Self-consistent modelling of the Milky Way structure using live potentials

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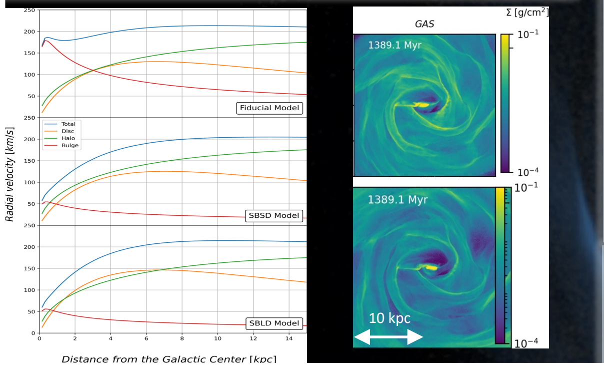
We use the hydrodynamical AREPO[1] moving-mesh code to perform numerical simulations of the Milky Way. In our models, the structures are obtained via the evolution of a live stellar disc and bulge, as well as a live dark matter halo and a gaseous disc, all of which move self-consistently with no pre-defined fixed potentials. We produce longitude-velocity (*lv*) plots of the projected gas surface densities to extract the skeletons of the main features (arms, bar), as well as the contours defining the terminal velocities of the gas. We then compare these with observations via minimisation of the symmetrised distance between the observed and simulated features for a best fit

1 Initial conditions



We set up six models, all following an Hernquist profile for the dark matter halo and stellar bulge, as well as an exponential profile for the stellar disc:

Model	M^{*}_{bulge} $[10^{10}M_{\odot}]$	M^{*}_{disc} $[10^{10}M_{\odot}]$
Fiducial [2]	1.05	3.2
SBSD	0.105	3.2
SBLD	0.105	4.15

For each of those models we distribute the gas following two surface density profiles: **exponential** and **flat**

Figure 1. (Left) Initial rotation curve for three different stellar distributions. From top to bottom: Fiducial, small bulge and small disc (SBSD), small bulge and large disc (SBLD) models. **(Right)** Top view of the SBLD model at ~ 1389 Myrs for the two different gas profiles: exponential (top) and flat (bottom).

2 Mapping the galactic structure

We extract the skeletons of the CO[3] *lv* map, as well as our simulations to later compare. We follow a series of steps:

I. Smooth the image with a Gaussian 2D Kernel

II. Create a binary image after finding the peaks via a Hessian matrix.

III. Final skeleton is obtained computing the medial axis of the previous image.

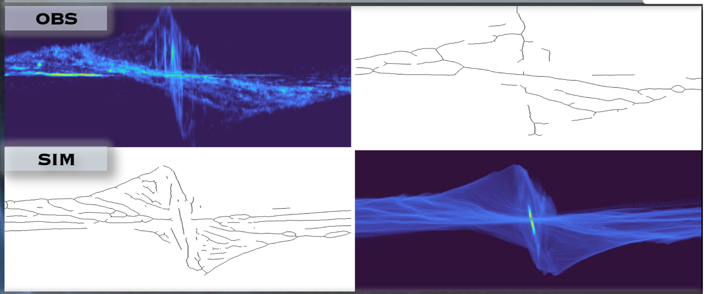
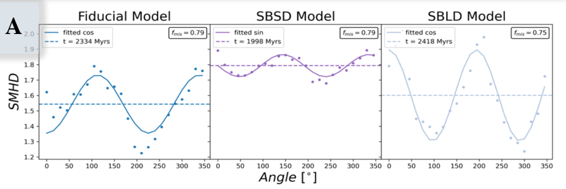


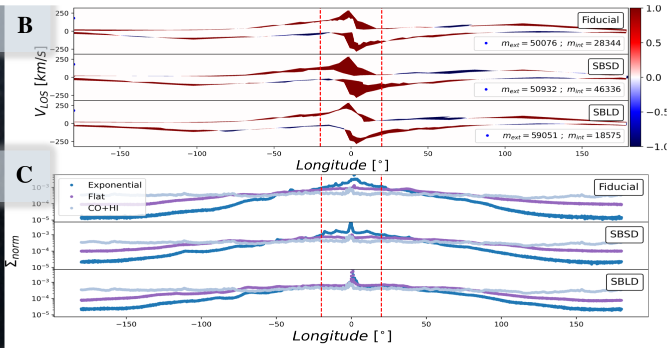
Figure 2. Longitude-velocity plots for the CO observations[3] (top) and SBLD model at a time ~2.3 Gyrs (bottom). The extracted skeletons for each case are shown in black and white.

3 Finding the best model

For each model, we look at a range of times and viewing angles and we compute three different metrics: **A, B, C**



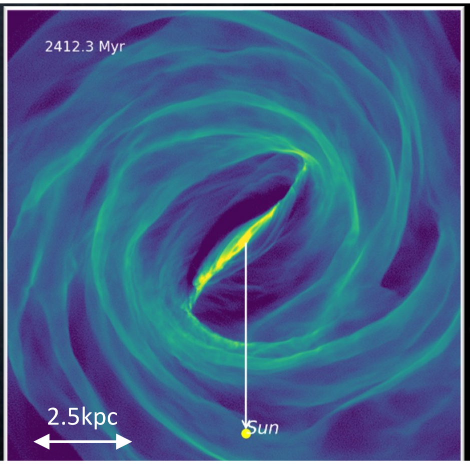
A. (**SMHD**)[5] Symmetrized Modified Hausdorff Distance between the observed and simulated skeletons as a function of viewing angle of the observer for the best snapshot of each of our three models. The lowest the metric the better the fit.



B. *lv* plots for the three different models. The colour scheme shows the metric used to study the **terminal velocity** by comparing the lv-space occupied by CO observations[3] and simulations, favouring the SBLD model **C.** Gas **surface density distributions** for each stellar and gas profiles at the optimal time. The observational data is a result of a combination of CO and *HI* emission[4]. These plots favour a flatter gas surface density profile for the Milky Way.

4 Best model

Here we present our best model for the galactic structure: small bulge and large disc (**SBLD**) at a time **~2.4 Gyrs**. This best fit shows a number of transient arms and an inner galactic bar. Its main features include a pattern speed of **21.9 km/s/kpc**, a bar orientation of **30°** and a length of **6.25 kpc**



Acknowledgements

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