Sombrero Galaxy (M104) Rotation curve

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1. Introduction

HI observations are an useful tool to study galaxy rotation curves. Observing the shift in the wavelength of the 21cm line, we can deduce that the part of the galaxy moving toward us would present a blueshift while the part moving away us would present a redshift. Observations at different distances from the galactic center will let us construct the rotation curve of the galaxy. For our line of sight, M104 is edge-on, effectively eliminating inclination corrections. In this project we construct the rotation curve of the Sombrero Galaxy (M104) from HI observations provided by Jacqueline van Gorkom.

2. Methods

2.1. P/V diagram

In the CASA Viewer, it is quite simple to obtain a Position/Velocity (P/V) diagram. By selecting the P/V tool in the menu bar, one can highlight a region and generate the diagram. The P/V diagram depends greatly on the individual parameters of the galaxy, such as inclination or gas distribution. Thankfully, CASA takes care of all of this and outputs the radial velocity as a function of offset in arcseconds. This diagram is shown in Figure 1.

2.2. Rotation Curve

The rotation curve extracted from the P/V diagram is shown in Figure 2. In order to display the rotation curve as a function of physical units, kiloparsecs, we used the small angle approximation:

$$kpc = D(0{,}000004848)\theta \tag{1}$$

where D is the distance in kiloparsecs and θ is the angular size of the object. We simply used the distance given by the *NASA/IPAC Extragalactic Database* (NED), 10.35 Mpc. The

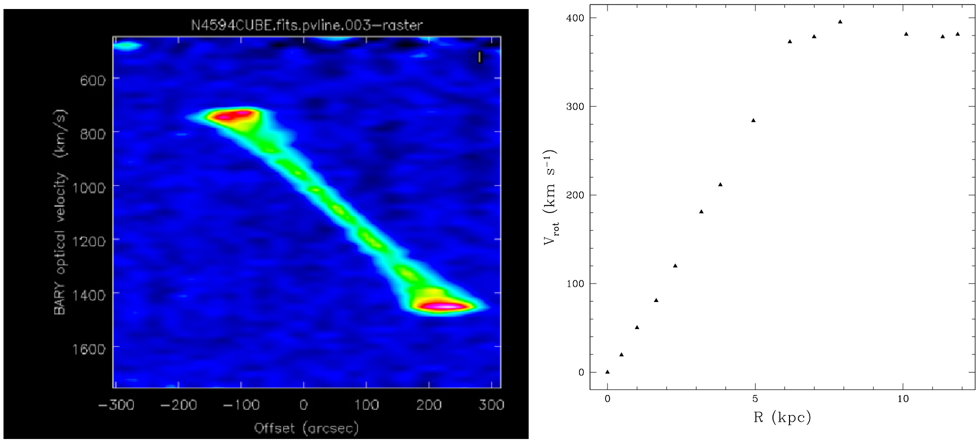

Figura 1: (**Left**)P/V Diagram of M104. (**Right**)Rotation Curve of the Sombrero Galaxy (M104)

proper method of determining the rotation curve, fitting contours, was simplified by reading off the rotation curve by eye.

The rotation curve of M104 exhibits a very fast rise, common of bulge dominated galaxies. The rotation curve also flattens out around 380 km/s at $\sim$ 6 kpc from the center.

3. Discussion

3.1. Morphology of M104

The most striking feature of M104 is its very large bulge, hence the nickname "Sombrero". The effect of this bulge is seen in the rotation curve via the steep, linearly rising component of the rotation curve in the inner radii of the galaxy. Due to this large bulge, the majority of this galaxy's gas and star formation is relegated to a ring around the center, clearly visible in the r-band image provided by Jacqueline van Gorkom.

3.2. Mas

In order to obtain the mass of the galaxy we assume that the system is in equilibrium i.e:

$$2T = U \tag{2}$$

This lets us compute the velocity terms of the mass of the galaxy, and the radii.

$$mv^2 = \frac{GMm}{r} \tag{3}$$

$$v = \sqrt{\frac{GM}{r}} \tag{4}$$

From the rotation curve Figure. we take a radii of $r = 12kpc$ with a corresponding velocity of $v = 380km\ s^{-1}$ and also with the gravity constant in units of pc and $M_\odot$ $G = 4{,}302 \times 10^{-3} \frac{pc}{M_\odot}(\frac{km}{s})^2$ we obtain a mass of:

$$M = \frac{rv^2}{G} = 4{,}699 \times 10^{11} M_\odot \tag{5}$$

This mass is in agreement with previous works which reports that M104 is $\sim 4M_{MW}$ the mass of the Milky Way, and its contribution is mainly due to the barionic matter, due to the fact that we are working for radius $r < 14Kpc$ we don't see a strong contribution of the dark matter halo.