BHOA

BLACK HOLE OBSERVATIONS IN ANDROMEDA

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Abstract

The mass of the black center at the core of the Andromeda Galaxy can be calculated using data collected from 26-west. Ten points ten arc minutes apart on either side of the galactic center were determined. These points can be observed with 26-west to obtain velocity. Velocity compared to distance from the center should produce a graph that is similar to published galactic rotation curves.

Purpose

BHOA's objective was to determine both the velocity and mass of the Andromeda Galaxy using a radio telescope to collect data for a rotation curve.

Background

Andromeda was a figure in Greek mythology known for being rescued from the clutches of a sea monster by Perseus. This name was also later given to the closest galaxy to the Milky Way at 2.5 million light years from the Milky Way's galactic center. The Andromeda Galaxy is also known as Messier object 31, originally thought to be a nebula. It is approaching the Milky Way at approximately 100 km/s, and the two galaxies will collide in 5 billion years. The Milky Way and Andromeda Galaxies are of comparative size and structure.

Just like the Milky Way, M31 harbors a supper massive black hole at its core. Black holes are formed from neutron stars and white dwarfs, the remains of a massive star after supernova.

A Black Hole is an object of highly concentrated mass such that the amount of gravity raises the escape velocity past the speed of light. This means light can not escape and the actual black hole can not be seen. The visible portion of the black hole is the accretion disk- where incoming stars and dust are backed up in a sort of traffic jam orbiting the black hole. When an object enters a black hole, it passes first through the event horizon, the surface of a black hole where the escape velocity is equal to the speed of light. Once inside the event horizon, it stretches and is compressed. The portion of the object closest to the black hole is pulled more strongly towards the singularity, the center of the black hole theorized to be a single point where the curvature of space time along with gravity becomes infinite. The singularity is only a single point if the black hole is not rotating. Rotating black holes have angular momentum and drag-space time around their event horizon. The singularity in such a black hole is a ring.

Rotating black holes produce Doppler shift. Radio waves show the decrease of wavelength and increase of frequency of the approaching side (blue shift) and the lengthening of wavelength/decrease of frequency of an object receding (red shift). Objects entering black holes show red shift until they pass the event horizon, at which time nothing, including light and radio waves, can escape.

Besides rotating and not rotating, black holes also vary in size and formation. Primordial black holes are hypothetical left over from the gravitational collapse of matter in the dense early universe. Most of these would have already evaporated due to a phenomenon known as Hawking radiation. Stellar black holes are formed from the gravitational collapse of a series of stars. Black hole theory says that this can occur whenever an object is compressed to its critical mass through gravitational collapse. Usually a massive star that goes supernova leaves behind a neutron star which can form such a black hole.

Intermediate black holes are perhaps an “evolutionary link” between stellar mass and super massive black holes. Super massive black holes, such as Sagittarius A at the center of the Milky Way, are at the centers of many galaxies. They are millions to billions times the size of Earth’s sun and are either formed from the simultaneous collapse of a cluster of stars, the gradual growth of a smaller black hole, or the fusion of several black holes. Micro black holes have been created in particle accelerators.

In 1796 Pierre-Simon Laplace theorized the idea of black holes. Using Einstein's Theory of General Relativity, Karl Schwarzchild determined the force of a gravitational field on a point of mass, showing that black holes could exist. The idea that the Milky Way harbors a central black hole was confirmed with the use of Chandra and Hubble telescope images from 1999-2002

Since then, astronomers have located black holes in varying sizes and in distant galaxies. Not being able to see light from a black hole makes observation difficult. However, black holes are sources of x-ray and radio emissions.

Gravitational Lensing can be used to detect black holes. It is when the gravity of a black hole bends light from an observer's perspective causing a star to appear to be located in another position.

Black holes can also be found by observation of phenomena such as stars seeming to orbit empty space. Accretion disks may seem like a dead giveaway; however, neutron stars and white dwarfs may also have this attribute.

