Matter Mystery May Be Coming Out of the Dark

By CURT SUPLEE
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After four years of searching, an Italian-Chinese research team may have finally detected one of the most fervently sought commodities in modern science: a particularly weird form of the invisible "dark matter" that makes up at least 90 percent of everything in the cosmos.

"If it's true, it's exceedingly important, and would shed light on how galaxies formed in the early universe," said astrophysicist Virginia Trimble of the University of California at Irvine and the University of Maryland.

Indeed, many physicists would regard a definitive sighting of the coveted dark-matter candidates called "WIMPs"—for weakly interacting massive particles—as guaranteed to win a Nobel Prize.

But on the same day last week that the Italian-Chinese team made its announcement, another group, centered at the University of California at Berkeley and searching for exactly the same exotic stuff with a different high-tech system for 12 months, announced that it had been unable to detect a single WIMP.

The seemingly contradictory announcements, made at a scientific conference in Marina del Rey, Calif., on Friday, have left physicists skeptical but hopeful.

"We're looking forward to the resolution," said Morris L. Aizenman, executive officer for the division of astronomical sciences at the National Science Foundation, which supports the Berkeley collaboration. "But controversy is just a natural part of science.

"It's a tremendously exciting time," he added. "We're getting very close to understanding something that's a principal component of the universe itself."

Whichever result—if either—turns out to be correct, the situation is encouraging "because two experiments are coming into very interesting territory," said Bernard Sadoulet of Berkeley, who heads the U.S. collaboration.

It has been apparent for decades that all the matter we can see in the sky—from lustrous galaxies and star clusters to the gloomiest clots of interstellar dust—cannot possibly account for more than a fraction of the mass in the universe.

For example, when astronomers look at spiral galaxies, they immediately see something wrong: The outermost stars are revolving much faster than they should be if the visible matter constituted the total mass of the galaxy.

Instead, the stars behave as if the entire galaxy were surrounded by a titanic "halo" of unseen but gravitationally dense material extending far into space and containing maybe four times more mass than all the stars, gas and dust combined. Our galaxy, the Milky Way, is no exception.

Because this mystery mass doesn't give off radiation that can be observed with conventional instruments, it is called "dark matter."

Some of it can be explained as unusual forms of the same familiar material (protons, neutrons and whatnot) that makes up objects of the visible world. Recently, astronomers have found dark stars, gas blobs and other dim-bulb oddities known collectively as MACHOs—massive compact halo objects—lurking outside the galactic perimeter.

Those objects, however, make up little of the total dark matter. Well-established principles of physics dictate that protons, neutrons and electrons combined do not exceed 20 percent of the total mass of the cosmos, if it has the density that most scientists believe it does. Even throwing in neutrinos—uncharged particles that may have a tiny mass—won't explain the clumps and clusters observed in the universe.

So most dark matter must consist of something else. Theory predicts that there is a category of particles that only interact with ordinary matter through gravity and through the "weak" force that governs, among other things, the decay of radioactive elements.

These WIMPs could be doppelganger counterparts to photons (the smallest units of light) called photinos, or neutralinos, or other *-inos* still unknown. In any event, they would have been abundant in the early universe and would react so infrequently with ordinary matter that they could easily persist today, some 10 or 15 billion years after the Big Bang.

The preferred method of trolling for WIMPs involves waiting for the extremely rare occasion that one happens to smack directly into the nucleus of an atom of ordinary matter, knocking the atom backward and in the process generating electric voltage, waves of vibration or flashes of light, depending on what it hits.

Fortunately, there are *a lot* of WIMPs. By one estimate, about 10 trillion of them shoot through every kilogram (2.2 pounds) of matter every second. And they're fast. Because the whole galaxy is moving through the WIMP halo, these particles are traveling about 150 miles per second relative to us. But even then, a WIMP whacks a nucleus in a detectable way only once a day per kilogram, on average.

Still, that's enough to start looking. The Italy-based researchers use a detector made of 250 pounds of sodium iodide, which emits a distinctive flash of light when the nucleus of one of its atoms is battered. The detector is buried under a mile of rock alongside a highway tunnel northeast of Rome to minimize the effect of cosmic rays.

Earth moves faster through the presumptive WIMP halo in June than in December (see illustration). "It's like riding a bicycle in the rain," Sadoulet said. "You will encounter more raindrops if you're riding into the wind." So the flash count should be higher in summer and lower in winter. And that is what the Italian detector showed, although the deviation from the annual average was small.

The 10-university Berkeley collaboration, by contrast, employs one-pound detectors of germanium and silicon, cooled to within a tenth of a degree of absolute zero. When a WIMP strikes an atom in those crystals, the electric signal and vibration energy are readily distinguishable from those caused by conventional effects, namely a stray neutron banging into the crystal. After a year's worth of searching, the group found nothing it could definitely attribute to WIMPs. The experiment will soon be moved to a deep mine in Minnesota, which should increase sensitivity 100-fold, Sadoulet said.

