3D MHD Modeling of the Gaseous Structure of the Galaxy.

Gilberto Gómez and Donald Cox
University of Wisconsin - Madison, U.S.A.

Abstract.
We show the results of our 3D MHD simulations of the flow of the Galactic atmosphere as it responds to a spiral perturbation in the potential.

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1. The simulations.

The problem we are interested in is the formation of gaseous structures in a spiral galaxy due to the response of the ISM to an imposed spiral perturbation to the gravitational potential. To explore it, we used the code ZEUS in polar coordinates, spanning a three dimensional grid that ranges from 3 to 11 kpc in r, 0 to 1 kpc in z, and 0 to π in angle. The perturbation has a pitch angle of 15^{O} and rotates with $\Omega_P = 12$ km s^{-1} kpc^{-1}. So, the whole grid is inside corotation.

Figure 1 shows the results of the case we defined as our standard case (isothermal equation of state at 10^4 $^{\mathrm{O}}$K and magnetic field of about 2μG in the midplane). As the gas approaches the arm, there is a downward converging flow that terminates in a complex of shocks just ahead of the midplane density peak. The density maximum slants forward at high z, preceeded by a similarly leaning shock. The latter diverts the flow upward and over the arm, as in a hydraulic jump. Behind the gaseous arm, the flow falls with velocities of around 20 km s^{-1}, generating further secondary shocks as it approaches the lower z material. The downflow shock is clearly visible both in r and ϕ above $z = 400$ pc. The gaseous arms tend to lie somewhat downstream of the potential minimum.

In the interarm region, the velocity field shows a very similar behavior to that at the gaseous arm. There is a forward leaning shock, similar up-above-down motion, and a shock as the gas falls back down. There is also a similar density structure at high z.

In contrast, a case with no magnetic field and very similar density distribution shows a prominent vertical shock and very small vertical motions.

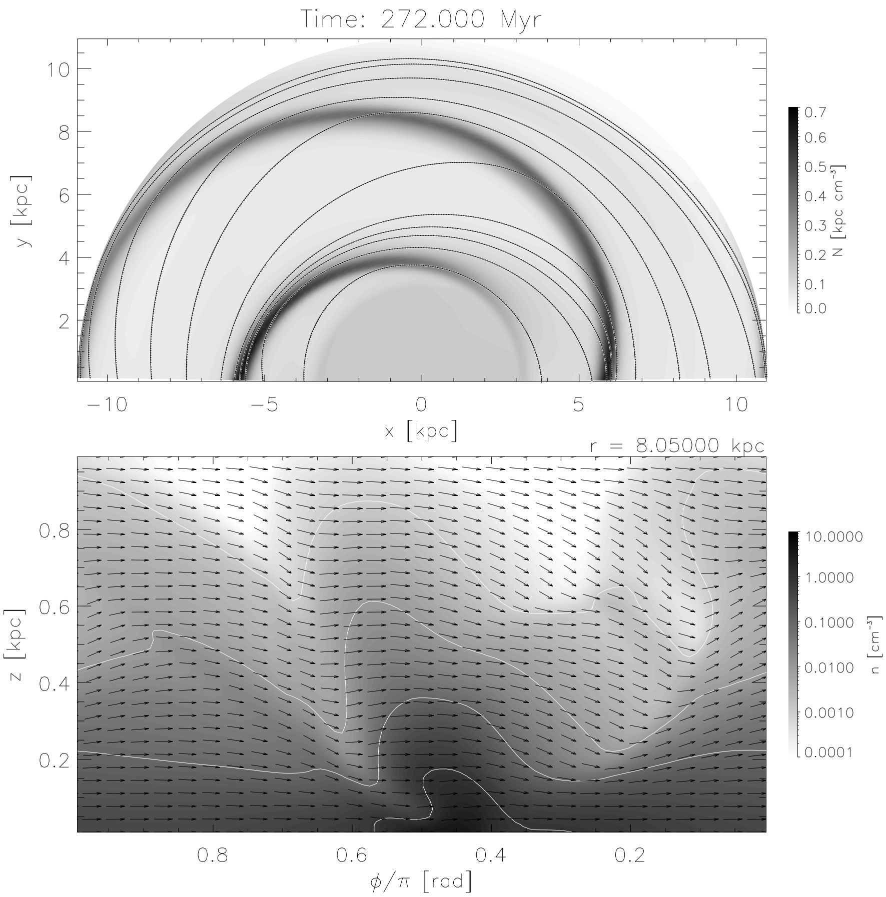

Figure 1. The upper panel shows the column density of the simulation for the two arm case. The continuous lines in the upper panel show the clockwise velocity field of the gas in the midplane. The lower panel shows density along a cylindrical surface at $r = 8$ kpc. White contours show density increasing in factors of 10, starting at 10^{-3} cm^{-3}.

In Gómez & Cox (2002) we present more details of this simulation, a non-magnetic case, and a four-arm case. We also discuss some of the observational signatures of this model.

References

Gómez, G. C. and Cox, D. P. *ApJ* 580:235, 2002