Where's Waldo? Unveiling a metal-poor extension of the Milky Way thin disc with Pristine-Gaia-synthetic

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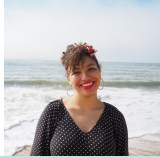
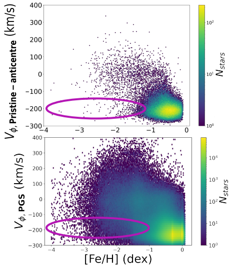
LAGRANGE
PRISTINE



FROM THE PRISTINE SURVEY TO PRISTINE-GAIA

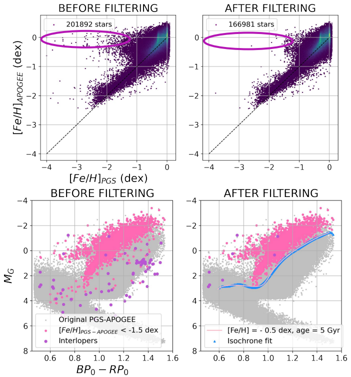
2022: rework of Fernández-Alvar et al. 2021
→ metal-poor subset of fast-rotating, prograde stars populating the MW thin disc
→ with the Pristine survey (Starkenburg et al. 2017): narrow-band survey based on metallicity-sensitive CaHK filter, delivering reliable photometric metallicities down to ~ -3.0 dex
→ Galactic anticentre (170°< *l* <190°, -40°< *b* <40°)
→ our anticentre sample: 114 450 stars

2023: this work
→ Pristine-Gaia synthetic metallicity catalogue (PGS): BP/RP information of ~ 219M Gaia DR3 sources (Gaia collaboration et al. 2023) used to compute synthetic CaHK magnitudes mimicking the response of the Pristine CaHK filter and infer corresponding photometric metallicities (Martin et al. 2023, submitted)
→ whole sky (6,500 deg^2 covered in the northern sky)
→ our sample with Gaia-RVS velocities: 9 556 173 stars



Can we confirm the existence of the metal-poor thin disc with PGS?

HOW TO FILTER INTERLOPERS ?



→ 17% of PGS-APOGEE stars are filtered
→ Similarly, we clean the full PGS

STARTING POINT

→ Interlopers hamper our analysis. **They can populate the metal-poor extension we are trying to highlight**: need to be filtered out
→ We take APOGEE DR17 (Abdurro'uf et al. 2022) metallicities = **reference spectroscopic metallicities** and compare them with those of PGS

→ Presence of 'metal-poor in PGS, metal-rich in spectroscopy' stars, i.e. **with $[Fe/H]_{PGS} < -1.5$ dex AND $[Fe/H]_{spectro} > -0.5$ dex**
→ Especially at low metallicity ([Fe/H] < -1.5 dex), i.e. where stars populating the so-called 'thin disc metal-poor tail' are located

GDR3/PGS FLAGS FILTERING

→ GDR3 cuts: RUWE < 1.4, relative parallax uncertainty < 20%, $M_G < 7.5$ mag
→ PGS cuts: metallicity grid flag > 0.9, $prob_{var} < 0.3$, $\delta_{CaHK} < 0.05$ mag

ISOCHRONE FILTERING

We choose a value of [Fe/H] and age to fit an isochrone that will remove the populations that:
→ for a given age, should be more metal-poor
→ for a given metallicity, should be younger

REFERENCES

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ACKNOWLEDGEMENTS

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WHY IS THIS STRUCTURE INTERESTING?

The formation processes leading to the Milky Way we know are encoded in the properties of the first stellar populations, mostly through orbital motion and chemical content. These first populations are characterized by their very low metal content and have been the object of searches for the past decades, e.g. Frebel & Norris 2015. With the rise of surveys like Gaia, Pristine and WEAVE, new structures and signatures are being identified, such as individual extremely/very-metal-poor prograde, fast-rotating stars (Sestito et al. 2019). Evidencing the presence of a substructure composed of such stars could thus provide valuable hints to better understand the different stages of early galactic evolution, in particular those of the Milky Way disc.

