Preparing for Mira spectra in *Gaia* DR4: Improving the GSP-Spec pipeline in the cold giants domain

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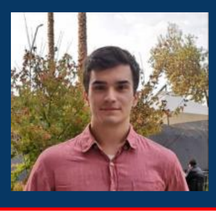
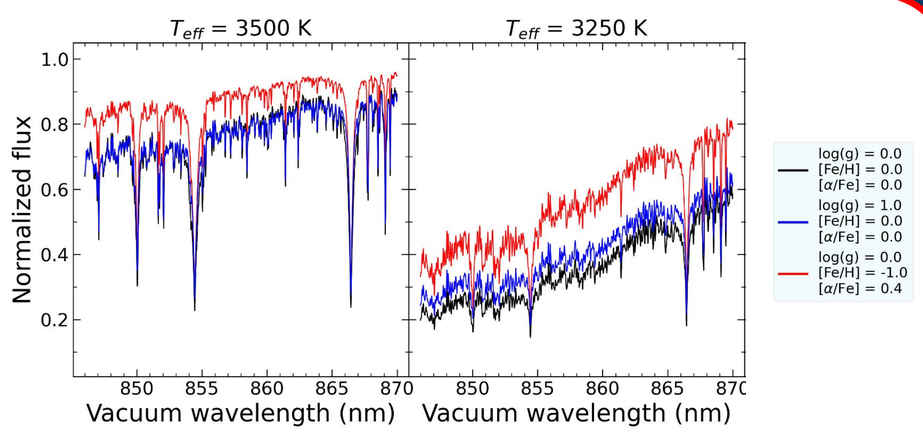


Motivation

Miras are **giant IR-bright standard candles** with **cold atmospheres (T_{eff} ≲ 3500 K)**, where absorption bands of molecules produce a parameter-dependent pseudo-continuum, introducing **significant difficulties in the parameterization** of their spectra.

A sample of Miras with stellar parameters (**T_{eff}, log(g), [Fe/H], [α/Fe]**), would allow for a **large-scale chemical and dynamical study of the Galaxy's stellar populations** in its faintest and most obscured regions.

We are **working on improving GSP-Spec's [1] performance for the cold giants domain**, with the **goal of reliably characterizing RVS epoch spectra of Mira variables in *Gaia* DR4**, opening a new path for studies of the Milky Way and its satellites.



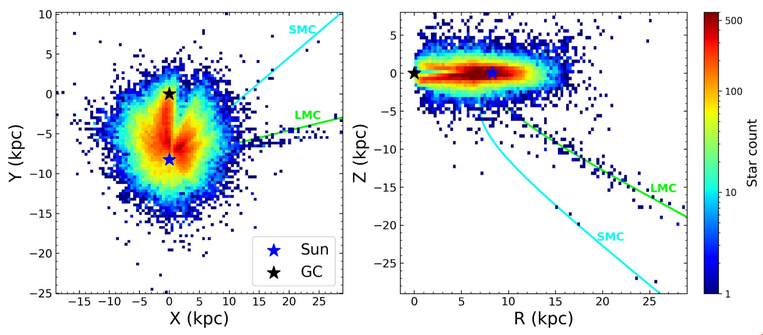
Sample of M-giants in *Gaia* DR3

We study a sample of **82.2k M-type giants** with **publicly available stacked RVS spectrum** in *Gaia* DR3.

48k are classified as Miras in *Gaia* DR3 [2].

We reach ~10 kpc away from the Sun in regions near the Galactic plane.

