Chemical evolution models for the Milky Way thick and thin discs in the Gaia Era

Valeria Grisoni
PhD student
University of Trieste

In collaboration with:
F. Matteucci and E. Spitoni

Vipava 2018, October 9th
9th Gaia Science Alerts Workshop

Outline of my talk

- **Part#1:**

  First, we study the chemical evolution of the thick and thin discs of the Galaxy in the Solar Neighborhood by comparing detailed chemical evolution models with recent data from the AMBRE Project (Grisoni et al. 2017).

- **Part#2:**

  Then, we extend our previous study to the other Galactocentric distances and explore the abundance gradients along the Galactic thin disc (Grisoni et al. 2018).

- **Part#3:**

  Finally, we test our models in the light of the new data provided by asteroseismology, i.e. stellar ages (Spitoni et al. 2018).

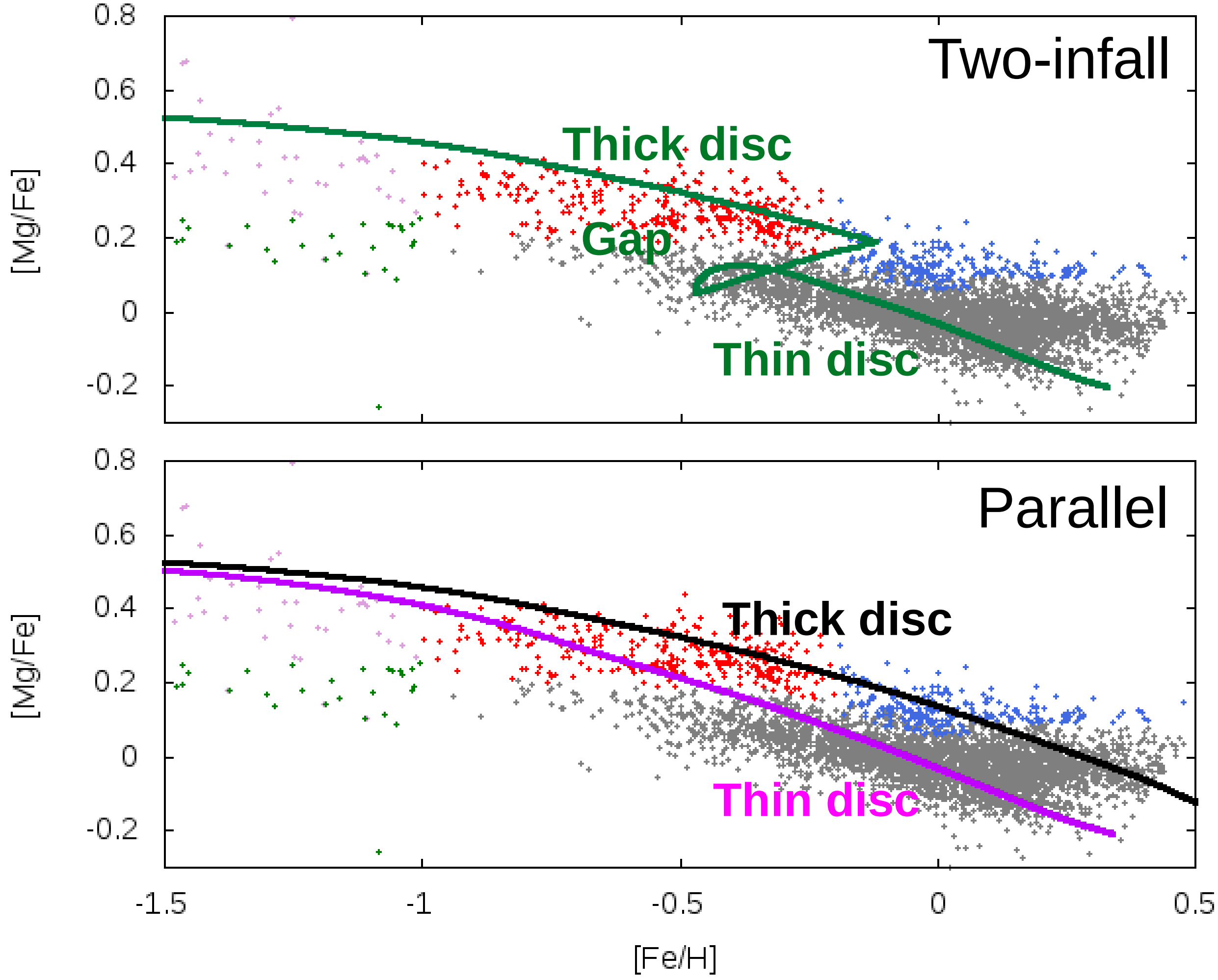
Part#1: the models for the Galactic disc(s)

In Grisoni et al. (2017), we model the thick and thin disc evolution by adopting two different chemical evolution approaches:

i) a revisited two-infall approach (Chiappini et al. 1997; Romano et al. 2010) applied to the thick and thin discs;

