ASTRONOMY

Case Closed for a Giant Black Hole

Confronted with extraordinary claims, astronomers, like a skeptical jury, want to be convinced beyond a reasonable doubt. And there are few claims more out-of-the-ordinary than the notion of supermassive black holes, solar system–sized objects with the mass of billions of stars. For decades, researchers have tried to prove such monsters lay hidden in the centers of galaxies. The jury of their peers wasn't completely convinced, however.

Now any doubts may be swept away. Holland Ford of Johns Hopkins University and the Space Telescope Science Institute announced at a National Aeronautics and Space Administration (NASA) briefing last week that he and his colleagues had used the repaired Hubble Space Telescope to peer deep into the core of M87, a giant elliptical galaxy 50 million light-years away. There they found powerful evidence for a monster black hole in the swirling gases of a pancake-like disk. "This is an excellent day for the prosecution," says Tod Lauer of Kitt Peak National Observatory, one of many arguing the case for the massive beasts. Even to skeptics, the case is overwhelming. "I have to concede there's something very large and very dark there....I'll accept the black hole is in there," says a previously dubious Daniel Weedman, head of NASA's astrophysics division.

The case to be made for black holes is a difficult one, since they are almost impossible to observe: They are so dense that not even light can escape from them. The only detectable signatures of a black hole are thought to be the effects of its immense gravity on nearby stars and gas. The velocity of stars whipping around unseen companions has already convinced some astronomers of the existence of "garden-variety" black holes: those formed through the collapse of a single star. And the powerful bursts of radio waves and other radiation emanating from the cores of "active" galaxies and so-called quasars seemed to hint at the existence of much larger black holes, producing such emissions by compressing and heating nearby gas.

In 1978, the late Peter Young and his colleague Wallace Sargent of the California Institute of Technology thought they saw another clue in M87: a brightening near the center that could be explained by a dense cluster of stars bound in a tight orbit around a black hole. That idea got a huge boost in 1992 when Lauer and Sandra Faber of the University of California, Santa Cruz, took a closer look at M87's core with the Hubble and saw an even more dramatic peak in brightness (*Science*, 31 January 1992, p. 536).

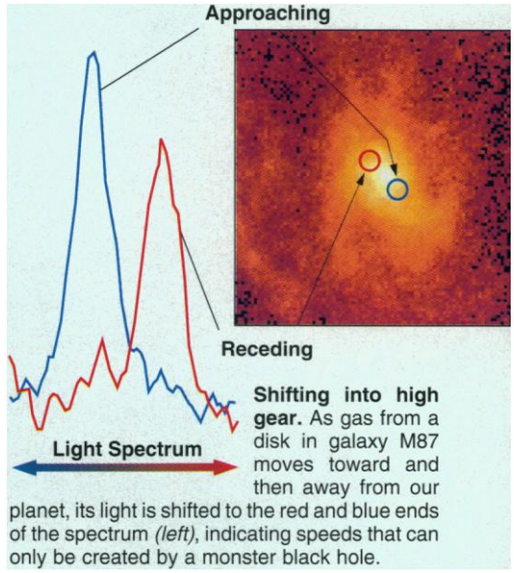
The case, however, was far from closed. Theorists could construct galaxies with unusual distributions of stars that would produce a similar bright pinpoint without a black hole. The final proof, said astronomers, would be material moving at high velocities near M87's nucleus. The Hubble's original faulty optics kept it from producing these sightings.

With the telescope now in good shape, astronomers found their "smoking gun" in a rotating disk of hot gases, first spotted by the Hubble in February, that surrounds the center of M87. To detect the disk's velocity, astronomers measured the color of the gases using Hubble's Faint Object Spectrograph. As the disk spins around the core, the gas on one side moves towards Earth, and on the other side it moves away from us. These motions shift the wavelengths of light from the gas, and the extent of the shifts tell astronomers exactly how fast the gases are moving: 1.2 million miles per hour.

At those speeds, says Richard Harms of Applied Research Corp., a co-investigator with Ford, the disk "requires a very strong gravitational field to hold it together." Jokes Ford, "If it is not a black hole, it's something stranger." The measurements allow a simple calculation of the mass needed to restrain the disk, adds Harms, and that figure comes to 2 or 3 billion solar masses—agreeing with an earlier estimate made by Lauer and Faber.

Proof of a giant black hole doesn't exhaust the mysteries of M87. There's a huge, unexplained plume of high-velocity material shooting out of the galaxy's core, and astronomers now plan to explore whether M87's black hole is somehow channeling portions of its surrounding gases into this jet. And the black hole—or rather its proof—is producing other gravitational effects that may warrant investigation. Since the data first came in, notes Ford, "we've been walking about a foot off the ground."

–John Travis



SOURCE: STSCI/NASA

Shifting into high gear. As gas from a disk in galaxy M87 moves toward and then away from our planet, its light is shifted to the red and blue ends of the spectrum *(left)*, indicating speeds that can only be created by a monster black hole.

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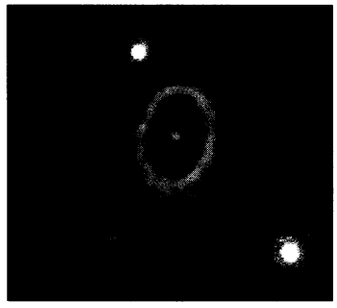
Running Rings Around a Supernova

During the 7 years since it exploded onto the astronomy scene, Supernova 1987A has been photographed as often as a Hollywood celebrity. But this shot, taken by the repaired Hubble Telescope and released 2 weeks ago, reveals something never before seen—a delicate double halo. "This is an unprecedented and bizarre object," says astronomer Christopher Burrows of the Space Telescope Science Institute, who discovered the rings. And as befits an astronomical enigma, researchers have several theories to explain it.



CHRISTOPHER BURROWS, ESA/STSCI/NASA

Burrows speculates that the double rings are being "painted" by another star near the one that exploded to create 1987A. He notes that the rings are not centered on 1987A, but on a fainter companion, which can be seen if the picture is greatly enlarged. He speculates this companion may be a dense, collapsed star, emitting rotating beams of light from its poles like searchlights. The beams could trace out the rings on a bubble of gas ejected from 1987A just before it exploded.

Others think there may be a simpler explanation. "A more economical way to think about it is to talk about the star you know is there," says Harvard University astronomer Robert Kirshner. He suggests that 1987A itself may have created the rings by ionizing parts of the gas bubble, making the rings glow like neon lights—although why the rings were formed in a double halo, he says, is beyond him at the moment. Whatever the cause of the phenomenon, there is much to learn from studying the object, says Kirshner. "If you want to know how stars die, this sort of study will show us what the death throes are like."

–Faye Flam