

March 3, 1998

Wary Astronomers Ponder An Accelerating Universe

By JOHN NOBLE WILFORD

AT their telescopes in the last few years, astronomers have been searching the heavens for evidence that the expansion of the universe is slowing down. The mutual gravitational attraction of all matter in stars, planets and everything else known or hypothesized should be putting a gradual brake on the outward rush of space since the explosive moment of cosmic creation in the theorized Big Bang.

The preliminary results of the search are now in, and they are stunning. The expansion of the universe appears to be accelerating, instead of decelerating.

"Our observations show that the universe is expanding faster today than yesterday," Dr. Adam Riess, a young astronomer at the University of California at Berkeley, said in an interview last week. An analysis by him and an international team of scientists indicated that the cosmic expansion rate is about 15 percent greater now than when the universe was half its current age, about seven billion years ago.

The group including Dr. Riess and another one, led by Dr. Saul Perlmutter of Lawrence Berkeley National Laboratory, used similar techniques of measuring the cosmic expansion rates over time by studying distant exploding stars, called supernovas. At first, the astronomers were not sure they could believe what they were seeing. But as they examined more supernovas and explored sources of possible error or alternative explanations, they have grown bold in describing the implications of their research at recent meetings.

"Try as we might, we have not found any errors," Dr. Alexei V. Filippenko, a University of California astronomer who has worked on both teams, told colleagues 10 days ago at a meeting in Marina del Rey, Calif. "We get a nonzero cosmological constant."

Translated, that means the astronomers are increasingly confident that they have detected the first strong evidence that the universe is permeated by a repulsive force, the opposite of gravity. The simplest explanation, other astrophysicists agree, is that the force is something called the cosmological constant. As conceived by theorists, this force is a property of the vacuum of space itself, an energy that acts on a large scale to stretch space and thus counteract gravity's restraining power.

If the observations are correct, this is one more case of astronomers handing cosmologists a new piece to a jigsaw puzzle, which is always maddeningly incomplete, and asking them to find a way to fit it into a satisfying theoretical whole. Knowledge of an accelerating expansion could lead to a revised recipe of just what the universe is made of. It could resolve a paradox raised by previous controversial suggestions that the universe appears to be younger than its oldest stars. It could also change thinking about cosmic evolution and the ultimate fate of the universe.

Reflecting the cautious excitement and fervid conjecture touched off by the new findings, Dr. Michael S. Turner, an astrophysicist at the University of Chicago and Fermi National Laboratory, said: "If it's true, this is a remarkable discovery. It means that most of the universe is influenced by an abundance of some weird form of energy whose force is repulsive."

If he were alive, no one would be more bemused by this turn of events than Albert Einstein. Soon after he invented his general theory of relativity in 1915, Einstein was unsettled to find it demanded that the universe either expanded or contracted over time. But like nearly all scientists at the time, he assumed the universe was static, neither expanding nor contracting. What to do?

To compensate for what he considered a flaw in his theory, Einstein introduced the idea of the cosmological constant, symbolized in equations by the Greek letter lambda. The repulsive energy force would presumably counteract gravity and make the universe in his theory stand still. Soon after Edwin P. Hubble discovered the expanding universe in 1929, Einstein renounced the cosmological constant as the greatest blunder of his career.

For years, scientists agreed, dismissing lambda as "that fudge factor." In the last decade, however, they reluctantly dusted it off as a means of balancing the books on the matter and other forces that are required to support the favored interpretation of Big Bang theory.

In this model, called the inflationary Big Bang, the universe should contain a critical density of matter, just enough to slow expansion

to a halt, given infinite time. Scientists express this condition of critical density as ω equals one. Too little mass -- if ω equals less than one -- and the universe would expand forever, growing ever more tenuous. If ω equals more than one, then the universe would collapse of its own weight, contracting in what is called the Big Crunch.

So far, astronomical observations and other research have established that the mass density of the universe amounts to no more than 30 percent of the preferred critical value. That includes the mass from ordinary matter in galaxies and a large component of mysterious exotic particles, invisible and still hypothetical. Despite this matter deficit, cosmologists clung to inflation theory because it had passed many tests and provided a satisfying explanation for early conditions in the universe.

