Revisiting the [Y/Mg]–age relation with NLTE abundances and TESS asteroseismic ages

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Figure 1. The 1.65-meter Ritchey-Chrétien telescope used to observe the stars analyzed in this study.

Figure 2. The Molėtai Astronomical Observatory.

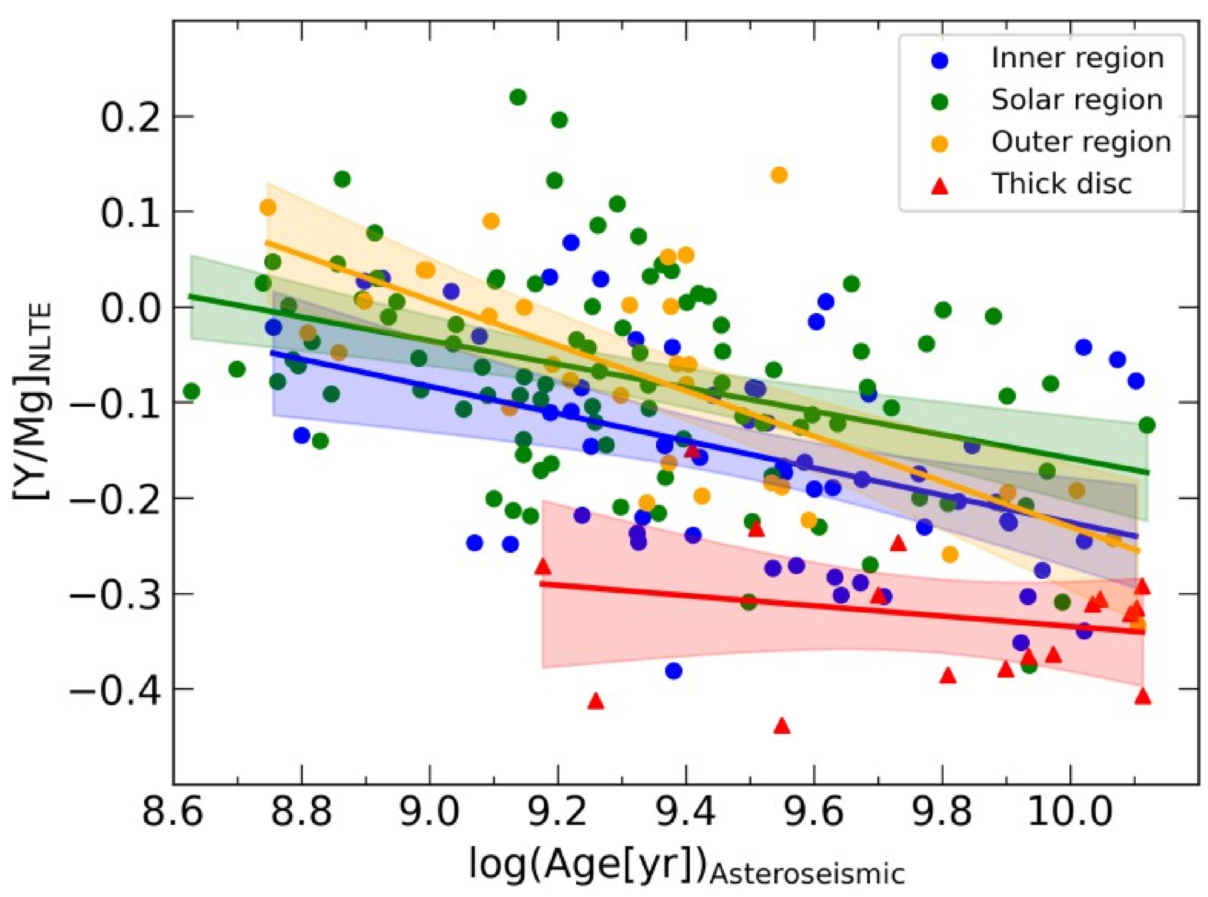

Figure 3. [Y/Mg] vs. asteroseismic age for thin- and thick-disc stars. Thin-disc stars are color-coded by mean galactocentric distance: blue (<7.5 kpc), green (7.5–8.5 kpc), and pink (>8.5 kpc).

1. Context / Introduction: Stellar Ages and the [Y/Mg] Chemical Clock

Stellar ages are difficult to determine directly, especially for field stars. Abundance ratios such as [Y/Mg] offer a promising empirical alternative because Y and Mg trace different nucleosynthetic channels and enrichment timescales: yttrium is mainly produced by the slow neutron-capture process in AGB stars, while magnesium is an α-element produced on much shorter timescales by massive stars and core-collapse supernovae. This makes [Y/Mg] extremely sensitive to stellar age and a useful tool both for estimating ages of individual stars and for tracing the chemical evolution of the Milky Way. Although this relation has been known for decades (e.g. Nissen 2015), we revisit it here using more precise ages and abundances.

2. Data and Methods: Spectroscopy and Asteroseismology

We present the stellar sample analyzed by Pakštienė et al. (2026), consisting of 1250 bright F, G, and K giants with V < 8 mag, located in a field centred on the northern TESS continuous viewing zone. High-resolution spectroscopic observations were obtained with the Vilnius University Echelle Spectrograph (VUES) mounted on the 1.65 m telescope at the Molėtai Astronomical Observatory in Lithuania (Figs. 1 and 2). Mg and Y abundances were determined spectroscopically and corrected for NLTE effects. Solar-like oscillations were searched for using TESS light curves, processed with the Lightkurve package. Asteroseismic parameters were obtained for 218 giants, whose ages were derived using the PARAM and BASTA Bayesian tools, based on seismic observables, spectroscopic stellar parameters, and stellar-evolution models (MESA, PARSEC, and BaSTI isochrones).

3. [Y/Mg]–Age Relation: Thin vs. Thick Disc Stars

Our results (Fig. 3) show that the [Y/Mg]–age relation is population-dependent. Thin-disc stars display a clear negative correlation between [Y/Mg] and age, confirming the usefulness of this abundance ratio as a chemical clock. However, the relation is not universal across the disc: stars located in the inner disc, solar region, and outer disc follow different trends, reflecting variations in star-formation efficiency and chemical enrichment history with Galactocentric distance. The outer thin disc shows the strongest age dependence and higher [Y/Mg] values at a given age, while the inner disc and solar region show flatter relations. In contrast, thick-disc stars exhibit only a very weak correlation, with uniformly low [Y/Mg] values. This confirms that [Y/Mg] is a reliable age indicator mainly for thin-disc stars, but not for the older thick-disc population.

4. Implications for Galactic Archaeology and Conclusions

The clear radial dependence of the [Y/Mg]–age relation shows that this chemical clock cannot be applied as a single universal calibration across the Milky Way. The steeper trend in the outer disc, the progressively flatter relations toward the inner disc, and the very weak correlation in the thick disc reflect different star-formation efficiencies and chemical enrichment histories. These results confirm and extend previous findings: the radial variation of s-process-to-α-element ratios reported by Viscasillas Vázquez et al. (2022, 2025), and the conclusion by Tautvaišienė et al. (2021) that [Y/Mg] is not a reliable age indicator for thick-disc stars.

Literature.

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