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Abundance study of two magnetic B-type stars in the Orion Nebula Cluster

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Abstract. We present the results of an abundance analysis of two magnetic B-type stars in the Orion Nebula Cluster that support the lack of a direct relationship between the existence of a magnetic field and a nitrogen excess in the photosphere.

1. Motivation

The effects of magnetic fields on internal mixing in massive stars remain largely unknown. Collecting He and CNO abundances for magnetic OB stars is needed to assess the efficiency of rotational mixing and to constrain evolutionary and interior models (e.g. Meynet *et al.* 2011). We present the determination of the atmospheric parameters and chemical abundances of two magnetic B-type stars in the very young Orion Nebula Cluster (ONC) based on high-resolution optical spectra acquired with FIES at NOT.

2. The targets

The two ONC stars analysed are LP Ori (HD 36982; B1.5 Vp) and NU Ori (HD 37061; B0.5 V). They have been shown to host a strong magnetic field with a polar strength in the range 600-900 G assuming a dipolar geometry (Petit *et al.* 2008; Petit & Wade 2012). LP Ori and NU Ori are moderate to fast rotators with $v \sin i$~80 and 200 km s^{-1}, respectively (Petit & Wade 2012; Simón-Díaz *et al.* 2011). NU Ori is of particular interest because it is one of the fastest-rotating magnetic B stars known.

3. Determination of parameters and chemical abundances

The analysis is based on the non-LTE line-formation code DETAIL/SURFACE and Kurucz model atmospheres. For LP Ori, $T_{\rm eff}$ is derived from Si II/III ionisation balance and $\log g$ from fitting the Balmer line wings. The abundances are inferred from a classical curve-of-growth analysis (Morel 2012, and references therein). The set of unblended lines is selected from a comparison with a spectrum of a slowly-rotating analogue (δ Ceti). A specific method is used for NU Ori because of the high $v \sin i$ (see details in Rauw *et al.* 2012, and Cazorla *et al.*, these proceedings). The atmospheric parameters and abundances are estimated by finding the best match between a set of observed H, He, and CNO line profiles and a grid of rotationally-broadened, synthetic profiles (see Fig.1 for some illustrative fits). The star is part of an SB1 binary system with $\mathcal{P}$~19 d and a mass ratio above 0.19 (Abt *et al.* 1991). To explore the impact on our results, we have repeated the analysis using composite, synthetic spectra. We assumed a luminosity ratio of 30%, i.e., that the secondary is a main-sequence B1 star of $\sim 10\,M_{\odot}$ with $T_{\rm eff} = 26\,000$ K, $\log g = 4.3$, and abundances typical of B stars. This may be considered as a rather extreme case (the lines of the secondary are not visible in our spectrum; see Fig.1).

Table 1. Results of the analysis.

	LP Ori	NU Ori Companion ignored	NU Ori Companion taken into account
$T_{\rm eff}$ [K]	21 500±1000	30 800±1000	31 600±1000
log g	4.30±0.15	4.30±0.15	4.30±0.15
ξ [km s^{-1}]	[5] (fixed)	[10] (fixed)	[10] (fixed)
y	0.071±0.018	0.097±0.030	0.101±0.030
log ϵ(C)	8.27±0.13	7.96±0.19	8.04±0.19
log ϵ(N)	7.91±0.36	7.68±0.26	7.55±0.26
log ϵ(O)	8.70±0.42	8.48±0.27	8.53±0.27
[N/C]	–0.36±0.29	–0.28±0.32	–0.49±0.32
[N/O]	–0.79±0.33	–0.80±0.17	–0.98±0.17

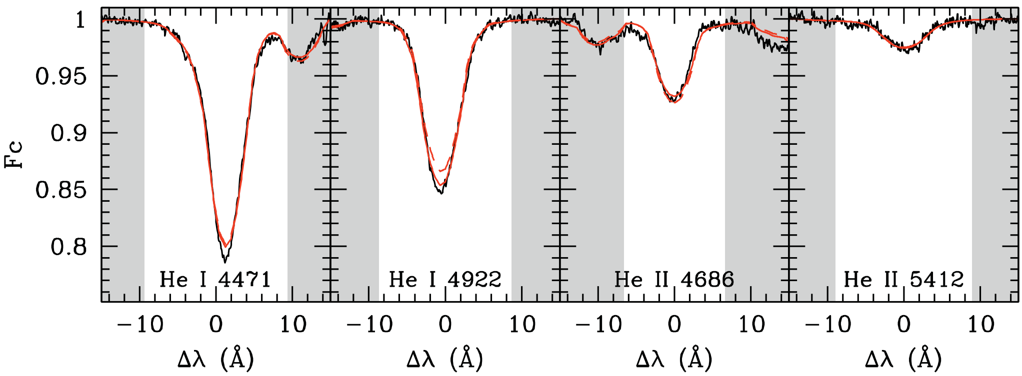

Figure 1. Examples of fit to the He lines in NU Ori (black and red lines: observed and best-fitting synthetic profiles, respectively). The dashed, red lines show the line profiles computed for the final, mean parameters. The quality of the fit was not evaluated within the grey-shaded areas.

4. Results and discussion

The analysis proved difficult because of the substantial line broadening due to rotation. The abundances are weakly constrained, but neither star shows evidence for a He or a N excess (Table 1). The data for NU Ori are compatible with a star that just arrived on the ZAMS and is too young to have dredged up CNO-cycled material to the surface or dramatically spun down because of magnetic braking. These results confirm the diversity of surface nitrogen abundances found in magnetic, early B-type stars (Morel 2012).

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