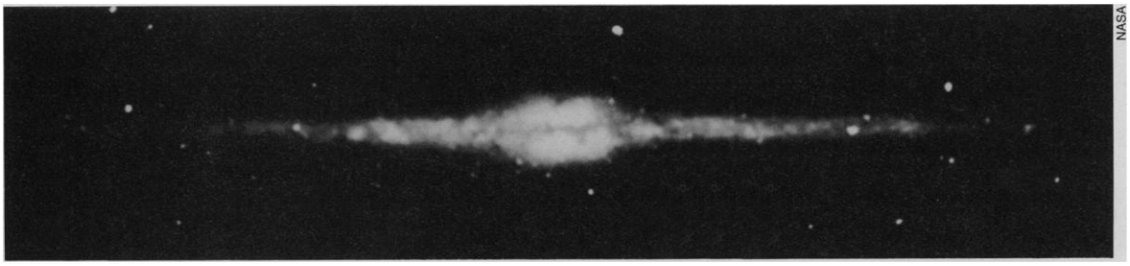
ASTRONOMY

At the Galactic Center, a Nest Of Stellar Oldsters

A swarm of stars seen through a small gap in the dust and gas that shrouds the galaxy's central bulge may have set a cosmic record. If so, a mystery that began 50 years ago when the astronomer Walter Baade of the Mount Wilson Observatory first peered into the gap and spotted the stars—so-called RR Lyrae variables—will at last be solved. These low-mass stars have used up almost all their hydrogen fuel and grown tremulous, pulsing every few hours. That behavior marks them as exceptionally old, compared to other stars in the galaxy's disk. But just how old?



Lost in the bulge. Our galaxy's oldest stars may reside in its central bulge, seen in a near-infrared image from the Cosmic Background Explorer satellite.

Now Young-Wook Lee of Yale University has pinned an age on these oldsters. At a conference last week at the University of California, Santa Cruz, he announced that, by analyzing the stars' color, he has dated them at more than 16 billion years old. That's not only older than their fellow residents in our galactic disk, it's also more than a billion years older than the oldest stars previously identified anywhere in the galaxy. The confirmed record-holders reside in globular clusters, the dense knots of stars that are scattered outside the main part of the galaxy in a vast, spherical "halo." They nicely fit a three-decade-old theory about how the galaxy formed from primordial gas that even today has powerful adherents. But Lee's discovery isn't so accommodating: "This basically contradicts the classical outside-in collapse model [in which the halo stars were the first to form]," declares Yale astronomer Richard Larson. "It tells us that the galaxy formed inside-out."

Supporters of the classical model don't agree that Lee has clinched the case. But few are dismissing his results, which are based on a widely accepted scheme by Yale astronomer Robert Zinn to explain the range of color of "horizontal-branch" stars, a special breed of old, low-mass stars that includes the RR Lyraes. Astronomers already knew that some of the color variation reflects the stars' content of "metals"—elements heavier than hydrogen. Metal-rich stars tend to be redder, since the metals make the gas of a star more opaque, hampering the escape of energy produced in the star's core. As a result the star swells and its surface is cooler and redder than it would be otherwise. But even among horizontal-branch stars containing the same amount of metals, astronomers see a range of colors, from blue to red.

The missing factor—that is, the cause of the otherwise inexplicable blue—is age, Zinn argued. The older the star, the less of its nuclear fuel will remain. With less energy being produced in its core to sustain it against gravity, the star will shrink, heating its surface and skewing its light toward the blue end of the spectrum. And Lee found, based on recent observations by Alistair Walker of the Cerro Tololo Interamerican Observatory in Chile and Donald Terndrup of Ohio State University, that the RR Lyrae stars in the galaxy's central bulge are exceptionally blue. They are so much bluer than RR Lyrae stars of similar metallicity in the galactic halo—stars already thought to hold the galactic age record of about 15 billion years—that Lee calculated they had to be 1.3 billion years older.

To some theorists, that comes as a surprise. "I would have expected the bulge to be younger [than the halo]," says Cambridge University theorist Simon White. White and some other astrophysicists accept the traditional picture of galaxy formation, developed 30 years ago by Olin Eggen of Cerro Tololo, Donald Lynden-Bell of Cambridge University, and Allan Sandage of the Observatories of the Carnegie Institution. They argued that the halo stars came first when they coalesced out of a vast "proto-galactic" gas cloud as it collapsed over a period of perhaps 200 million years (a rapid pace, by cosmological standards). Only afterward, the trio argued, did the remaining gas settle into a flattened disk with a central bulge, the familiar form of the galaxy.

Even before Lee's finding, this classical concept had fallen on hard times. One threat was the mounting evidence that while some globular clusters in the halo are as much as 15 billion years old, others are at least 3 billion years younger. That was hard to square with the model's picture of rapid halo formation. And, together with other evidence, it led some astronomers to favor an alternate picture.

In the revisionist scenario, which was developed by Zinn and Leonard Searle of the Observatories of the Carnegie Institution, the disk and bulge formed first from a smaller gas cloud. The halo was added later, piecemeal, as so-called protogalactic fragments plastered themselves to the young galaxy over several billion years. This "inside-out" picture squares with the observations of a range of ages in halo stars. And it implies that the oldest stars should be found at the galaxy's center.

Now comes Lee with the first clear evidence bearing out that prediction; no wonder inside-out supporters like Larson are elated. "It all fits together reasonably well," agrees Zinn.

But supporters of outside-in formation aren't giving up just yet. Marcia Rieke of the University of Arizona concedes that the result could cause "substantial damage to the ELS picture"—but only "*if* the bulge is older than the halo." Bruce Carney of the University of North Carolina, Chapel Hill, points out a possible loophole. While conceding that Lee's interpretation of the star colors is "entirely plausible," he argues that "if you assume a different chemical composition [for the RR Lyrae stars], you can get different ages."

And Sandage, one of the fathers of the model now under attack, seems unperturbed by the new result. He declined to comment specifically on Lee's claim, but he told *Science* that the outside-in model allows "a hierarchy of collapse times," in which denser parts of the protogalactic cloud would collapse first, leaving other parts to follow much later. "Those critics who say ELS is dead don't understand what we said." He expects the debate to continue; after all, as he wrote in 1990, "the study of origins is the art of drawing sufficient conclusions from insufficient evidence."

–Ray Jayawardhana

Ray Jayawardhana was The Economist's *Richard Casement Fellow in science journalism in 1991.*

Additional Reading

Young-Wook Lee, "Evidence for an Old Galactic Bulge from RR Lyrae Stars in Baade's Window," to appear in *Astronomical Journal*, November 1992.

Allan Sandage, "On the Formation and Age of the Galaxy," *Journal of the Royal Astronomical Society of Canada* **84**, No. 2, 1990.