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THE INFLUENCE OF SPIRAL ARMS ON ACTION-BASED DYNAMICAL MILKY WAY DISK MODELLING

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ABSTRACT

- One sentence on what RoadMapping is.
- Overall axisymmetric RoadMapping modelling works in the presence of non-axisymmetric spiral arms, as long as the volume is big enough.

Keywords: Galaxy: disk — Galaxy: fundamental parameters — Galaxy: kinematics and dynamics — Galaxy: structure — [TO DO]

1. INTRODUCTION

- Explain what RoadMapping is, also Acronym
- Summarize BR13
- Summarize results of Paper 1, mention that non-axisymmetries were not considered there
- Main question: Does axisymmetric RoadMapping modelling work in the presence of non-axiysmmetric spiral arms?
- Consequences: Both potential and orbit DF are not axisymmetric, i.e., the fitted axisymmetric potential model and DF do per se not contain the truth.
- How to approach this: Use simulation by D'Onghia et al. 2013 and apply RM to it
- The potential model we use is chosen mostly for practical reasons and is not necessarily the optimal one for the simulation. Also, we use a single qDF as DF - because it is the simplest thing to do. Also independently of the non-axisymmetries the chosen models might deviate from the truth. Where we investigated deviations between model and truth in isolated test cases, here several assumptions break down simultaneously.

2. DATA FROM A GALAXY SIMULATION

- Figure: (x,y) and (R,z) distribution of particles, centroids of survey volumes marked, the main survey volume (4kpc on spiral arm) marked as circle

2.1. *Description of the galaxy simulation*

2.2. *Survey volume and data*

- Mention that we do not consider any measurement errors

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2.3. *Symmetrized potential model*

2.4. *Quantifying influence of spiral arm*

3. *RoadMapping* MODELLING

3.1. *Potential and DF model*

- Very short intro for actions
- Introduce potential model, explain that form of disk was mostly chosen to the closed form expression of Phi which allows for fast calculation. Both MNHH, DEHH and KKS pot.
- Mention action calculation and that we tested explicitely that fixing Delta=0.45 and using staeckel interpolation grid does not degrade the analysis
- Write down DF formula, simplest DF possible. Others use much more complicated ones.

3.2. *Likelihood*

- Write down likelihood formula
- Introduce outlier model as new aspect
- Refer to Paper 1 for details how to evaluate it, but mention shortly that it is a combination of nested-grid and MCMC

4. RESULTS

4.1. *A single application of RoadMapping*

4.1.1. *Fiducial test*

- $r_{max} = 4kpc$
- $N_* = 20,000$
- MNHH potential

4.1.2. *Recovering the stellar distribution*

- Figure: (x,y) and (R,z) distribution of residuals of true and best fit stellar distribution. Mark spiral arms as circles with radius Rg.
- Figure: 1D histograms in R,z,phi, comparison of true, best fit and best fit in symmetrized potential
- Figure: 1D histograms in velocity and different (R,z,phi) bins comparison of true, best fit and best fit in symmetrized potential

