cording 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

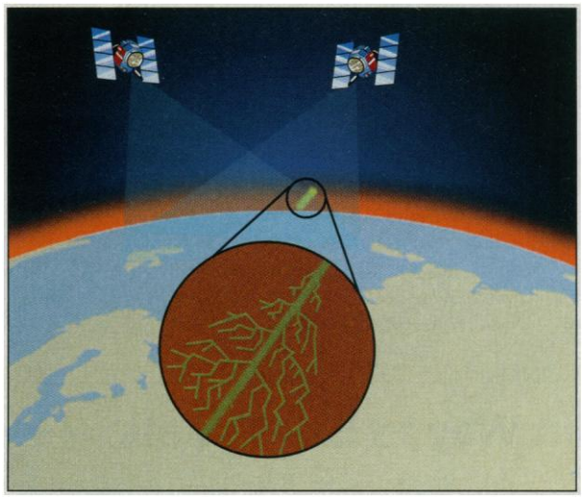
Seeking a Source of Potent Cosmic Rays

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