$10 million per year—is funding an array of new studies to find answers. The Office of Naval Research (ONR), for instance, has nearly doubled its spending in the field over the last 5 years to about $6.5 million annually. This year, its agenda includes research to pinpoint the level at which noises begin to temporarily degrade the hearing of some marine mammals. It is also beginning to build a three-dimensional computer model that can predict how some kinds of whales will react to sounds. "We want to be able to swim a simulated whale through a sound field and have it behave realistically," says ONR's Bob Gisiner.

In a related effort, the Pentagon's environmental research program wants WHOI's Tyack to help it improve efforts to track whales by the sounds that they make, partly so they can move potentially harmful activities away from the animals. In research directly related to the Bahamas stranding, Tyack also hopes to place on the back of a beaked whale a new sensor that gives scientists detailed information about a whale's underwater behavior (see sidebar on p. 577). Other Navy agencies hope to equip ships with computer software that will warn captains when they are operating in whale-rich waters.

Air-gun assault

Other government agencies are also pursuing sound studies. At the National Oceanic and Atmospheric Administration (NOAA), researchers plan to work with the shipping industry on building quieter vessels; they would also like to compile an accurate marine "sound budget" of all the noise in the sea. Chris Fox, a marine geophysicist at NOAA's Pacific Marine Environmental Laboratory in Newport Beach, Oregon, is hoping the agency will fund an examination of old Navy records that might show how ocean noise has changed over decades and that it will build a multimillion-dollar listening network to put such data in a global context. A National Academy of Sciences panel will also start assembling an "ambient noise" research agenda, with recommendations expected next year.

Preliminary NOAA studies using listening posts moored along the mid-Atlantic ridge have already produced some surprising results, Fox notes. The hydrophone arrays, designed to listen for underwater earthquakes and volcanoes, have sometimes been overwhelmed by low-frequency pulses produced thousands of kilometers away by oil exploration ships using pressurized air-gun arrays. "A single seismic survey vessel can sonify the entire North Atlantic," he says.

Such seismic studies also interest the Interior Department's Minerals Management Service (MMS). It has a small research program aimed at understanding how the spread of oil drilling into the deep waters of the Gulf of Mexico might affect sperm and other whales living in the area. In part, MMS is reacting to past studies, done off Europe and Australia, that have shown that some whales avoid exploration activities.

There is also a move to make companies a bigger part of future studies. Jack Caldwell, an oil industry researcher at Core Laboratories in Houston, Texas, helped organize a scientific panel that later this year will offer recommendations on possible areas of support. The goal, Caldwell said at an MMC meeting last year, is to produce "nuts-and-bolts, practical information," such as exactly which species of marine mammals are likely to be sensitive to air guns, and where they are likely to be found.

In the meantime, Balcomb continues to document the aftermath of the Bahamas stranding. Before the beachings, he notes, his team had spotted about 50 of the unusual Cuvier's beaked whales in the study area. But since "that unforgettable morning" last March, he says, researchers have seen just one. **–DAVID MALAKOFF**

MEETING AMERICAN ASTRONOMICAL SOCIETY

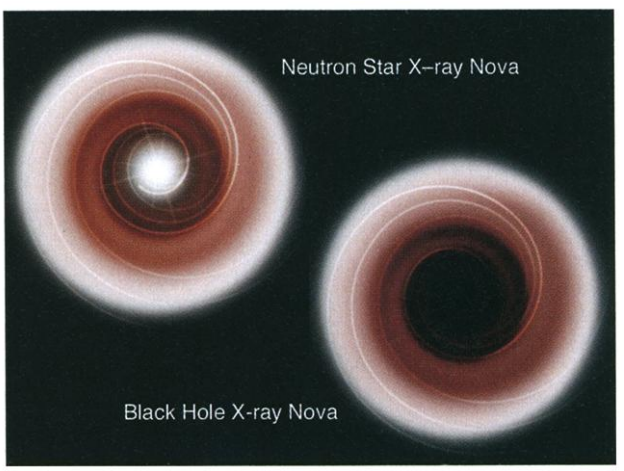
Celestial Zoo Gains Some Exotic Specimens

SAN DIEGO—In the second week of the new millennium, nearly 3000 scientists and educators gathered here for the 197th biannual meeting of the American Astronomical Society, held in conjunction with the American Association of Physics Teachers. Just a few kilometers from the city's world-famous zoo, speakers added bizarre new members to the cosmic bestiary.

