much to improve the country's science, however. In the long term, Mongolian administrators acknowledge that a better educated population will be essential. And that means supplementing the country's only major university. So in 1997 Chadraa converted a former Russian high-rise building into a campus, called the Ulaan Baatar University, that is run by the University of Colorado, Denver (UCD). The unusual arrangement, which UCD pioneered in Moscow and Beijing, gives the 60 Mongolian students now enrolled a chance to learn English, earn a U.S. degree, and apply for study in Denver or other U.S. universities. The academy and its U.S. partner share the cost of the $4000 annual tuition. In addition, the Mongolian government subsidizes 30 graduate students at Denver and at other U.S. universities.

Chadraa, who also holds the position of university rector, acknowledges that the UCD relationship is a gamble. "It's hard for us—the textbooks, the tuition are very expensive, and we have spent a lot of money developing this." But such a connection is a vital step toward raising a new generation of English-speaking researchers. For their part, UCD officials see the arrangement, which they hope will at least break even, as an opportunity to expand their presence in Asia.

Mongolia's efforts to build a peaceful democratic society and create a market economy win praise from foreigners, who contrast it with the chaos enveloping other parts of the former Soviet Bloc. Nevertheless, day-to-day life remains bleak. "Mongolia is a small country, and there is little support for science," says one Mongolian researcher, noting that "science is at the bottom of the list" of programs funded by the country's Ministry of Enlightenment, which supports education, culture, and science. That is the harsh reality in a nation of few roads, schools, and exports, and whose airline is hard pressed to pay for maintenance on its single Airbus jet. But Mongolian researchers are betting they can extend the country's history of international contacts to bolster its scientific prowess.

–ANDREW LAWLER

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MEETING AMERICAN ASTRONOMICAL SOCIETY

New Clues to the Habits of Heavyweights

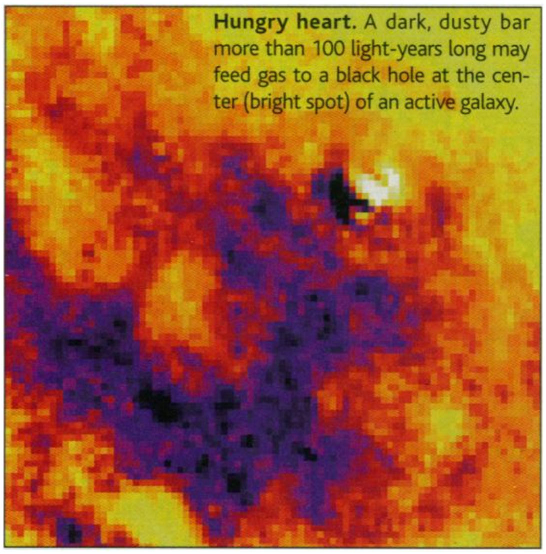
AUSTIN, TEXAS—People who go to extremes often make the news, and the same goes for outlandish celestial objects: neutron stars and black holes. At the astronomy meeting here, clues to two mysteries emerged: how black holes fuel themselves and how some newborn neutron stars hide from view.

A Black Hole's Feeding Tube

What feeds the cosmic manic-depressives called Seyfert galaxies? When these flickering galaxies are at their brightest, a tiny region at their core can outshine the entire Milky Way. Astrophysicists have theorized that a bar of gas, perhaps 100 light-years across, forms and acts as a "feeding tube" to squirt material into a central black hole, where the material gives off one last "Geronimo!" of brilliant electromagnetic radiation before vanishing into the gravitational maw. Eventually the bar disappears and gas settles more slowly to the center of the galaxy, which ceases its hyperkinetic ways and gives off a merely ordinary glow.

Until the American Astronomical Society meeting, however, no such bar had ever been reported. At the meeting, a team led by Almudena Alonso-Herrero of the University of Arizona, Tucson, and Roberto Maiolino of the Osservatorio di Arcetri in Florence, Italy, announced that they had used the Hubble Space Telescope (HST) and other instruments to pick out a small bar and trace the motion of its gas, which appears to be streaming toward the center of a Seyfert galaxy in full throat. "It could be that this is catching [a black hole] in the actual act of fueling," says Michael Regan, an astronomer at the Carnegie Institution of Washington.

If so, the implications could go beyond Seyfert galaxies, because other so-called "active" galaxies—such as the much more brilliant quasars—may work in a similar way. Astronomers doubt that the full picture of how black holes are fed has emerged just yet, but Maiolino points out that Seyferts, with properties midway between ordinary galaxies and quasars, are good places to test the physics of the feeding. And Seyferts like the one his team studied, called Circinus, are much closer than quasars, making them easier to study. At a distance of 10 million light-years, Circinus "is a next-door neighbor compared to quasars," says Maiolino.