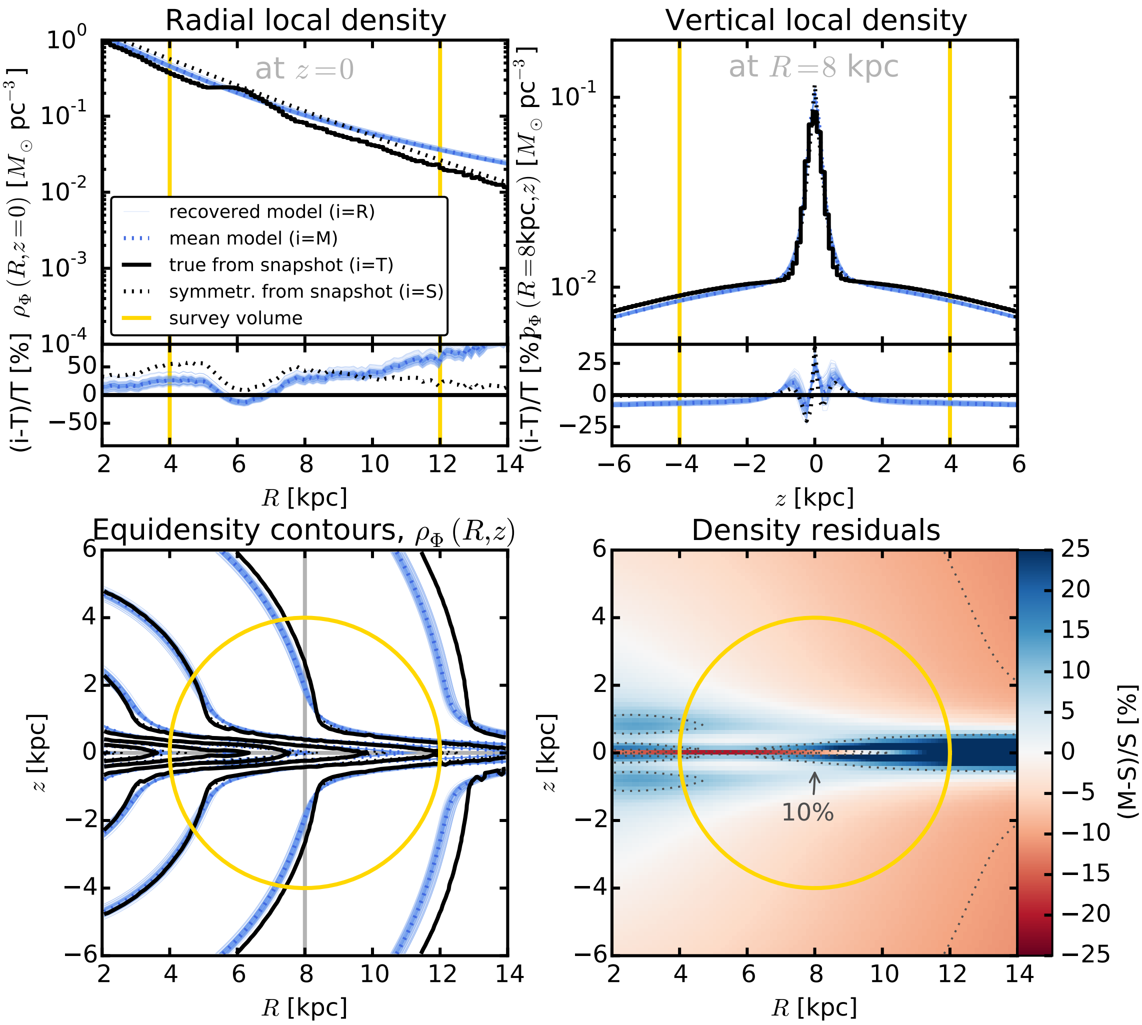

Figure 1. Comparison of the true density distribution $\rho_{\Phi,\mathrm{T}}$ in the galaxy simulation snapshot (solid black line, averaged over ϕ) with the axisymmetric density distribution $\rho_{\Phi,\mathrm{R}}$ recovered with *RoadMapping* (solid blue lines) from $N_* = 20,000$ stars in the survey volume with $r_{\max} = 4$ kpc (yellow line), as described in Section [TO DO]. The first two panels show density profiles along $(R, z = 0)$ and $(R = 8\text{ kpc}, z)$, together with the relative differences between true and recovered ρ_Φ. The third panel displays equidensity contours of the matter distribution in the (R, z) plane. Overplotted are also the symmetrized "true potential's $\rho_{\Phi,\mathrm{S}}$ (dotted black line) (see Section [TO DO]) and the $\rho_{\Phi,\mathrm{M}}$ of the recovered mean model in Table [TO DO] (dotted blue line). The last panel shows the relative difference between the symmetrized "true $\rho_{\Phi,\mathrm{S}}$ and the recovered mean model $\rho_{\Phi,\mathrm{M}}$. Over wide areas even outside of the survey volume the relative difference is less than 10%. At $R \gtrsim 8$ kpc and $z \sim 0$ it becomes apparent that the chosen potential model cannot perfectly capture the structure of the disk. [TO DO: Make sure that this plot actually contains the final analysis and sym. model that I want to show.] [TO DO: Maybe it would be more interesting to see a best fit MNd directly to the potential to see, how well the potential model can actually perform?] [TO DO: Maybe use only stars in the cone that the survey volume probes???]

