COSMOLOGY

Astronomers See a Cosmic Antigravity Force at Work

Seemingly in defiance of common sense, space itself appears to be permeated by a repulsive force that is counteracting gravity on large scales. That, at least, is the reluctant conclusion of an international team of astronomers who have used the brightness of distant exploding stars called supernovae to gauge how cosmic expansion has changed over time. Gravity should have gradually slowed that outward rush. But as team member Alexei Filippenko of the University of California, Berkeley, announced at a meeting near Los Angeles last week,* the dimness of the supernovae—pointing to unexpectedly great distances—implies that cosmic expansion has actually sped up in the billions of years since the stars exploded.

"My own reaction is somewhere between amazement and horror," says Brian Schmidt of the Mount Stromlo and Siding Spring Observatory in Australia, who leads the group, called the High-z Supernova Search Team. "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." But after intense efforts to account for the dimness with prosaic effects such as dust in the cosmos or some intrinsic dimness of those remote explosions, says Schmidt, the team concluded with a statistical confidence of between 98.7% and 99.99% that cosmic expansion is receiving an antigravity boost.

Astronomers expressed caution over what would be a momentous turn of events, saying there could be still-undiscovered differences between galaxies now and billions of years ago—and hence in the brightness of the supernovae they host. "Even the most conservative explanations for the results are quite amazing," says Rocky Kolb, a cosmologist at the University of Chicago who attended Filippenko's talk. A cosmic repulsion "would be such a fundamental result that I think everyone should reserve judgment." No one, however, is arguing with the data themselves: Just last month, an independent team presented data from another set of distant supernovae that suggested, more tentatively, an acceleration of roughly the same amount (*Science*, 30 January, p. 651). "This is what the observations are telling us," says Filippenko.

The discovery of an accelerating universe would have a major impact on the reigning theory of how the big bang got started. In the simplest version of this theory, known as inflation, the universe contains just enough matter to make it geometrically "flat"—a mass density that would also slow the cosmic expansion to a halt, given infinite time. Earlier supernova results and other measures have shown no sign of the gravitational brake that so much mass would apply (*Science*, 31 October 1997, p. 799). But because both matter and energy can curve space-time, a mysterious background energy—which Albert Einstein named the cosmological constant, or lambda—might make up the deficit and flatten the universe again. This background energy would push rather than pull, speeding up the cosmic expansion over time.

Physicists do not have a good explanation for the source of the energy; it could somehow be related to the fleeting "virtual" particles that quantum theory says wink in and out of existence in empty space. But some cosmologists have been drawn to the concept, in part because it would be compatible with more refined versions of inflation that would not require a radical overhaul of the theory. So astronomers have gone looking for lambda by trying to detect its influence on cosmic expansion.

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> —Brian Schmidt

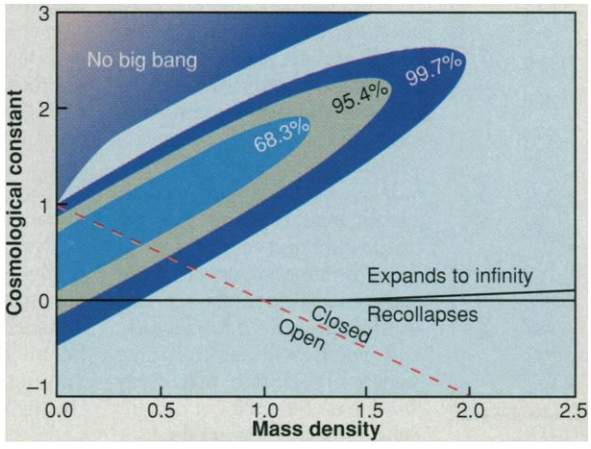
The High-z team probes the expansion with distant supernovae. The team electronically subtracts images of the same regions of the sky, taken weeks apart, to find new supernovae of a class called type Ia, thought to occur when a white dwarf star rips so much material from a nearby companion star that the dwarf suddenly explodes like a giant thermonuclear bomb. They then record the gradual brightening and fading of each one with the Hubble Space Telescope or with ground-based instruments.