Methods

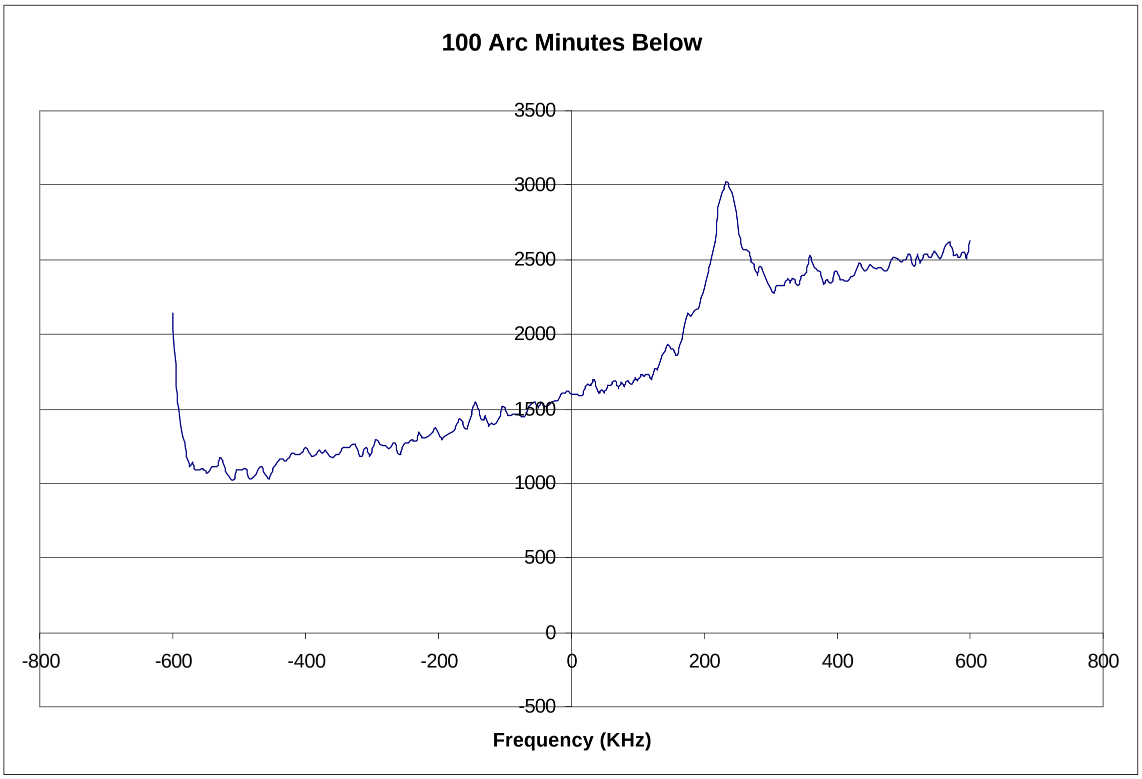
The points along the radius of the Andromeda Galaxy were determined by using the SIMBAD coordinates for the galactic center and then applying the unit circle for 10 to 100 arc minutes left and right of the center. These 21 points were then observed using the 26-meter West telescope on four occasions. The settings used were a gain of 50, offset of 1.11 and attenuation of 9971 with a frequency from -600 to 600 KHz. Data was analyzed in excel with the use of graphs scaled to the frequency range -600 to 600 KHz. The values had to be converted to MHz in order to determine velocity. The value was then divided by the frequency of hydrogen and multiplied by the speed of light. The velocity of the local standard of rest was then added to the observed velocity to obtain the radial velocity with respect to the Milky Way.