Staring Into a Black Hole's Abyss

According to astrophysical theory, a black hole has no surface—just an immaterial "event horizon" that acts as a one-way passage from our universe to oblivion. Matter and radiation crossing this point of no return are lost forever. Now, two major space observatories may have found the first evidence that event horizons indeed exist. According to Ramesh Narayan of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts, the results confirm one of the most remarkable predictions of general relativity.

The first glimpse of the abyss comes from the Hubble Space Telescope. Joseph Dolan of NASA's Goddard Space Flight Center in Greenbelt, Maryland, spent 8 years analyzing old data from the High Speed Photometer on board Hubble. In far-ultraviolet observations of Cygnus X-1, a binary system consisting of a normal star and a black hole, Dolan noticed millisecond flickerings that grew quicker and fainter with time. These "dying pulse trains" behave just as you would expect from a blob of gas spiraling into a black hole, Dolan says: brightening and dimming faster and faster as the gas's ever-tightening orbit swings it toward and away from the observer many times a second, and finally fading out as the gas disappears beyond the black hole's event horizon. If instead the gas blob were slamming into the surface of another type of compact object, such as a neutron star or a white dwarf, the last radiation pulse would be the brightest.



Telltale difference. Swirling gas clouds glow as they strike a neutron star, but they just vanish into a black hole.

CREDIT: ADAPTED FROM M. WEISS/CXC

Dolan admits that the dying pulse trains—if that's what they are—are almost completely masked by random brightness fluctuations in the steady emission of Cygnus X-1. "They are needles in a haystack," he says. "We need to follow up on these observations with ultraviolet or x-ray instruments. If we find more of them, that would be a smoking gun."

Meanwhile, what looks like stronger evidence comes from NASA's Chandra X-ray Observatory. Narayan, together with his CfA colleagues Michael Garcia, Stephen Murray,

and Jeffrey McClintock, used the observatory to study binary star systems containing normal stars paired with massive compact objects. In such a system, gas flowing from the normal star onto its compact companion heats up enough to emit x-rays. Sometimes, enough gas goes down the drain to create bright x-ray outbursts, but most of the time it trickles in, producing x-rays at a steady, low level. From the orbital speed of the normal star, the astronomers can calculate how massive the companion is—and thus whether it is a neutron star or a black hole.

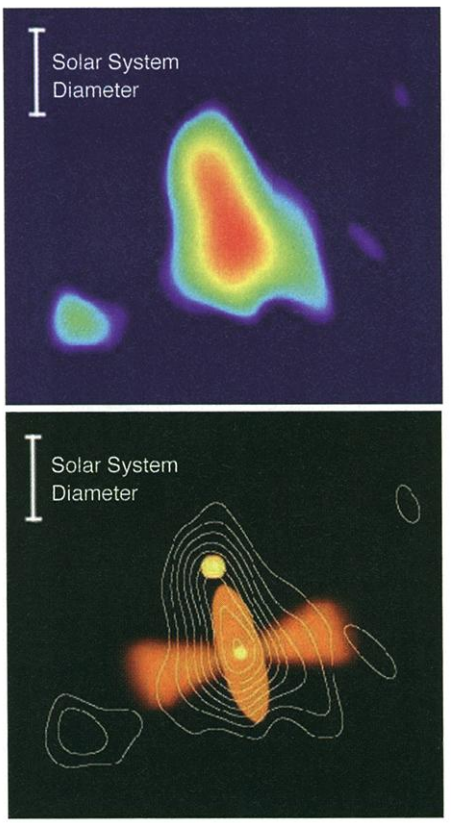
Chandra showed that, while in their quiescent state of x-ray emission, binaries with black holes are only about 1% as luminous as binaries containing neutron stars. Apparently, the gas disappears into a black hole leaving hardly a trace. In the case of a neutron star, on the other hand, it slams onto the surface, releasing large amounts of additional energy. "It's like watching a river that either just disappears over the edge of a waterfall, where it can't be seen anymore, or runs into a dam, creating a lot of turbulence," Narayan says.