Although type Ia's do not all reach exactly the same peak brightness, the variation can be corrected for: Those that fade more quickly are less luminous. The correction allows type Ia's to serve as approximate "standard candles," whose apparent brightness is a measure of their distance. The team compares those distances to the "redshifts" of the light—a measure of how fast cosmic expansion is sweeping the supernovae outward—to gauge the expansion when they exploded, as much as halfway back to the big bang.

What the team found left many of its members "stunned," says Berkeley's Adam Riess, lead author on the paper being prepared on the results. The 14 distant type Ia's in the study turned out to be, on average, 10% to 15% farther away than they would be even in a low-density universe, in which the expansion would have slowed very little. "Not only don't we see the universe slowing down; we see it speeding up," says Riess. If the universe is indeed flat, then the results imply that it contains roughly twice as much energy in the cosmological constant as in matter.

That conclusion survived detailed corrections for any dust that might be veiling the supernovae and making them look more remote than they are. It also survived another test, which Riess and Filippenko did in tandem with the other supernova team, led by Saul Perlmutter of Lawrence Berkeley National Laboratory in California. To see whether the distant supernovae behave the same way as closer ones, they compared how the spectral fingerprints of distant and nearby supernovae change during the explosion. No significant differences turned up, Riess says.

Group members stress that their findings still need careful scrutiny by the astronomical community. "To be honest, I'm very excited about this result," says group member Robert Kirshner of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. But for all the group's vigilance, he says, it's still conceivable that some "sneaky little effect" is



Expansive universe. A large fraction of the universe's makeup may reside in a cosmological constant—a repulsive energy in space. The shaded regions indicate where the true value probably lies.

* Third International Symposium on Sources and Detection of Dark Matter in the Universe, 18–20 February, Marina del Rey, California.

mimicking the acceleration. "It's a remarkable result," says Marc Davis of Berkeley, who is not part of either group, but he agrees, "it's clearly going to take some time to digest this."

That certainly goes for theorists. Kolb, for one, says that the universe is starting to look like a cosmic version of the Marx brothers movie *Monkey Business*, in which more and more people show up in a ship's stateroom, leading to chaos. The universe already contains visible and dark matter as well as radiation; now there's a mysterious new guest. "It's crazy," he says. "Who needs all this stuff in the universe?"

Martin Rees of the University of Cambridge, Britain's Astronomer Royal, sees it differently. Like Kepler, who was troubled that planetary orbits were ellipses and not perfect circles, theorists who long for a simpler universe might just be missing "the really big picture," he says. Newton's theory of gravity ultimately made sense of elliptical orbits, and some missing concept may ultimately make sense of a seemingly baroque universe. Cosmic simplicity's aesthetic lure, says Rees, "may seem, in retrospect, as shallowly motivated as was Kepler's infatuation with circles."

–James Glanz

AIDS THERAPY

Controversial Trial Offers Hopeful Result

A bitter, yearlong ethical dispute over the use of placebos in anti-HIV drug trials in poor countries moved into a new phase last week. A trio of U.S. and international health organizations announced that a U.S.-funded trial in Thailand has demonstrated that a brief, relatively inexpensive course of drugs given during the final weeks of pregnancy can lower the transmission of HIV from mothers to their newborn infants. Plans are now under way to make the cheap therapy available to thousands of HIV-infected women in the developing world, says Joseph Saba, spokesperson for the Joint United Nations Program on HIV/AIDS (UNAIDS).

Saba calls the results a "statistically significant" victory for AIDS research that was hastened by the fact that the therapy was tested against a placebo. This increased the statistical power of the study and gave health authorities confidence to recommend that the therapy be widely used and that other placebo-controlled trials be modified, he says. But critics, who condemned this and similar trials last April (*Science*, 16 May 1997, p. 1022), continue to maintain that the use of placebos was unnecessary and unethical.

