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Multiple, short-lived "stellar prominences" on the O giant ξ Persei: a magnetic star?

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Abstract. We present strong evidence for a rotation period of 2.0406 d of the O giant ξ Persei, derived from the N IV λ1718 wind line in 12 yr of IUE data. We predict that ξ Per has a magnetic dipole field, with superposed variable magnetic prominences. Favorable dates for future magnetic measurements can be predicted. We also analysed time-resolved He II 4686 spectra from a campaign in 1989 by using the same simplified model as before for λ Cephei, in terms of multiple spherical blobs attached to the surface, called stellar prominences (Sudnik & Henrichs, 2016). These represent transient multiple magnetic loops on the surface, for which we find lifetimes of mostly less than 5 h.

Key words: stars: early-type – stars: individual: ξ Persei – stars: magnetic field – stars: winds, outflows – stars: rotation

1. Stellar rotation and wind variability

The well documented cyclic variability on the estimated rotational timescale in UV wind lines of early-type stars still lack a proper explanation. Except for the $\sim$ 7% of O stars with a dipolar magnetic field (Grunhut et al., 2017), the unknown rotation period often hinders modeling of the many variable surface phenomena, which likely drive the wind variability. To search for the rotation period of the O7.5III(n)((f)) star ξ Per ($v \sin i = 230\,\mathrm{km\,s^{-1}}$) we analysed the equivalent-width (EW) variations of the N IV λ1718 line in 307 IUE spectra over 12 years in the velocity range $[-405\,\mathrm{km\,s^{-1}}, v \sin i]$, which represents the lower wind. In the power spectrum (Fig. 1, top left), we identify the peak at 2.04058 d as the rotation period. We can exclude twice this value, as often used before, because of the constraining stellar radius of $\sim 11\,\mathrm{R_\odot}$. The phase-folded data shows a sinusoidal behavior (Fig. 1, bottom left, which includes the ephemeris). The most likely explanation is that the star hosts a magnetic field with maximum strength at maximum EW. For a dipolar field, the footpoints of strong UV DACs should stem from only one of the magnetic poles. With the implied $i = 56^\circ$, and only one pole visible, β should be near $\sim 90^\circ - i = 34^\circ$. Such a field has been hitherto undetected, possibly because of its weakness, and/or because all magnetic measurements so far have been taken at unfavorable phases.

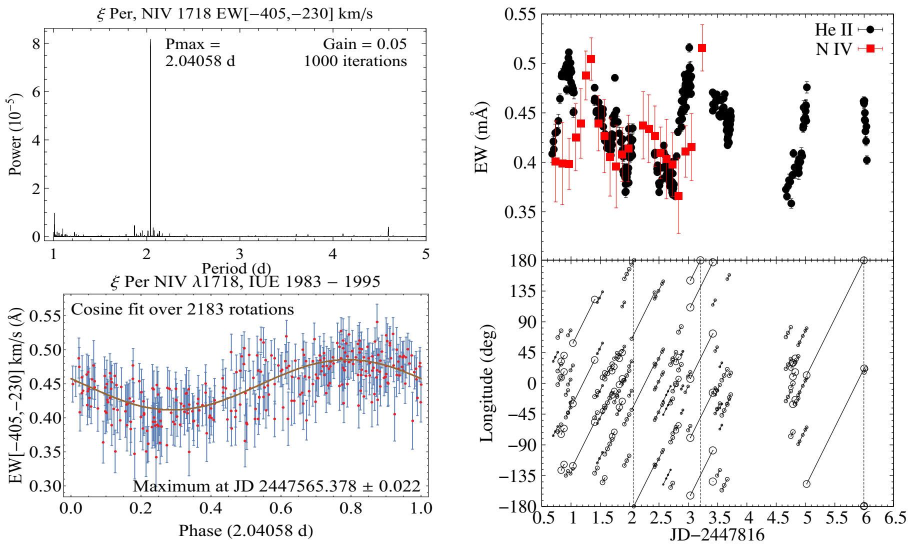

Figure 1. *Top left:* Cleaned power spectrum of N IV λ1718 EWs. *Bottom left:* Phase plot of 307 datapoints over 12 years. *Top right:* Overplot of scaled N IV and He II EWs in 1989, showing a similar trend. *Bottom right:* Model fit results of subsequent quotient He II spectra displayed as circles at the fitted stellar longitude with 0° at the line of sight and size proportional to the fitted optical depth ($0.08 < \tau < 0.38$).

2. Model fits of He II λ4686 spectra

We applied the same stellar prominence model as for λ Cep (Sudnik & Henrichs, 2016) to 322 He II λ4686 spectra with 6 d coverage in 1989 of ξ Per. To fit subsequent quotient spectra, multiple (≤ 5) prominences with lifetimes up to 5 h are needed (Fig. 1, bottom right). These are proposed to be at the footpoints of weaker intermediate DACs. Cancellation effects may make magnetic detection of these prominences difficult (Kochukhov & Sudnik, 2013). Similar behavior is also observed in other O stars, which suggests a common phenomenon.

References

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