Andromeda Galaxy Three Times Bigger in Diameter Than Previously Thought

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The lovely Andromeda galaxy appeared as a warm fuzzy blob to the ancients. To modern astronomers millennia later, it appeared as an excellent opportunity to better understand the universe. In the latter regard, our nearest galactic neighbor is a gift that keeps on giving.

Scott Chapman, from the California Institute of Technology, and Rodrigo Ibata, from the Observatoire Astronomique de Strasbourg in France, have led a team of astronomers in a project to map out the detailed motions of stars in the outskirts of the Andromeda galaxy. Their recent observations with the Keck telescopes show that the tenuous sprinkle of stars extending outward from the galaxy are actually part of the main disk itself. This means that the spiral disk of stars in Andromeda is three times larger in diameter than previously estimated.

At the annual summer meeting of the American Astronomical Society today, Chapman will outline the evidence that there is a vast, extended stellar disk that makes the galaxy more than 220,000 light-years in diameter. Previously, astronomers looking at the visible evidence thought Andromeda was about 70,000 to 80,000 light-years across. Andromeda itself is about 2 million light-years from Earth.

The new dimensional measure is based on the motions of about 3,000 of the stars some distance from the disk that were once thought to be merely the "halo" of stars in the region and not part of the disk itself. By taking very careful measurements of the "radial velocities," the researchers were able to determine precisely how each star was moving

in relation to the galaxy.

The results showed that the outlying stars are sitting in the plane of the Andromeda disk itself and, moreover, are moving at a velocity that shows them to be in orbit around the center of the galaxy. In essence, this means that the disk of stars is vastly larger than previously known.

Further, the researchers have determined that the nature of the "inhomogeneous rotating disk"-in other words, the clumpy and blobby outer fringes of the disk-shows that Andromeda must be the result of satellite galaxies long ago slamming together. If that were not the case, the stars would be more evenly spaced.

Ibata says, "This giant disk discovery will be very hard to reconcile with computer simulations of forming galaxies. You just don't get giant rotating disks from the accretion of small galaxy fragments."

The current results, which are the subject of two papers already available and a third yet to be published, are made possible by technological advances in astrophysics. In this case, the Keck/DEIMOS multi-object spectrograph affixed to the Keck II Telescope possesses the mirror size and light-gathering capacity to image stars that are very faint, as well as the spectrographic sensitivity to obtain highly accurate radial velocities.

A spectrograph is necessary for the work because the motion of stars in a faraway galaxy can only be detected within reasonable human time spans by inferring whether the star is moving toward us or away from us. This can be accomplished because the light comes toward us in discrete frequencies due to the elements that make up the star.

If the star is moving toward us, then the light tends to cram together, so to speak, making the light higher in frequency and "bluer." If the star is moving away from us, the light has more breathing room and becomes

lower in frequency and "redder."

If stars on one side of Andromeda appear to be coming toward us, while stars on the opposite side appear to be going away from us, then the stars can be assumed to orbit the central object.

The extended stellar disk has gone undetected in the past because stars that appear in the region of the disk could not be known to be a part of the disk until their motions were calculated. In addition, the inhomogeneous "fuzz" that makes up the extended disk does not look like a disk, but rather appears to be a fragmented, messy halo built up from many previous galaxies' crashing into Andromeda, and it was assumed that stars in this region would be going every which way.

"Finding all these stars in an orderly rotation was the last explanation anyone would think of," says Chapman.

On the flip side, finding that the bulk of the complex structure in Andromeda's outer region is rotating with the disk is a blessing for studying the true underlying stellar halo of the galaxy. Using this new information, the researchers have been able to carefully measure the random motions of stars in the stellar halo, probing its mass and the form of the elusive dark matter that surrounds it.

Although the main work was done at the Keck Observatory, the original images that posed the possibility of an extended disk were taken with the Isaac Newton Telescope's Wide-Field Camera. The telescope, located in the Canary Islands, is intended for surveys, and in the case of this study, served well as a companion instrument.

Chapman says that further work will be needed to determine whether the extended disk is merely a quirk of the Andromeda galaxy, or is perhaps typical of other galaxies.

The main paper with which today's AAS news conference is concerned will be published this year in The Astrophysical Journal with the title "On the Accretion Origin of a Vast Extended Stellar Disk Around the Andromeda Galaxy." In addition to Chapman and Ibata, the other authors are Annette Ferguson, University of Edinburgh; Geraint Lewis, University of Sydney; Mike Irwin, Cambridge University; and Nial Tanvir, University of Hertfordshire.

More information at www.astro.caltech.edu/~schapman/m31.html

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