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## A Few Starry and Universal Truths

Astronomers tell of a bright past, dark future

By Charles Petit

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Don't change plans for the weekend, but the universe may be at a crucial juncture: on the cusp of a shift from a rosy and bright past to a future of dark and endless oblivion.

Astronomers, who gathered in Washington last week for the American Astronomical Society's annual meeting, report that bleakness lies ahead. The universe, it seems, not only will expand forever but after slowing steadily since its birth in the so-called big bang, 12 billion to 15 billion years ago, it is speeding up again, an accelerating expansion into darker and darker decay. On the other hand, a decades-long effort reveals that the past was surprisingly well lit, with twice as much starlight since time began as had been supposed.

Science being uncertain, the latest theories may eventually collapse. But they tell a strange tale. Looking first to the past, the faint infrared glow of fossil radiation, a sort of pervasive heat, cannot be explained by any nebulae or stars seen shining now. Technologically, the feat is stunning. It is as if one could enter Carnegie Hall during a concert and find, in the rafters and foundation, faint echoes of all the music that has filled the chamber since it opened to Beethoven's Leonore Overture on May 5, 1891, then calculate a melodic sum of how many people have performed there.

The ancient radiation implies the universe has been a doubly more productive star factory than most astronomers had thought. By some reckonings, some 7 billion years ago--about halfway back to the beginning--stars were forming 30 times faster than today. Michael Hauser of the Space Telescope Science Institute in Baltimore has sought this ancient radiation for 23 years. He and teams of colleagues used an instrument called the Diffuse Infrared Background Experiment, bolted to a satellite called Cosmic Background Explorer (COBE). The scientists gathered the data over a 10-month period starting in December 1989, shortly after the now defunct satellite's launch. Hauser calls the infrared glow a "cosmic bank account" in which most starlight is deposited, after scattering off dust and otherwise careering around the universe. To cover the whole sky, the team made 200 million observations in all. Years were spent subtracting the infrared emissions of nearby known objects, like dust from the solar system and the Milky Way galaxy, to measure the dim background glow.

Closed or open? So much for sunny pasts. Other astronomers studying distant corners of the universe are predicting an infinitely dim future of dying galaxies racing apart faster and faster, continuing forever as all stars eventually go black. For years, cosmologists have wondered if the universe is "closed" and will collapse to a big crunch, or "open," with expansion forever in the cards. It now seems open--in spades. The evidence, while not ironclad, is plentiful. Neta Bahcall of Princeton University and her colleagues have found that the distribution of clusters of galaxies at the perceivable edge of the universe imply that the universe back then was lighter than often had been believed. There appears to be 20 percent as much mass as would be needed to stop the expansion and lead the universe to someday collapse again.

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Strong signs that the expanding universe is actually starting to speed up come from astronomers using ground-based and orbiting telescopes to chart supernova exploding stars in galaxies, a gauge of how fast the universe has expanded so far. Says Saul Perlmutter of the Lawrence Berkeley Laboratory, a leader of the effort: "No big crunch. The galaxies out there seem to be accelerating outward. Not much, but they are not turning around either."

If so, even gravity, weakened over distances spanning a universe, is surrendering to some other deep phenomenon, perhaps embedded in the vacuum itself, pushing apart the fabric of space. This may give the ghost of Albert Einstein solace. He invented a term in his equations of general relativity to prevent the universe from collapsing and called it the cosmological constant. He later called it his greatest mistake. Subsequent discovery that the universe is expanding seemed to render it unnecessary. Now, the cosmological constant appears real anyway. Gravity held it at bay for a while, but over the breadth of the universe, "it will eventually win. The universe must eventually accelerate, faster and faster to infinity," says David Spergel, professor of theoretical cosmology at Princeton.

[Photo captions] 1. To find the infrared starlight accumulated in the universe, astronomers, using images from the orbiting COBE satellite, started with a picture of the entire sky. 2. Then they subtracted light from solar system dust, shown in blue, and took out, as much as possible, the glow from Milky Way galaxy dust. 3. What was left is the infrared signature of all the stars everywhere else. It is about twice what they expected.

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