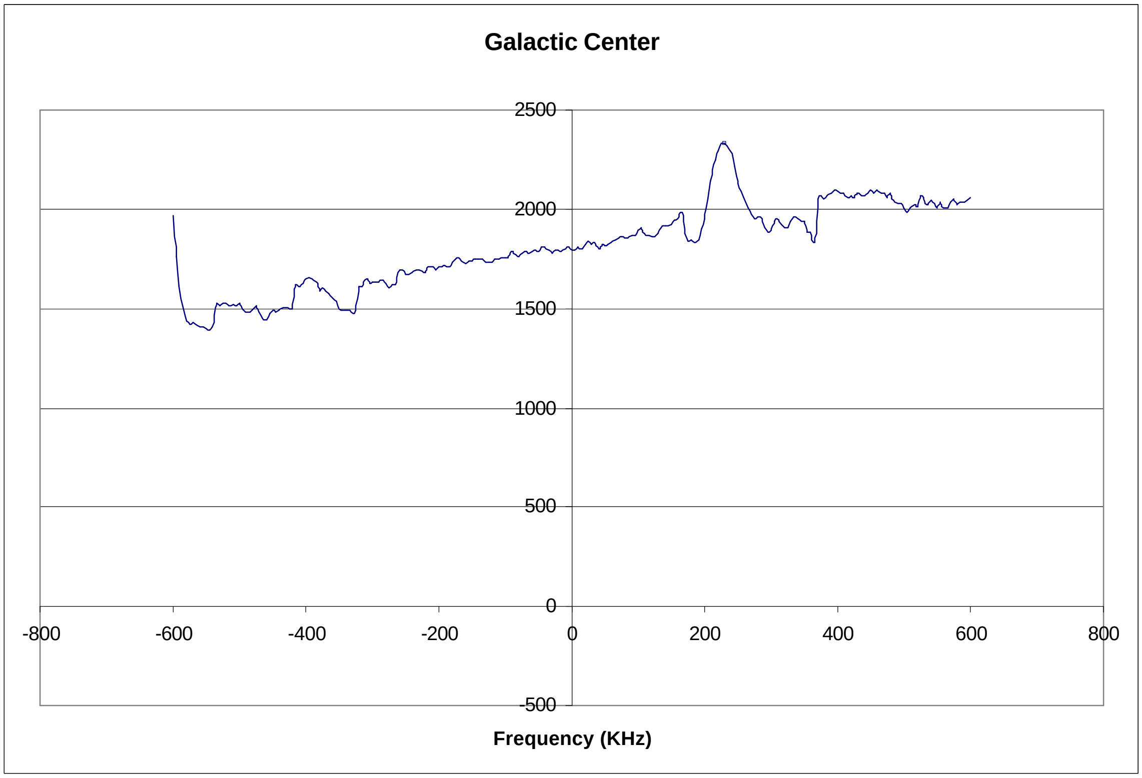
To obtain the mass of the Andromeda Galaxy, the velocity was converted to m/s and then squared. The radius from the center was converted to radians, and these values were then multiplied by the distance to M31: 2.42e22 meters and divided by the gravitational constant: 6.672e-10. All of this was then divided by the number of kilograms per solar mass, 2e30. Since the measurements are for 100 of 200 total arc seconds, this value was then doubled for a result of 320 billion solar masses.

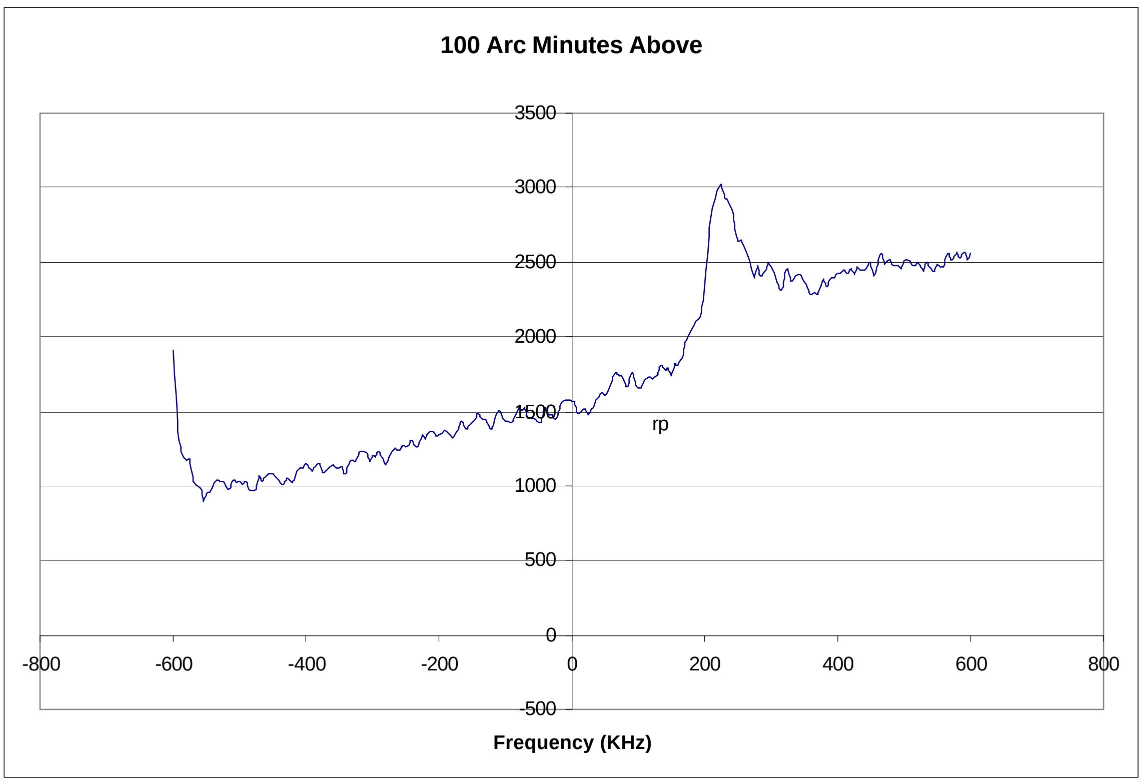
To obtain the mass of the black hole, the maximum velocity was converted to m/s and then squared. The radius from the center with the largest velocity, 55 arc minutes, was converted to radians, and these values were then multiplied by the distance to the Andromeda Galaxy: 2.42e22 meters and divided by the gravitational constant: 6.672e-10. All of this was then divided by the number of kilograms per solar mass, 2e30. This value then came out as 8,855,072,501

