# Study Sheds Light on Dark Matter

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Astronomers have made the most direct measurements yet of dark matter, some of the most prevalent stuff in the universe -- about which almost nothing is known.

First detected in 1994, dark matter is now believed to account for an estimated 23 percent of the universe. The matter we can see (stars, planets, cosmic clouds) totals about 4 percent. The remainder, more than 70 percent, is composed of mysterious dark energy, which, theoretically, is causing the universe to expand at an accelerating pace.

While dark matter is now a widely accepted theoretical construct, few direct measurements of its presence or properties have been made.

Because the mysterious stuff can't be seen, the most compelling evidence for its existence has been indirect. It's traceable through such indications as fluctuations in the cosmic microwave background or the eccentric orbits of small galaxies orbiting larger ones.

In a new study, astronomers have made the first measurements of these eccentric galactic orbits and found that their previous estimates of the properties of dark matter were correct. The galaxies' movements corresponded to the expected proportions of visible and invisible matter.

The study, led by Francisco Prada of Germany's Max Planck Institute for Astronomy, looked at the motion of about 3,000 small galaxies orbiting much larger galaxies.

Using data from the Sloan Digital Sky Survey, the motion of the satellite galaxies indicated the presence of a much larger, invisible mass. In other words, the larger galaxies are located at the center of giant concentrations of dark matter.

"This is a very important test of our understanding of how the universe works," said one of the researchers, Anatoly Klypin of New Mexico State University. "This is one of the most direct probes of the distribution of dark matter and the properties of dark matter."

The study further found that the gravitational pull of dark matter weakened at its periphery, a unique property not exhibited by bodies composed of ordinary matter.

"We detected a specific law -- the decline in dark-matter density toward the periphery,"

said Klypin. "The goal of our research is now to measure that law."

Dennis Zaritsky, an astronomer at University of Arizona at Tucson, first postulated dark matter in 1994. Zaritsky saw the excessive motion of satellite galaxies, indicating the presence of an invisible mass, but made no attempt to measure it.

"He was the first to see there was something wrong with motion," said Klypin. "Now (that) we've measured the law, we can reject other theories like MOND."

Modified Newtonian dynamics, or MOND, is an alternative theory that suggests the laws of gravity change at the edge of galaxies.

The new study will be presented at an astronomy conference in the Canary Islands, Spain, at the end of the month.

The study wouldn't have been possible without the Sloan Digital Sky Survey, an international, multi-institute effort to map 100 million cosmic objects. The study examined 250,000 galaxies from the survey to find 3,000 candidates for studying the gravity of dark matter.

The researchers then looked at the "red shift" of the satellite galaxies -- a standard measure of the velocity of a body as it moves away from an observer. As an object recedes, the light emanating from it stretches into the red region of the visible spectrum. The faster it is traveling, the greater the red shift.

Though astronomers are getting closer to measuring the properties of dark matter, what it actually *is* remains utterly mysterious.

"We don't have the slightest clue what it is, but we know its properties," said Klypin. "We can't see it, but we know it's there. This just shows how complex the whole problem (of understanding the universe) is."