The Thai study, whose main findings were released on 18 February, offered pregnant women the antiretroviral drug AZT orally for a brief period (4 weeks) before they went into labor to reduce the amount of virus they passed on to their children. The drug was already known to be effective in reducing HIV transmission when given in a more complex and expensive regimen involving intravenous injections and postnatal therapy for the child (*Science*, 4 August 1995, p. 624). The short regimen costs $80 or less—one-tenth the cost of standard treatment. To make sure the study yielded clear-cut results, researchers gave half the women in the trial AZT and the other half, a sugar pill.

Last week, a special analytical panel took a look at the preliminary data from 392 patients and concluded that short-term AZT therapy was working spectacularly well. According to a statement issued by UNAIDS and other sponsors, HIV transmission declined from a background rate of 18.6% in the placebo group to 9.2% in the test group—a 51% reduction. (In contrast, the original tests conducted in Europe and the United States of the longer term, more complex therapy reduced transmission by 70%.) The "results show that a simplified AZT regimen can be well tolerated and is effective in significantly lowering perinatal transmission from HIV-infected women who are not breast-feeding," the UNAIDS joint statement concluded. Helene Gayle, who heads the division of the U.S. Centers for Disease Control and Prevention (CDC) that sponsored this trial, says these results argue for "extending this therapy throughout the developing world." Gayle and others caution, however, that it's not clear how well it will work for children who breast-feed for half a year or more—as in Africa—and may be exposed to HIV in milk.

MAJOR PERINATAL HIV PREVENTION TRIALS

Location	Size	Funding	Therapy	Enrollment
Thailand	392	CDC	AZT	closed
Thailand	1550	NIH	AZT	ongoing
Côte d'Ivoire	1200	CDC	AZT	in revision
Côte d'Ivoire	780	France	AZT	in revision
Ethiopia	710	NIH	AZT	not begun
South Africa, Tanzania, Uganda	1900	UNAIDS	AZT+ 3TC	in revision
Uganda	1500	NIH	Nevirapine	in revision
Uganda	408	NIH	HIV antibody	not begun
Kenya	450	NIH	bottlefeed 3+ mo.	closed
South Africa	700	South Africa	Vitamin A	ongoing
Zimbabwe	1800	Denmark	Vitamin A	ongoing
Malawi	700	NIH	Vitamin A	closed
Tanzania	960	NIH	Vitamin A	closed
Kenya	1000	EC	Vaginal lavage	ongoing

Because short-term AZT therapy worked so well, the research sponsors moved rapidly last week to offer it to all patients in ongoing trials. AZT trials sponsored by CDC and the French government in Côte d'Ivoire, designed to enroll 1900 women, are now being revised to exclude the use of placebos. Another trial sponsored by the National Institutes of Health (NIH) in Ethiopia is being revised to omit placebos, as are trials sponsored by UNAIDS in South Africa, Tanzania, and Uganda. Researchers who collaborated on these trials were planning to meet at NIH this week to discuss how to restructure the protocols.

Without doing a placebo study, Saba says, investigators could not have gotten these decisive results so quickly. Observed transmission rates "have a huge range," he says, from 15% to 44%. Trial designers were concerned that the effect of short-term AZT therapy might be lost if no placebo were included.

Critics are not convinced. Sidney Wolfe, medical affairs chief of the Ralph Nader group Public Citizen in Washington, D.C., says he has unearthed data on a subset of women in the original U.S.–European study known as the "076 trial" that show that short-term therapy was effective. Wolfe claims the data were available as early as February 1994. A "disgraceful loss of life would have been avoided," Wolfe claims, if there had been no use of placebos.

Saba insists, however, that last week's results are the "first reliable data" on the value of short-term AZT therapy. And Lynne Mofenson, an NIH official who helps coordinate the perinatal HIV studies, says researchers had always planned to examine early data from one trial and, if warranted, drop placebos.

Saba and other organizers of the trials are now using the early data from Thailand to argue for increased funding of anti-HIV therapy. They aim to bring together government officials, health workers, and pharmaceutical executives for a meeting in Geneva in late March to consider how to make short-term AZT therapy available in the developing countries.

–Eliot Marshall