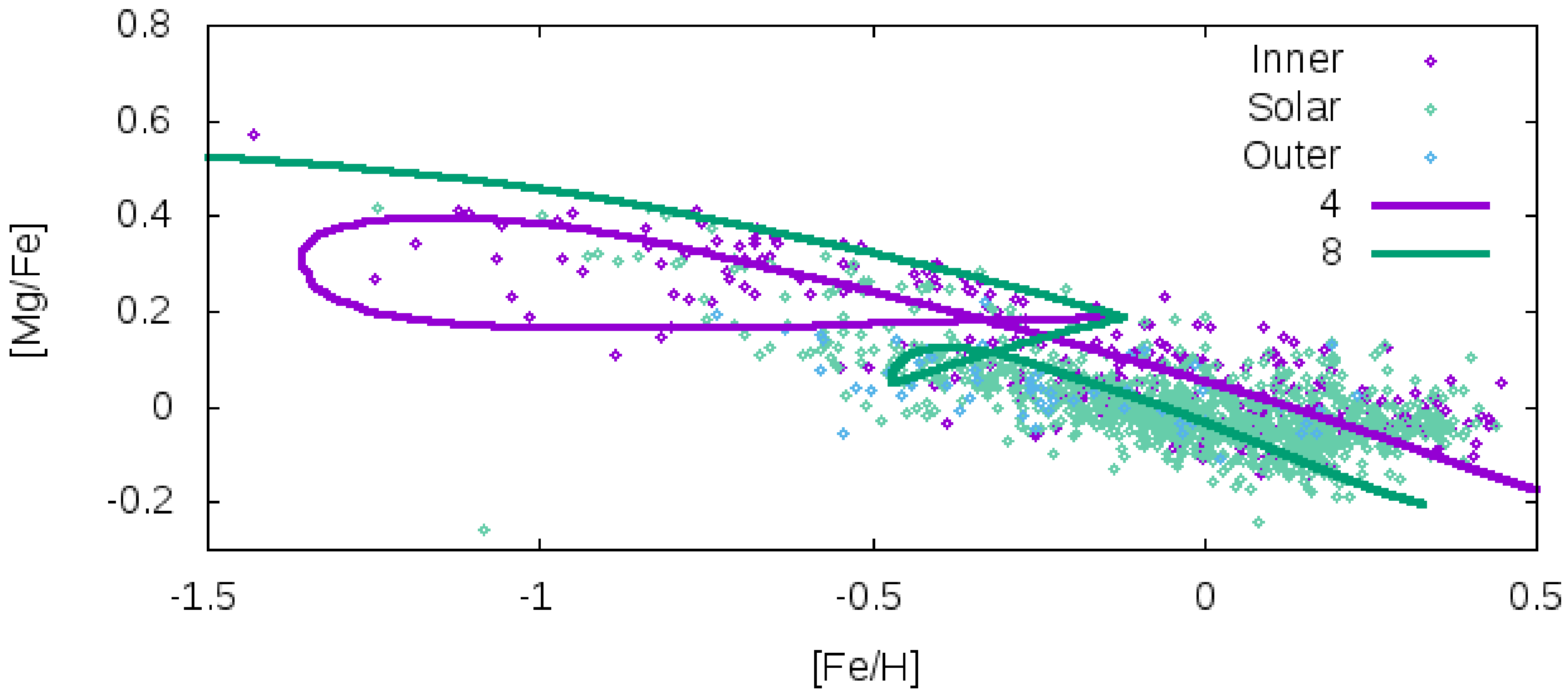
ii) a new parallel approach, where thin and thick discs start forming at the same time.

Results of Grisoni et al. (2017)



Observed and predicted [Mg/Fe] vs. [Fe/H] for the two-infall model (upper panel) and the parallel model (lower panel). The data are from the AMBRE Project (Mikolaitis et al. 2017).

The only way to interpret the MRHA stars in terms of the two-infall model is by assuming radial migration, i.e. stars moving from other Galactocentric radii.

