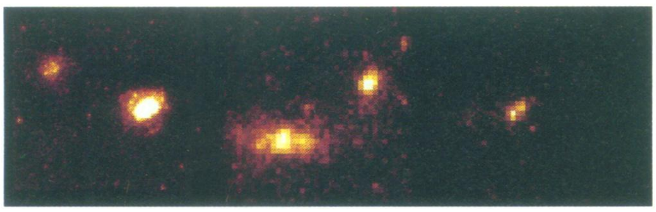
Astronomy

Ron Cowen reports from Arlington, Va., at a meeting of the American Astronomical Society

Tracking the evolution of galaxies

Two teams of astronomers using the Hubble Space Telescope have found evidence that mergers have played a key role in creating today's collection of galaxies.

One of the research groups, which includes Steven B. Mutz and Rogier A. Windhorst of Arizona State University in Tempe, measured the size of several hundred spiral and elliptical galaxies with Hubble's wide-field and planetary camera. In their analysis, the astronomers examined 75 of these galaxies in greater detail, calculating their distance from Earth by taking spectra with two ground-based telescopes. The galaxies — 47 spirals and 28 ellipticals — ranged in distance from about 2.6 billion to 7.8 billion light-years.



Keel, U. of Alabama/NASA

Near-infrared images taken by the Hubble Space Telescope show that some distant galaxies occur in pairs.

Mutz and his co-workers estimated what sizes nearby spiral and elliptical galaxies would appear to be if these bodies were located billions of light-years from Earth. They then compared these calculated sizes with those measured by Hubble for galaxies that actually reside at such faraway distances. The elliptical galaxies seen by the telescope are about one-half to one-third the size of the ellipticals that lie closer to Earth, Mutz says. In contrast, the faraway spirals are about the same size as those nearby.

Galaxies that lie billions of light-years from Earth are observed as they appeared in their youth, billions of years ago. Thus, the finding indicates that elliptical galaxies in the distant past were smaller than ellipticals of today.

But how did these small ellipticals become the larger elliptical galaxies of the present-day universe? A second study now adds to the body of evidence suggesting that groups of the smaller galaxies merged under the influence of gravity to form the larger bodies.

In this study, Windhorst, Barbara Franklin of Arizona State University, and William C. Keel of the University of Alabama in Tuscaloosa and their colleagues compared the likelihood that nearby galaxies, observed with ground-based telescopes, and distant galaxies, detected by Hubble, occur in pairs. The team found that slightly more than one-third of the distant galaxies pair off, compared with just 7 percent of nearby galaxies. Studies suggest that pairing is a prelude to merging.

The new finding suggests that mergers were more common in the early universe and have played a significant role in the evolution of galaxies, the researchers conclude.

However, Mutz and his colleagues also note an alternative explanation for their finding that ellipticals appear smaller than expected in the past. Because the team measured the dimensions of galaxies based on the location of starlight, it's possible that ellipticals in the early universe were the same size as those today but that stars had only ignited in a narrow, core region of the galaxies.

If this scenario proves correct, then stars at the center of elliptical galaxies should be older, and thus redder, than those in outlying areas. This April, Mutz and his colleagues will start putting this theory to the test, surveying in the near-infrared some of the elliptical galaxies previously imaged in their Hubble study. For this study, the team will use a high-resolution telescope at Steward Observatory near Tucson recently outfitted with a mirror that changes position to compensate for the distorting influence of atmospheric turbulence.

Topsy-turvy world of Cassiopeia A

Hurled into space when a massive star ends its life in a powerful explosion, the ejected gas and dust that make up a supernova remnant offer tantalizing clues about the nature of the dying star, as well as its violent demise. The most detailed information comes from studying the remnants of supernova explosions that occur in our own galaxy. And the youngest known remnant in the Milky Way, Cassiopeia A, tells a tale about a star that seems to have turned itself inside out.

Most of the remnant consists of an expanding shell of gas and dust, but astronomers have known since its discovery in the 1950s that Cassiopeia A also has a faint jet of material extending from the shell's northern section. Spectra of the jet, taken over the last few years by Robert A. Fesen of Dartmouth College in Hanover, N.H., reveal that it is rich in relatively heavy elements, such as sulfur, but deficient in lighter elements, including oxygen and helium.

Heavier elements are produced deeper inside massive stars than lighter elements, notes Fesen. Thus, although the jet lies among the outermost parts of the remnant, it comes from the innermost part of the star that exploded as a supernova, conclude Fesen and Dartmouth colleague Kurt Gunderson.

The speed of the jet may explain its rapid advancement from the star's interior. Analyzing images and spectra taken with the 4-meter telescope at Kitt Peak National Observatory near Tucson, Ariz., Fesen and Gunderson discovered that the jet's fastest debris shoots out at speeds of up to 12,000 kilometers per second. In contrast, debris from the exploded star's outermost layer, which consists of helium and hydrogen, moves at about 75 percent of that speed. Ejected debris rich in both sulfur and oxygen, which comes from a layer just slightly deeper than the hydrogen-helium gas, moves at just half the jet's speed.

Fesen/Michigan-Dartmouth-MIT Obs.

Broken ring of light near center of image is the Cassiopeia A supernova remnant, which lies 9,000 light-years from Earth and ranks as the youngest known remnant in the Milky Way. Two streaks (arrows) that seem to emerge from an opening in the ring are part of a jet of high-speed material. The jet may have originated from the inner part of the massive star that exploded to become the supernova.

According to Fesen, the findings indicate that although the Cassiopeia A supernova explosion proceeded relatively smoothly, accompanying it were several eruptions of underlying material breaking through what was once the star's surface layer. The orientation of the jet hints that the remnant may contain many more such plumes that aren't visible from Earth, he notes.

Fesen says it remains unclear why some gas and dust closer to the core of the star that exploded as Cassiopeia A received a more energetic kick than material nearer its surface. With only eight known supernova remnants in our galaxy, researchers don't yet know if this scenario is rare, he adds. Observations by other astronomers indicate that the outer and inner layers of the star that exploded in a nearby galaxy as supernova 1987A have mixed in that remnant, but the innermost material hasn't raced ahead as it did in Cassiopeia A.