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Dynamical effects of a cloud complex on stellar and HI components in a galaxy

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Abstract. We investigate the dynamical effects of a molecular cloud complex with a mass ~ $10^7 M_\odot$ and a size of ~ few 100 pc, on the vertical distribution of stars and HI in a galactic disc. The complex has a strong local confining effect reducing the vertical scale-heights of stars and HI to less than 1/3 of their initial values.

Key words : molecular clouds - galaxies : kinematics and dynamics

1. Introduction

The interstellar molecular hydrogen gas is contained in large virial structures called Giant Molecular Clouds. Observations indicate that many such clouds cluster together to form very massive and extended entities called GMC complexes (Sanders et al. 1985). A typical complex has a size of 400 pc, thickness of 120 pc and mass of $10^7 M_\odot$. It turns out that the mass density within such a complex ($1 M_\odot/pc^3$) is more than six times the total mass density of $0.15 M_\odot/pc^3$ as given by the Oort limit (Oort 1960). The objective of this work is to understand the dynamical effects of such a massive entity on the neighbouring stellar and HI matter. With its dominating gravitational field, we expect the neighbouring stars and HI to be pulled towards the midplane of the galaxy, where the complex is located, resulting in the reduced scale-heights for these.

2. Calculations

The galactic stellar disc is assumed to consist of a single isothermal stellar component, with the mass density distribution along z-axis showing a $sech^2$ behaviour (Spitzer 1942). The combined Poisson equation and force equations due to the disc and the complex (Schmidt 1956) are solved numerically, to get the self-consistent, modified, stellar density distribution (see Jog & Narayan 2001 for details).

The distribution of gas (HI) density is not only affected by the force due to complex, but also by that due to redistributed stellar density. Calculations similar to the stellar case with the inclusion of self gravity of gas, give the modified gas distribution.

3. Results

Effect on Stars :

1. We find that the mid-plane density at the centre of the complex shoots up to $0.185 M_{\odot}/pc^3$ which is 2.6 times its original value of $0.07 M_{\odot}/pc^3$ (see Fig. 1).

2. The scale-height of the disc decreases from 300 pc to 88 pc at the centre of the complex, i.e., to less than 1/3 of its original height, making the disc look pinched (see Fig. 2).

3. Another interesting result is that the effect of the complex is felt over a large radial distance of ~ 500 pc from the centre.

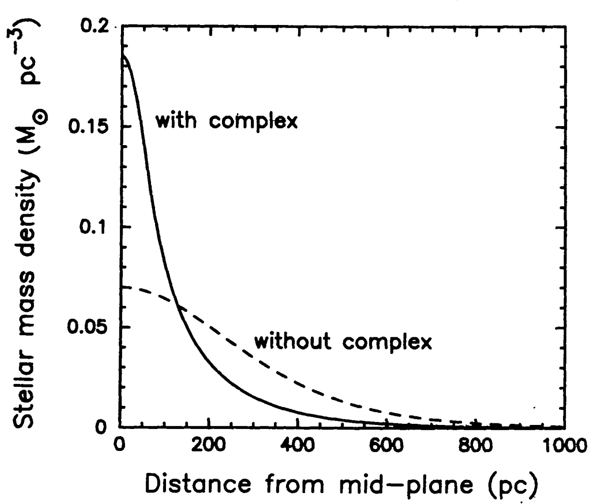

Figure 1. shows a plot of modified stellar disc density in the presence of cloud complex (solid line) and the undisturbed stellar density (dashed line) versus **z**, the distance from midplane.

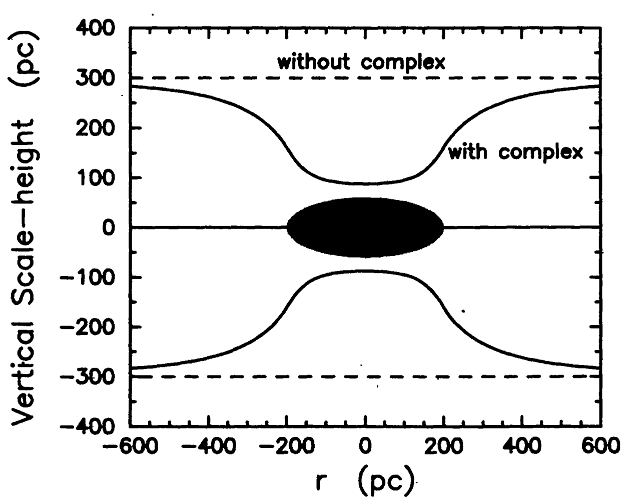

Figure 2. shows a plot of the vertical scale-height for the modified stellar distribution versus **r**, the radial distance from complex centre. Also shown is an outline of the cloud complex.

Effect on HI : The neighbouring HI responds to the double potential of the complex and the corrugated stellar disc. On the contrary, the gas has a negligible effect on stars, in the presence of the complex. The overall effects are similar to that felt by the stars except that the HI trough is of a wider base.

4. Implications

1. **Corrugated disc :** In our Galaxy, the molecular hydrogen ring between 4 – 8 kpc consists of many such cloud complexes. This could result in large scale corrugation of stellar and HI components of galactic disc, detection of which is within the present observational capabilities (see Jog & Narayan 2001).

2. **Variation in galactic potential :** The presence of cloud complexes would result in locally non-uniform galactic potential. This is contrary to the uniform potential which is generally used for simplicity.

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