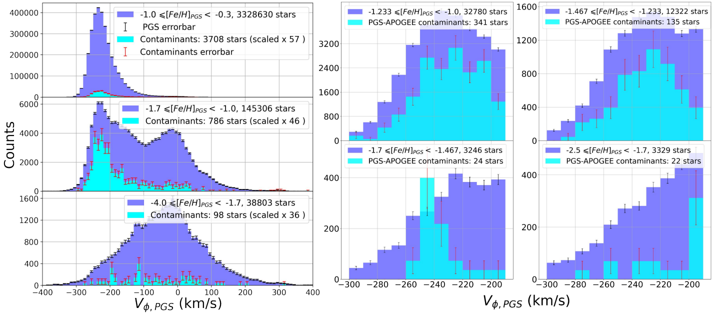
RESULTS

1) ROTATIONAL VELOCITY DISTRIBUTION

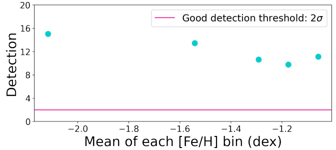
After filtering, we are contrasting two subsets:
- **PGS, filtered (9 556 173 stars)**
- **PGS-APOGEE 'contaminants'** = stars with $|\Delta_{[Fe/H]PGS-APOGEE}| > 2\sigma(\text{dist } \Delta_{[Fe/H]})$ (**4592 stars, scaled accordingly**)

→ At lower [Fe/H]: **we recover a population with halo kinematics** = with little/no net rotation and a large velocity dispersion: **expected**
→ **We also evidence a significant fraction of fast-rotating (thin disc-like) sources** in PGS, especially between -1.0 and -1.7 dex, although the V_φ **distribution is dominated by contaminants** in these regions.

We can look into the **significance of the remaining PGS fast-rotating metal-poor stars once the contaminants are taken into account.** We can quantify this using the statistics of PGS in small [Fe/H] bins (figure on the right).



$$detection = \frac{N_{PGS} - N_{PGS-APOGEE-contaminants}}{\sigma_{PGS-APOGEE-contaminants}}$$

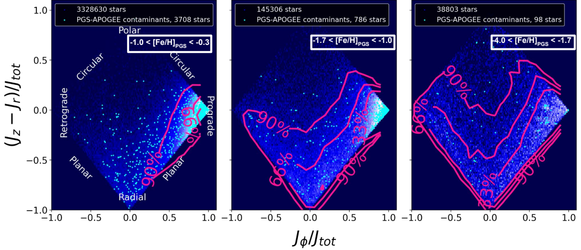


At [-300, -180] km/s (fast rotators) the signal received by PGS is always >> $5\sigma_{PGS-APOGEE-contaminants}$ down to - 2.5 dex

2) WHICH ACTION COMPONENTS ARE MOST REPRESENTED?

We investigate the action space using the orbital parameters of Kordopatis et al. 2023 (figure on the right), where the contours and density scale are the main sample and the contaminants are overplotted.

→ The metal-rich bin (left panel) is dominated by a prograde, planar thin disc-like population.
→ **Surprisingly, we find a significant fraction of stars (33%) remaining close to the plane and showing prograde motions, even at very low metallicity** (middle and right panels): hint at the possible presence of a metal-poor population with thin disc characteristics among typical halo stars (e.g. Sestito et al. 2019).



CONCLUSIONS

✅ **We evidence the presence of a substructure composed of prograde, fast-rotating metal-poor stars down to -2.5 dex**

✅ **Most PGS detections are >>> $5\sigma_{PGS-APOGEE-contaminants}$**

💡 **The robustness of this result must be enhanced through MCMC (draws on V_φ and [Fe/H])**

💡 **Improving the spectroscopic reference sample is key to better describe contaminants at [Fe/H] ≤ -2.5 dex**

💡 **The choice of the Poisson noise adopted to describe the error bars in V_φ could also be improved**