The Hubble Telescope Stars in Atlanta

When the Hubble Space Telescope's blurry vision was discovered, many astronomers shelved their hopes that the instrument would provide quick answers to some of their most pressing questions about the size, age, and fate of the universe. But as astronomers learn to cut through some of the Hubble's optical fog with longer observations and computer processing, they are finding that they have a shot at answering some big questions after all. At the American Astronomical Society (AAS) meeting in Atlanta earlier this month, researchers heard the latest from the Hubble, including hints of how globular clusters are born and where quasars go when they die.

Are Globular Clusters Born In Galactic Collisions?

The oldest stars, nearly as old as the universe itself, are collected in clumps that adorn galaxies like antique diamonds. Like ancient jewelry whose origin has been lost in the mists of time, these starry clumps, called globular clusters, leave astronomers wondering where they came from and what conditions in the early universe led to their proliferation.

Now astronomers think they are seeing shining new globular clusters—new enough to betray clues to their source. Reported at the AAS meeting, the observations imply that some clusters are born when galaxies collide, and that their prevalence in certain types of galaxies may signal a violent past.

These surprising suggestions come from pictures taken with the Hubble Space Telescope by astronomers Jon Holtzman and Sandra Faber of the University of California, Santa Cruz, and their colleagues. They aimed the Hubble's wide field planetary camera at the nearby elliptical galaxy NGC1275. To earthbound telescopes the center of the galaxy appears as a bright blur, but the high resolution of the telescope cut through the opaque brightness to reveal thousands of globular clusters sparkling like buried treasure. It's not the first time people had seen globular clusters at the center of another galaxy. But these were different because they looked freshly minted.

"They were really bright and really blue," says Holtzman, explaining that for stars, blue is the color of youth. "Normal globular clusters have ages of about 10 billion years, while these clusters have ages of at most several hundred million years," he says.

One of the most striking features of these clusters, Holtzman says, was their uniformity in color, which implied a common age—and a common genesis. "What we're speculating is that perhaps there was a violent event in the history of this galaxy that triggered all at one time the formation of these clusters," he says. "In particular, we suggest this violent thing may have been an interaction or collision with another galaxy." Such cataclysmic events could stir up peaceful interstellar gas, triggering the formation of clumps of stars, says Holtzman.

The peculiar, rippled structure of NGC1275, together with the fact that a large chunk of matter appears to be falling into it, has long led to the suspicion that NGC1275 formed when two galaxies collided and merged, says astronomer François Schweizer of the Carnegie Institution of Washington. But this is the first time that observers have spotted nascent clusters in the debris of the collision.

Schweizer says the link between globular clusters and mergers lends credibility to the idea that galactic collisions were once commonplace. He had earlier proposed that all galaxies of NGC1275's type, the ellipticals, formed from mergers. Such collisions would destroy the neat pinwheel arrangement of stars in spiral galaxies, says Schweizer, creating the haphazard swarm of stars typical of ellipticals. Critics of the merger idea had pointed out that ellipticals contain many more globular clusters, sometimes 100 times more, than could come from two spiral galaxies. But if mergers can give birth to additional clusters, he says, the clusters become evidence supporting the merger theory rather than arguing against it.

If mergers did spawn many of the globular clusters in today's universe, it's no surprise that they tend to be old; violent events would probably have happened much more often in the early universe, when things were more crowded. "The universe has matured and slowed down a little," says Holtzman, "but once in a while, something still happens."

New Strategy in the Hunt for Black Holes

Ever since Einstein postulated the concept of black holes, astronomers have searched the heavens for signs of these infinitely dense, light-trapping, time-stopping monsters of runaway gravity. In recent years the search has homed in on the cores of some galaxies, where black holes are thought to lie buried in a dense fog of stars. At the AAS meeting astronomers Todd Lauer of the National Optical Astronomy Observatories and Sandra Faber of the University of California, Santa Cruz, announced a new way to hunt for such black holes—one that has already added weight to the case for a black hole in a nearby galaxy.