4.1.3. *Recovering the potential*

- Figure: density overview plot
- Figure: vcirc, surfdens overview plot
- Figure: local potential overview plot, scatter plot of stars color coded according to deviation of true and best fit (maybe also symmetrized) potential. normalize potential such that at solar circle pot=0. Both in % of true potential and number of sigma away.
- Figure: forces overview plot, incl. local forces scatter plot
- Discuss somehow that the model parameters are actually themselves not very good recovered. Maybe violin plot?

4.1.4. *Recovering the action distribution*

- Figure: residuals in action space, comparison of true/symmetrized vs. best fit actions (maybe also true vs. best fit in symmetrized potential), overplot Lz=vcirc*Rg of spiral arms

4.2. *Investigation of different aspects*

4.2.1. *Test suite*

- $r_{max} = 1, 2, 3, 4, 5kpc$
- $N_* = 20,000$
- MNHH potential + KKS potential
- $R_{obs} = 5and8kpc$

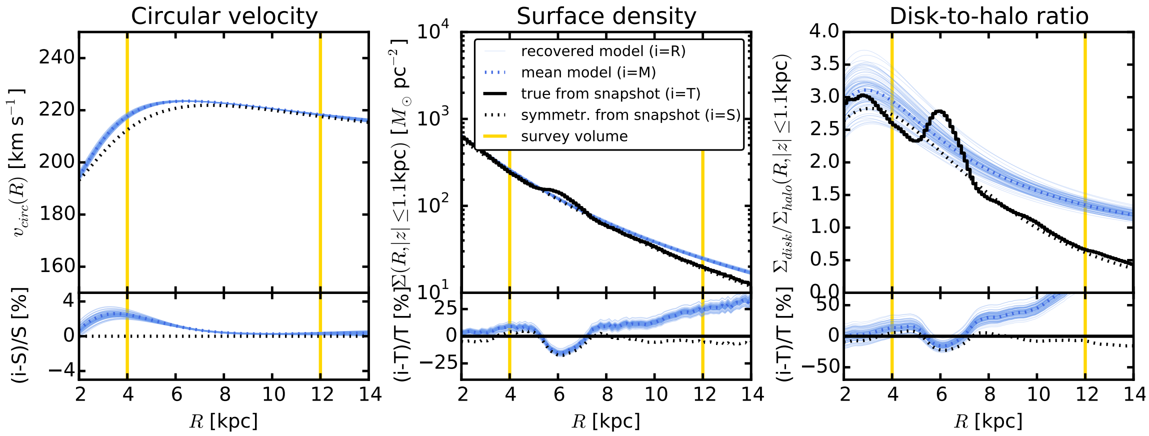

Figure 2. Comparison of the circular velocity curve, surface density profile within $|z| \leq 1.1$ kpc and disk-to-halo ratio of the surface density along R for the true potential of the galaxy simulation snapshot (solid black line) and the axisymmetric model potential recovered with *RoadMapping* (solid blue lines) (see Section [TO DO]). Overplotted are also the profiles of the symmetrized "true potential (dotted black line) (see Section [TO DO]) and the recovered mean model (dotted blue line) (see Table [TO DO]). The circular velocity curve is recovered to less than 5%, especially at larger radii. For the surface density and disk-to-halo ratio *RoadMapping* recovers the truth at radii $\lesssim 8$ kpc. The deviations at larger radii are connected to the discrepancies in the density in Figure [TO DO]. [TO DO: When I have the force I can probably also calculate the true circular velocity curve!]

4.2.2. *Survey volume and choice of potential model*

- Figure: x-axis: r_{max}, y-axis: one panel with mean stellar rms deviation in FR and one with Fz. With different potentials and r_{max}.

4.2.3. *Influence of spiral arms*

- Figure: x-axis: $\langle\kappa\rangle$, y-axis: one panel with mean stellar rms deviation in FR and one with Fz. Analyses with same potential but at different positions and sizes within the galaxy.

- Figure: x-axis: $sigma_\kappa$, y-axis: same as above figure.

5. SUMMARY AND CONCLUSION