Hungry heart. A dark, dusty bar more than 100 light-years long may feed gas to a black hole at the center (bright spot) of an active galaxy.

CREDIT: J. HESTER AND P. SCOWEN/ARIZONA STATE UNIVERSITY/NASA

Theories say that gas bars could form spontaneously, when gravity amplifies slight ripples in the disk of a galaxy. As gravity pulls in more and more gas, it would smash together in the bar, forming shock waves that could brake the spinning motion that the gas shares with the galaxy as a whole. No longer in the grip of centrifugal force, the material would quickly drain along the bar toward the black hole, like a roulette ball falling to the center of the wheel after it loses its spin. The final acceleration of the material around and into the black hole would throw off photons and produce the Seyfert galaxy's radiation, from an area the size of the solar system.

Ground-based telescopes can't resolve the fine detail needed to see such a bar at the center of another galaxy, so the team turned to the HST, working in infrared wavelengths that can penetrate dust at galactic centers. When the team took a close look at Circinus, one of the nearest Seyferts, the bar popped out of the HST images. Alonso-Herrero says that once they knew exactly where to look, they were then able to use data from the 3.9-meter Anglo-Australian Telescope in Australia to estimate the gas velocities from slight shifts in the wavelengths of the light that emerged.

"We were really amazed at how the observations resemble" the theory, says Alonso-Herrero. "It does appear to be forcing gas into the middle, in the way that models predict," says Andrew Wilson, an astrophysicist at the University of Maryland, College Park, who visited the team's poster presentation here.

But not every Seyfert may dine the same way. In a poster right next to Alonso-

Herrero's, Regan and the Carnegie Institution's John Mulchaey reported their own new HST observations of 104 galaxies of various types. Although the observations are mostly less detailed than the Circinus images, they suggest that such bars aren't always present in active Seyferts. The study also showed that the bars can turn up in ordinary galaxies, many of which are also thought to have black holes at their cores.

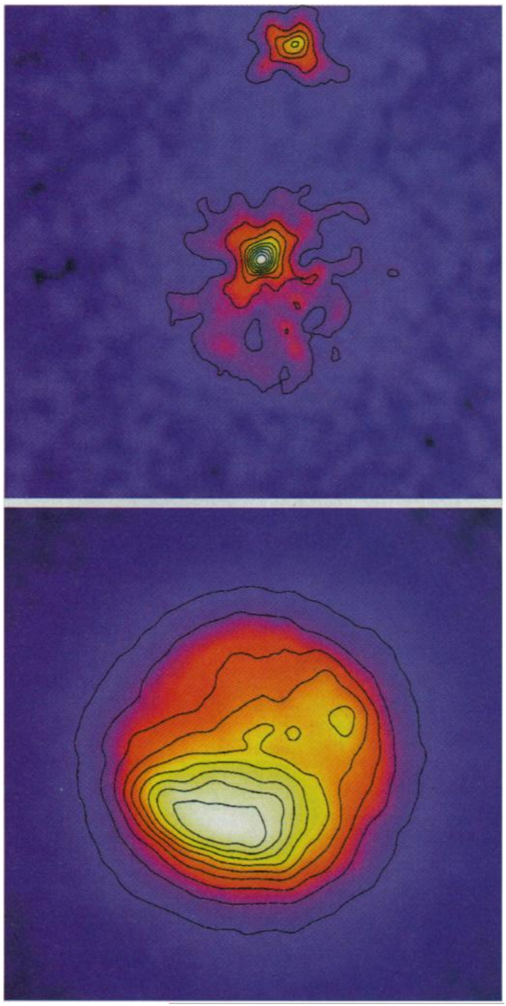
Whether Circinus is an isolated case now becomes the "tough question," says Alonso-Herrero. By relying partly on visible rather than infrared light, Regan and Mulchaey could have missed bars in some now-active Seyfert galaxies, she thinks. Then again, a Seyfert might not need a bar for the full duration of its outburst. A short-lived bar might supply a black hole with enough gas to keep it radiating for hundreds of millions of years, then disperse. "If bars are the way [fueling] happens, they're not doing it all the time," says Regan. "I think what we're coming to is that it's not the simple answer." **–JAMES GLANZ**

"Magnetars"—the Missing Pulsars?

