Probing the characteristics of the thick disc outside the Solar neighborhood

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The Milky Way's thick disc

- Existence suggested by Gilmore & Reid (1983)
  - Old population
  - Rotational lag higher than the thin disc ($V_{\text{lag}} \sim - 50 \text{ km/s}$)
  - More metal poor and alpha enhanced

Different ways to form the thick disc:
- Radial migration? (Schonrich & Binney 2009, Roskar et al 2008 ...)
- Minor mergers? (Villalobos & Helmi, 2008 ...)
- Accretion of a massive satellite? (Abadi et al. 2003; Brook et al. 2005)

- Need to compare model predictions with observations!
  - Scale height & length? [M/H]?
  - Kinematics? Vertical gradients?
  => Large statistics are mandatory
The FLAMES survey

689 LR8 spectra of stars, outside the Solar neighborhood (14 < \( m_v \) < 18.5)

Ojha et al. (1994): Proper motions + photometry

FLAMES/GIRAFFE: \( R \approx 6500 \), \( \lambda = 8400-8810 \) Å (c.f. Gaia/RVS low resolution mode)

Mean SNR ~ 50

Thick Disc target field

\( l \approx 277°, b \approx 45° \)
Chemical & kinematic characterization of the observed sample

(Kordopatis et al. 2011b)

Teff + logg + [M/H]

(This work: DEGAS & MATISSE alg.)
Chemical & kinematic characterization of the observed sample

(Teff + logg + [M/H])
(This work: DEGAS & MATISSE alg.)

+ V mag ; (B-V) (Ojha et al. 1994)

(Kordopatis et al. 2011b)
Chemical & kinematic characterization of the observed sample

(Kordopatis et al. 2011b)

$\text{Teff} + \log g + [M/H]$
(This work: DEGAS & MATISSE alg.)

$V \text{mag} ; (B-V)$ (Ojha et al. 1994)

$D_{\text{istances}} + l, b + V_{\text{rad}}, \mu_l, \mu_b$
Chemical & kinematic characterization of the observed sample

(Kordopatis et al. 2011b)

Teff + logg + [M/H] (This work: DEGAS & MATISSE alg.)
V mag ; (B-V) (Ojha et al. 1994)

{l, b} + Distances + {V_rad, μl, μb}

Positions: X,Y,Z
velocities: U,V,W(+Vφ)
Orbital eccentricities

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(Kordopatis et al. 2011b)
Selection of the Galactic components*

* According to their position
Advantage: weak priors
But: Pollution from other components

~Halo: \( Z > 5 \) kpc

~Thick disc: \( 1 < Z < 4 \) kpc

~Thin disc: \( Z < 800 \) pc
Thin disc, thick disc & halo are distinct populations: 
$[\text{M/H}] + \text{kinematics}$
**Thick disc:**

=> Kinematics: rotational lag greater than the one expected (cf. Gilmore et al. 2002)

=> [M/H] similar to the canonical disc
Vertical gradients

For $1 < Z < 4$ kpc:

$$\frac{\partial V}{\partial Z} = -21 \pm 6 \text{ km s}^{-1} \text{ kpc}^{-1}$$

$$\frac{\partial [M/H]}{\partial Z} = -0.09 \pm 0.04 \text{ dex kpc}^{-1}$$

Are they intrinsic to the thick disc?
Vertical gradients

Comparison with the Besançon* model:

\[ \Rightarrow \text{Gradients can be explained as a smooth transition between the Galactic components} \]
Scale heights & radial scale lengths

Jeans Equations*:

\[
\frac{\sigma_{V\phi}^2}{\sigma_{Vr}^2} - 2 + \frac{2r}{h_r} - \frac{v_c^2 - V_{\phi}^2}{\sigma_{Vr}^2} + \frac{\sigma_{Vz}^2}{\sigma_{Vr}^2} = 0
\]

\[\frac{\partial \ln \sigma_{Vz}^2}{\partial Z} - \frac{1}{h_z} + \frac{K_z}{\sigma_{Vz}^2} = 0\]

* we assume \( \rho(z) \sim \exp(-z/h_z) \)

- Thin disc: \( h_r = 3.1 \pm 0.2 \text{ kpc} \)
  \( h_z = 220 \pm 10 \text{ pc} \)

- Thick disc: \( h_r = 3.4 \pm 0.5 \text{ kpc} \)
  \( h_z = 845 \pm 50 \text{ pc} \)

\( \{ \) No dependence to the \([M/H]\) \( \}

=> No evidence of accreted satellite relics (≠ Gilmore et al. 2002)

=> In disagreement with pure migration mechanism (≠ Schonrich & Binney 2009)
Orbital eccentricity distributions

**Thin disc**: circular orbits, some contaminators

**Thick disc**: centered at rather low eccentricity

**Halo**: high eccentricity

*Assumed Galactic potential: NFW halo, Hernquist bulge, Miyamoto-Nagai Disc*
Orbital eccentricity distributions

Sales et al. (2009) & Di Matteo et al. (2011): stars formed \textit{in situ} have a lower eccentricity distribution
Orbital eccentricity distributions

In situ formation of the stars of the thick disc?

BUT: criteria being debated

A change in the merging conditions can change the ecc. distribution

Sales et al. 2009
Conclusions & Perspectives

- Thin disc, thick disc & halo => distinct populations
- Thin and thick disc have similar $h_r$ (~3 - 3.5 kpc)
- $h_z_{\text{thin}}=220 \text{pc}$, $h_z_{\text{thick}}=850 \text{ pc}$
- Vertical gradients explained as smooth transitions of the Galactic populations
- No evidence of satellite relics
- Radial migration to form the thick disc: Not the dominant mechanism

$\Rightarrow$ Scenario of thick disc formed from minor mergers is favored

- Similar work being done with stars observed towards the south Galactic pole
- ESO-Gaia survey (FLAMES) & Gaia: thousands (millions!) of stars
Merci de votre attention