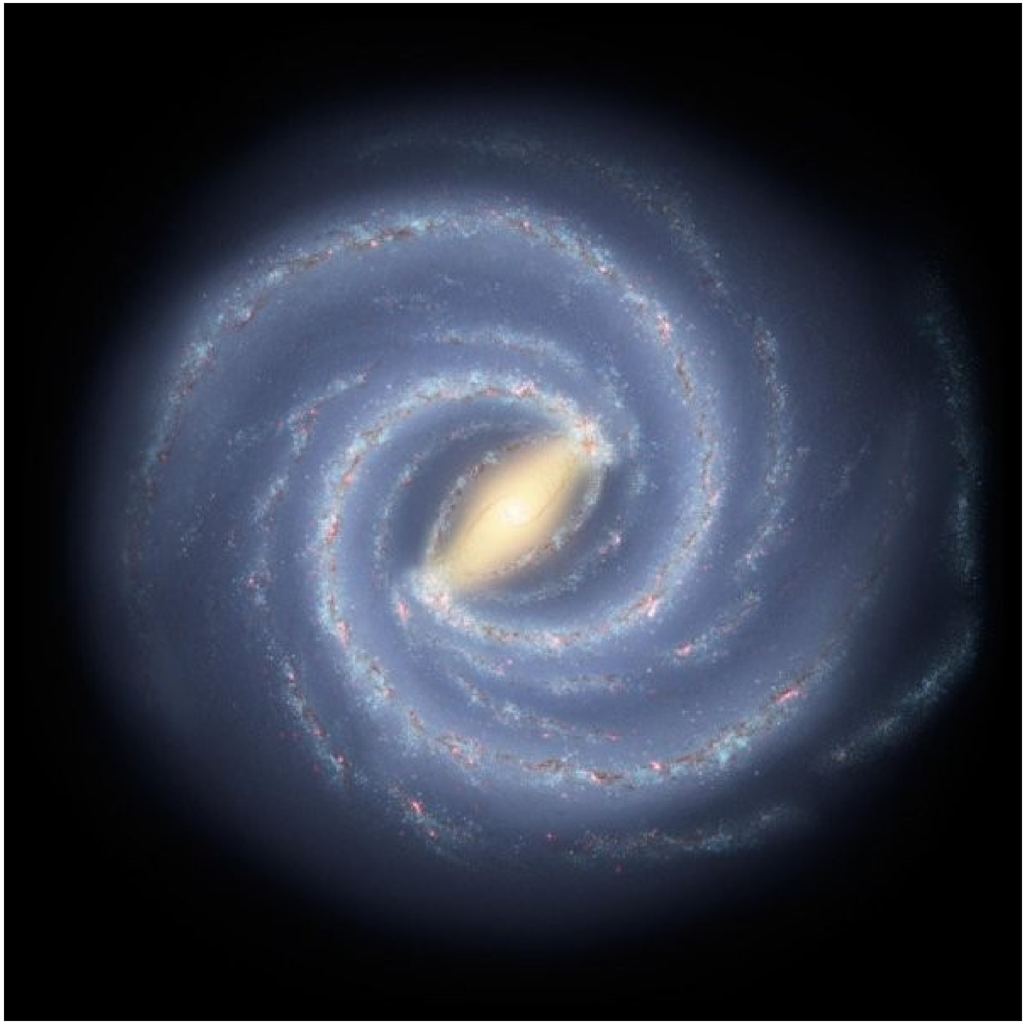


Observed and predicted [Mg/Fe] vs. [Fe/H] for the two-infall model at various Galactocentric radii (inside-out scenario). The data are color-coded according to their guiding radii (Hayden et al. 2017).

Part#2: Abundance gradients

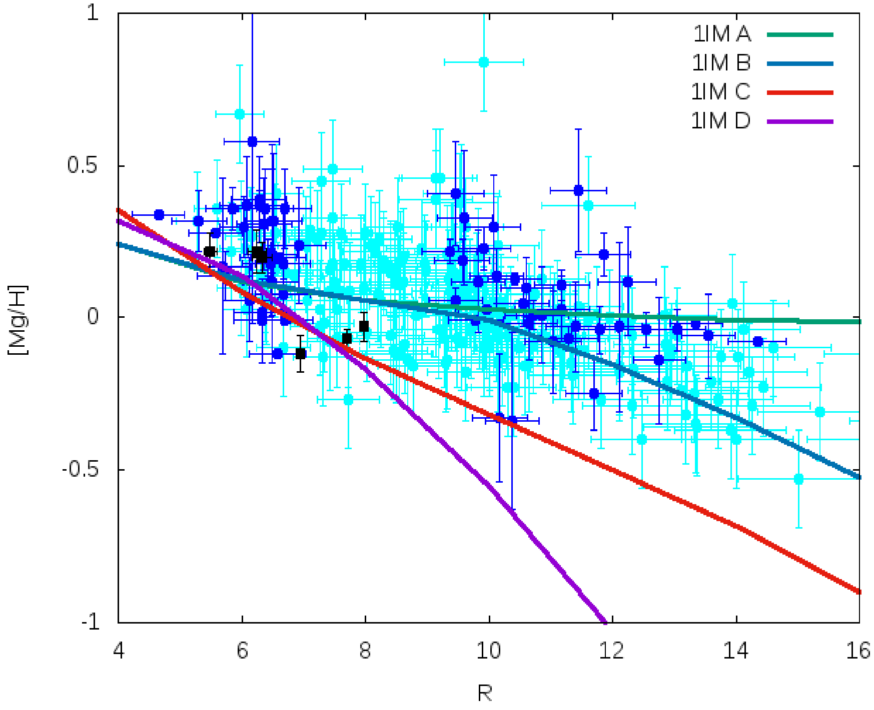
How do gradients form?

