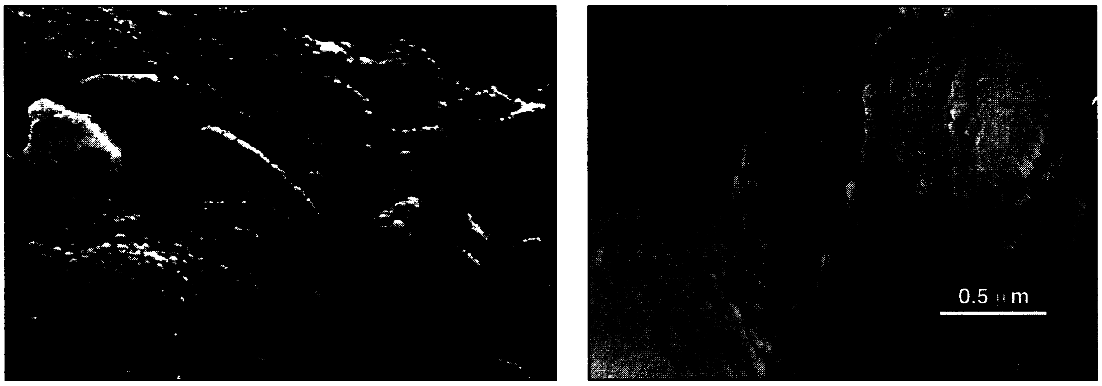
smaller, she says.

Finally, just because Bradley failed to find any structures resembling microfossils doesn't mean they are not there, says Thomas-Keprta. The McKay group has seen layers in some parts of the meteorite all along, but hadn't discussed them because they weren't sure what they were; they suspect that lamellae are clays starting to weather out of the pyroxene. But to maximize the chances of finding possible microfossils, they look most closely on the rims of the so-called carbonate rosettes, Thomas-Keprta says, and there they find no layers.

D. MCKAY *et al.*

J. BRADLEY *et al.*



Battle of the bugs. A wormlike form *(left)* is a prime example of a possible microfossil from Mars, but some argue that a mineral structure from the same meteorite *(right, lower center)* might also pass for a microfossil.

Bradley has a counter-rebuttal for each of these defenses. He says that some lamellae do indeed mimic the putative microfossils, appearing jumbled in lifelike poses, ranging up to a micrometer in length, and even exhibiting a distinct, wormlike S-shape (see images). And he and his colleagues say they find layers on both pyroxene and carbonate. In the rims of rosettes, Bradley agrees that there are no lamellae. But there, he argues that the impostors may be nonbiological magnetite "whiskers" or grains, as he and his colleagues have suggested before. So in the view of Bradley and his colleagues, "although some of the elongated forms of ALH84001 could conceivably be martian nanofossils, the majority appear to be either emergent substrate lamellae or magnetite [grains]."

How can all this be resolved? Bradley's results show that "there are definitely nonbiological processes that can produce these 'buglike' morphologies," says Brownlee. But Bradley can't prove whether the particular structures imaged by the McKay group are microfossils or artifacts. "Who knows?" says Washington's Brownlee. "I'm not nearly as hopeful as when I first saw the McKay paper." If the shapes of structures can't settle the issue, perhaps the McKay group's planned dissection of a microfossil will help. But the claim of life on Mars may have to stand or fall on other evidence. "It may not be possible to prove they are microfossils from Mars," says Brownlee.

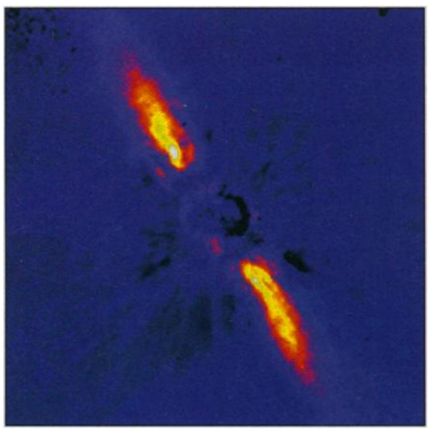
–Richard A. Kerr

ASTRONOMY

Dust Disks May Point Way to Exoplanets

UTRECHT, THE NETHERLANDS—Dust is not always a sign of failure, says Carsten Dominik of Leiden Observatory in the Netherlands. Astronomers have traditionally believed that the formation of planets would leave little or no dust around a star because all the dust would end up in planets; a disk of dust, they thought, was a sign that no planets had formed in that particular system. But Dominik and his colleagues have now found a dust disk around 55 Cancri, a dim, sunlike star in the constellation Cancer that is thought to be accompanied by one or possibly two massive planets (*Science*, 26 July 1996, p. 429). Apparently, dust disks and planets are not mutually exclusive after all.

