SUMMARY OF THE THESIS

The thesis focusses on the study of the vertical structure of disk galaxies and their dark matter halos through theoretical modeling and numerical calculations.

Part 1

The first part of the thesis involves development of a theoretical model of a spiral galaxy to study its disk vertical structure. The vertical scaleheight of the stars and gas in a galactic disk is determined by a balance between the gradient of pressure and the component of the net gravitational field perpendicular to the galaxy plane. Since gas constitutes a subdominant mass fraction of the galactic disk, its contribution to the disk gravity is ignored in general. In this thesis, a spiral galaxy is modeled as a 3-component model of gravitationally -coupled stars, HI and H_2 gas in the force field of the dark matter halo. Besides the model does not implicitly assume a flat rotation curve and is therefore applicable to dwarf galaxies as well which have linearly rising rotation curves. Given the vertical velocity dispersion and the surface density values for each of the disk components as a function of radius, the model calculates the vertical density of the stars and gas at each radius and hence their vertical scaleheight.

The immediate fallout of the above model, highlighting the importance of gas gravity, lies in solving the long-standing puzzle of the steep vertical stellar density distribution of the disc galaxies near the midplane. Over the past two decades, observations have revealed that the vertical density profile of stars in galaxies near the midplane is substantially steeper than the $sech^2$ function that is expected for a self-gravitating system of stars. However, the physical origin for this has not been explained so far. In this thesis, it was shown that the inclusion of the self-gravity of the gas in the dynamical model of the Galaxy solves the problem. Being a low dispersion com- ponent, the gas resides closer to the mid-plane compared to the stars, and forms a thin, compact layer above it, thereby strongly governing the local disc dynamics (Banerjee & Jog 2007). Further, the model was used to obtain the radial distribution of vertical scale heights for four dwarf irregulars: DDO 154, Ho II, IC 2574 and NGC 2366 (Banerjee et al. 2011).

Part 2

The second part of the thesis concerns probing the dark matter halo density profiles of edge-on spiral galaxies in the nearby universe using both the observed HI rotation curve and the HI vertical scaleheight data. The density profile of the dark matter halo is traditionally constrained using the observed rotation curve of the spiral galaxies. But the rotational velocity at any radius depends on the radial component of the net gravitational force of the galaxy, which, however, is weakly dependent on the shape of the dark matter halo. Therefore, in principle, one cannot trace the dark matter halo shape using the observed rotation curve alone. However, for a given rotation curve, the HI vertical scaleheight is strongly dependent on the halo flattening and therefore can be used as a diagnostic tracer

of the shape and density profile of the dark matter halo.

In this thesis, both the observed HI rotation curve and the HI vertical scaleheight data were used on an equal footing to constrain the galactic dark matter halo density profile. The assumed density profile of the halo is axisymmetric and is characterized by four free parameters, namely the core density, the core radius, the vertical-to-planar axis ratio and the density index. As part of the thesis, a highly optimized grid-search code is developed to obtain the best-fit values of the above parameters with respect to both the rotation curve and the scaleheight data. For each grid point (characterized by a set of values of the core density, core radius, vertical-to-planar axis ratio and density index), the code calculates the HI vertical scaleheight by solving 3-coupled, second order, ordinary differential equations using Fourth Order Runge Kutta Method of Integration using the technique of successive approximation. Since we are solving second order ordinary differential equations, we need two initial conditions for each of the three coupled equations, namely the density and the vertical gradient of the density at the plane for each component. The latter is taken to be zero. The former, however, is not known apriori and is indirectly determined from the observed surface density by trial and error method, which was automated within the code. For about 50,000 grid points, the code calculates the HI vertical scaleheight as a function of radius in less than an hour. The above method was employed to study the dark matter density profiles of the Milky Way, the Andromeda (or M31) and the superthin low surface brightness galaxy UGC 7321 (Banerjee & Jog 2008, Banerjee, Matthews & Jog 2010, Banerjee & Jog 2011).

References

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