Like the discovery of young globular clusters (see previous story), the new hole-hunting strategy takes advantage of the Hubble Space Telescope's superior resolving power. When Lauer and Faber used the wide field planetary camera to photograph the dense core of M87, a galaxy thought to harbor a

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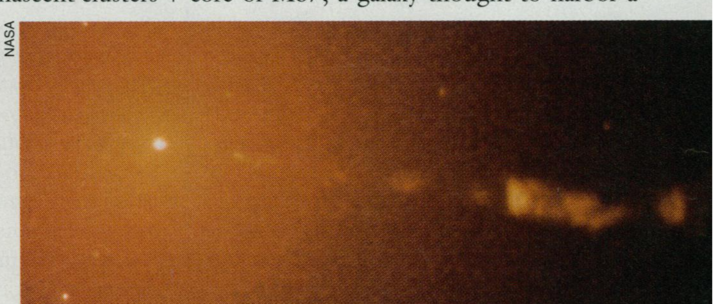

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A penetrating gaze. *The Space Telescope peers into the centers of other galaxies to reveal young, blue globular clusters* (left), *probably spawned by a galactic merger, and a concentration of starlight* (right) *that may signal a black hole.*

black hole, they observed a sharp peak in brightness at the very center. The brightness rose to some 500 times the peak seen in the lower-resolution ground-based images—bright enough, according to the theory proposed in the 1970s by now-deceased Caltech astronomer Peter Young, to signal the presence of a black hole.

Young had argued that the density of stars in an ordinary galaxy should increase toward the center, but only to a certain point; eventually, the density of stars—and their collective brightness—would level off. But if a massive black hole lurks at the center of a galaxy, he said, it should draw in a continuous stream of stars, making the density of stars rise to a sharp pinpoint, or "cusp."

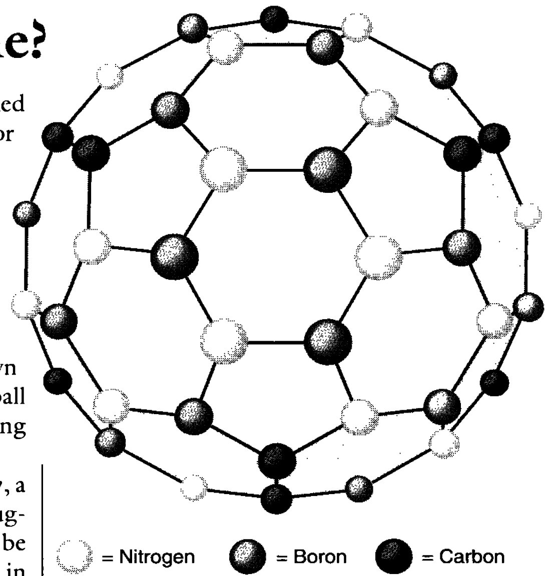
And that's just what Lauer and colleagues observe. The beam of starlight the Space Telescope revealed coming from the galactic center suggests that the stars may be falling toward a black hole wielding as much as 2 billion to 3 billion times the mass of the sun. "This is the first time we've seen possible evidence of a black hole influencing the structure of a galaxy itself," says Lauer.

M87's brilliant center joins earlier evidence for massive black holes in this and several other galaxies. Such galactic nuclei are powerful beacons of x-rays and radio waves, believed to be generated as a central black hole sucks in material. Evidence also comes from spectra that reveal stars whipping around galactic centers at unexpectedly high velocities, as if they were in the grip of some vast, unseen mass. That pattern has not yet been seen in M87, but like some other suspect galaxies, M87 has a telltale "jet" of high-velocity material shooting out. "This jet is a sort of smoke coming out of a fire at the center of the galaxy," says Lauer.

That fire once burned a whole lot brighter, if Lauer's calculations are correct: They suggest the black hole is massive enough to have once powered a quasar. Quasars—the most powerful objects in the sky—apparently only lived in the very early universe, since they are now seen only at great distances. Noone knows where the black holes that powered quasars went, but Lauer's mass estimate supports one proposal: that they lie dormant—or at least dimmed—at the hearts of modern galaxies.

Still, the black hole hunt won't be over in M87, says Lauer, until he gets a second piece of evidence from the Space Telescope: high-resolution spectra, which should show exceptionally fast-moving stars close to the center. In the meantime he wants to survey other suspect galaxies to see if they, too, show this sharp cusp in brightness. And he'd like to apply the same test to some non-black hole galaxies, just to make sure the effect doesn't show up everywhere. ■ FAYE FLAM

CBN Ball, Anyone?



