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A Fake Galactic Survey

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Abstract.
We developed 3D MHD simulations of the large scale response of the ISM to a spiral perturbation. We tested our results by generating synthetic maps of the sky and comparing them with real observations.

We then turn the procedure around. By placing an imaginary observer inside this galaxy, we found the characteristics that he/she might deduce from the observations, and compared them with the real behavior of the gas in the simulations.

1. Introduction.

The simulations we used are described in Gómez & Cox (2002) and Gómez & Cox (2003). We'll focus in a case with four spiral arms, since it has the arms similar to the ones from Georgelin & Georgelin (1976), as traced by Taylor & Cordes (1993). The galactocentric distance is taken to be $r_{\odot} = 8$ kpc.

2. $v - b$ diagram.

Figure 1 show the $b - v$ diagram for the $l = 75^{\rm O}$ direction. In this direction, the line-of-sight crosses the Perseus and the Norma arms. As described in Gómez & Cox (2002), as the gas enters the arms, it forms a forward-leaning shock. Then the gas speeds up as it goes above the arm, and falls behind it. The position chosen for the observer places it just downstream from the Sagittarius arm. Therefore, this diagram would show show the gas with negative velocities at large galactic latitudes.

Structures with a "w" shape appear at the position of the spiral arms. When the observer looks at an arm from the downstream (concave) side, the higher latitude forward leaning shock appears to the observer as being closer than the arm in the midplane. In the case shown Figure 1, that means that a higher density appears to the observer at less negative velocities. Then, as the gas speeds up above the arm, the "w" turns to larger negative velocities.

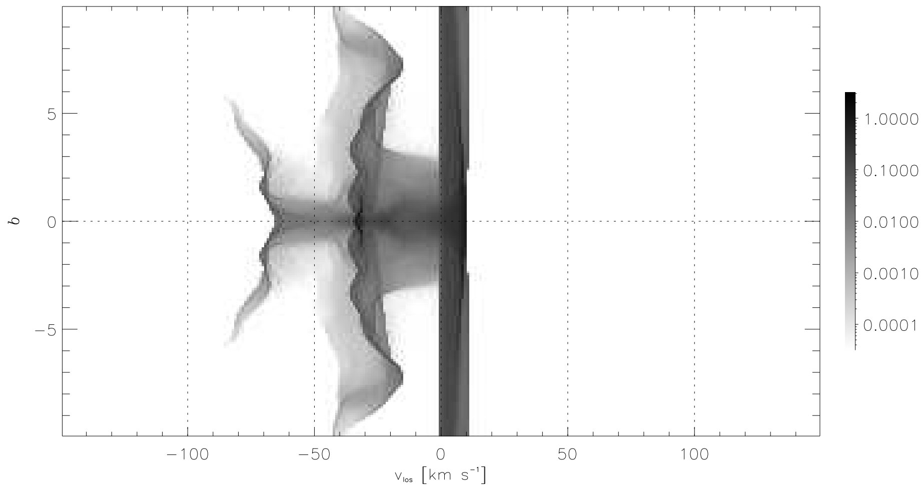

Figure 1. $v - b$ diagram for the four-arm model along $l = 75^{\rm o}$. The "w"-shaped structure is a direct consequence of the 3D structure of the gaseous arms.

3. Rotation curve

We measured the rotation curve of the gas in the simulation by trying to emulate the way it is measured in the Milky Way. In the case of the gas inside the solar circle, for an array of galactic longitudes, we looked for the maximum line-of-sight velocity (minimum for negative longitudes) and assumed that it arises from the tangent point. Figure 2 shows the so derived rotation curves. The dotted line shows the case for the northern galaxy, while the dashed line show the rotation curve for the southern galaxy. For comparison, the rotation curve that arises from the hydrostatic plus rotational equilibrium in the initial conditions is presented as the continuous line.

For the gas outside the solar circle, the standard procedure is to estimate the distance toward a given source, and measure the velocity at which that source is moving. We estimated the rotation curve outside the solar circle by assuming that we can find a source in each grid point of the simulation. By assuming that measurements of the outer rotation would be more reliable if the source is closer to the observer, we decided to use a weight function that decays exponentially with the distance from the observer to the i-th azimuthal grid zone, for a given galactocentric radius.

Blitz & Spergel (1991) report that the rotation curve is systematically higher in the range $55^{\rm o} < l < 80^{\rm o}$ (6.5 kpc $< r <$ 7.8 kpc for $r_\odot$ = 8 kpc) than in the corresponding negative longitudes by some 7 km s^{-1}. The converse happens in the $40^{\rm o} < l < 55^{\rm o}$ range (5 kpc $< r <$ 6.5 kpc). This behavior and the amplitude of the oscillations are reproduced by our simulations, although around $r = 7.5$ kpc, the difference between our rotation curves is larger than 10 km s^{-1}.

The fact that the measured curve falls below the rotation set by the rotational hydrostatics and the background potential creates lines of sight in which the gas never reaches the velocity that the tangent direction should have, and therefore,

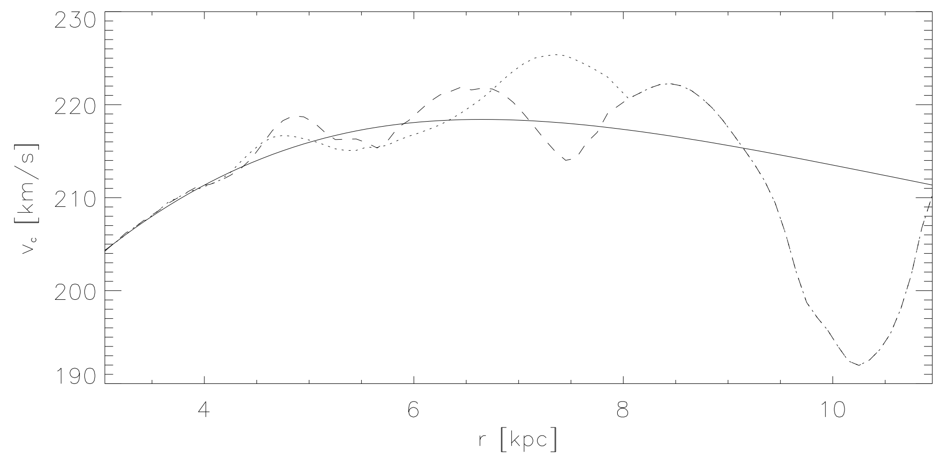

Figure 2. Rotation curve derived from the full simulations. The continuous line is the rotation law in the setup, the dotted line is the derived rotation for positive longitudes, and the dashed line is for negative longitudes.

if this "true rotation" is used to estimate distances, no gas is assigned to those regions. The gas distribution so obtained would have large holes.

Once we have a rotation curve, we can estimate the error in kinematic distance created by assuming that the gas moves in circular orbits. Using the measured rotation curve, the error in the estimated distances appears to be of the order of 1 kpc, except at large radius, where the strongest oscillations are.

References

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