A Dark Matter

Astronomers may be closing in on the invisible cosmic majority

Anybody who ever doubted that nature has a perverse sense of humor should consider the plight of the astronomers trying to map out the structure of the cosmos. Most of the mass of the universe seems to exist as some form of "dark matter" that is invisible through any kind of telescope. Studies of how galaxies rotate and move about one another indicate that they are enveloped in halos of such material. But researchers do not know what dark matter is made of. They have considered everything from undiscovered subatomic particles to snowballs floating in space.

Now at last they have a clue. Three teams have made observations hinting that at least some of the dark matter surrounding our galaxy consists of diminutive relatives of the sun: faint, low-mass stars and brown dwarfs, objects larger than planets but still too small to shine like stars. Kim Griest of the University of California at San Diego has collectively dubbed such objects MACHOs (massive compact halo objects)—a riposte to his particle physicist colleagues who propose that dark matter is composed of WIMPs (weakly interacting massive particles).

The key question that has daunted researchers attempting to learn about dark matter is, How can one identify something that cannot be seen? In 1986 Bodhan Paczyński of Princeton University realized that astronomers could, in principle, perceive the gravitational tug produced by MACHOs even though the objects themselves are nearly undetectable. Einstein's theory of relativity states that gravity can bend light. If a MACHO were to pass between the earth and a more distant star, its gravitational field would act as a magnifying lens, bending and focusing light from the background star. Because of that effect, the background star would appear brighter than normal. As the MACHO continued on its path, it would move out of alignment, and the star would return to its usual brightness.

Paczyński realized that searching for such an event—known as gravitational microlensing—would require monitoring the exact brightnesses of huge numbers of stars over an extended duration. "In 1986 it was science fiction—the technology wasn't there to monitor a million stars," Paczyński recalls.

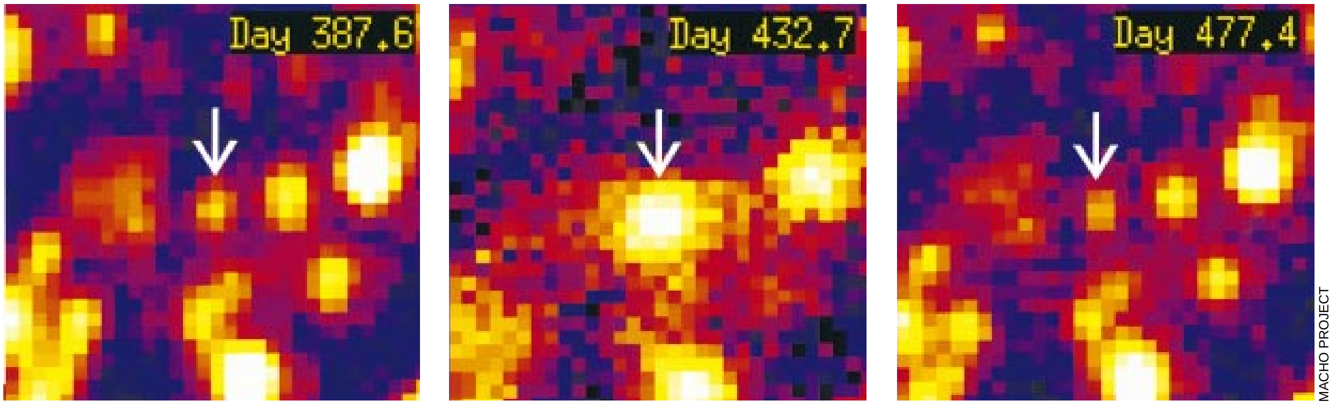
Since then, improved digital light detectors and high-speed computers have swiftly transformed fiction into a practical reality. By 1993 at least three sets of investigators (a U.S.-Australian team led by Charles Alcock of Lawrence Livermore National Laboratory, a U.S.-Polish group led by Paczyński and a French collaboration headed by Michel Spiro of the Saclay Research Center in France) had begun a determined hunt for the blips of light that might settle the dark matter question. Last fall all three teams reported tentative sightings of the microlensing phenomenon—a rapid-fire succession of results that Paczyński refers to as "stimulated emission."

Griest, who participates in Alcock's group, recounts that he and his colleagues had been monitoring 1.8 million stars in the Large Magellanic Cloud, one of the Milky Way's satellite galaxies, for nearly a year without detecting anything unusual. "We were ready to put upper limits on the amount of MACHO dark matter when out popped a good event," he reports. As the news spread through the collaboration, rumors began to circulate that the French team had just recorded an event of its own. The two groups ended up making simultaneous announcements. Shortly thereafter Paczyński and his co-workers announced a third, similar event seen toward the center of our galaxy.

All the observed events display one of the most telling characteristics of microlensing: a slow brightening followed by a perfectly symmetrical dimming. No known kind of variable star or other astronomical object would show such a pattern. Moreover, the French and U.S.-Australian groups can demonstrate that the stars did not change color during the event—a trait expected of microlensing but one not shared by known variable stars.

So have astronomers finally solved the riddle of the dark matter? Well, not exactly. First of all, the researchers could be looking at a new kind of variable star. Second, the data are impressive but by no means perfect. Griest points to a strange-looking data point in his light curve that "still makes me nervous." And the identity of the microlensing objects remains ambiguous. Based on the duration of the detected events, the three groups calculate that they have probably recorded bodies much less massive than the sun. But such estimates contain considerable uncertainty; the objects detected so far could actually be solar-mass stars, which emit too much light to make up a substantial part of the dark halo of the Milky Way.

The researchers are racing to analyze more data so they can establish useful statistics on the total amount of matter tied up in dark, low-mass MACHOs. "We're cranking really hard," Griest replies, more than once, when asked about his group's progress. That eagerness to uncover a previously undetected component of the universe—one that may outweigh all the visible stars in the night sky—is easy to understand. As Griest reflects, if his results pan out, "we're starting a whole new field of astronomy." —*Corey S. Powell*



STELLAR BRIGHTENING (seen in the center of these digital images) is thought to result from the gravitational pull of an unseen body—possibly the long-sought "dark matter"— that passed between the earth and a more distant star.