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A spectropolarimetric survey of evolved stars

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Abstract. We present the preliminary results of a spectropolarimetric observational campaign conducted on a sample of evolved stars to investigate the possible presence of intrinsic linear polarization. The observations were made with the high resolution *Catania Astrophysical Observatory Spectropolarimeter* (CAOS) and cover a sample of 21 stars with spectral classes between F and K.

1 Introduction

The discovery of linear polarization signals across the high resolution spectra of the Sun (the so-called *Second Solar Spectrum*, Stenflo & Keller 1997) has opened a new era for the comprehension of the solar atmosphere.

Today, high resolution linear spectropolarimetry has been extended to the stellar context, proving to be an important diagnostic tool for atmospheres and circumstellar environments. Indeed, linear polarization across individual spectral lines has been reported for the Mira star χ Cygni (Lèbre et al. 2014; López Ariste et al. 2019), for the red supergiant Betelgeuse (Aurière et al. 2016; López Ariste et al. 2018), as well as for the post-AGB 89 Herculis (Leone et al. 2018; Gangi & Leone 2019).

In this context, we undertake a spectropolarimetric observation campaign on a sample of evolved stars, to understand if the presence of linear polarization is a common feature among the evolved stages of the stars. We present here the preliminary results of such campaign.

2 Observations and data analysis

We have performed a 3 year campaign of optical high resolution linear spectropolarimetry of evolved F-G-K bright giant stars with CAOS (R=55000, Leone et al. 2016) at the 0.91 m telescope of the stellar station of the Catania Astrophysical Observatory (G. M. Fracastoro Stellar Station, Serra La Nave, Mt. Etna, Italy). Data were reduced and Stokes Q/I, U/I and null spectra N were extracted. To detect any possible polarimetric signature hidden in the signal-to-noise (S/N) level we have applied the Least-Square Deconvolution method (LSD, Donati et al. 1997). Firstly, for each star we have constructed the line mask from a synthetic spectrum computed by SYNTHE (Kurucz 2005) with appropriate stellar parameters. We have chosen the spectral region between 4250 Å and 8000 Å. Lines weaker than the noise level were excluded, as well as specific elements like H, CaI, NaI and telluric lines. Finally, for each atomic line we adopted the strength of the specific line as weight. Depending on the spectral type, up to 3600 spectral lines have been used for the LSD computation.

3 Preliminary results

We have found linear polarization across the absorption LSD profiles for about 71% of stars of our sample (Fig. 1). Among them:

- 3 do not show any temporal variability within the period of monitoring (e.g., see Fig. 1, A). A longer variability is then not excluded;
- 6 show a day-to-day variability in the intensities and/or in the morphologies of the Stokes Q/I and U/I profiles (e.g., see Fig. 1, C.b).

In some cases we have also found evidence of polarization signals across the Hα profile (e.g., Fig. 1, B) as well as single photospheric absorption lines (e.g., Fig. 1, C.a).

4 Discussion and conclusion

The origin of linear polarization across spectral lines in stars can have many contributors, making the physical interpretation difficult. In our case, an analysis of the polarimetric signals reveals that, for the majority of our sample stars:

- The possible contribution from the continuum depolarization can be neglected;
- The Zeeman effect is unlikely to be the major contributor to the observed linear polarization.

Further pieces of evidence hint that the observed polarization could have an intrinsic atomic contribution that is fuelled by anisotropies of the stellar radiation field and dynamics in the photospheric environment.

Our preliminary results confirm that the presence of linear polarization may be widespread among stars and that a broad and in-depth spectropolarimetric study is recommended. At this purpose we stress also the necessity of a *line-by-line* study: while the LSD method is able to produce a very high signal-to-noise ratio (S/N, $10^3 - 10^4$) line profiles, on the other hand any information on the behaviour of single lines is lost. The latter, in turn, could be crucial in better constrain the underlying physical processes (e.g., Zhang et al. 2019).

