightly choreographed sequence of observations using telescopes around the world and the Hubble Space Telescope.

"We are studying cosmic fireworks that fade away within weeks, so we have to move fast," says team member Greg Aldering. "While some team members are surveying distant galaxies using the largest telescope in the Andes Mountains of Chile, others in Berkeley are retrieving that data over the Internet and analyzing it to find supernovae. Once we find likely supernovae we rush out to Hawaii to confirm that they are supernovae and measure their redshifts using the Keck telescope, the world's largest.

"Meanwhile, team members at telescopes outside Tucson and on the Canary Islands are standing by to measure the supernovae as they fade away. The Hubble Space Telescope is called into action to study the most distant of our supernovae since they are too hard to accurately measure from the ground."

Between this past Christmas and New Year, the Supernova Cosmology Project discovered even more deep-space supernovae, which they will use to check the results they reported today. The Hubble Space Telescope is obtaining very precise measurements for four of these this week, even as the results from previous supernovae are being reported.

Speaking today at the American Astronomical Society meeting, Robert Knop of the Berkeley Lab said "This is our most successful supernova search yet -- our own brand of New Year's fireworks. We found over 15 supernovae, including the most distant ever confirmed with spectroscopic identification. These explosions occurred about 7 billion years ago and the light has only just reached us this past week."

Team member Ariel Goobar of the University of Stockholm says, "Reaching out to these most distant supernovae teaches us about the 'Cosmological Constant' which Einstein once called his greatest mistake" -- because if the newly discovered supernovae confirm the story told by the previous 40, astrophysicists may have to invoke Einstein's cosmological constant to obtain agreement with the popular inflation theory which explains how the universe developed shortly after the Big Bang.

This question can only be addressed using those supernovae so distant that only the Hubble Space Telescope can measure them. The work so far has made extensive use of the Cerro Tololo Interamerican Observatory in Chile and the Wisconsin-Yale-NOAO telescope on Kitt Peak, both supported by the National Science Foundation, as well as the Keck 10-meter telescope in Hawaii, the William Hershel Telescope and Isaac Newton Telescopes on the Canary Islands, and of course NASA's Hubble Space Telescope.

The research is supported at the Ernest Orlando Lawrence Berkeley National Laboratory by the United States Department of Energy and the National Science Foundation's Center for Particle Astrophysics.

The Berkeley Lab is a U.S. Department of Energy national laboratory located in Berkeley, California. It conducts unclassified scientific research and is managed by the University of California.

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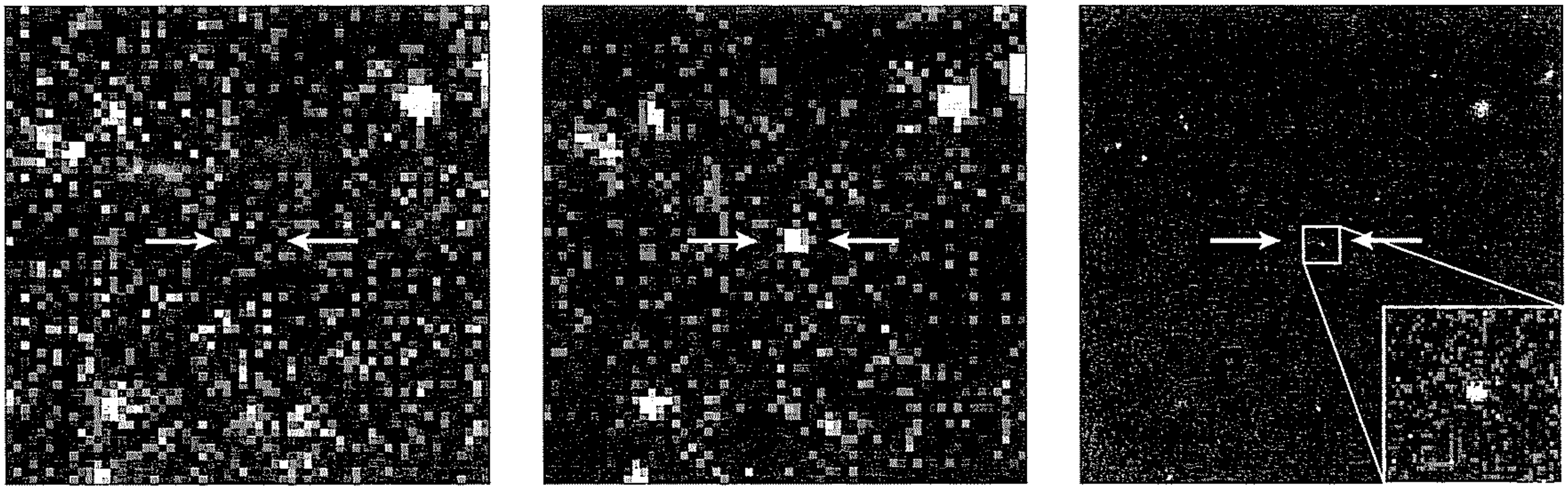
Before SN 1997ap discovery	SN 1997ap discovery	SN 1997ap follow-up
Cerro Tololo Interamerican Observatory 4-meter Telescope	Cerro Tololo Interamerican Observatory 4-meter Telescope	Hubble Space Telescope
February 1997	March 1997	April/May 1997



False-color images from observations by the Supernova Cosmology Project of one of the two most distant spectroscopically confirmed supernova. From the left: the first two images, from the Cerro Tololo Interamerican Observatory 4-meter telescope, show a small region of sky just before and just after the the appearance of a type-Ia supernova that exploded when the universe was about half its present age. The third image shows the same supernova as observed with the Hubble Space Telescope. This much sharper picture allows a much better measurement of the apparent brightness and hence the distance of this supernova. Because their intrinsic brightness is predictable, such supernovae help to determine the deceleration, and so the eventual fate, of the universe.

Credit: Perlmutter *et al.*, The Supernova Cosmology Project