A CBN ball. *Round chemistry rolls on.*

SOURCE: JELSKI ET AL. ILLUSTRATION: J. CHERRY

A year and a half ago, many scientists looked on the 60-carbon sphere known as C_{60}, or buckminsterfullerene, as an elusive molecular unicorn whose very existence was uncertain. Now that the stuff is available by the spoonful, nobody doubts its reality anymore. Theorists are not content, however. Last week, they gave skeptics something new to swallow: In two separate papers, they argued that the known fullerene fauna—the 60-carbon buckyball and its relatives—may be just the beginning of a diverse new molecular menagerie.

In the 22 January *Inorganic Chemistry*, a trio of researchers report calculations suggesting that synthetic chemists should be able to replace 48 of the carbon atoms in C_{60} with 24 boron atoms and 24 nitrogen atoms to create what they call a CBN ball. Meanwhile, other researchers argue in the 23 January *Nature* that fullerenes may exist in inside-out versions, dramatically different from their cagelike relatives.

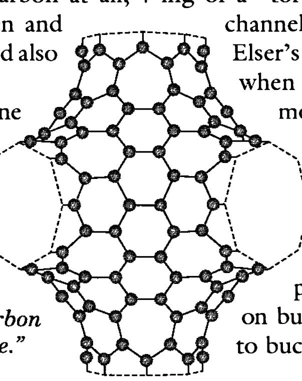
The first of these theoretical creations, CBN ball, "would be similar to buckyball in many respects," says theorist Daniel Jelski of the State University of New York (SUNY), Fredonia. But its chemical behavior should be much richer, think Jelski and his colleagues James R. Bowser of SUNY, Fredonia, and Thomas F. George of Washington State University in Pullman. "In comparison to buckyballs, which have one kind of reactive site, CBN ball has at least five distinct reactive sites," Jelski explains. The dozen carbon atoms provide one kind of site; boron and nitrogen atoms occupying different chemical neighborhoods on the surface of the molecule account for the other four.

On top of its potential do-it-all reactivity, CBN ball should be at least as stable as C_{60}, according to the researchers' preliminary calculations. In a second paper, submitted for publication elsewhere, Jelski and his colleagues (including Xinfu Xia of SUNY, Buffalo) go even further: They suggest that a 60-atom ball containing no carbon at all, just 30 atoms each of nitrogen and boron—call it a BN ball—should also be stable.

To confirm all this, someone will have to make the stuff. Richard Smalley of Rice University has already doped a few boron and nitrogen atoms into standard C_{60} spheres—an encouraging precedent, though it doesn't guarantee success, the researchers say. One approach they suggest would build on existing techniques for making buckyballs, in which graphite or other carbon-loaded starting materials are burned and fullerenes are extracted from the soot. To form the 60-atom CBN balls, chemists might try making and burning precursors containing carbon, nitrogen, and boron. A precursor containing no carbon at all, such as borazine ($B_3H_6N_3$), might yield the carbonless BN ball.

While Jelski and his colleagues try to spice up the buckyball structure with new elements, physicist Veit Elser and his colleagues at Cornell University think there are some fullerene novelties to be found in plain old carbon. In their *Nature* paper, they propose that the black, insoluble gunk that buckyball researchers find at the bottom of their glassware after extracting the soluble fullerene molecules might contain extensive, three-dimensional carbon networks displaying the "negative curvature" of a saddle, instead of the positive curvature of ordinary buckyballs. The negative curvature might give these networks an overall structure consisting of a "tortuous labyrinth of pores and channels," Elser says. The materials, Elser's group surmises, would arise when rings made up of seven or more carbons take the place of the five-member carbon rings that enable standard fullerenes to form closed cage structures.

Elser, for one, says he's pleased to have turned the tables on buckyballs: "This is our reaction to buckymania." ■ IVAN AMATO



Fullerenes in the saddle. *Networks of six- and seven-carbon rings show "negative curvature."*

SOURCE: V. ELSER ET AL. ILLUSTRATION: J. CHERRY