In 1990, reviewing all the data, Dr. Turner proposed a formula for a "best-fit universe" that accorded with inflation theory. By his calculations, the universe contained 5 percent ordinary matter and 25 percent mass in the form of cold dark matter, invisible and exotic. The cosmological constant, the energy of empty space, would account for the balance of 70 percent, bringing the universe up to critical density.

The new findings appear to make a prophet of Dr. Turner and others who were beginning to share his views. In January, both teams studying supernovas, measuring how fast these stars were rushing outward when they exploded, reported that the cosmic expansion rate had slowed little or not at all over billions of years. The universe's mass, in ordinary and exotic matter, added up to no more than 20 to 30 percent of critical density. The universe, therefore, seemed destined to expand forever.

After more analysis of the observations, the teams realized they were probably seeing the direct evidence for the mysterious background energy known as the cosmological constant. Not only was the universe's expansion not slowing down, it was speeding up.

Dr. Perlmutter's group, the Supernova Cosmology Project, has studied 40 distant supernovas in detail. Describing their results in January, Dr. Perlmutter acknowledged that the evidence strongly suggested a cosmological constant, but went no further. "We were trying to be very conservative until we had more observations," he said last week.

The other group, called the High-Z Supernova Search Team, has examined only 14 supernovas but was less restrained in its more recent report. Dr. Brian Schmidt of the Mount Stromlo and Siding Spring Observatory in Australia, said in an interview reported in the current issue of the journal *Science* that his team concluded with a statistical confidence of between 98.7 and 99.9 percent that cosmic expansion is receiving an antigravity boost, presumably from energy of the cosmological constant.

"My own reaction is somewhere between amazement and horror," said Dr. Schmidt, the team leader. "Amazement, because I just did not expect this result, and horror in knowing that it will likely be disbelieved by a majority of astronomers -- who, like myself, are extremely skeptical of the unexpected."

Dr. Riess, whose research led to the conclusion of an accelerating expansion, said: "We are trying not to rush to judgment on the cosmological constant. There could be some other sneaky little effect we have overlooked, something that makes the supernovas dimmer and appear to be farther away than they really are or some variations in the behavior of more distant supernovas that are deceiving us."

But nothing has emerged to make the astronomers doubt their findings, he said. The accelerating expansion indicates that the repulsive force could account for at least 65 percent of the critical density, thus closing the gap between known mass and the much-admired model in which the universe is characterized as ω equaling one. And if the universe was once expanding more slowly than it is now, this would make it older -- about 14 billion years old, or a billion years or more than new estimates for the age of the earliest known stars.

Dr. Perlmutter saw a need to observe more nearby supernovas for comparison with ones being observed at distances of seven billion light-years. This should produce a more refined measure of differences in the expansion rate over time and perhaps reveal any distorting variations in supernovas then and now.

Still, many astrophysicists and cosmologists are beginning to think that Einstein was on to something, though for the wrong reason. The cosmological constant as a repulsive energy force may exist, after all. Physicists can think of no known principle to forbid it. Indeed, theories of quantum mechanics suggest that the energy of the cosmological constant could come from "virtual particles," which may be winking in and out of existence in empty space.

"Actually, the cosmological constant is the least interesting explanation, and that's pretty interesting in itself," Dr. Turner said.

Astrophysicists conceive of other possible sources of repulsive energy in forms that go by such names as X-matter and quintessence. These are speculative concepts in which mysterious textures in the early universe that created conditions for a cosmic background energy and might even help explain the formation of galaxies. Scientists are likely to venture other ideas if evidence for an

accelerating universe continues to mount.

"It gives us confidence that two groups that are very competitive and very good are getting the same results," Dr. Turner said.

[Copyright 2006 The New York Times Company](#) | [Home](#) | [Privacy Policy](#) | [Search](#) | [Corrections](#) | [XML](#) | [Help](#) | [Contact Us](#) | [Work for Us](#) | [Back to Top](#)