VERTICAL EQUILIBRIUM OF HI IN THE GALACTIC DISK.

Implications for mass models of the disk

S. MALHOTRA
Princeton University
Department of Astrophysical Sciences
Princeton NJ08544, USA.

1. Introduction

The analysis of vertical distribution and kinematics of disks of galaxies can yield the local mass density in the disk, distinct from the integrated mass inside a radius, derived from a rotation curve. HI is a particularly good tracer because of its ubiquity, ease of observation, and near isothermal nature. In the simplest case one considers the turbulent pressure gradient of the gas balancing the gravitational force in the z-direction. But the atomic gas may be subject to other pressures, for example, magnetic, cosmic ray or radiation pressure. The relative contributions of these are essentially unconstrained. The mass densities obtained from the analysis of HI vertical equilibrium can be verified with a similar analysis only in the solar neighborhood, where the vertical distribution and kinematics of stars can give an independent measure of the total midplane mass density (ρ_0).

2. Tangent Point Analysis and Results

The velocity dispersion and the scale heights are obtained from a full modeling of tangent point emission of HI as seen in the 21 cm transition in the inner Galaxy ($R \simeq 3-8$ kpc). The model used takes into account emission from a large path length along the line of sight, corresponding to an interval (ΔR) of typically ≤ 1 kpc in galactic radius; and is parametrized by the scale height of the gas, the centroid in z, the rotation velocity and the velocity dispersion. These parameters are assumed to be constant over the interval ΔR. This modeling is carried out for the 21 cm surveys of Weaver & Williams(1974), Bania & Lockman (1984), and Kerr et al. (1986) to measure these parameters. Similar modeling has been done for molecular gas (Malhotra 1994a)

L. Blitz and P. Teuben (eds.), Unsolved Problems of the Milky Way, 499–500.

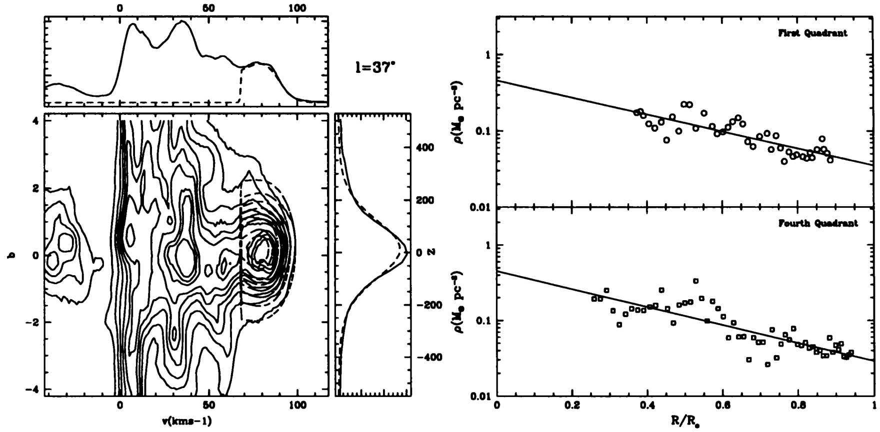

Figure 1. (a)Latitude-velocity maps of the 21 cm emission at the $l = 37°$. The best fit model is shown superposed on the data. Contour levels are defined at 10, 20, 30, .. 90% of the peak temperature in the best-fit model. The fitting is done only for $V > V_{\rm crit}$.(b)The midplane mass density of the disk $\rho_0 = \sigma_v^2/4\pi G\sigma_z^2$ (open circles: WW survey, open squares: Parkes survey). Exponential disk models are fitted to the WW data in the first quadrant and Parkes data in the fourth. The best fit scale-lengths are 3.4 ± 0.3 kpc and 3.1 ± 0.3 kpc for the first and the fourth quadrant respectively. The error bars on the scale-length are calculated by bootstrapping the measurements of $\rho_0(R)$.

Figures 1 shows the HI 21cm emission for one of the longitudes, and the best-fit model having velocity dispersion $\sigma_v = 9\,{\rm km\,s^{-1}}$, and a Gaussian scale height $\sigma_z = 95\,{\rm pc}$. The scale height of HI increases with radius while the velocity dispersion remains constant at $9 \pm 1\,{\rm km\,s^{-1}}$. The total midplane total mass density $\rho_0 = \sigma_v^2/4\pi G\sigma_z^2$, and is determined for each Galactic radius ($R = R_0 \sin l$). The radial profile of the midplane mass density is an exponential with a scale length of 3.3 ± 0.3 kpc (figure 1b), and extrapolates to $\rho_0 = 0.03\,M_\odot\,{\rm pc^{-3}}$, factor of $\simeq 3$ smaller than the ρ_0 measured for stars. This is consistent with a constant mass-to-light ratio of the disk, and extra pressure support for the HI layer constant with radius.

A more complete analysis can be found in Malhotra (1994b). This research was supported by by NSF grant AST89-21700 to Princeton University. Attendance at the meeting was supported by the IAU and a travel grant from the American Astronomical Society.

References

Bania, T. M., Lockman, F. J., 1984, ApJS, 54, 513
Kerr, F.J., Bowers, P.F., Jackson, P.D., Kerr, M., 1986, A&AS, 66, 373
Malhotra, S., 1994a, ApJ, 433, 687.
Malhotra, S., 1994b, preprint.
Weaver, H., Williams, D.R.W 1973, A&AS, 132, 20