- Inside-out scenario (Matteucci and Francois 1989; Chiappini et al. 2001)
- Variable SFE
- Radial gas flows
- Different IMF



Results of Grisoni et al. (2018)

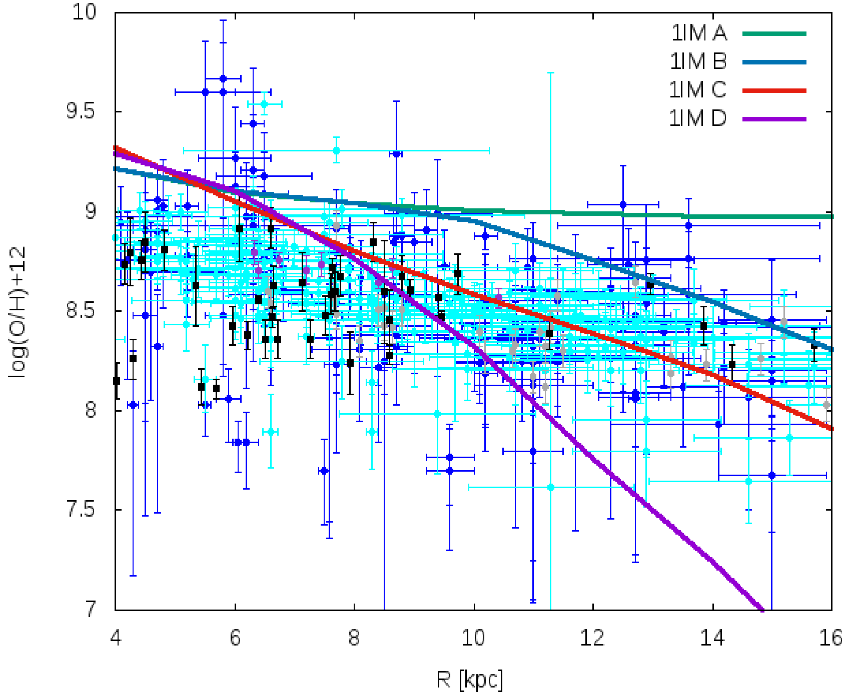
We compare observations with our model predictions for the one-infall model: **1IMA (only inside-out)**, **1IMB (variable star formation efficiency SFE)**, **1IMC (radial gas flows)**, **1IMD (variable SFE+radial gas flows)**.



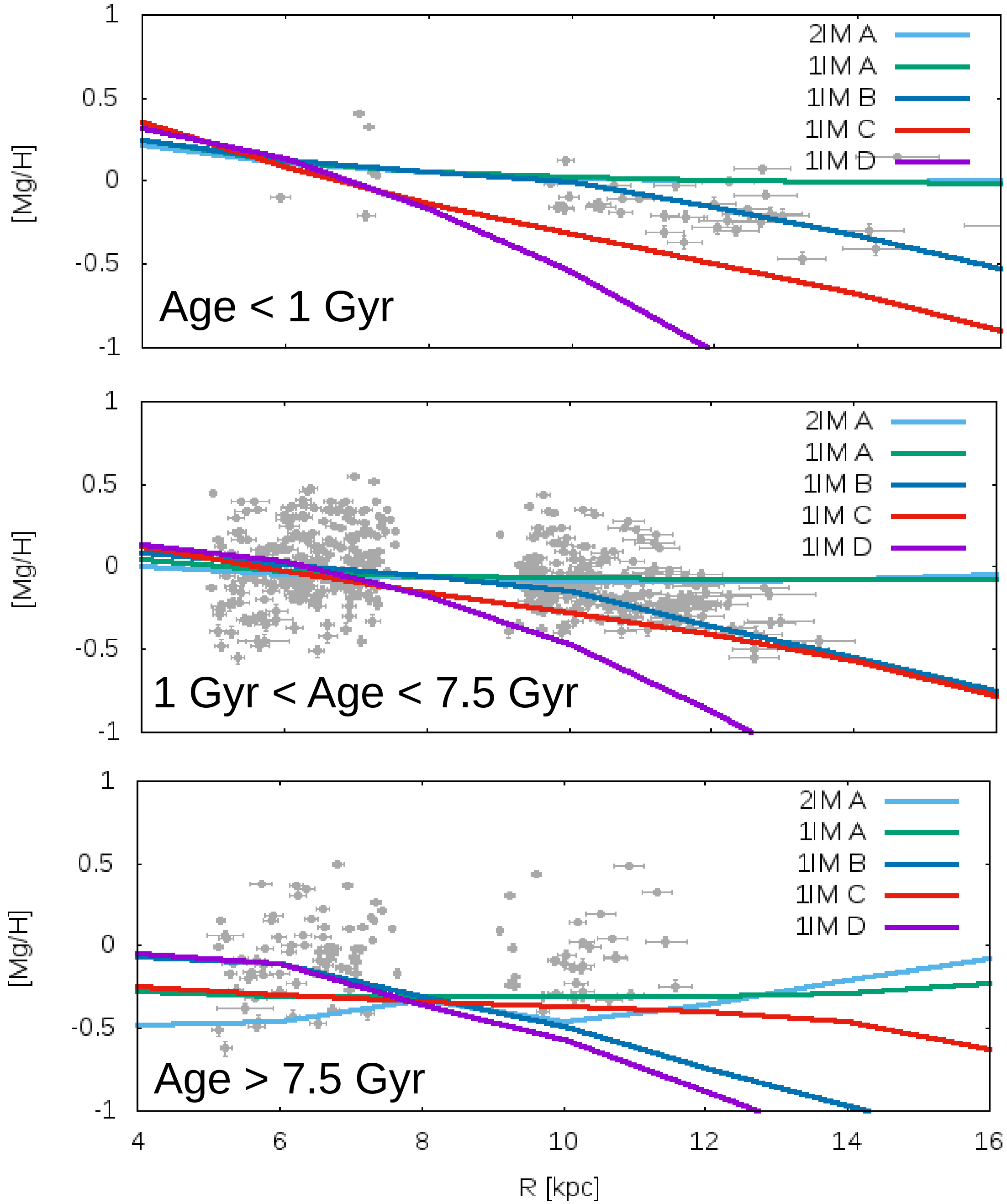
Observed and predicted abundance gradient for magnesium. The data are from Genovali et al. 2015 (blue dots), Luck and Lambert 2011 (light-blue dots) for Cepheids, and from Magrini et al. 2017 (black squares) for young OCs.