Data

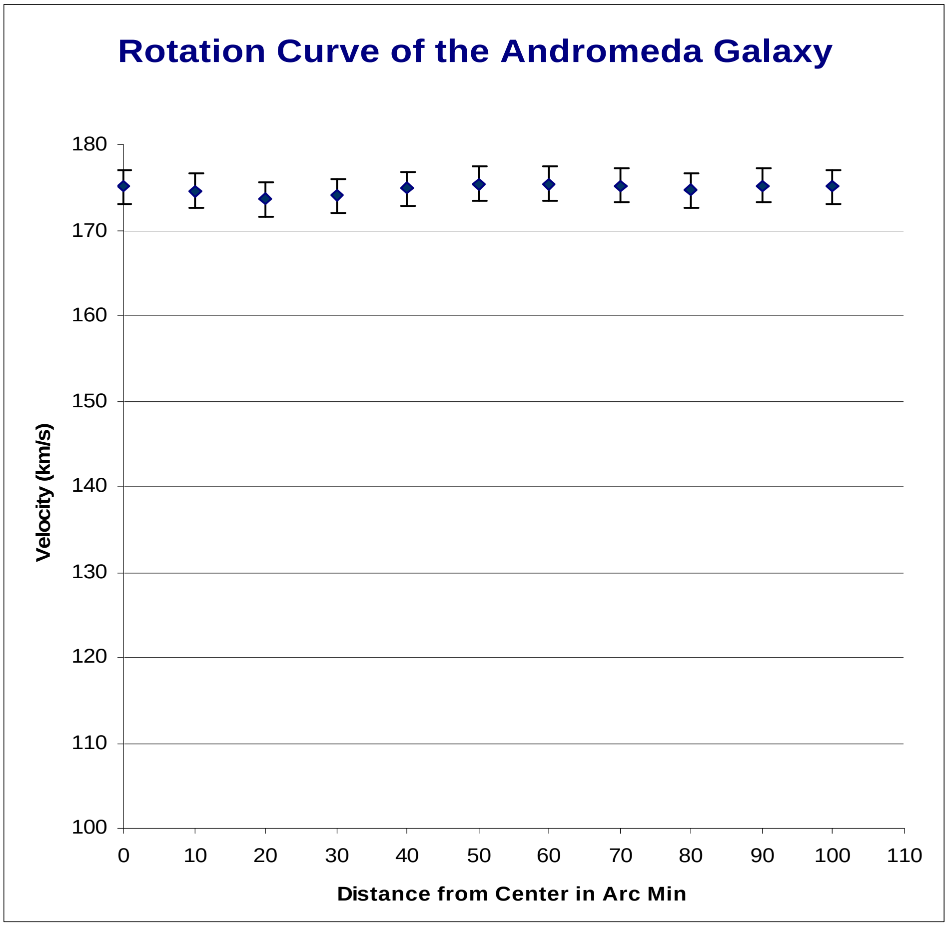
The average value for the shift in frequency was 230 KHz. Most graphs showed the peak in hydrogen at 230 KHz from 1420 MHz. The maximum shift was 235 KHz at the lower end and the minimum shift was 225 KHz at the upper end of the galaxy.







Points on the rotation curve had a maximum of 173.6061 km/sec at 20 arc minutes and a maximum of 175.4241 km/sec at 50 and 60 arc minutes from the center.



The mass of the galaxy obtained was 320 billion solar masses. The black hole was 8,855,072,501 solar masses.

Discussion

Difficulties encountered include the limited time for research and the unpredictable weather patterns. The accuracy of data is of course in question, as getting a large enough sample size consecutively was improbable. The beam width of the telescope also was a challenge, as it measures in widths of 30 arc minutes, although the points were 10 arc minutes apart. At times it was unclear whether M31 was being observed as it is further away than objects in our own galaxy and not easy to distinguish from background radiation in the Milky Way.

Conclusion

By using the data that was gathered, the gravitational curve and mass of the galaxy were found. Many calculations and measurements were required to come to this ultimatum. This confirms other astronomer's calculations since the determined mass was in the accepted range.

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