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The Extremely He-rich Star HD144914

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The star HD 144941 is the most extreme representative of magnetic massive helium stars. In its atmosphere, almost all hydrogen is replaced by helium. The helium surface fraction is 0.95. The abundance of metals is about 10 times less than solar in absolute numbers, the metallicity is typical of massive early-type stars. We have determined the period and the parameters of magnetic field variability for this star. A model describing the magnetic variability of this object is proposed.

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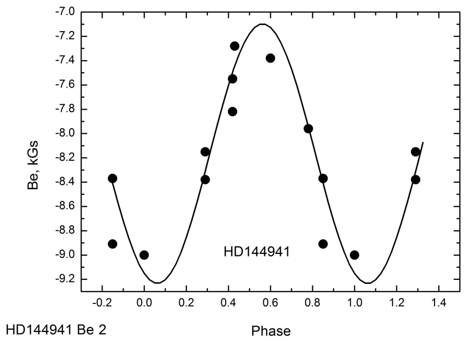
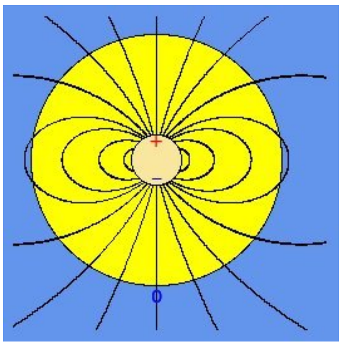
1. The abundance of helium in the atmosphere of HD 144941

In HD 144941 hydrogen is "blown out" by the stellar wind, the canonical mechanism of the formation of helium superabundance [1]. The longitudinal magnetic field reaches $B_e = -9$ kG. In [1] the authors used an incorrect rotation period of the star, hence an incorrect idea about the magnetic field structure. Our frequency analysis of B_e measurements gave a period $P = 6.969 \pm 0.065$ days. The modeling of the magnetic field structure of the star was carried out by the method developed in [2]. For this purpose the inclination angle of the rotation axis $i = 15°$ was estimated from $v sini = 7$ km/s. In this case, as the star rotates, the negative magnetic pole is almost in the center of the visible disk at phase $\Phi = 0$. The observed (points) and model (solid line) data are shown in Fig. 1a. Differences between them do not exceed 3°. The model average surface magnetic field $B_s = 11226$ G, the strength of the magnetic field at the magnetic poles $B_p = 15159$ G. The magnetic field measurements were carried out by hydrogen lines [1]. Figure 1b shows the magnetic field lines in the dipole plane, the circle in the center is the convective nucleus, which formed after the formation of the magnetic structure. Figure 2a shows the He/H–B_s dependence of helium abundance on the magnetic field. The point on the upper right side demonstrates the uniqueness of this star. Obviously, the diffusion of helium occurs along the magnetic lines, resulting in the helium accumulation at the magnetic poles. The increase in helium abundance with the increase in the magnetic field helps suppress microturbulence [3]. Figure 2b shows the change in the radii of He-rich stars with age, as they move along the evolutionary tracks. The star HD144941, which evolves as the rest of the objects, is marked by a large open circle. The star left the ZAMS about 10^6 years ago. It is a usual He-rich star that has a uniquely strong magnetic field and uniquely strong diffusion. Thanks to this, helium "accumulates" on the surface of the star near the the magnetic poles. It is believed that the magnetic field gets its strength from the parent protostellar clouds [4].

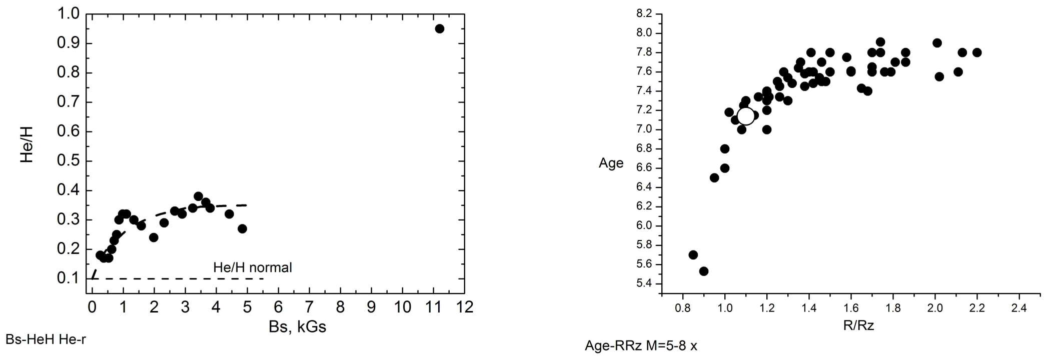


a)



b)

Figure 1: a) The model magnetic phase curve and the magnetic field measurements obtained in [1]. b) The magnetic field lines in the dipole plane, the circle in the center is the convective core, which formed after the formation of the magnetic structure.



a) b)

Figure 2: a) Helium abundance He/H vs. the magnetic field B_s. On the upper right side, the point demonstrates the uniqueness of this star by the magnitude of the strong magnetic field and helium content. b) The change in the radii of He-rich stars with age, as they move along the evolutionary tracks. The star HD 144941, which evolves as the rest of the objects, is marked with a large open circle. The star left the ZAMS about 10^6 years ago.

2. Conclusion

We have determined the inclination angle of the magnetic dipole axis to the axis of rotation $\beta = 65°$ for HD 144941, although the typical value of β for magnetic stars are within $\beta = 0$–$20°$. This is caused by the known property of magnetic stars, the slow rotation. The moment of rotation transmitted to the surrounding clouds along the magnetic lines [5] results in the loss of torque in the early stages of evolution. The mechanism of braking is most effective in the cases $\beta = 0$–$20°$. This star probably did not experience the "effective braking," and its slow rotation is caused by a weak initial moment. The longitudinal magnetic field of HD 144941 varies by a harmonic law with a period of 6.969 days, constant $B0 = -8219 \pm 58$ G, and a semi-amplitude $B1 = 922 \pm 126$ G. The main difference between HD 144941 and other He-rich stars is the uniquely large helium abundance with an unusually high surface magnetic field strength B_s. Figure 2a clearly shows how much this star stands out from the rest of the He-rich stars. We constantly face the "north" pole of the star, at which helium is concentrated.

References

[1] N. Przybilla, L. Fossati and C.S. Jeffery, *HD 144941: the most extreme helium-strong star*, *Astron. Astrophys.* **654** (2021) A119 [2110.11267].

[2] E. Gerth and Y.V. Glagolevskij, *Modeling and mapping of magnetic stars on the base of field sources*, *Bulletin of the Special Astrophysics Observatory* **56** (2003) 25.

[3] Y.V. Glagolevskii, *Dependence of Chemical Peculiarities on Magnetic Field in Magnetic Cp-Stars*, *Astron. Zh.* **71** (1994) 858.

[4] Y.V. Glagolevskij, *Remarks on Difference of Properties of Am and Ap Stars*, *Astrophysical Bulletin* **76** (2021) 91.

[5] T.C. Mouschovias and E.V. Paleologou, *The angular momentum problem and magnetic braking: an exact, time-dependent solution.*, *Astrophys. J.* **230** (1979) 204.