Hubble Telescope Dates the Universe

Astronomers have calculated the birth date of the cosmos more precisely than ever before. Another team has sharpened the currrent estimate of the density of ordinary matter in the universe.

"After all these years, we are finally entering an era of precision cosmology," notes Wendy L. Freedman of the Carnegie Observatories in Pasadena, Calif.

"Now, we can more reliably address the broader picture of the universe's origin, evolution, and destiny."

For 8 years, Freedman and her colleagues have used the Hubble Space Telescope to measure the rate of expansion of the universe, a key factor in determining the age, size, and fate of the cosmos. This week, at a briefing in Washington, D.C., the team presented its conclusions.

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The spiral galaxy NGC 4603 contains pulsating stars known as Cepheid variables that have helped determine its distance from Earth, 108 million light-years.

The universe is either 12 billion years old or 13.5 billion years old, depending upon which of the two leading models of the cosmos her team invokes, reports Freedman.

Both models hold that the universe will expand forever. Twelve billion years corresponds to a cosmos that is slowing its expansion but has too little mass to bring the expansion to a halt. The 13.5-billion-year-old universe is one that contains both matter and an odd type of energy that speeds up the expansion, as suggested by observations of distant, exploded stars (SN: 12/19&26/98, p. 392).

Freedman and her team calculated the numbers using a value for the Hubble constant—the current rate of expansion of the universe—that they say is accurate to within 10 percent. Using four different ways to measure distances in the cosmos, the astronomers find a Hubble constant of 70 kilometers per second per megaparsec. In other words, a galaxy 1 megaparsec, or 3.3 million light years, from ours moves away at a speed of 70 km/s.

Because the new value is similar to preliminary results that Freedman has previously reported, "it is not a surprise," says theorist David N. Spergel of Princeton University. "But [the team's] determination of the Hubble constant does represent our best current estimate of the expansion rate."

For decades, astronomers argued whether the universe was 10 billion or 20 billion years old. The difference was so large that vastly different assumptions about the cosmos could not be proved right or wrong. Now, Freedman's team and a rival group led by Allan R. Sandage, also of Carnegie, have determined values of the Hubble constant that almost overlap within the uncertainties of the measurements. Both teams used the Hubble telescope.

The Sandage group's number is slightly lower, at 60 km/s/megaparsec, implying a slightly older universe, according to team member Abhijit Saha of the National Optical Astronomy Observatories in Tucson.

Earlier estimates of the Hubble constant led to a paradox—the cosmos seemed younger than its oldest stars. That problem has been resolved: The age of the universe crept up while age estimates for the oldest stars drifted down.

Not long ago, astronomers believed these stars to be 15 billion years old, but recent calculations suggest ages between 9.5 and 14 billion years, with an average of about 11.5 billion, says Brian C. Chaboyer of Dartmouth College in Hanover, N.H.

Measuring the Hubble constant has been a prime goal of the Hubble telescope. The constant dates back to a startling discovery made in 1929 by the telescope's namesake, astronomer Edwin P. Hubble. Distant galaxies, he found, appeared to be speeding away from the Milky Way, with the more remote galaxies fleeing faster.

The Hubble constant relates a galaxy's distance to its recession velocity. Measuring a galaxy's speed is relatively easy—the shift in the wavelength of light emitted by a star reveals the motion—but determining that distance has proved more problematic.

In the absence of a cosmic yardstick, astronomers use so-called standard candles, especially a group of yellowish, blinking stars called Cepheid variables. The intrinsic brightness of any Cepheid star is proportional to how quickly it pulsates. By comparing this brightness with the star's apparent brightness in the sky, astronomers can determine the distance to the Cepheid's home galaxy.

Such a measurement also reveals the distance of other, brighter stars that happen to lie within the same galaxy and also act as standard candles. These candles include exploded stars known as type 1a supernovas, which all have about the same intrinsic brightness. Because supernovas are visible at greater distances than Cepheids, researchers can use them to gauge the distance of galaxies even farther from Earth, providing a more accurate determination of the expansion rate.

In all, Freedman's team observed nearly 800 Cepheids, various type 1a supernovas, and two other indicators to record the distances to 18 galaxies. "The bottom line is there are four independent techniques now that actually agree extremely well within their uncertainties," says Freedman.

Spergel notes that scientists will soon be able to obtain an even more precise value of the universe's size, which is proportional to the inverse of the Hubble constant. Three new sources of data should do the trick: the Sloan Digital Sky Survey, a mammoth galaxy-mapping project already under way, and two space missions scheduled to measure radiation left over from the Big Bang. All these data could yield a value for the Hubble constant accurate to within 2 percent, Spergel says.

The Space Interferometry Mission, slated for launch in 2005, should also provide a more precise number for the Hubble constant, Freedman adds.

Future missions also promise more precise values for other cosmic quantities. Relying on improved measurements of the amount of deuterium forged in the Big Bang, Scott Burles of the University of Chicago and his colleagues report in the May 24 PHYSICAL REVIEW LETTERS a sharpened estimate of the density of ordinary matter, or baryons, in the universe. The same spacecraft that will explore the relic radiation from the Big Bang will put that estimate to a rigorous test. *—R. Cowen*