Stars in the LMC and SMC

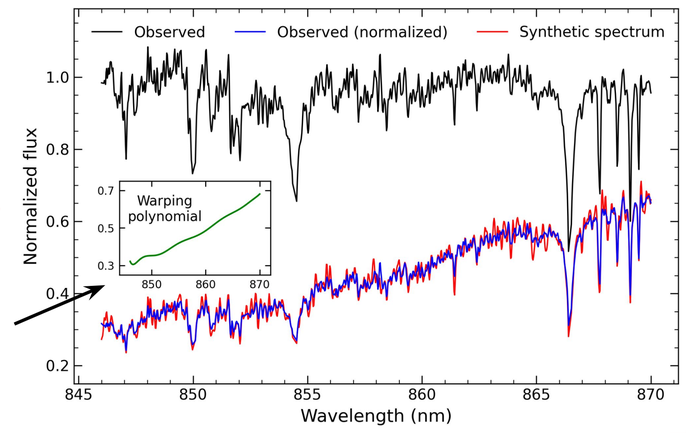


A tailored continuum normalization

RVS spectra can have **inconsistent normalizations**.

Renormalization helps **break the degeneracy between the continuum and the stellar parameters**.

We use a matrix of Chebyshev polynomials, obtaining a better performance.



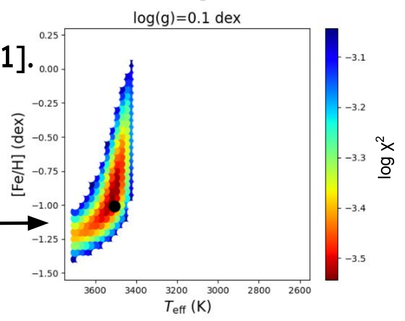
Estimating stellar parameters

We **compare the observed spectra with the 4D grid of models** used in [1], using a log χ^2 statistic. We **derive initial estimates** for the stellar parameters, and **renormalize the continuum of the observed spectra**.

We then **run the *MatisseGauguin* (MG) workflow** [1].

Where MG fails, we interpolate **a finer grid of models** and derive estimates using a log χ^2-weighted grid-mean (WGM) method.

Monte Carlo iterations are used to derive uncertainties.

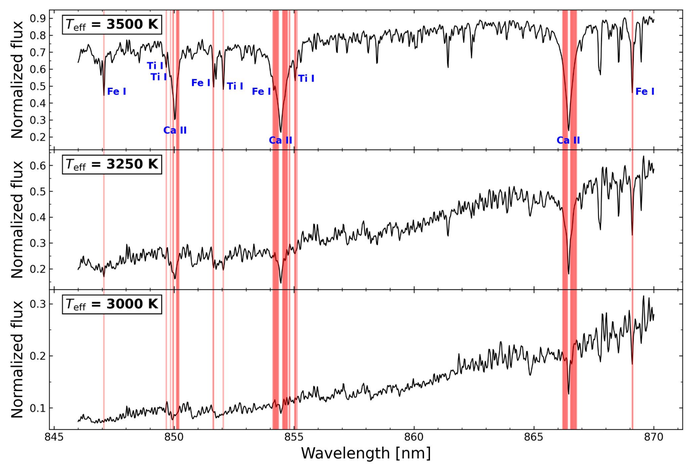


Flux sensitivity to stellar parameters

Molecular line profiles do not change much with the stellar parameters.

They change the observed atomic line profiles, which are very sensitive to the parameters, but with strong degeneracies.

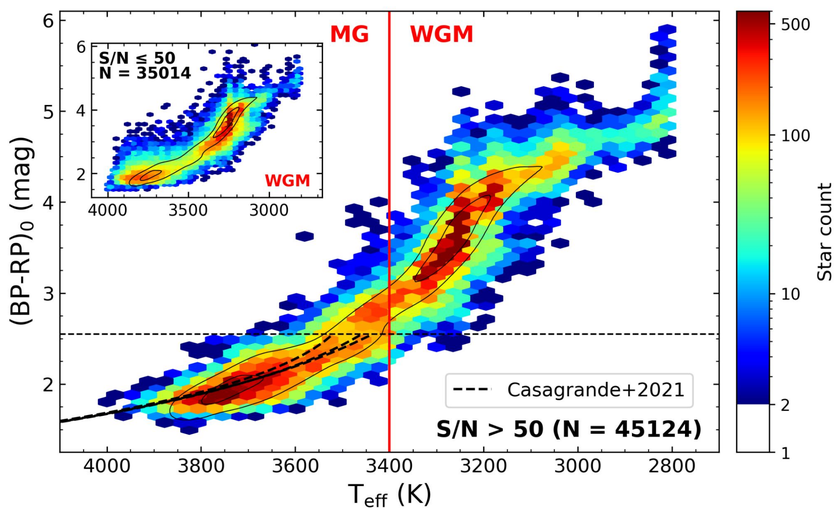
Only the **wavelengths with highest sensitivity are used for the WGM method**.



