such as pinching skin folds between calipers and an equation based on body height and body weight, were used on the same people, and the numbers varied wildly. Cummings also cited studies of runners in which extensive training—and consequent body fat loss—did not consistently induce amenorrhea.

Cummings then presented his own data that show that female runners had a lower caloric intake than sedentary controls. Some of the runners had a caloric deficit—burning more calories than they ate—and the deficit was greater in women who are amenorrheic. Therefore, he stated, when amenorrhea arises in female athletes, it's because of poor nutrition, not low body fat.

He contends that menstruation depends on a combination of factors that are probably nutritional, though the exact mechanism remains unknown. That's a more complex answer than pinning the blame on body fat and, Cummings says, "It is much easier to accept a simple falsehood than a complex truth."

Frisch, however, still remains unswayed. "I feel that we have very good, documented evidence for what we've published," she says.

–Mike May

Mike May is an associate editor at American Scientist *magazine in Durham, North Carolina.*

ASTRONOMY

Spinning in the Dark

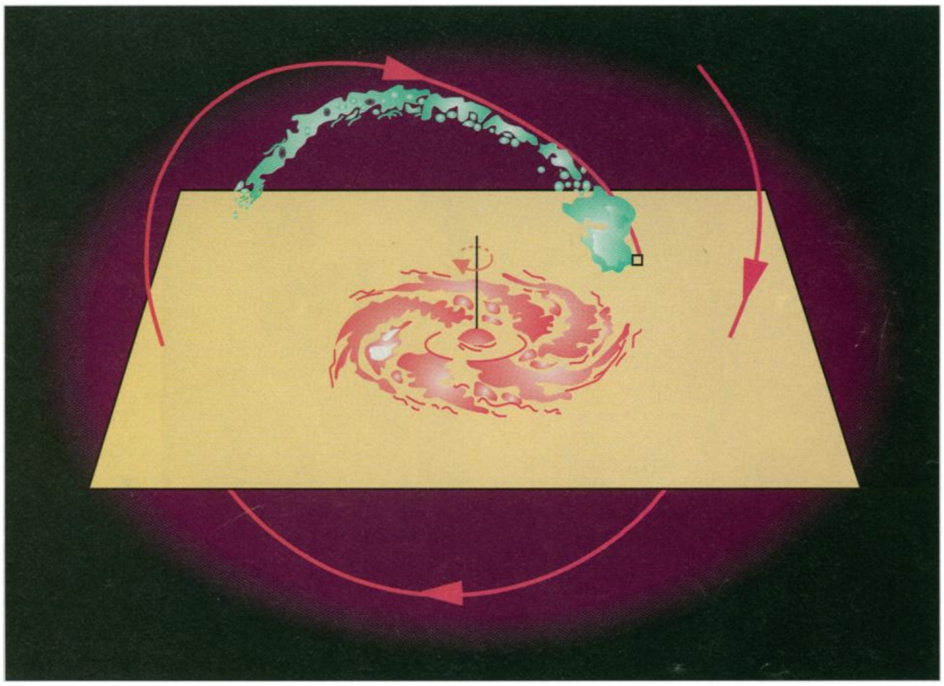
Back in the 1970s, when astronomers Vera Rubin and Kent Ford deduced that galactic rotations were affected by huge surrounding masses of invisible material known as "dark matter," most of their fellow astronomers ignored them. But today many observations confirm this now widely accepted idea. Recently, astronomers at the University of California, Santa Cruz, came up with the best measure yet of the mass of dark matter in our own galaxy. And it's pretty massive—perhaps 10 times greater than what we can see.

The astronomers arrived at that conclusion by measuring the speed of our nearest neighbor galaxy—the Large Magellanic Cloud. Our galaxy's mass produces a gravitational tug on our smaller neighbor, affecting its speed as it spins around us. That speed, says principal investigator Douglas Lin, is faster than it would be if it was just being pulled along by the gravity produced by the visible Milky Way. Therefore there must be a lot of invisible Milky Way, he reported last week at the meeting of the American Astronomical Society. While the visible part of the galaxy weighs about 100 billion solar masses, Lin estimates that the total mass is 600 to 800 hundred billion solar masses.

To get his estimate, Lin first had to get a fix on the speed of the Magellanic Cloud—something that hadn't been previously measured because, he says, it's tough to do. From our distant vantage point the small galaxy appears to move imperceptibly slowly. Since the time Columbus discovered America, Lin points out, the cloud has drifted just 1 arc second, less than 1% of the width of the full moon. There's no astronomical data going back to 1492, so the researchers used photographic plates dating back to 1974, showing the stars in this neighboring galaxy. Since then, they've drifted only a tiny fraction of an arc second, and Lin extrapolated this movement back another 482 years.

It turns out that moving 1 arc second in 501 years is really quite fast—147 miles per second relative to the center of our galaxy. That only looks tiny because it is so far away—the same way a jet going 500 miles an hour seems to creep across the sky. Knowing the velocity, Lin could then use Kepler's law to compute the Milky Way's mass, which is proportional to the cloud's velocity squared as it orbits around us.

Lin says his mass calculation of 600 to 800 billion solar masses is twice as good as previous estimates, based on motions of individual stars. Furthermore, he determined that the extra mass extends up to five times the radius of the visible galaxy, forming a big—but unseen—halo around the Milky Way. It's wide enough, Lin says, that "the Large Magellanic Cloud is moving through that halo."



More than meets the eye. Our Milky Way is embedded in a huge mass of "dark matter" *(red)*, which tugs at the Large Magellanic Cloud that is spiraling around us.

"People have been trying to get the velocity of the large Magellanic Cloud for many years," says Rubin, who is at the Carnegie Institution of Washington. She has used the rotation pattern of other galaxies to measure their masses, and others have used a variety of other techniques to measure the amount of dark matter that lurks in clusters of galaxies. Those estimates combined, Rubin says, lead to an interesting conclusion: The total is not enough to keep the universe from expanding. "We are being driven to the conclusion from dynamics, that we live in a low-density, ever-expanding universe," she says. Many astronomers disagree with Rubin on this point, saying that better measurements will reveal more dark matter. "The bottom line," she says, "is that we have a lot to learn."

Dark matter aside, the observation of Lin and colleagues has already taught astronomers a lot about the history of the Milky Way and the Magellanic Cloud. It explains a stream of hydrogen gas trailing behind the cloud: This material is probably getting torn off as the small galaxy moves through the Milky Way's dark halo like a comet moving through the solar system. And some of the tiny "dwarf" galaxies in our neighborhood may have also been broken off from the Magellanic Cloud, Lin says. Even some of the anomalous star clusters in our galaxy may have come from our orbiting neighbor. Gradually, as the smaller neighbor circles us, it will lose more and more material in our dark halo, finally disappearing completely in 20 billion years.

–Faye Flam