HD 158450: A MAGNETIC CHEMICALLY PECULIAR STAR IN A YOUNG STELLAR GROUP

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ABSTRACT. We report on the discovery of the Zeeman resolved spectral lines, corresponding to the very large magnetic field modulus $\langle H \rangle = 11.1$ kG, in the spectrum of the chemically peculiar star HD 158450 belonging to the recently discovered Mamajek 2 stellar group. We determined fundamental parameters and projected rotation velocity of the star. Dynamical 3D mean orbit calculations showed that Mamajek 2 stellar group has an age of 135 ± 5 Myr. Based on this age, we estimate that HD 158450 has completed about 12% of its main-sequence life. The importance of the detailed study of HD 158450, a member of a stellar group with a well determined age, for understanding the origin and evolution of stellar magnetic fields is discussed.

Key words: Stars: magnetic fields; stars: individual: HD 158450, HD 66318

1. Introduction

The new stellar group, named Mamajek 2, was discovered by Mamajek (2006) on the basis of common parallel motions and similar trigonometric parallaxes of the stars. It contains the bright B8 giant μ Oph and eight further B and A-type stars. In his work Mamajek (2006) proposes the coevality of this group located at a present distance of 170 pc from the Sun with an age of 120 ± 25 Myr. This author suggests that the Mamajek 2 group may have formed in the same star forming region as the Pleiades, NGC 2516 and α Persei cluster and the AB Dor stellar group.

The dynamical age of this group calculated under a modeled Galactic potential was determined in Jilinski et al. (2008) as the time elapsed since the NGC 2516 and Mamajek 2 orbital convergence. This dynamical results showed that Mamajek 2 group and the open cluster NGC 2516 may have had a common origin at the age of 135 ± 5 Myr. On the other hand the calculation showed that the α Persei cluster has a completely different past dynamical evolution when compared with Mamajek 2 group.

2. The star HD 158450

One of the stars of Mamajek 2 group, HD 158450, shows a highly peculiar spectrum. This star was included in the list of "the brighter stars of astrophysical interest in the southern sky" by Bidelman & MacConnell (1973) as a peculiar A star of the Sr-Cr-Eu type.

2.1. Observations

We have one high-resolution spectrum of this star obtained at June 2, 2007 (MJD = 54253.31316) with the FEROS spectrograph attached to the 2.2 m telescope of ESO at La Silla, Chile, with a resolution R = 48 000 and a spectral range coverage from 3800 to 8800 Å.

2.2. The Magnetic Field

The analysis of this spectrum indicates the presence of a strong magnetic field resulting in the magnetic splitting of some spectral lines. The most prominent spectral feature is the Fe II 6149.258 Å line (see Figure 1), commonly used for magnetic field strength determination (Mathys 1997). In unpolarized light the profile of this line in the presence of a magnetic field is a simple doublet. The mean magnetic field modulus (the line-intensity weighted average over the visible stellar hemisphere of the modulus of the magnetic vector) can be estimated by the well known formula:

$$\frac{1}{2} \cdot \Delta\lambda_Z = 4.67 \cdot 10^{-13} \cdot g_{\mathrm{eff}} \cdot \lambda^2 \cdot \langle H \rangle ,$$

where $\Delta\lambda_Z$ is the measured Zeeman splitting in Å,

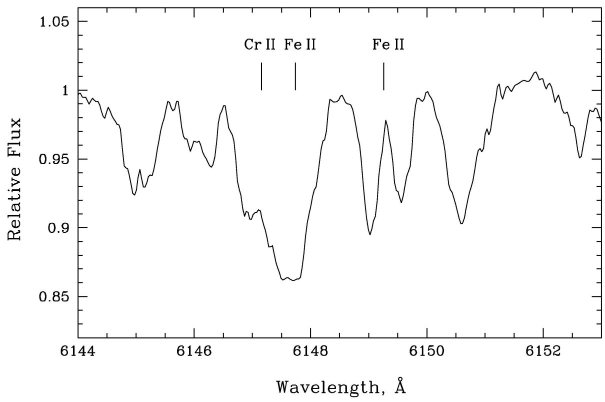

Figure 1: Spectrum of the Ap star HD 158450 showing the lines of Cr II 6147.154 Å, Fe II 6147.741 Å, and Fe II 6149.258 Å. Note the direct magnetic splitting of the Fe II 6149.258 Å line.

$g_{\rm eff} = 1.35$ - the effective Landé factor, λ - the central wavelength of the unshifted line in Å, and $\langle H \rangle$ - the mean magnetic field modulus in Gauss. Thus, the measured mean magnetic field modulus of HD 158450 turns out to be $\langle H \rangle = 11.1$ kG.

The presence of a magnetic field on the surface of this star was recently discovered by Kudryavtsev et al. (2006) from the spectropolarimetric observations of a sample of chemically peculiar stars at the 6-m telescope of the SAO RAS, Russia. These authors found the mean longitudinal component of the magnetic field to be $\left\langle {B_l}^2 \right\rangle^{\frac{1}{2}} = 1570 \pm 180$ G, whereas the individual values of the longitudinal magnetic field vary for different dates from -2920 ± 200 to $+810 \pm 240$ G, indicating strong variation of the magnetic field strength with stellar rotation.

2.3. The Stellar Parameters

We used the $B2-G$ Geneva index (Rufener 1988) to estimate the effective temperature of HD 158450. Estimating the reddening of the star as $E(B-V) = 0.31$ (Mamajek 2006) and employing the relation $E(B2-G) \sim E(B-V)$ we find the dereddened index $(B2-G)_0 = -0.477$ which gives, with the calibration of Hauck & North (1993), an effective temperature of $T_{\rm eff} = 8880$ K. Placing the star on the isochrone for a cluster age of 135 Myr (Lejeune et al. 2001), we determine stellar mass $M = 1.96\,M_\odot$.

Based on the Schaller et al. (1992) evolution tracks, we estimate that HD 158450 has completed only about 12% of its main-sequence life.

The approximation of the Fe II 6149.258 Å magnetically splitted line by a synthetic spectrum showed that this star has the low projected rotational velocity of $v \sin i = 9 \pm 1$ km s^{-1}. The radial velocity of HD 158450 measured by us is $v_{\rm rad} = -17.3$ km s^{-1}.

3. Discussion and Conclusions

The origin and evolution of the strong magnetic fields of upper- and middle-main-sequence stars continue to be the subject of long debates. Two different theories have been suggested: according to one of them, the stars would acquire their fields at the time of their formation – this is the fossil field theory; according to the other theory, the fields would be generated and maintained by a dynamo mechanism acting inside the star.

The study of the evolution of magnetic fields across the main sequence will provide important observational constraints for testing theoretical predictions. Magnetic field measurements for stars, members of stellar clusters or groups having well-determined ages, are very important. Recent discoveries of stars with strong magnetic fields close to ZAMS may be seen as an argument in favour of the fossil-field theory. Photometric and longitudinal magnetic field monitoring of HD 158450 is needed to determine its rotational period.

It is interesting to mention that Bagnulo et al. (2003) discovered a very strong magnetic field on the surface of the star HD 66318 belonging to the open cluster NGC 2516 which has, as it was shown in Jilinski et al. (2008), a common origin with Mamajek 2 group: the mean field modulus of HD 66318 is $\langle H \rangle = 14.5$ kG. With $T_{\rm eff} = 9200 \pm 200$ K, $M = 2.1 \pm 0.1\,M_\odot$, the star HD 66318 is quite similar to HD 158450 in the Mamajek 2 group.

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