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References

Aurière, M., López Ariste, A., Mathias, P., et al. 2016, A&A, 591, A119
Bressan, A., Marigo, P., Girardi, L., et al. 2012, MNRAS, 427, 127
Donati, J.-F., Semel, M., Carter, B. D., et al. 1997, MNRAS, 291, 658

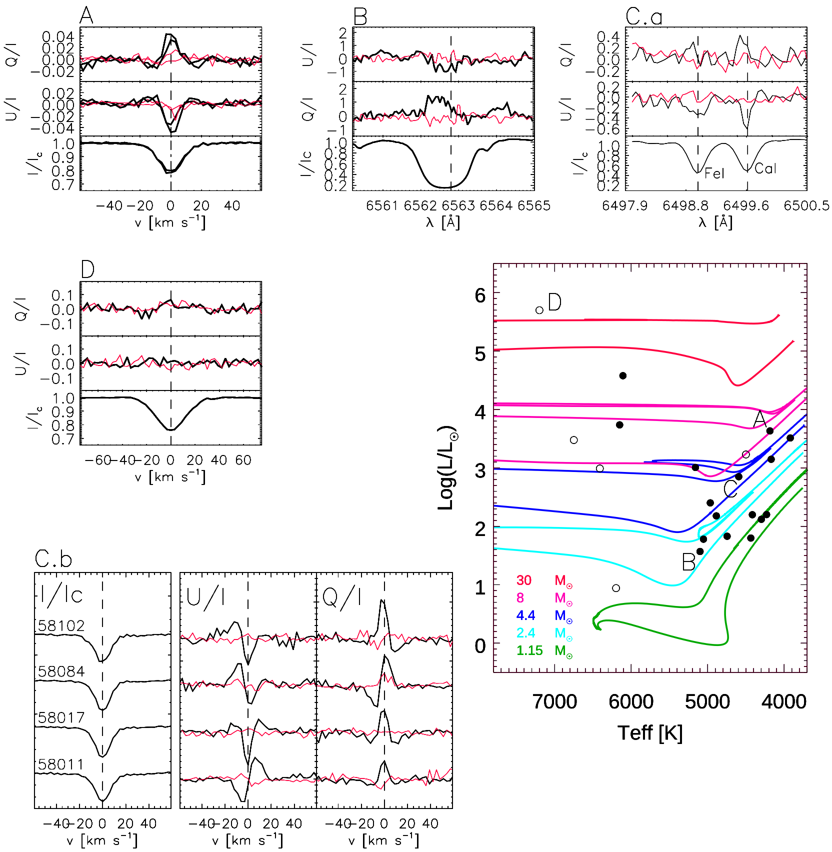

Figure 1. Distribution in $Log(L/L_{\odot})$ versus T_{eff} for the selected stars. The continuum lines represent the PARSEC V1.2s evolutionary tracks (Bressan et al. 2012), for masses $M = 1.15, 2.40, 4.40, 8.00, 30.00\ M_{\odot}$ and metallicity $[Fe/H] = 0.01$. Filled circles represent stars with detected linear polarization, while open circles represent stars with zero polarization. **A**: example of LSD Stokes profiles that do not show temporal variability within the period of monitoring. **B**: example of polarized signal detected across the H_{α} profile. **C.a**: example of linear polarization detected across single photospheric absorption lines. **C.b**: example of LSD Stokes profiles which show day-to-day scale variability. **D**: example of LSD Stokes profiles which show no signal. Null spectra are shown in red.

Gangi, M., & Leone, F. 2019, Astronomische Nachrichten, 340, 409
Lèbre, A., Aurière, M., Fabas, N., et al. 2014, A&A, 561, A85
Kurucz, R. L. 2005, Memorie della Societa Astronomica Italiana Supplementi, 8, 189
Leone, F., Avila, G., Bellassai, G., et al. 2016, ApJ, 151, 116

Leone, F., Gangi, M., Giarrusso, M., et al. 2018, MNRAS, 480, 1656
López Ariste, A., Mathias, P., Tessore, B., et al. 2018, A&A, 620, A199
López Ariste, A., Tessore, B., Carlín, E. S., et al. 2019, arXiv e-prints, arXiv:1909.03720
Stenflo, J. O., & Keller, C. U. 1997, A&A, 321, 927
Zhang, H., Gangi, M., Leone, F., et al. 2019, arXiv e-prints, arXiv:1903.08675