Calculating the Rotation Curve of the Milky Way

E. Alt, C. Bennett, D. Carr, L. Fulmer, J. Heup, J. Mayeshiba, S. Park, S. Stanimirovic
University of Wisconsin Astronomy Department

Abstract
Using the University of Wisconsin’s Small Radio Telescope (SRT), we have measured the Milky Way’s rotation by examining 21 cm hydrogen emission. We observed every 3 degrees of Galactic longitude from 20 < l < 75 degrees and applied a new method for distinguishing the Galactic HI emission from the background noise. From these observations—and using our knowledge of the Doppler Effect—we calculated the radial velocity ($V_r$) of a sample of Galactic hydrogen clouds located closest to the Galactic Center. Using a simple geometrical method, we then related $V_r$ to the orbital speed of clouds around the Galactic Center. We use this rotation curve to calculate the total mass of the Milky Way via classical mechanics. Finally, we can calculate the dark matter component of the Milky Way galaxy by comparing the measured orbital speed with the speed predicted by the mass of visible matter in our galaxy.

Introduction
A galactic rotation curve (GRC) shows how the orbital velocity of the matter within a galaxy changes as a function of radius from the galactic center (Haynes 2014). By measuring the actual GRC of the Milky Way, we can compare our findings - the observed orbital speed at a particular radius - to the expected rotational speed at that radius based solely on the mass summation of observed stars and gas within the galaxy. If there is any discrepancy between the observed mass and predicted mass, we can extrapolate the presence and distribution of dark matter and its gravitational effect within our Milky Way.

Observational Techniques
We used Astronomy Department’s Small Radio Telescope (SRT) located in Pine Bluff, WI to measure galactic HI emission in the Milky Way disk. In order to determine the distances to the HI regions, we used the Tangent Point Method (Figure 1). We narrowed our longitudinal range to 20 < l < 75 degrees to complications close to the Galactic center, and measured every 3 degrees to obtain well-sampled observations. We held two observing sessions within the ideal time frame of LST = 15-22 hours.

We used a new calibration method to distinguish galactic HI emission from background noise, calculating a gain function by subtracting measurements with the calibration diode off from measurements with the calibration diode on. We then corrected HI spectra for the telescope gain.

Results

![Figure 1: Geometry of the Tangent Point Method. In any observed direction, point C is the closest to the Galactic center and provides a simple geometrical way of estimating distance to the observed HI cloud.](Image)

Conclusions
The measured GRC deviates from the theoretical model predicted by the amount of visible (stellar) galactic mass, implying the existence of additional matter that we cannot see. This extra matter is commonly known as dark matter. Our observations agree well with other studies of the GRC. Using these data, we were able to calculate the total mass of the galaxy via Newtonian physics, giving a result of ~10^{11} solar masses.

Refernces: