ABSTRACT. At the surface of ∼7% of single hot stars stable mainly dipolar strong magnetic fields have been detected. The main hypothesis today is that these magnetic fields are of fossil origin. In other words, these fields formed from the seed field in the molecular clouds from which the stars were formed. The recent observational and theoretical results confirm this theory: the properties of the observed fields correspond to those expected from fossil fields. Massive stars are stars whose initial mass exceeds about 8 solar masses. Massive stars play a significant role in the chemical and dynamical evolution of galaxies. However, much of their variability, particularly during their evolved supergiant stage, is poorly understood. To date magnetic field was registered only at three hot stars of I-II luminosity types: ρ Leo (B1 Ib), ζ Ori Aa (O9.2 Ib), and ϵ CMa (B1.5 II). We performed high-accuracy spectropolarimetric observation of the hot supergiant ζ Per (B1 Ib) over 26 nights from 1997 to 2012 with long-slit spectrograph mounted in the coude focus of 2.6-m reflector ZTSh at the Crimean Astrophysical Observatory. We also used circularly polarized spectra obtained during 2 nights in 2008 with echelle spectrograph ESPADONS mounted at 3.6-m CFHT. Effective magnetic field $B_e$ (longitudinal component of the field integrated over visible hemisphere) of ζ Per was calculated in the line He I 6678.149 Å. Statistically significant longitudinal magnetic field ($B_e/\sigma_B > 3$) was registered in 14 from 199 single measurements. These significant magnetic field values are all in the range from −145 to +148 G with the mean error 27 G. We suppose the supergiant ζ Per can be magnetic, but its magnetic field properties is difficult to detect likely due to the insufficient precision of the used spectropolarimetric measurements compared to the expected field strength.

Key words: stars: early-type – stars: supergiants – stars: magnetic fields – stars: individual (ζ Per).
1. Introduction

At the surface of \(\sim 7\%\) of single hot stars stable mainly dipolar magnetic fields have been detected. The main hypothesis today is that these magnetic fields are of fossil origin. In other words, these fields formed from the seed field in the molecular clouds from which the stars were formed. The recent observational and theoretical results confirm this theory: the properties of the observed fields correspond to those expected from fossil fields.

Massive stars are stars whose initial mass exceeds about 8 solar masses. These stars play a significant role in the chemical and dynamical evolution of galaxies. However, much of their variability, particularly during their evolved supergiant stage, is poorly understood.

To date only three hot supergiants have been found to host a magnetic field. Kholtygin et al. (2007) reported the possible detection of the magnetic field with polar strength 240 \(\pm\) 50 G on \(\rho\) Leo (B1 Ib). Bouret et al. (2008) reported the detection of a weak magnetic field of 50-100 G on the supergiant \(\zeta\) Ori Aa (O9.2 Ib). The result was confirmed by Blazere et al. (2015). Fossati et al. (2015) detected the magnetic field with polar strength of at least 13 G on the bright giant \(\epsilon\) CMa (B1.5 II).

\(\zeta\) Per (HD 24398, HR 1203, B1 Ib) is a hot supergiant, which main stellar parameters are shown in Table 1. We present here the results of magnetic field measurements on \(\zeta\) Per.

2. Observations

Spectropolarimetric observations of \(\zeta\) Per were carried out with the long-slit spectrograph and the circular polarization analyzer mounted in the c\'oude focus of the 2.6-m reflector ZTSh at the Crimean Astrophysical Observatory (26 nights from 1997 to 2012, spectral resolution \(R \sim 30000\)). We also used polarimetric data collected during 2 nights in 2008 with the echelle spectrograph ESPADONS (spectral resolution \(R \sim 65000\)) mounted at the 3.6-m CFHT (Hawaii, USA). Effective magnetic field \(B_e\) (longitudinal component of the field integrated over visible hemisphere) of \(\zeta\) Per was calculated in the line He I 6678.149 Å (effective Lande factor \(z = 1\)) with the procedure discussed in detail by Butkovskaya & Plachinda (2007).

3. Results

In Figure 1 individual magnetic field \((B_e)\) measurements \((N = 199)\) of \(\zeta\) Per are presented. Statistics on the magnetic field measurement is illustrated in Figure 2. Most \(B_e\) values fall in the range from \(-50\) to \(+50\) G, and the mean value \(<B_e> = 2.6 \pm 5.2\) G. The mean error of a single measurement, \(<\sigma_B> = 52\) G, while the minimum error is 19 G. Statistically significant longitudinal magnetic field \((B_e/\sigma_B > 3)\) was registered in 14 single measurements. These significant magnetic field values are all in the range from \(-145\) to \(+148\) G with mean error 27 G.

4. Conclusion

We suppose the supergiant \(\zeta\) Per can be magnetic, but its magnetic field properties is difficult to detect likely due to the insufficient precision of the used spectropolarimetric measurements compared to the expected field strength.
Figure 2: Distribution of the magnetic field $B_e$ (top panel), its errors $\sigma_B$ (middle panel) and signal-to-noise ratio $B_e/\sigma_B$ (bottom panel). Normal distribution curve is shown on the top panel by the strong line.

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