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New Data Suggest Universe Will Expand Forever

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Examining the distant light from stars that exploded before the Sun was born, astronomers have determined that the universe has apparently been expanding at a slow, steady rate since the beginning and is destined to expand forever.

The findings, if supported by further observations, suggest the answer to the fundamental question about the fate of the universe: Will it go on expanding, as it has since its creation in a theorized Big Bang? Or will the gravity of its mass eventually bring the universe to a halt, or possibly cause its collapse in a Big Crunch?

The new research also means that the universe could be as much as 15 billion years old, thus resolving a paradox posed by earlier findings that suggested an age for the universe that was younger than many of its constituent stars. But some theories about the early universe may have to be reconsidered.

In a remarkable display of agreement for the contentious field of cosmology, two teams of astronomers today reported observations of a certain class of exploding stars, or supernovas, showing that galaxies and other objects about halfway back in cosmic time were receding at velocities comparable to those of objects in more recent epochs. The results were announced at a meeting here of the American Astronomical Society.

"All the indications from our observations of supernovas spanning a large range of distances are that we live in a universe that will expand forever," said the leader of one team, Dr. Saul Perlmutter of Lawrence Berkeley National Laboratory in California. "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."

Dr. Peter Garnavich of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., a leader of the other team, said the low deceleration of the expansion rate means that the universe is much older, about 15 billion years old, than had been calculated by some astronomers, whose estimates had ranged as low as 8 billion years. If the universe was not expanding at a faster rate earlier, then it has taken longer for it to reach its present size.

When the astronomers speak of matter in their calculations, they include everything -- ordinary matter that is seen or has not yet been detected, as well as the dark matter that is thought to include exotic particles, the existence of which has only been theorized. Recent research indicates that the mass of such matter is no more than 20 percent to 30 percent of what is considered the critical density needed to hold the expanding universe in check.

In an independent study of the expansion rates of 14 distant radio galaxies, Dr. Ruth A. Daly, a Princeton University astronomer, said "our results are basically almost identical" to those of the Berkeley and Harvard-Smithsonian supernova observations. "We are 95 percent confident that the universe is going to expand forever," Dr. Daly said.

Remarking on the close agreement of the different studies, Dr. Neta A. Bahcall, a Princeton astrophysicist, said this reinforced confidence that the conclusions are correct, or else everyone has overlooked some hidden flaw.

None of the astronomers at a news conference could think of any reasons for skepticism. But they cautioned that many more supernovas would need to be observed in detail before the issue could be resolved and a more precise value placed on estimates of the universe's deceleration.

"The field is moving very quickly," Dr. Perlmutter said at the news conference. He had just returned from the Keck Observatory in Hawaii with more data. By the beginning of the new millennium, he predicted, the extent to which the universe has decelerated, if at all, should be known.

The findings were not entirely unexpected. For more than a year, astronomers have been reluctantly coming to the realization that the universe is lightweight; it has a low mass density. The higher the density, the greater would be the deceleration of the expanding universe. But preliminary studies of distant objects like supernovas had begun to show little, if any deceleration.

The supernovas being studied belong to a class known as Type Ia. Their intrinsic brightness can be determined by how quickly each supernova fades away, making them reliable distance milestones for clocking any deceleration, compared with the expansion velocities of supernovas in more recent times.

Because the light of these supernovas fades in a month or so, astronomers must act quickly to make their measurements. They are using telescopes in Chile, the Canary Islands, Hawaii and Arizona, as well as the Hubble Space Telescope. The Hubble is called upon to study the most distant supernovas, some as far as seven billion light-years away, that are difficult to measure accurately from the ground.

The research confronts theorists with new challenges. A low-density universe does not readily conform to what is known as the inflationary model of the Big Bang theory. According to this model, in its first moments the universe underwent an extremely rapid expansion, then settled down to a more stately pace as it cooled off and gathered matter into stars and galaxies.

One prediction of the inflation model is that the universe should have a critical density. That would be just the right amount of mass to keep it from collapsing of its own weight or expanding into vanishing infinity. At the critical density, expressed as omega-equals-one, the universe would be in a state of equilibrium between collapse and eternal expansion.

If, as it now seems, the universe falls considerably short of critical density, theorists have already begun to add to their equations something called the cosmological constant. This is a kind of theoretical antigravity force -- an energy in the vacuum of space that attenuates the effects of mass gravity. In the absence of sufficient mass -- if omega is less than one -- this force could slow down cosmic expansion to allow for a bigger, older universe.

Like most astronomers who observe the heavens, Dr. Daly said it was now up to particle physicists and cosmologists to "figure out a way to have a cosmological constant, if you want to preserve inflation" as a keystone of their theories explaining the origin and evolution of the universe. Some theorists are already pondering ways that the inflation model could still be compatible with a low-density universe.

"I never underestimate the power of a theorist to come up with a new model," Dr. Perlmutter said.