"This is the only serious claim so far for the observation of an event horizon," says Roeland van der Marel of the Space Telescope Science Institute in Baltimore, Maryland. "It's certainly an interesting piece of the [black hole] puzzle." But Craig Wheeler of the University of Texas, Austin, warns that the interpretation of the data depends on assumptions about the nature of the gas flow that may not be correct. Of the two main models for accretion flows, he says, Garcia and colleagues based their work on the less popular one. "It seems this would change something, given that the underlying nature of the flow is so different," Wheeler says.

Telescope Pair Spots Hefty Stellar Cradle

By linking two sets of radio telescopes, astronomers have gotten their first look at the accretion disk that surrounds a massive protostar—a place where stars and planets are being born. Some 150 billion kilometers across, the new disk is only slightly larger than disks previously found around less massive protostars, but it is tens to hundreds of times more massive, says Debra Shepherd of the National Radio Astronomy Observatory (NRAO) in Socorro, New Mexico. Comparing these bulky baby stars with normal-sized ones, Shepherd says, will help theorists predict how a disk feeds its growing star and whether the leftovers congeal into planets and other orbiting bodies. The observations are "a boon to theorists," agrees Alain Lecavelier des Etangs of the Institute of Astrophysics in Paris.

Astronomers have long been eager to peer into the inner sanctums of rare massive protostars. Although many smaller protostars lie within viewing range, the nearest massive protostar is thousands of light-years away—too far for ordinary telescopes to resolve its disk. But last year, NRAO linked the 27 dishes of its Very Large Array (VLA) radio telescope to another 25-meter antenna in Pie Town, 50 kilometers away. In effect, the link created a much larger instrument able to "see" in extremely sharp detail. Right now, says Marc Claussen of the NRAO, a collaborator on the project, "in terms of the combination of sensitivity and [angular] resolution, the Pie Town link is unsurpassed."



Massive protostar. Radio emissions from Orion reveal a stellar accretion disk, cones of ejected gas, and a small companion star.

Using the new setup, Shepherd examined a massive protostar known as G192.16-3.82. This giant, some 6000 light-years away in the constellation Orion, is probably just 200,000 years old and weighs 8 to 10 times as much as the sun. The mass of the protostar's accretion disk is about 20 solar masses. The new observations also hint that the blob of radio emission hides a nearby companion protostar. "In our models, we had to add this companion to match the observations," Shepherd says. The presence of the neighboring star may be the cause of a tilt that the astronomers observe in the disk around the massive star.

The researchers expect to gather many more high-resolution glimpses of nascent solar systems in the future, after the VLA is linked to nine new antennas in what will be known as the Expanded Very Large Array.

Radical Theory Takes a Test

In one of the meeting's most provocative talks, Margaret Burbidge, an astronomer at the University of California, San Diego, presented evidence supporting a theory that, if correct, would turn cosmology inside out. Although the theory, a rival to the big bang model of the origin of matter, still has few friends among mainstream astronomers, one of them is now putting it to the test.

Burbidge's evidence comes from quasars—pointlike sources of radiation that may include optical light, radio waves, and x-rays. The wavelength of their radiation has generally been stretched by more than 100%. If, as most astronomers believe, these redshifts are a result of the quasars' rapid outward motion as the universe expands, they indicate that quasars are billions of light-years away from Earth. The widely accepted view is that quasars are the bright nuclei of remote active galaxies, probably powered by supermassive black holes.