Furthermore, for HII regions and (young) Planetary Nebulae…

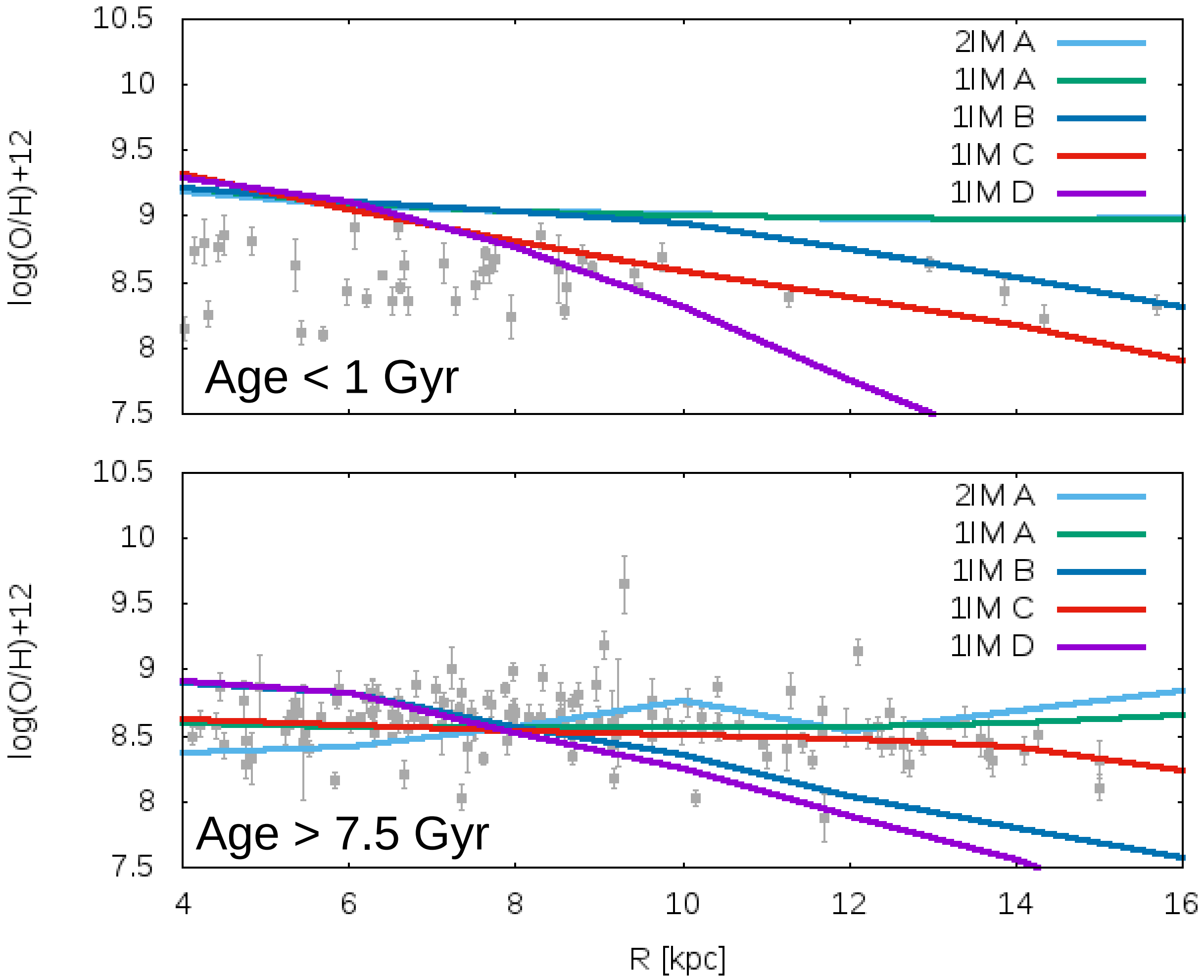
We compare observations with our model predictions for the one-infall model: **1IMA (only inside-out)**, **1IMB (variable star formation efficiency SFE)**, **1IMC (radial gas flows)**, **1IMD (variable SFE+radial gas flows)**.



Observed and predicted abundance gradient for oxygen. The data are from Deharveng et al. 2000 (gray dots), Esteban et al. 2005 (violet dots), Rudolph et al. 2006 (blue dots), Balser et al. 2015 (light-blue dots) for HII regions and from Stanghellini and Haywood (black squares) for young PNe.



