Ridgway stumbled upon were too faint to yield spectra, so they had to estimate their distance from other clues.

One clue was the intensity of the galaxies' light in various wavelength ranges. Together, these measurements gave Hu and Ridgway an overall color distribution, which they could compare to that of light from known galaxy types. The best match, they found, was to the reddish light of an old elliptical galaxy—displaced all the way to the infrared by the expansion of the universe. Based on that and other clues, Hu and Ridgway report in last month's *Astronomical Journal*, the objects are most likely elliptical galaxies at a distance equivalent to a time five-sixths of the way back to the Big Bang.

Not all galaxy researchers accept that conclusion. "Without a spectrum, it's hard to tell exactly how far away these things are," says George Djorgovski of the California Institute of Technology. Peter Eisenhardt of the Jet Propulsion Laboratory in Pasadena, California, adds that evidence for the proposed distance is "not very compelling."

Hu and Ridgway aren't disputing that, and they have suggested alternative explanations for the objects' faint, extremely red light. One possibility is that they are nearby galaxies of a hitherto unknown kind, consisting entirely of faint, low-mass stars that emit most of their radiation in the infrared region of the spectrum. A more exotic possibility is that they are precursors of present-day galaxies, located at a distance even greater than Hu and Ridgway favor—farther away and closer to the origin of the universe than any known object. In that case, their actual color could be the blue of a young galaxy, and the galaxies' redness could be entirely due to redshifting.

Both possibilities are startling, say other astronomers, but no less startling than Hu and Ridgway's favored explanation of aged galaxies in the early universe. The exceedingly old universe implied by that picture is in sharp conflict with recent hints that the universe is expanding rapidly and hence is comparatively young—a mere 10 billion years old. But whether this conflict is real or only apparent won't be clear until astronomers can record spectra of the two red galaxies to pin down their distance. And that may be a tough job for current telescopes, say Hu and Ridgway.

One clue, says Eisenhardt, may come when NASA's Space Infrared Telescope Facility (SIRTF) is launched later this decade. If Hu and Ridgway are right, SIRTF may detect peaks in the red galaxies' light at just the wavelength at which the red giant stars that are abundant in an old galaxy shine brightest. For now, says Djorgovski, the Hawaii finding is "a good beginning, but we have a long way to go."

–Ray Jayawardhana

ASTRONOMY

Keeping Tabs on Cometary Breakups

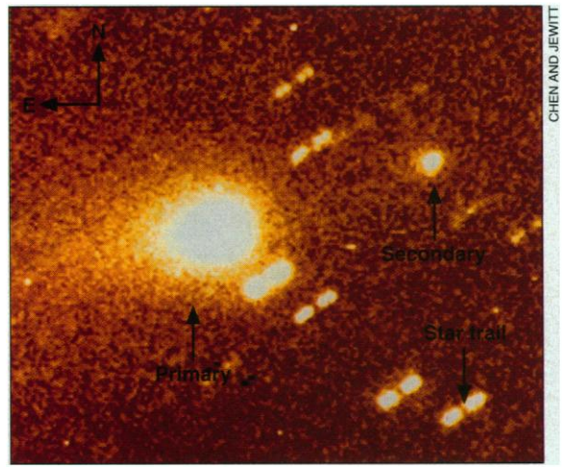
Comet Shoemaker-Levy 9 is now homing in on Jupiter, and many eyes are trained on it in anticipation of a collision in July. The comet initially caught astronomers' eyes for a different reason, however. During its last encounter with Jupiter (a near miss in July 1992), the giant planet's gravity tore it into some 20 fragments, transforming an unremarkable object into a celestial string of beads. But although Shoemaker-Levy 9 may be the most spectacular fragmented comet, two astronomers from the University of Hawaii report that split comets may not be unusual. And it doesn't always take a brush with a giant planet to produce them.

In a study reported in the April issue of *Icarus*, Jun Chen and David Jewitt searched high-resolution images of recent comets for signs of breakup. Only a few split comets had been spotted in the past, says Jewitt, but that may be because the fragments can be faint and move apart quickly: His and Chen's sensitive, systematic search suggests that an average comet nucleus splits about once a century—an unexpectedly high rate. "It's an interesting result because they have calculated the splitting rate from a homogeneous data set," says comet expert Michael A'Hearn of the University of Maryland, although he adds that the sample is too small to be sure of the result. But the finding already has investigators wondering why comets might be so unstable and pondering the possibility that some of the small asteroids inhabiting Earth's neighborhood are actually bits of passing comets.

Chen and Jewitt collected images of 49 comets made between 1986 and 1993 with charge-coupled devices (CCDs), an electronic imaging technology that is 100 times more sensitive than photographic plates. By rapidly displaying, or "blinking," at least four successive images of each comet taken a few minutes to an hour apart, they searched for multiple fragments moving together—evidence that they had once been part of a single nucleus. The researchers found that three of the 49 comets had fragmented nuclei.

Based on the rate at which the fragments move apart, the researchers calculated that their technique could only detect comets that had split within 6 years before the image was made; any longer and the fragments would no longer appear in a single CCD image. Since 6% of their sample exhibited split nuclei, they concluded that a typical comet must split once a century. One other study—15-year-old work by Paul Weissman of the Jet Propulsion Laboratory—had suggested a comparable rate of splitting, but it was not considered definitive because it was based on historical observations of widely varying quality.

The splitting rarely produces equal-sized fragments, Chen and Jewitt think; otherwise, few comets would remain large enough to be visible for more than a few tours around the sun. Instead, the researchers say, comets seem to "peel off" tiny fragments, containing perhaps a thousandth of the mass of the main body. Besides explaining some comets' longevity, that would also put the fragments in the right size range—tens of meters across—to account for some of the small, nearby objects that astronomers in NASA's Spacewatch program have recently detected.



Comet with a sidekick. A split comet nucleus.

Planetary scientist Eugene Shoemaker of the U.S. Geological Survey in Flagstaff, Arizona (a codiscoverer of Shoemaker-Levy) doubts that comets contribute much to this swarm of objects. "The orbits of Earth-crossing comets are very different from the orbits of most of these tiny fragments that Spacewatch detects," he says. That's true for many of the Spacewatch objects, Jewitt concedes, but he says that two or three of them do have orbits consistent with a cometary origin.

Just why comets are prone to breakup isn't clear. Most never come as close to a giant planet as Shoemaker-Levy 9 did, and although the heat of the sun might fracture a comet by boosting the pressure in internal gas pockets, some comets split long before they approach the sun. As Weissman puts it, "Random splitting events seem to occur for reasons we don't understand." Comets, it would seem, are just a fractious bunch.

–Ray Jayawardhana

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