Burbidge is not so sure. At the meeting, she described how she and two collaborators—Halton Arp of the Max Planck Institute of Astrophysics in Garching, Germany, and Yaoquan Chu of the Beijing Astronomical Observatory—had found a pair of quasars flanking a galaxy known as Arp 220. The galaxy is only 250 million light-years away; the redshifts of the quasars, on the other hand, indicate that they are about 6 billion light-years away.

A chance alignment? Burbidge doesn't think so. So far, she says, 11 nearby active galaxies with high-redshift "paired quasars" have turned up since she discovered the first one 4 years ago (*Science*, 22 November 1996, p. 1305). Burbidge thinks that in each case, the paired quasars and the associated galaxy might be equally close to observers on Earth. "The evidence is accumulating," she says, that redshift is a shaky measuring rod.

Arp goes further. He thinks the quasars originated inside the galaxies, as clumps of new matter created billions of years after the big bang. Arp and a handful of other cosmological dissidents believe that matter is still coming into being in some parts of the universe, including the cores of active galaxies. The newly created matter is flung out in two opposite directions, just like the radio-emitting jets of high-energy particles that stream out of many active galaxies. The high redshift of the ejected matter, they say, may be due to its youth (an idea developed by the Indian astrophysicist Jayant Narlikar) or to relativistic effects.

James Moran of the Harvard-Smithsonian

CREDIT: D. SHEPHERD, M. CLAUSSEN, S. KURTZ/NRAO, AUI, AND NSF

Center for Astrophysics in Cambridge, Massachusetts, is putting Arp's iconoclastic ideas to a simple test. If the ejection theory is correct, he points out, the paired quasars near a galaxy should move across the sky. Using 1998 data from the National Radio Astronomy Observatory's Very Long Baseline Array, Moran is trying to detect the proper motion of one of the quasars apparently associated with a galaxy known as M 106 or NGC 4258, located in the Big Dipper, 25 million light-years from Earth. "We should have results later this year," Moran says, although he reckons that "a null result will probably not satisfy" the true believers.

At 78, Burbidge—a former director of the Royal Greenwich Observatory in England and former president of the American Association for the Advancement of Science—can afford to do unfashionable research. Still, few of her colleagues are willing to follow her down a path that would throw measurements of cosmic distances into turmoil. "She has earned the right to do whatever she thinks best," says an influential U.S. astronomer who asked not to be named. "But 99% of the astronomical community is pretty sure that quasar redshifts are due to the expansion of the universe and tell us distances."

Largest Structure in the Universe

Astronomers at the Cerro Tololo Inter-American Observatory in Chile have spotted the largest coherent structure in the universe: a supercluster of galaxies measuring almost 600 million light-years across. The real surprise, though, is the supercluster's enormous distance—some 6.5 billion light-years away, where the universe appears as it was 6.5 billion years ago. Theorists have trouble explaining how such huge structures could have formed so early in cosmic history.

Astronomers began piecing together the galactic aggregation about 10 years ago, says Gerard Williger of the National Optical Astronomy Observatories and NASA's Goddard Space Flight Center in Greenbelt, Maryland. Luis Campusano of the University of Chile and Roger Clowes of the University of Central Lancashire, England, had discovered a large group of quasars in that part of the sky. Most astrophysicists believe that quasars are the bright cores of very distant active galaxies. The new observations indicate that the region occupied by the quasar group contains about three times as many distant galaxies as anyone expected to find.

"In fact, we've put some galaxy flesh on the quasar skeleton," Williger says. Most of the galaxies are too distant and dim to be seen directly, but they leave a telltale absorption fingerprint in the light from still more distant quasars that passes through the galaxies' extended gaseous halos on its way to Earth.