Time evolution of the radial abundance gradient for magnesium observed by Anders et al. (2017) and predicted by Grisoni et al. (2018).



Time evolution of the radial abundance gradient for oxygen observed by Stanghellini and Haywood (2018) and predicted by Grisoni et al. (2018).

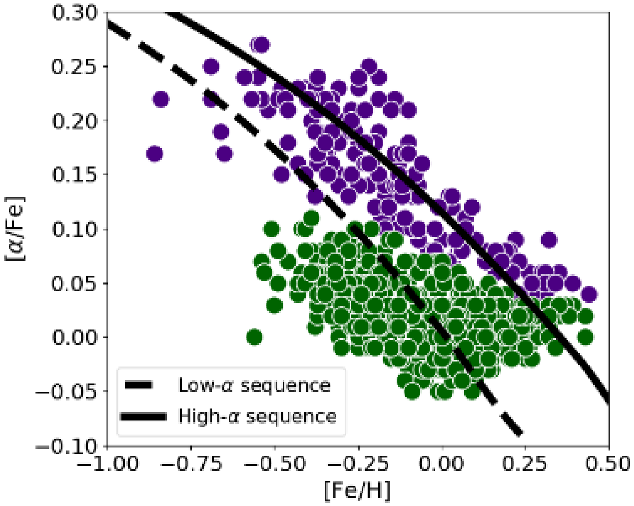
Part#3: Stellar ages

In the light of the new data provided by asteroseismology (i.e. stellar ages), in Spitoni et al. (2018) we further constrain the two different chemical evolution approaches presented in Grisoni et al. (2017):

i) the two-infall approach;

ii) the parallel approach.

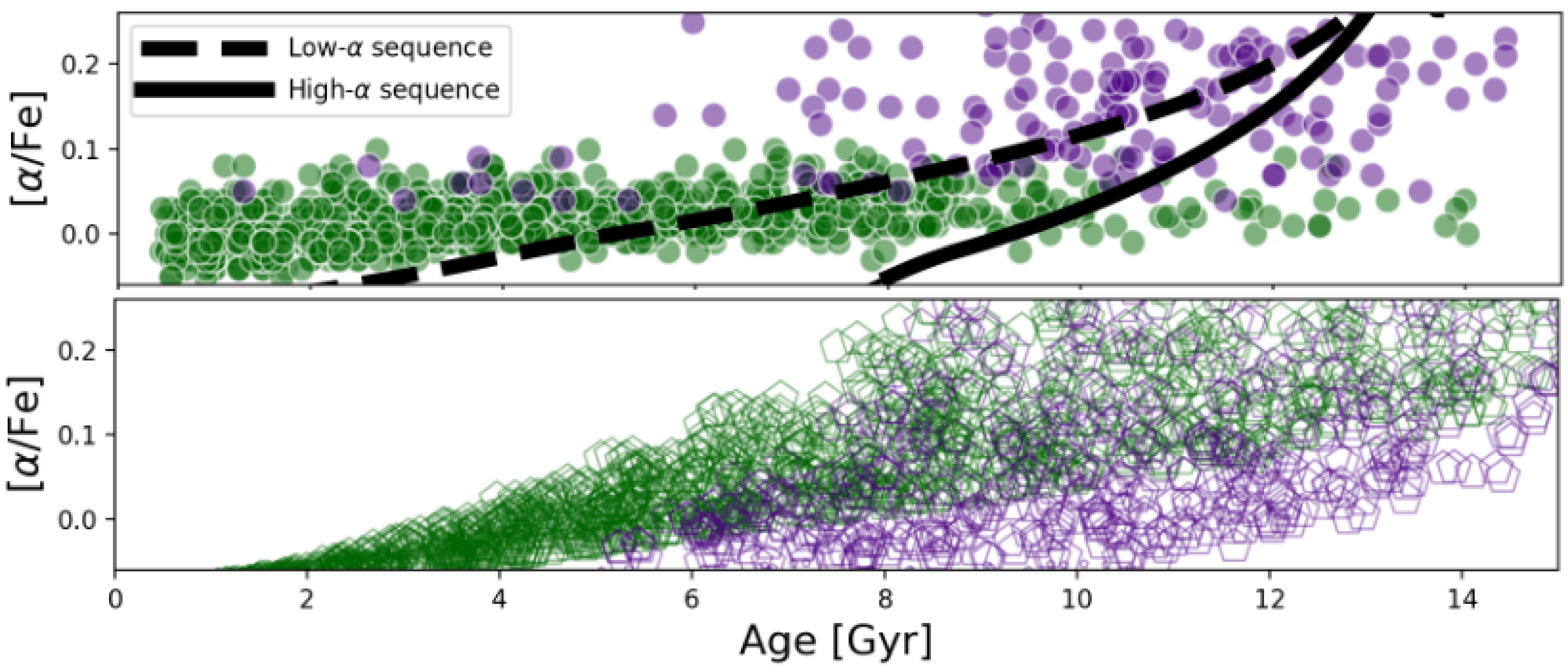
Results of Spitoni et al. (2018)