Neutron stars, the ultradense cinders left behind when stars collapse in supernova explosions, inhabit a realm of weirdness almost as strange as that of black holes. Astrophysicists who struggle to grasp their bizarre properties have at least felt sure they understood how these stars begin: as pulsars, magnetized objects spinning rapidly after their violent birth and generating searchlight beams of radio waves. But now, recent findings of freshly forged neutron stars with radically different behaviors have put a new spin on that seemingly safe picture.

The culprits are "magnetars," infant neutron stars apparently girdled by far stronger magnetic fields than pulsars have—so strong that the stars screech to a near standstill in a cosmic eye blink after their formation. Although magnetars were theoretical curiosities a year ago, astronomers are unveiling a growing number of them hurling x-rays and gamma rays, not radio waves, from the hearts of recent supernova blasts. Speakers at this month's meeting of the American Astronomical Society here ventured that magnetars may represent 10% of all young neutron stars, if not more. Given an anomaly of that size, "the previous pulsar paradigm is probably precluded," Massachusetts Institute of Technology astronomer Victoria Kaspi proclaimed—provocatively.

Not all astronomers are willing to jump paradigms, after all. But many agree that magnetars could help solve what Eric Gotthelf of Columbia University calls the "missing pulsar problem." Supernovae freckle the Milky Way with bright puffs of expanding debris, like the bursts of a July 4th fireworks display. Within each of these remnants, astronomers have assumed, a pulsar should lurk. Two stunning discoveries in 1968 seemed to cement this scenario: the famed Crab and Vela pulsars, broadcasting radio beams from within their respective supernova clouds. But since then, among hundreds of known remnants, researchers have found less than a dozen inhabited by radio pulsars. In the most recent washout, astronomers have yet to spot a whirling stellar corpse in the debris left by the great supernova of 1987.



Magnetar unmasked? High-energy x-rays from the center of a supernova remnant called RCW 103 reveal a compact object (*top*)—a possible radio-quiet neutron star, which is hidden at lower energies (*bottom*).

CREDIT: GOTTHELF *ET AL., ASTROPHYSICAL JOURNAL*, 1997, 487, L175

Three factors help explain this puzzle, astronomers have believed. First, the radio beams from many pulsars may point away from Earth, making them undetectable. Second, supernovae can impart high-velocity "kicks" to pulsars and eject them from their remnants, which fade rapidly with time. Last, pulsars are notoriously faint and hard for radio surveys to spot.

Gotthelf now thinks another factor may make a bigger contribution to the pulsar deficit: Many neutron stars don't fit the classic Crab pulsar mold. At the meeting, he and colleague Gautam Vasisht of NASA's Jet Propulsion Laboratory in Pasadena, California, described several they have analyzed, including an x-ray–emitting neutron star that appears embedded in a 2000-year-old supernova remnant called Kes 73. Despite its youth, the neutron star spins just once every 12 seconds, the slowest rate ever seen. If the supernova left the collapsed core of the precursor star whirling 10 to 100 times per second at birth—as required by nearly all supernova models—then a magnetic field up to 1000 times stronger than an ordinary pulsar's must be applying the brakes, Gotthelf said. Such a strong field could stifle the neutron star's radio emissions but generate bursts of x-rays and gamma rays by literally cracking its exotic crust.

X-ray satellites have spotted a dozen other examples of isolated young neutron stars in supernova remnants, many of which have leisurely spins. That's enough to convince Gotthelf and Vasisht that they represent an important new class of objects. "Taken collectively, there are now more of these at the centers of supernova remnants than there are Crab-like pulsars," Gotthelf says. "It's clear there's another evolutionary path." Theorists aren't sure why some collapsing stars would spawn such magnetically fierce beasts while others would produce tame pulsars, but the evidence to date supports two different categories, Gotthelf believes. "As soon as Chandra [an x-ray satellite formerly called AXAF] goes up this year, we're going to find a lot more of these things," he predicts.

Other pulsar experts are biding their time. "The claim that magnetars rather than ordinary radio pulsars are the more common products of supernova explosions seems to me to remain pretty speculative," says astronomer Stephen Thorsett of Princeton University. Pulsar-hunter Andrew Lyne of the University of Manchester in England agrees: "The statistics are very sparse at the moment. Neutron stars with high magnetic fields simply may be an extension of the normal scheme with which we are familiar."

Even if more magnetars turn up, astronomer Shri Kulkarni of the California Institute of Technology in Pasadena thinks they won't offer a catch-all explanation for the missing pulsars. "There's a bit of bandwagonism going on," he says. "There is not just one class of objects we can call magnetars. My claim is that it's a zoo out there."

–ROBERT IRION

Robert Irion is a science writer in Santa Cruz, California.