Just how big a headache the supercluster will give theorists depends on how much matter is locked up in it, says Piero Rosati of the European Southern Observatory in Germany. "You have to prove there's mass collapsed here; otherwise it wouldn't be really relevant," Rosati says. Rosati and his colleagues have detected other distant, large superclusters by their x-ray emission, a method that gives a direct estimate for the mass of the cluster, he says. Similar techniques might show that the new supercluster is less fearsome than it appears. "If this is just a bunch of galaxies, it may not be that important," Rosati says. "Sheets and superstructures of galaxies are everywhere in the universe."

—GOVERT SCHILLING

Govert Schilling is an astronomy writer in Utrecht, the Netherlands.

SOURCE: R. N. DUBOIS

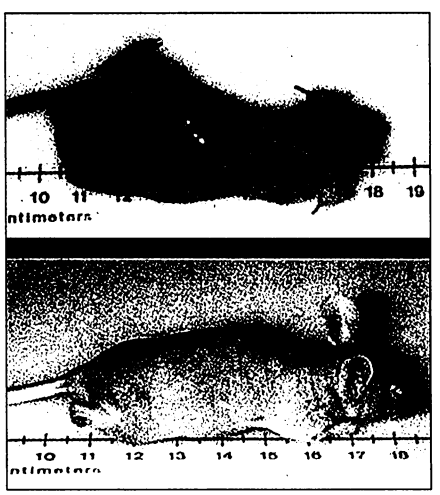
CANCER RESEARCH

Anti-Inflammatories Inhibit Cancer Growth—But How?

A debate has emerged about how NSAIDs—nonsteroidal anti-inflammatory drugs—protect against colon and other cancers

"Prescribing aspirin for cancer" sounds like an exercise in medical futility. But such a treatment may not be pointless after all: Beginning about 15 years ago, evidence began accumulating from both animal work and epidemiological studies on humans indicating that aspirin and related drugs, known as NSAIDs, hinder the development of colon cancer and perhaps other cancers as well.

"NSAIDs protect against cancer—no ifs, ands, or buts," says gastroenterologist Andrew Dannenberg of the Weill Medical College of Cornell University. But, he adds, because aspirin and older NSAIDs can cause potentially dangerous gastrointestinal bleeding, there was "a reluctance to push forward with this [idea] for people with low to moderate [colon cancer] risk." Within the past 2 to 3 years, however, the availability of a new generation of more specific—and therefore safer—NSAIDs has touched off a spate of clinical studies aimed at determining whether these drugs can be used to prevent or treat cancer. Early results suggest they can.



Protected. Both mice received transplants of human cancer cells, but treatment of the bottom animal with an NSAID greatly slowed the growth of the cells.

But researchers are deeply divided on whether they exert this potentially beneficial effect by blocking a single enzyme or by stimulating programmed cell death by other routes. The issue is important, because figuring out the mechanism could aid the design of better chemopreventive drugs. Consequently, on 8 January, the National Cancer Institute (NCI) brought many of the leading researchers in the field together in Rockville, Maryland, for a workshop aimed at examining the evidence on both sides.

The COX-2 explanation

The surge of interest in using NSAIDs to combat cancer is the outgrowth of the decade-old discovery that the body has two versions of an enzyme called cyclooxygenase. Aspirin and all the other NSAIDs then in use inhibit both versions of the enzyme, but it soon became clear that only one of them, COX-2, is important for inflammation. This enzyme converts a long-chained fatty acid called arachidonic acid to prostaglandins, which in turn trigger inflammatory reactions in the body. The other cyclooxygenase, COX-1, also makes prostaglandins, but they are needed to maintain the stomach lining and normal kidney function. Thus, researchers surmised, inhibition of COX-1 likely accounts for such NSAID side effects as gastrointestinal bleeding. This conclusion led to a new generation of drugs that inhibit only COX-2 (*Science*, 22 May 1998, p. 1191) and that