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CONFIRMATION OF THE MAGNETIC NATURE OF THE δ SCUTI STAR HD 21190

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Using time-series photometry of the δ Scuti star HD 21190 obtained by the *Hipparcos* mission, Koen et al. (2001) discovered a variability period of 3.6 h. According to these authors, the spectral classification of this star is F2 III SrEuSi: based on the strength of Sr II, Eu II, and Si II lines, making it the most evolved Ap star known. González et al. (2008) presented a search for pulsational line profile variations in high time-resolution UVES spectra of HD 21190 and could show that this star presents the best known example of a δ Scuti star with moving bumps in its line profiles characteristic of higher-order overtone pulsation. Indications that a few Ap stars can show a hybrid δ Sct – γ Dor variability were reported by Balona et al. (2011) who used *Kepler* observations of stars in the δ Scuti instability strip.

On the other hand, pulsations of δ Scuti type among Ap stars are not expected from a theoretical point of view. The models by Saio (2005) led to a clear prediction that lower radial overtone pulsation modes typical of δ Scuti stars are suppressed by the magnetic field in Ap stars. Obviously, magnetic field measurements in this type of pulsating stars with Ap characteristics are of utmost importance to understand the interplay between the magnetism and the physical processes taking place inside the stars.

The first measurement of a longitudinal magnetic field in HD 21190 was presented by Kurtz et al. (2008) who used the multi-mode instrument FORS 1 mounted at the 8-m Kueyen telescope of the VLT with the GRISM 600B. This multi-mode instrument is equipped with polarization analyzing optics, comprising super-achromatic half-wave and quarter-wave phase retarder plates, and a Wollaston prism with a beam divergence of 22″ in standard resolution mode. A detailed description of the assessment of the longitudinal magnetic field measurements using this instrument is given by Hubrig et al. (2016). The measurements revealed the rather weak longitudinal magnetic field $\langle B_z \rangle = 47 \pm 13$ G.

Since the longitudinal field strength depends on the viewing aspect and typically is variable with rotation in Ap stars, further observations were needed to confirm the detection. We succeeded to reobserve HD 21190 with FORS 2 at the VLT on 2016 March 15 using the same instrumental setup as in 2008. A magnetic field detection at a significance level of more than 4σ ($\langle B_{\rm z} \rangle_{\rm all} = -254 \pm 59$ G) was achieved for HD 21190 using for the measurements the entire spectrum, and at a significance level of more than 3σ ($\langle B_{\rm z} \rangle_{\rm hyd} = -237 \pm 75$ G) using the hydrogen lines. To obtain an independent error estimate, we applied Monte Carlo bootstrapping tests, where we generated 250 000 statistical

variations of the original dataset by the bootstrapping technique, and analyzed the resulting distribution $P(\langle B_z \rangle)$ of the regression results. Mean and standard deviation of this distribution are identified with the most likely mean longitudinal magnetic field and its 1σ error, respectively. The measurement uncertainties obtained before and after the Monte Carlo bootstrapping tests were found to be in close agreement. In Fig. 1 we present the distributions from our Monte Carlo bootstrapping tests for our data set.

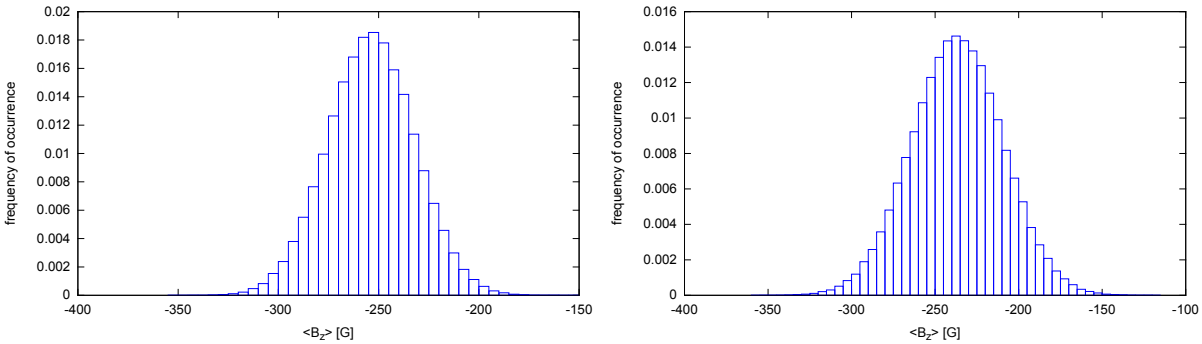

Figure 1. Distributions from our Monte Carlo bootstrapping tests for the data set of HD 21190 from 2016 March using the entire spectrum (left panel) and only the hydrogen lines (right panel).

We note that there is no known case of an Ap star with a significant magnetic field that shows δ Scuti pulsations. Neiner & Lampens (2015) recently obtained two spectropolarimetric observations of the *Kepler* δ Sct – γ Dor hybrid candidate HD 188774. Only one observation showed a weak signal of about 76 G. Furthermore, the target did not show any Ap characteristics as the abundance analysis did not reveal any chemical peculiarity and no chemical spots were identified.

The confirmation of the presence of a magnetic field in HD 21190 shows that δ Scuti pulsations can indeed exist in stars with a magnetic field. Further observations are needed to determine the magnetic field geometry and the polar field strength of this currently unique star.

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