T_{eff}-color relation

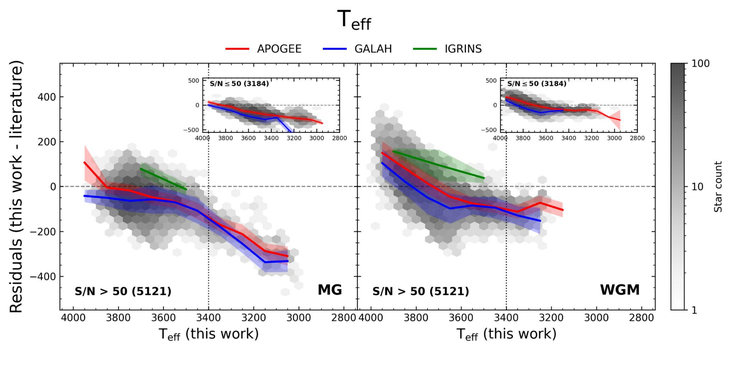
We compute intrinsic colors using $E(G_{BP} - G_{RP})$ values [3].

We find a **well-behaved T_{eff}-color relation** with excellent agreement with an empirical relation [4] (shown as dashed lines for different [Fe/H] values). We reach **colder temperatures than relations available in the literature**.



Validating against the literature

We validate our results against APOGEE DR17 [5], GALAH DR4 [6], and IGRINS [7].

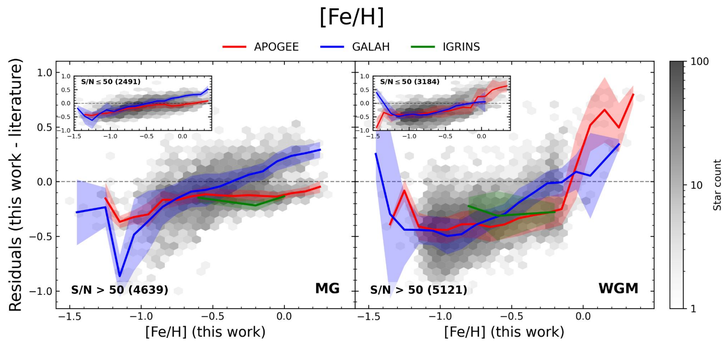


Small T_{eff} residuals are found with the literature references.

WGM temperatures show better agreement than MG values at T_{eff} < 3400 and S/N <= 30.

Near-constant [Fe/H] residuals are found **with both APOGEE and IGRINS when using MG**.

[Fe/H] values from the WGM method show strong systematic offsets.



Conclusions

- M-type giants and **Miras are powerful tracers** for studying the Galaxy. However, their cool atmospheres complicate the estimation of reliable chemo-physical parameters from their spectra.
- An improved pipeline has been developed to estimate the stellar parameters of cool-giants observed with *Gaia* RVS in DR3.
- **T_{eff} values obtained follow a reasonable T_{eff}-colour relation** down to 3000 K, and show typical offsets with literature values well within their uncertainties.
- **Chemical compositions derived are reliable down to T_{eff} ~ 3400 K,** with near-constant [Fe/H] and [α/Fe] offsets found against APOGEE.

Future work

- Use this updated pipeline to **analyze the epoch RVS spectra of LPVs in *Gaia* DR4**.
- Use the stellar parameters and distances (from period-luminosity relations) of the Mira sample to study the more obscured regions of the Milky Way, and the more distant halo, including its satellite galaxies.

REFERENCES

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