# Astronomers Measure Slowest Motion Across The Sky

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In the March 4th issue of Science, astronomers report that they have measured the slowest ever motion of a galaxy across the plane of the sky. This distant whirlpool of stars appears to creep along despite its actual speed through space because it is located so far from the Earth. Measuring this galaxy's glacial pace of only 30 micro-arcseconds per year stretched current radio astronomy technology to its limit.

"A snail crawling on Mars would appear to be moving across the surface more than 100 times faster than the motion we measured for this galaxy," said Mark Reid (Harvard-Smithsonian Center for Astrophysics), a co-author on the paper.

Reid and his colleagues used the National Science Foundation's Very Long Baseline Array (VLBA) to measure the motion across the sky of a galaxy located nearly 2.4 million light-years from Earth. While scientists have been measuring the motion of galaxies directly toward or away from Earth for decades, this is the first time that the transverse motion (called proper motion by astronomers) has been measured for a galaxy that is not a nearby satellite of the Milky Way.

An international scientific team analyzed VLBA observations made over two and a half years to detect minuscule shifts in the sky position of the spiral galaxy M33. Combined with previous measurements of the galaxy's motion toward Earth, the new data allowed the astronomers to calculate M33's movement in three dimensions for the first time.

M33 is a satellite of the larger galaxy M31, the well-known Andromeda Galaxy that is the most distant object visible to the naked eye. Both are part of the Local Group of galaxies that includes the Milky Way.

The astronomers' task was not simple. Not only did they have to detect an impressively tiny amount of motion across the sky, but they also had to separate the actual motion of M33 from the apparent motion caused by our Solar System's motion around the center of the Milky Way. The motion of the Solar System and the Earth around the galactic center, some 26,000 light-years away, has been accurately measured using the VLBA over the last decade.

"The VLBA is the only telescope system in the world that could do this work," Reid said. "Its extraordinary ability to resolve fine detail is unmatched and was the absolute prerequisite to making these measurements."

In addition to measuring the motion of M33 as a whole, the astronomers also were able to make a direct measurement of the spiral galaxy's rotation. Both measurements were made by observing the changes in position of giant clouds of molecules inside the galaxy. The water vapor in these clouds acts as a natural maser, strengthening, or amplifying, radio emission the same way that lasers amplify light emission. The natural masers acted as bright radio beacons whose movement could be tracked by the ultra-sharp radio "vision" of the VLBA.

Reid and his colleagues plan to continue measuring M33's motion and also to make similar measurements of M31's motion. This will allow them to answer important questions about the composition, history and fates of the two galaxies as well as of the Milky Way.

"We want to determine the orbits of M31 and M33. That will help us learn about their history, specifically, how close have they come in the

past?" Reid explained. "If they have passed very closely, then maybe M33's small size is a result of having material pulled off it by M31 during the close encounter," he added.

Accurate knowledge of the motions of both galaxies also will help determine if there is a collision in their future. In addition, orbital analysis can give astronomers valuable clues about the amount and distribution of dark matter in the galaxies.

Reid worked with Andreas Brunthaler of the Max Planck Institute for Radioastronomy in Bonn, Germany; Heino Falcke of ASTRON in the Netherlands; Lincoln Greenhill, also of the Harvard-Smithsonian Center for Astrophysics; and Christian Henkel, also of the Max Planck Institute in Bonn.

Source: National Radio Astronomy Observatory