Few in the field doubt that a definitive answer to the WIMP question will come soon, "probably within the next five years," said the NSF's Aizenman.

Meanwhile, "the big news" is not the Italian-Chinese or American results by themselves, said physicist Michael Turner of the University of Chicago. It's "that finally WIMP detectors are reaching enough sensitivity to detect the particles of dark matter that are holding together our galaxy. The 70-year [search for dark matter] looks like it is coming to a decisive conclusion in the next few years. Wow!"

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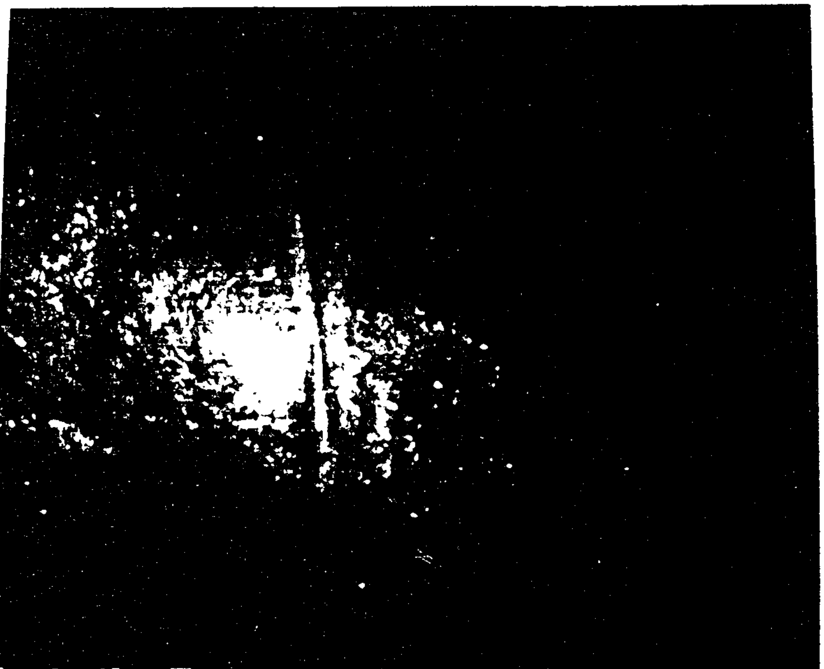


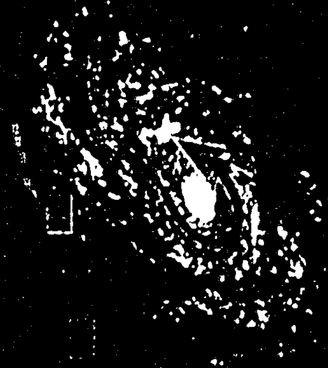
PHOTO BY HUBBLE HERITAGE TEAM (AURA/STSCI/NASA)

More Than Meets the Eye

For 50 years, since the existence of "dark matter" was suggested, scientists have inferred its presence in several ways, including the rotation patterns of galaxies, the fact that galaxy pairs don't tear each other apart, and the presence of galactic "superclusters."

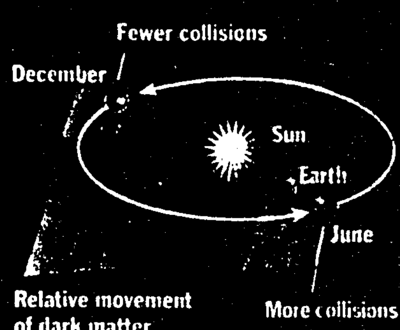
A Dark Boost

1. Like a whirlpool, the center of a spiral galaxy rotates faster than the outside.
2. If the galaxy were made up only of visible matter, its outer reaches would rotate at a predictably slower rate.
3. But the visibly outer edge of the galaxy rotates much faster than it should, indicating the presence of enormous quantities of phantom matter.



Encountering the Invisible

As Earth revolves around the sun, it theoretically passes through a wind of dark matter. Because the planet moves in different directions at different times of the year, the collisions with dark matter should vary with the seasons.



Dark Matter Candidates

ORDINARY MATTER

- **MACHOs**—brown dwarf stars (those that never got big enough to start fusion reactions and shine), white dwarf stars (burned-out remnants of stars like our sun) and black holes. None can constitute more than a fraction of dark matter.
- **Neutrinos**—chargeless particles that may have a tiny mass. There are about 2,000 in every cubic inch of the cosmos. But they move so fast that galaxies probably wouldn't have formed with appreciable mass in a torrent of neutrinos.

EXOTIC MATTER

- **Axions**—hypothetical particles with a mass about one-billionth that of an electron. There should be about 100,000 per cubic inch in the galactic halo, if they actually existed and could be detected.
- **WIMPs**—particles 10 to 100 times the mass of a proton. Predicted by a popular theory that says all the particles now known once had matching counterparts at the stupendous energy densities that prevailed just after the Big Bang. As the cosmos cooled, all the particles disappeared except the lightest ones. Those are WIMPs.

BY PATTERSON CLARK – THE WASHINGTON POST