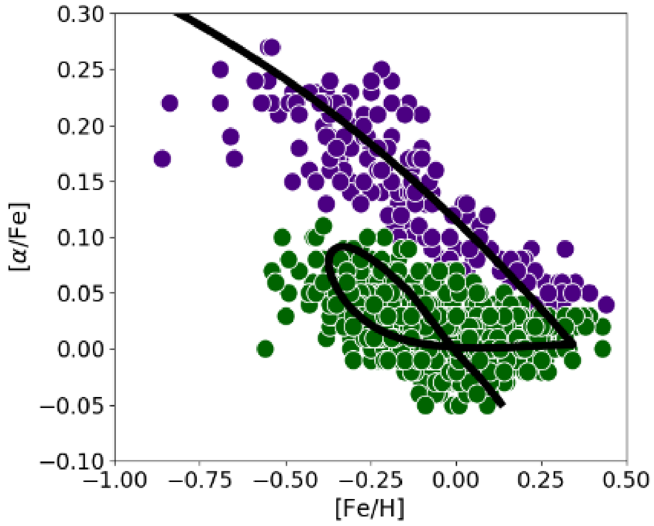


Upper panel: [α/Fe] vs [Fe/H] predicted by the parallel model (Spitoni et al. 2018) compared with APOKASC data by Silva Aguirre et al. (2018).

Middle panel: [α/Fe] vs age predicted by parallel model and compared with APOKASC data.

Lower panel: parallel model results, in which the observational errors have been taken into account.