A. M. LAGRANGE *et al.*/LABORATOIRE D'ASTROPHYSIQUE DE GRENOBLE



Dusty surroundings. Dust disks like this one around Beta Pictoris can coexist with planets.

Observing the star using the German ISOPHOT camera on board Europe's Infrared Space Observatory (ISO), Dominik's team found that it is "too bright" in the infrared. In a report soon to be published in *Astronomy & Astrophysics Letters*, they conclude that the excess radiation can only be explained by a disk of cool dust particles. More than a decade ago, IRAS, a U.S.–Dutch infrared satellite, observed such disks around other stars, but until now they have never been seen around stars suspected of hosting planets. The new discovery leads Dominik to suggest that a sunlike star surrounded by a dust disk might be a promising place to hunt for exoplanets.

The team found the bulk of the infrared excess around the wavelength of 60 micrometers, implying that most of the dust particles have temperatures between 40 and 100 kelvins. This puts the dust some 9 billion kilometers from the star, roughly the same distance as from our own sun to the Kuiper belt, a region beyond the orbit of Neptune that contains dust and numerous "ice dwarfs"—cometlike bodies tens of kilometers across. "This disk is comparable to the Kuiper belt in our own solar system," says Dominik, "although it contains a lot more dust. We wouldn't be able to see the Kuiper Belt from afar [with ISO]." Dominik adds that the disk around 55 Cancri is not the protoplanetary disk from which planets are believed to form; the star is much too old to show the remains of this primordial disk.

Supporting the Kuiper belt analogy is the second putative planet around 55 Cancri, which orbits at a large distance from the star. In our own solar system, the inner edge of the Kuiper belt is swept out by the gravity of Neptune, the outermost massive planet. In the same way, the second planet of 55 Cancri might define the inner edge of the dust disk, says Dominik. Just how the disk persists is something of a puzzle for astronomers, however. Microscopic dust particles should spiral down into the central star within 20 million years, so Dominik's team believes the disk must be continuously replenished in some way, presumably by erosion of larger objects, such as a large number of ice dwarfs similar to those in the Kuiper belt.

No one yet knows whether the ISO discovery implies that other "dusty" stars are promising places to look for exoplanets. According to theoretician Alan Boss of the Carnegie Institution of Washington, "we don't know for certain if we should 'expect' to find a ... dust disk around stars with planets or if [dust] disks generally imply the absence of planets." Dominik admits that the ISO observations of 55 Cancri do not decide this question either way, as other stars with planets have no observable dust disks, while many "dusty" stars do not show evidence of planetary companions.

"It would be nice to know if the orbital plane of the planet coincides with that of the dust disk," says Boss. "If so, then there would be a good argument that the planet and dust disk both owe their origin to a common protoplanetary disk." Dominik thinks the planets and disk must lie in the same plane, because they would be hard to explain unless they have a common origin.

–Govert Schilling

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

SPACE PHYSICS

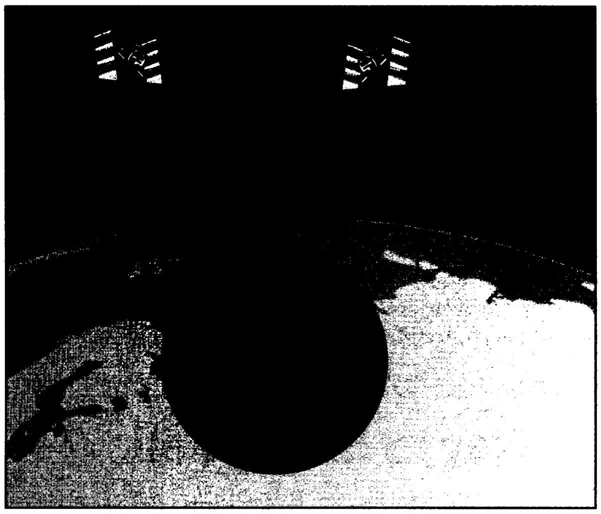
Seeking a Source of Potent Cosmic Rays

COLLEGE PARK, MARYLAND—Every so often, Earth's outer atmosphere is blasted by subatomic particles packing so much energy that they defy explanation. These so-called ultra-high-energy cosmic rays (UHECRs) pose a conundrum: No known source in our cosmic neighborhood has enough power to generate them, yet the particles must come from close by, because if they traveled far, they would lose energy to the ubiquitous microwave background radiation. And their mystery is heightened by their rarity. Ground-based detectors built to monitor a wide spectrum of cosmic rays, which constantly rain down on Earth, have spotted only a handful of these superenergetic particles. "We have just enough to know they exist, and that's the tantalizing part," says physicist James Cronin of the University of Chicago.

