Constraints on thin and thick disc formation from new analysis of 2MASS and SDSS surveys


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• Need for data re-analysis, combining multiple surveys
• Efficient model parameter space exploration
• Results on thick disc formation
• Results on thin disc outer structures: warp, flare and scale lengths
• Conclusion and perspectives
• Surveys: photometric, spectroscopic, multi-wavelength

• Need to combine them in a global analysis to gain in understanding complex problems
Modelling

• Population synthesis approach: many parameters but more understanding

• Link between scenarios and observations

• Confront scenarios with surveys (combined, different wavelengths, methods)

• Increasing complexity (start simple…)

Constraining parameters

- Statistical methods to constrain parameters (do not be satisfied with a solution!)
- Explore parameter space with efficient methods (MCMC, GA, ...)

*De Jong et al, 2010*
2 applications

• Study of thick disc and halo from SDSS+2MASS (MCMC) Robin, Reylé et al, 2014

• Preliminary study the outer disc from 2MASS (GA) Amores, Robin, Reylé, 2015 to be subm
**Thick disc and halo**

*From SDSS + 2MASS*

- Fit SDSS fields with no streams (photometry) (F1, F2, F3, F4 patches)
- Add 2MASS fields at intermediate latitudes and a larger longitude range
- MCMC fit, maximum likelihood g.o.f.: halo shape, thick disc shape, age, mean [Fe/H]
Thick disc shape:

Parabola + exponential

$sech^2$

Directions: $(0^\circ, 45^\circ)$
$(180^\circ, 45^\circ)$
NGP

Conclusion: not an exponential
Get rid of degeneracies of thick disc scale height

De Jong et al, 2010

Also constraining the scale length and the flare
Longer star formation?

- Assuming 2 epochs of formation (or a continuity)
- Free parameters for each episode: scale height, length, normalisation, flare
- Try different ages
<table>
<thead>
<tr>
<th></th>
<th>Old thick disc</th>
<th>Young thick disc</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>12 Gyr</td>
<td>12 Gyr</td>
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<tr>
<td>scale height (pc)</td>
<td>465.</td>
<td>826.</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>359.</td>
</tr>
<tr>
<td>scale length (pc)</td>
<td>2305.</td>
<td>3077.</td>
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<tr>
<td>normalisation</td>
<td>1.55</td>
<td>0.21</td>
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<tr>
<td></td>
<td>-</td>
<td>1.54</td>
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<tr>
<td>flare start radius (pc)</td>
<td>9359.</td>
<td>10020.</td>
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<tr>
<td></td>
<td>-</td>
<td>17364</td>
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<tr>
<td>flare slope (pc/kpc)</td>
<td>0.187</td>
<td>0.09</td>
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<tr>
<td></td>
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<tr>
<td>Lr</td>
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<tr>
<td>BIC</td>
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<td>120566.</td>
</tr>
</tbody>
</table>

Thick disc scale height and scale length decreases with time!
Main thick disc : ~10 Gyr about 80-90%, older thick disc 10-15%
Thin outer disc
Amores, Robin, Reylé in prep
Symmetrical warp model

Reylé et al, 2009
• 2MASS / BGM via Genetic Algorithm
• In-plane $|b| < 5^\circ$, K/J-K diagrams
• Outer disc: warp, flare, scale length $= f(\text{age})$
• Inner disc: spiral (in prep)

Reylé et al, 2009
Scale length changing with age, from 4 kpc to ~2 kpc
Warp: slope changing with age + asymmetry

Angle changing with age
Warp: radius changing with age
Fig. 3. $(\ell, b)$ map of relative residuals of the standard Galaxy model $(n_{\text{mod}} - n_{\text{obs}})/n_{\text{obs}}$.

Fig. 8. Same as Figure 6 lower panel but for $sim - 6$ varying warp and flare parameters with age, parameters shown in table 6.
Thin-thick disc relation

- Thick disc formation outside-in!
- Thin disc formation inside-out!
- The warp is a dynamical structure of which we can follow the evolution
- The thin disc is flaring as well as the old thick disc
Figure 10. Scale-height as a function of scale-length for mono-age populations in the 7 simulated galaxies. The scale-heights are measured at a radius of $2R_d$. The colourcode and panel order are the same as in Figure 5. We find that the observed anti-correlation between scale-height and scale-length can be reproduced in the simulations, and does not necessarily imply an absence of mergers.
Bovy et al 2012
Thin-thick disc relation

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Going-on and perspectives

- BGM applied on spectroscopic surveys (Gaia-ESO, SEGUE, APOGEE, Martins et al. 2014)
- Dynamics (Fernandez-Trincado et al, poster): the potential of the non-axisymmetric model
- Binary effects (c.f. Hurley’s scheme, R.Mor, C.Mateu, F. Figueras, et al)
- Development of tools for complexe data analysis in the Gaia perspective