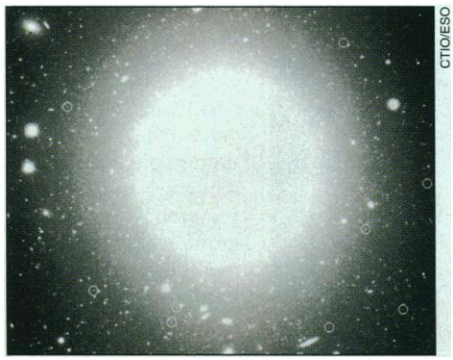
ASTRONOMY

Dying Stars Give Galactic Theory New Life

Death in the cosmos can shed light on birth. Astronomers are now using planetary nebulae, the wispy greenish halos around dying stars, to provide clues about creation—specifically, the creation of giant elliptical galaxies. These rare cosmological leviathans, when they are spotted, are often sitting at the center of swarms of smaller galaxies. Hard data about their genesis has been hard to come by, in large part because they're so far away, but new observations of the movements of nebulae—which will be discussed in the June issue of the European Southern Observatory (ESO)'s in-house journal *The Messenger*—appear to bolster the theory that such behemoths form through the merging of many smaller clumps of matter.



CTIO/ESO

Markers in motion. The pattern of movements of planetary nebulae *(circled)* around the bright core of galaxy NGC 1399 have been observed for the first time. The motion is consonant with a theory that the galaxy formed when numerous small clumps of matter came together.

Since the closest such elliptical galaxy, NGC 1399, is some 50 million light-years away, astronomers have been unable to get a good look at its dark outer realm which, in theory, holds clues about the galaxy's birth. So direct inquiries into that process have been stymied. "It's been an observational puzzle," says Ken Freeman of Australia's Mount Stromlo Observatory. But late last year at the ESO's 3.5-meter New Technology Telescope in La Silla, Chile, an international team of astronomers led by Freeman and colleague Magda Arnaboldi took up the challenge.

They were motivated by recent surveys of NGC 1399 that picked out 37 faint lights in its dim outer region—the planetary nebulae that form when a dying star sheds an outer layer of gas and then heats it until the gas becomes a glowing shell. The researchers believed these objects, some more than 100,000 light-years from the galaxy's bright, slowly rotating center, could be used to track the motion of rare luminous matter in that dark periphery. Some computer simulations of elliptical galaxy formation had offered specific predictions about that motion, and if the observations matched the predictions, it would be evidence that the simulations—and the model of galactic genesis they embrace—are accurate.

In these simulations, galaxies form through the aggregation of clumps of matter not quite developed enough to be called galaxies. The models predict that after the giant galaxy comes together, stars, gas, and other matter in the darker exterior should whiz around much faster than the slowpokes in the bright center. This rotational difference slowly emerges from the gravitational interactions that occur when the clumps of matter spiral inward to merge, explains theoretical astrophysicist Wojciech Zurek of Los Alamos National Laboratory, who helped develop the simulations that showed this effect.

To establish the rotation of the planetary nebulae, and thus NGC 1399's periphery, Freeman's group made use of an ESO spectrograph, a prismlike instrument that separates light into its component wavelengths. In particular, they looked at a specific wavelength of intense green light emitted by ionized oxygen atoms in the nebulae. Depending on each nebula's velocity with respect to Earth, the wavelength would be slightly longer or shorter than expected, a phenomenon known as the Doppler effect. Once they found each individual nebula's velocity, astronomers were able to derive the overall movement of visible matter in the periphery. Indeed, they found that it rotated around the hub faster than did more central material.

The outer rotation in NGC 1399 "matches very nicely" with the computer simulations made by Zurek and others, says Freeman. While other astronomers are reserving judgment on the match until they see the data, Alan Dressler of the Carnegie Observatories in Pasadena, California, does say the technique of using planetary nebulae as far-flung galactic probes seems promising. Freeman and his colleagues next plan to use them to study motions in another galaxy near NGC 1399, further proof that the moribund stars have given life to a new line of astronomical inquiry.

–John Travis

ASTRONOMY

Red Galaxies Hint at an Old Universe

In galaxies, red is a sign of maturity. Young galaxies blaze with hot, short-lived blue stars, but after a galaxy has been around for a few billion years, those stars have spent themselves, and slower-burning red stars predominate. It's no surprise that red galaxies are common in the present universe, where they have had plenty of time to age. But it came as a considerable surprise to Esther Hu and Susan Ridgway of the University of Hawaii to spot what they think are two old, red galaxies in a much earlier phase of cosmic history.

HU AND RIDGWAY

Old and faded. The two objects color-coded red in this infrared image may be old galaxies in the early universe.

If Hu and Ridgway are right, the discovery could stretch out the cosmic timeline. This redating would be needed because Hu and Ridgway estimate that the galaxies are so far off that their light began its journey to Earth when the universe was just a sixth of its present age. Since the galaxies themselves would have to be at least 3 billion years old to shed their youthful blue, the distance implies a cosmic age of perhaps 19 billion years—almost twice the age some cosmologists favor.

Hu and Ridgway caution that their distance estimates are too uncertain for anyone to start revising cosmological models yet. In the meantime, other astronomers are delighted to have a new mystery to explore. "I am very enthusiastic about this discovery," says Mark Dickinson of the Space Telescope Science Institute, who has spotted several somewhat less red galaxies at large distances. Dickinson thinks the discovery could be a hint of many more, since the finding "encourages you to go out and look for such things in a systematic way."

Hu and Ridgway spotted their galaxies by chance, while they were using the University of Hawaii's 2.2-meter telescope on Mauna Kea to search for galaxies reddened by dust. The extreme redness of the galaxies, however, marked them as another kind of object, at an unknown distance. In astronomy, the usual way to determine distance is to break an object's light into a spectrum, then measure the extent to which certain features of this spectrum have been "redshifted" (displaced toward the red) by the expansion of the universe, which carries off more distant objects faster than it does nearby ones. But the objects Hu and