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HEADLINE: Universe Will Keep **Expanding** Forever, Research Teams Say

BYLINE: Kathy Sawyer, Washington Post Staff Writer

BODY:
The **universe** will continue **expanding** outward forever instead of snapping back in a "big crunch," according to strong new evidence unveiled yesterday by five teams of astronomers. Experts said the findings, which contradict leading theory, could solve some scientific puzzles -- including a simmering debate about the age of the **universe** -- and create others, rippling through studies of nature's smallest particles, its large-scale cosmic structure and the ongoing quest for a "theory of everything" that would unify those fields.

Several groups, including two large international teams using the Hubble Space Telescope in tandem with the world's most powerful optical telescopes, presented a rare united front in a briefing at the annual winter meeting of the American Astronomical Society, where conflicts in data are common. These researchers said their evidence had been gathered separately using three different methods and therefore should suffer from no common flaw.

"For the first time ever, we're going to actually have data, so that you will go to an experimentalist to find out what the cosmology of the universe is, not to a philosopher," said Saul Perlmutter, leader of the International Supernova Cosmology Project based at the Department of Energy's Lawrence Berkeley National Laboratory in California.

Most astronomers agree that the universe began in a "big bang" about 15 billion years ago, when all of time and space were contained in a single dense point -- a singularity -- which suddenly blossomed outward in an expanding fireball of particles. One of the abiding questions has been how much matter the resulting universe contains, and what will be its ultimate fate. The most popular and simple theoretical models call for exactly the "critical density" of matter required to put the brakes on, allowing the universe to coast indefinitely on the verge of collapse.

The international groups, as well as two teams from Princeton University and one from Yale University, concluded that the universe contains only 20 percent of the matter required to provide enough gravity to halt the expansion.

Because of recent advances in technology, the researchers were able to draw these conclusions from studies of exploding stars, some of them halfway across the observable universe, with unprecedented measurements of their distances. These explosions, known as supernovae, are so intrinsically bright that their light is visible even though it has traveled as much as 7 billion or 8 billion years across time and space to reach Earth.

Supernovae of a certain type are ideal candidates for use as cosmic yardsticks because their brightness can be determined by measuring the rate at which they dim after they explode. This way, astronomers can tell if they are bright objects far away, or dim objects relatively close. "It's like reading the label on a light bulb. It tells the wattage," said Peter Garnavich of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., who represented the other international observing team.

The supernova light is feeble when it arrives here, its wavelengths stretched out (a phenomenon known as redshift) by the general expansion of space itself. Once the researchers determine the distance the light has traveled, and its redshift, they can calculate the rate at which the universe has expanded over its history, and also how much this rate is accelerating or slowing.

Perlmutter bowled over his audience with an unexpectedly large sample of 40 supernovae, some of them collected within the last five days. Garnavich's team presented three, including the most distant individual star -- albeit an exploding one -- ever observed.

Other teams also used new methods. Princeton's Neta Bahcall studied the evolution of the largest structures in the universe -- huge clusters of hundreds of galaxies, each with billions of stars -- to reach the conclusion that this is a "lightweight universe." And Ruth Daly, working with another Princeton team, measured the redshifts of 14 galaxies with "hot spots" emitting radio waves.

The researchers said that more observations are required to eliminate the possibility that intervening dust has skewed the results, and some outside experts noted that there are unknowns associated with the supernovae that could affect the interpretations.

But if the early conclusions are borne out in subsequent observations, said Daly, the lack of significant slowing in the expansion means the universe could be as much as 15 billion years old. (Previous estimates had calculated the age of the universe based on a density five times as dense as the new evidence indicates.) This would help eliminate an apparent paradox that arose in recent years, as increasingly refined data suggested the universe is unexpectedly young -- even younger than the oldest stars within it.

The findings also appear to breathe fresh life into the theory that there is a so-called cosmological constant -- a kind of reverse gravity that inhabits the vacuum of space and repels, rather than attracts, the researchers said. Albert Einstein proposed the idea and then rejected it as his greatest blunder, and it has been derided as a convenient "fudge factor" used to make equations work. But some scientists said the new evidence appears to represent observational evidence that this force actually exists -- and may currently be accelerating the outward expansion of everything in the cosmos.

"These observations seem to imply a real dilemma for a lot of particle physics models," said David Spergel of Princeton, a cosmologist and astrophysicist not affiliated with any of the teams. But he said the new data also "may be telling us" how to resolve some long-standing theoretical conflicts. It could even reflect "some kind of new physics happening now. . . . It may be that we happen to live at a special time."

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