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

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**Abstract**

Many spectral lines in OB stars show unexplained variability on a rotational timescale, which is cyclical but not periodic. This occurs in the so-called discrete absorption components (DACs) both in UV-wind line profiles and in many optical lines. Typical upper limits of ~300 G for a magnetic field are found in these stars. Here we search for the rotation period of the O giant ξ Persei in the N IV 1718 wind line in 12 y of IUE data. We also analyzed time-resolved optical spectra using the same simplified model as earlier for Cephei, in the N IV 1718 wind line in 12 y of IUE data. Here we search for the rotation period of the O giant ξ Persei in the N IV 1718 wind line in 12 y of IUE data.

**1. UV wind and Hα observations**

- DACs are explained by CIRs: Corotating Interacting Regions, which start near the surface.
- The unsolved research question is whether these DACs stem from a magnetic pole.
- Between the strongest DACs, (identified in the N IV line), there are intermediate DACs in Si IV.
- The cyclical behavior on a ~2d timescale is present in all three lines.
- There are blue to red moving Hα absorptions at positive velocity, indicating an intermediate inclination angle.

**2. Rotation period from NIV 1718**

- From the power spectrum we derive $P = 2.04058$ d as the rotation period. Phase folded data over 12 years shows a very strict periodicity, similar to the folded He II equivalent widths. Twice this value can be predicted if no fit can be achieved, start with new number of blobs with different parameters.

**3a. Model**

- Each prominence is represented by a corotating optically thin spherical blob of gas attached to the surface.
- Each blob with radius $r$ has central optical depth $τ$, width $w$, and is centered around $v_{r}$, as a function of velocity $v$. The parameter $A ≤ r^2$ takes into account the transient and eclipsing geometry (analyzed with exoplanets).
- $v_r$ is determined by corotation.
- Superposition of line profiles of $n$ blobs is mimicked.
- Because the line profile itself is not known, we work with subsequent quotient spectra.

**3b. Fit Strategy**

- Construct subsequent quotient spectra to remove the overall line shape to isolate relative changes.
- Take optically thin blobs with initial values $r = 0.2 R_*$, $w = 0.2$, and $τ = 70$ km/s.
- Constrain the rotation period by the inclination angle, radius and $v_r$.
- Fit by eye the first two quotient spectra and try to include the next quotients until no satisfactory fit is found by varying the location and number of the blobs.
- Take these parameters as input for a least-squares nonlinear model fit.
- Repeat for all quotient spectra for all datasets, with equal period.
- We propose [in analogy to solar prominences] that multiple (1 - 5) magnetic loops are present on the surface, with a short life time (~hours), which we call prominences.
- These prominences are proposed to be at the footpoints of weaker intermediate DACs.
- Cancellation effects may make magnetic detection of these prominences difficult (Kochukhov and Sudnik 2013).
- To (dis)prove this model we propose simultaneous high precision photometry (like by Ramsaramananto et al 2014) and spectroscopy with continuous coverage during more than one rotation period, and Zeeman Doppler Imaging.
- Similar η Cep data could be fit with the same model, which suggests a common phenomenon among O stars.

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**4. Covariability of UV, optical variations and model results**

- Simultaneous N IV 1718 and N IV 1718 EW, as measured between $v = \nu sin i = 230$ km/s and $-400$ km/s and arbitrarily scaled to the same amplitude. These lines are likely formed in the same region, and indeed show a similar trend, like in Fig. 1.
- Fit results are not unique: more periods can fit the same dataset.
- Model fits to quotient spectra need multiple (at most 5) features with lifetimes up to 5 h.
- The lifetime as a function of the number of blobs derived from the fits is in the order of hours, much smaller than the rotation period.
- The rotation period is 2.0406 d.
- $A = 3.3$, $P = 3.5$ h.
- $M = 26 M_\odot$.

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**5. Conclusions**

- The rotation period is 2.04058 d.
- A 4 d period would not be consistent with the adopted radius of ~11R_⊙ (Markova, 2004), as opposed to earlier work.
- This periodicity predicts that ξ Per has a bipolar like field, with the footpoints of strong DACs at only one of the magnetic poles.
- The cyclical behavior on a ~2d timescale is present in all three lines.
- There are blue to red moving Hα absorptions at positive velocity, indicating an intermediate inclination angle.

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**References**

- de Jong et al. (2001)
- Kochukhov and Sudnik 2013
- Ramsaramananto et al. 2014
- Zeeman Doppler Imaging

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**Figures**

- Fig. 2 – Equivalent widths of selected regions in N IV 1718 and He II 4686. Note that the two emission peaks in the He II line are at the zero value of the star (dashed lines), strongly suggesting a rotation effect. From the power spectrum we derive $P = 2.04058$ d as the rotation period. Phase folded data over 12 years shows a very strict periodicity, similar to the folded He II equivalent widths. Twice this value can be excluded as the rotation period because of the constraining stellar radius.

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