With so little to go on, researchers have few clues to the composition and potential sources of UHECRs. But physicists are planning ways to collect a lot more information on them over the next 2 decades. At a NASA-organized conference here at the University of Maryland last month, researchers backed a proposal to fly twin satellites—called the Orbiting Wide-Angle Light collector (OWL)—to keep watch for the flashes of light generated when energetic particles, including UHECRs, slam into the atmosphere, creating showers of secondary particles.

Astrophysicists have been scratching their heads for decades over UHECRs, defined as particles with 10^{20} electron volts (eV) or more of energy, 100 million times the energy of any particle created on Earth. In 1966, 3 years after the first 10^{20} eV cosmic ray was detected, physicists pointed out that a particle with that much energy would travel no more than about 20 million light-years, on average, before being transformed into lower energy particles by interactions with the newly discovered cosmic background radiation, the leftover glow from the big bang. The energy limit, about 5×10^{19} eV, has dogged astrophysicists ever since, as they have tried to explain observations of particles with higher energies.

At the NASA meeting, scientists discussed several leading theories about these enigmatic particles. It's possible, some said, that UHECRs might be accelerated to tremendous energies by supermassive black holes which are thought to be at the centers of some galaxies, or by powerful gamma ray bursters that might signify gigantic explosions of coalescing neutron stars. But none of these acceleration mechanisms has been seen close enough to the Milky Way to account for UHECRs.



OWL eyes. Satellites would see fluorescent streak as cosmic ray disintegrates into shower of secondary particles (inset).

Another idea, proposed by University of Chicago physicist David Schramm and his colleagues, is that "topological defects" formed shortly after the big bang, trapping huge amounts of energy in hot spots. Schramm suggests that these defects decayed into particles with much more energy than UHECRs, but interactions with the cosmic background radiation cooled them before they reached Earth. "Every explanation you come to leads to something that's very exotic and very exciting," says Schramm. "You know you're onto something interesting when the dullest [explanation] that's proposed is involving black holes."

Researchers are looking to the proposed new detectors to help them sort out these mysteries. Jonathan Ormes of the NASA Goddard Space Flight Center in Greenbelt, Maryland, the principal investigator for the proposed OWL mission, organized the meeting to build support for the project, which he hopes can be launched in 2010. Each of the two OWL satellites would contain about 10 square meters of photodetectors for observing the tracks of ultraviolet fluorescence generated by cosmic rays streaming through the atmosphere. They would provide a stereoscopic view of about 1 million square km of the atmosphere at a time and observe perhaps 500 to 1000 UHECR showers per year, according to Ormes. This will be a huge improvement over current ground-based facilities, which all combined observe roughly one UHECR shower per year. The data should help researchers determine the composition of UHECRs and pinpoint the directions from which they arrive.

But ground-based observation is also expected to advance dramatically with the multinational Pierre Auger project (*Science*, 1 September 1995, p. 1221), which is scheduled to begin construction in 1999. If all the money can be raised, the Auger collaboration, named for the discoverer of cosmic ray air showers, will cover 3000 square km with detectors at sites in Utah and Argentina. The detectors should be able to spot 50 to 100 UHECR showers per year.

At about the same time as Auger starts catching rays, a second international collaboration based in Italy hopes to fly a more modest space-based detector known as the Airwatch From Space. John Linsley of the University of New Mexico, Albuquerque, who detected the first UHECR and also has worked on the OWL project, describes Airwatch as less ambitious, just a "first step" in a series of planned satellites. Livio Scarsi, a physicist at the University of Palermo in Italy and the spokesperson for the team, says the project has already passed initial reviews for Italian Space Agency funding.

OWL's backers strongly support Auger and other, smaller ground arrays as steppingstones that should provide important data and motivation for OWL. "We have to do everything possible on the ground first," Ormes says. And if these steppingstones lead to an answer, physicists would be delighted. Says Cronin: "The prospect of really fundamental advances in physics or astrophysics is almost certain."

–David Ehrenstein