A Slimmer Milky Way Revealed by New Measurements

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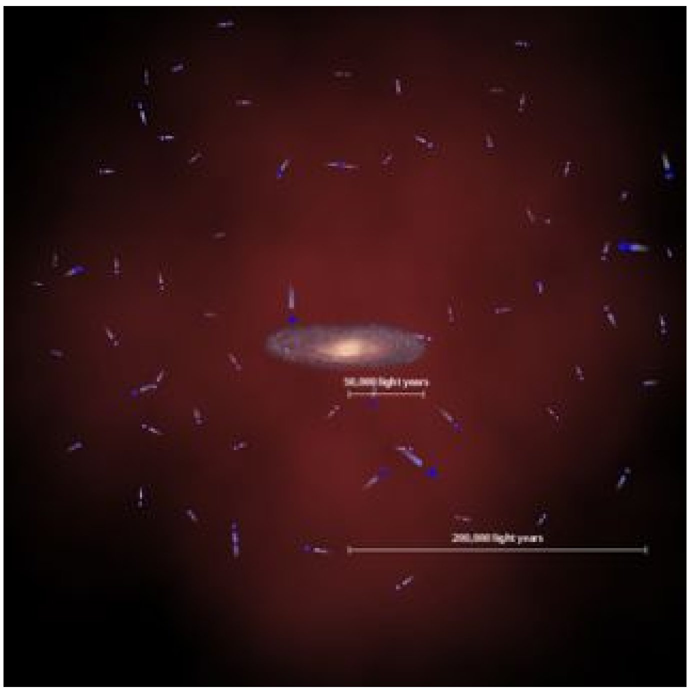

Researchers from the Sloan Digital Sky Survey (SDSS-II) have used the motions of distant stars to measure the mass of the Milky Way galaxy. The new mass determination is based on the measured motions of 2,400 "blue horizontal branch" stars in the extended stellar halo that surrounds the disk. These measurements reach distances of nearly 200,000 light years from the Galactic center, roughly the edge of the region illustrated above. Our Sun lies about 25,000 light years from the center of the Galaxy, roughly halfway out in the Galactic disk. The visible, stellar part of our Milky Way in the middle is embedded into its much more massive and more extended dark matter halo, indicated in dim red. The 'blue horizontal branch stars' that were found and measured in the SDSS-II study are orbiting our Milky Way at large distances. From the speeds of these stars, the researchers were able to estimate much better the mass of the Milky Way's dark-matter halo, which they found to be much 'slimmer' than thought before. Credit: Axel Quetz, Max Planck Institute for Astrophysics (Heidelberg), SDSS-II Collaboration

The Milky Way Galaxy has lost weight. A lot of weight. About a trillion Suns' worth, according to an international team of scientists from the Sloan Digital Sky Survey (SDSS-II), whose discovery has broad implications for our understanding of the Milky Way.

"The Galaxy is slimmer than we thought," said Xiangxiang Xue of the Max Planck Institute for Astronomy in Germany and the National Astronomical Observatories of China, who led the international team of researchers. "We were quite surprised by this result," said Donald Schneider, a member of the research team, a Distinguished Professor of Astronomy at Penn State, and a leader in the SDSS-II organization. The researchers explained that it wasn't a Galactic diet that accounted for the galaxy's recent slimming, but a more accurate scale.

The discovery, accepted for publication in The Astrophysical Journal, is based on data from the project known as SEGUE (Sloan Extension for Galactic Understanding and Exploration), an enormous survey of stars in the Milky Way and one of the three programs that comprise SDSS-II. Using SEGUE measurements of stellar velocities in the outer Milky Way, a region known as the stellar halo, the researchers determined the mass of the Galaxy by inferring the amount of gravity required to keep the stars in orbit. Some of that gravity comes from the Milky Way stars themselves, but most of it comes from an extended distribution of invisible dark matter, whose nature is still not fully understood.

To trace the mass distribution of the Galaxy, the SEGUE team used a carefully constructed sample of 2,400 "blue-horizontal-branch" stars whose distances can be determined from their measured brightness. Blue-horizontal-branch stars can be seen at large distances, Xue explained, enabling the team to measure velocities of stars all the way out to distances of 180,000 light years from the Sun.

The most recent previous studies of the mass of the Milky Way used mixed samples of 50 to 500 objects. They implied masses up to two-trillion times the mass of the Sun for the total mass of the Galaxy. By contrast, when the SDSS-II measurement within 180,000 light years is corrected to a total-mass measurement, it yields a value slightly under one-trillion times the mass of the Sun.

"The enormous size of SEGUE gives us a huge statistical advantage," said Hans-Walter Rix, director of the Max Planck Institute for Astronomy. "We can select a uniform set of tracers, and the large sample of stars allows us to calibrate our method against realistic computer simulations of the Galaxy." Another collaborator, Timothy Beers of Michigan State University, explained, "The total mass of the Galaxy is hard to measure because we're stuck in the middle of it. But it is the single most fundamental number we have to know if we want to understand how the Milky Way formed or to compare it to distant galaxies that we see from the outside."

All SDSS-II observations are made from the 2.5-meter telescope at Apache Point Observatory in New Mexico. The telescope uses a mosaic digital camera to image large areas of sky and spectrographs fed by 640 optical fibers to measure light from individual stars, galaxies, and quasars. SEGUE's stellar spectra turn flat sky maps into multi-dimensional views of the Milky Way, Beers said, by providing distances, velocities, and chemical compositions of hundreds of thousands of stars.

The new results on the mass of the Galaxy are described in a paper titled "The Milky Way's Circular Velocity Curve to 60 kpc and an Estimate of the Dark Matter Halo Mass from Kinematics of 2400 SDSS Blue Horizontal Branch Stars," which will be published this fall in *The Astrophysical Journal*. The abstract is on the Web at arxiv.org/abs/0801.1232 .

Source: Penn State