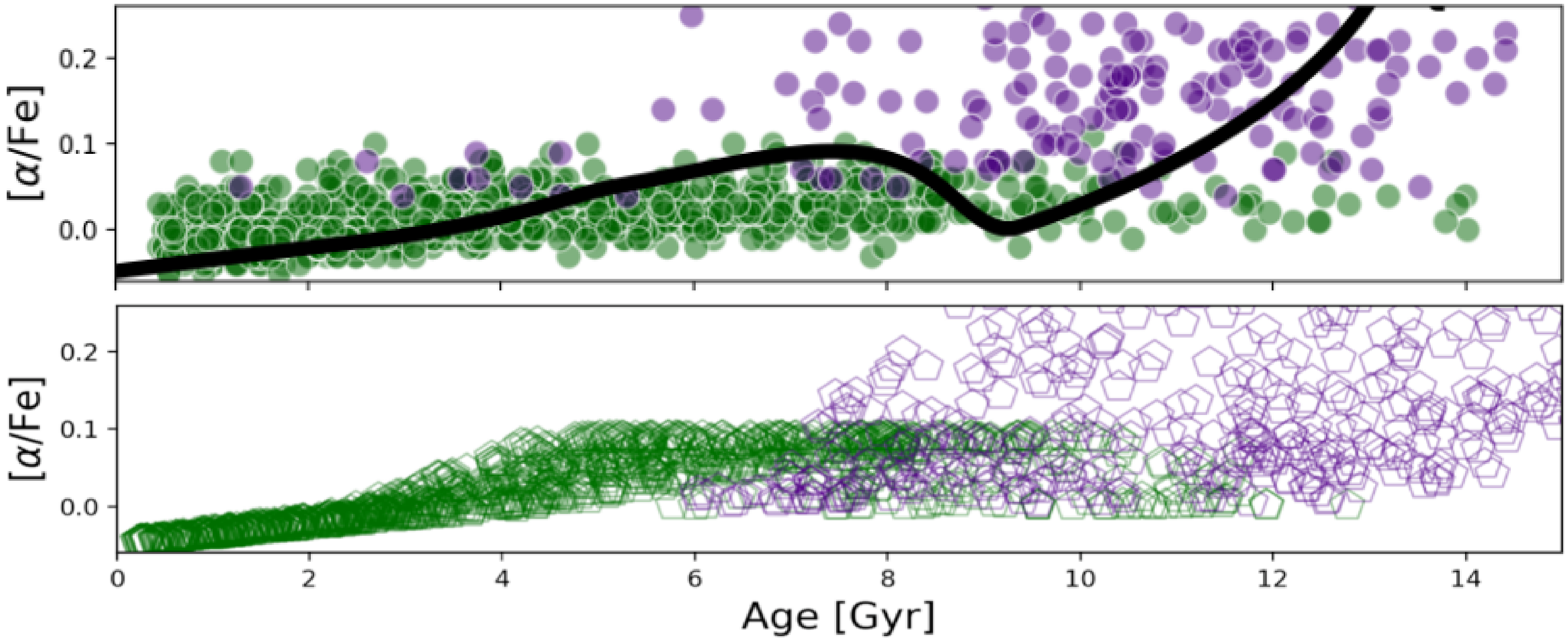


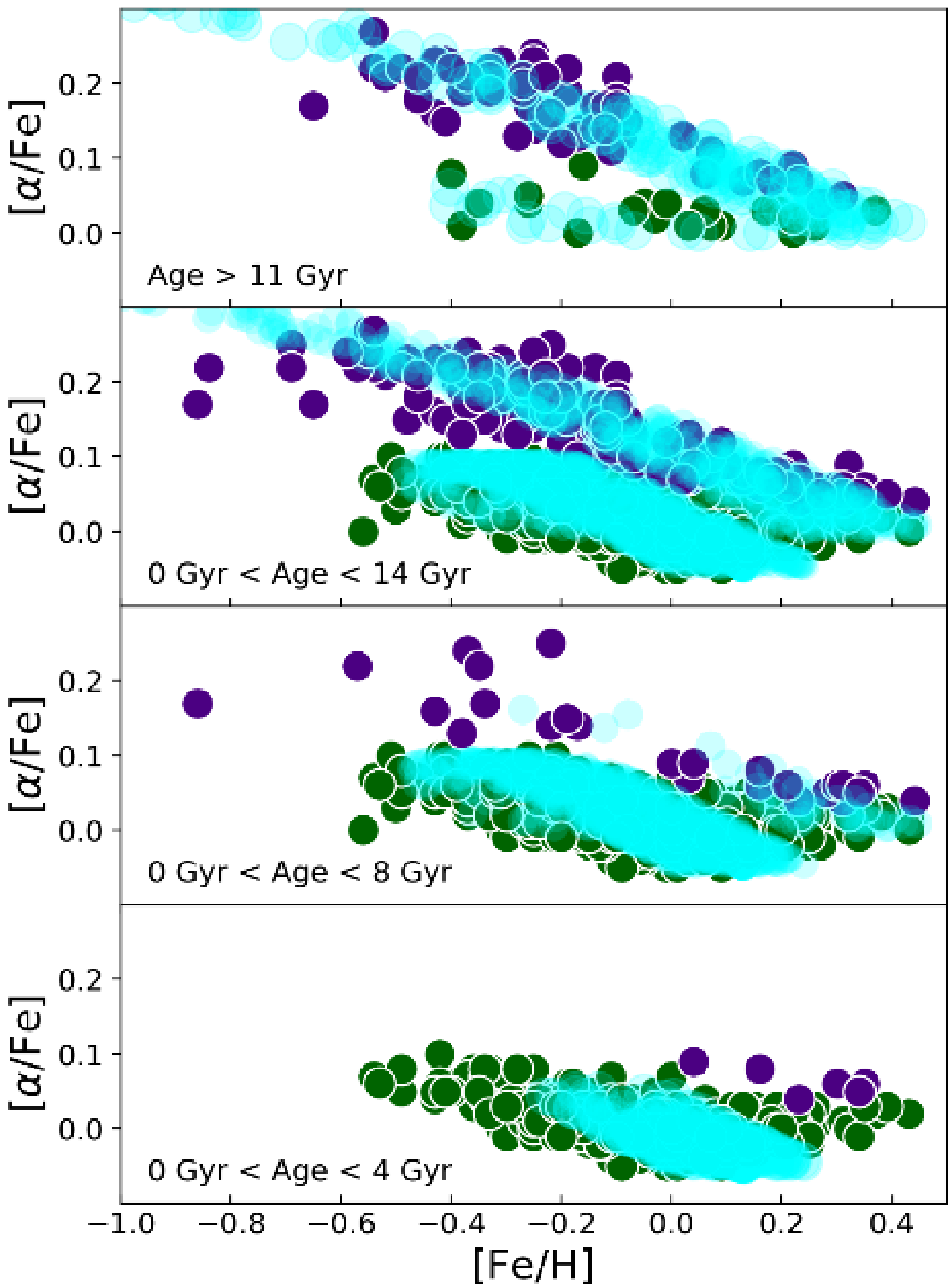


Upper panel: [α/Fe] vs [Fe/H] predicted by the two-infall model (Spitoni et al. 2018) compared with APOKASC data by Silva Aguirre et al. (2018).

Middle panel: [α/Fe] vs age predicted by the two-infall model and compared with APOKASC data.

Lower panel: two-infall model results, in which the observational errors have been taken into account.





[α/Fe] vs [Fe/H] at different age ranges, observed by Silva Aguirre et al. (2018) and predicted by the two-infall model taking into account the observational errors on age and metallicity by Spitoni et al. (2018).

Summary and conclusions

- **Evolution of the Galactic thick and thin discs:**

  Between the two scenarios presented by Grisoni et al. (2017), we favor the two-infall approach relative to the parallel one in the light of the new data provided by asteroseismology, i.e. stellar ages (Spitoni et al. 2018).

- **Abundance gradients along the thin disc:**

  The main conclusions of Grisoni et al. (2018) are summarized as follows.

  -Concerning the present-day abundance gradient, the inside-out scenario provides a too flat gradient and cannot explain the observational data from Cepheids, young OCs, young PNe, and HII regions which show a steeper gradient. To recover the steeper gradient, we need further ingredients such as the variable star formation efficiency or radial gas flows.

  -For the time evolution of abundance gradients, the model with variable star formation efficiency predicts a flattening of the gradient with time; on the other hand, the models with constant star formation efficiency predict a steepening. However, no firm conclusions can be drawn from the observational data.