Contrib. Astron. Obs. Skalnaté Pleso **48**, 284 – 286, (2018)

Monitoring and modelling magnetic variability in two white dwarfs with very weak magnetic fields

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Received: November 5, 2017; Accepted: November 9, 2017

Abstract. We have measured the magnetic field strengths $\langle B_z \rangle$ and $\langle |B| \rangle$ of two very weak field magnetic white dwarfs WD 2047+372 and WD 2359-434, and have used these data to obtain simple magnetic field models.

Key words: white dwarfs – magnetic fields

Only a few fields weaker than 1 MG are known in white dwarfs (WDs) We have been carrying out the most sensitive survey to date for weaker fields, in the range of a few kG up to 1 MG, using ISIS at the WHT, FORS at the ESO VLT, ESPaDOnS at the CFHT, and the MSS at the BTA/SAO. This survey discovered a field of $\langle |B| \rangle \sim 60$ kG in the bright DA3.4 WD2047+372 ($T_{\rm eff} = 14710$ K), the third weakest MWD field securely detected. For our results so far, see Landstreet et al. (2012, 2015, 2016, 2017); Bagnulo et al. (2015); and references in these articles.

We have obtained time series for WD2047+372 and WD2359-434 (DAP5.8, $T_{\rm eff} = 8540$ K). We measure the mean line-of-sight field $\langle B_z \rangle$ and the mean field modulus $\langle |B| \rangle$ averaged over the visible hemisphere, as well as the equivalent width of the core of Hα. These measured values are then searched for periodic variability due to rotation of the underlying WD.

The results are as follows. WD2047+372: $\langle B_z \rangle$ varies periodically, +15 to –11 kG, $P = 0.243$ d; $\langle |B| \rangle \approx 60$ kG $\approx$ constant. WD2359-434: $\langle B_z \rangle$ is almost constant at +5 kG; Hα core equivalent width varies strongly with $P = 0.112$ d; $\langle |B| \rangle$ is hard to measure, but appears to vary between ~ 50 and ~ 100 kG.

Modelling is difficult because (1) the intrinsic width of the Hα core is much wider than vsini broadening, seriously limiting the information in the line profiles about the magnetic field, and (2) our LTE synthesis tools cannot compute accurately the deep Hα line cores of DA stars. Our data for WD2047+372 are consistent with a simple dipole model, $i = 27°$, $\beta = 86.5°$, $B_d = 92$ kG (see the left panels of Fig. 1); however, this model is not strongly constrained. The data

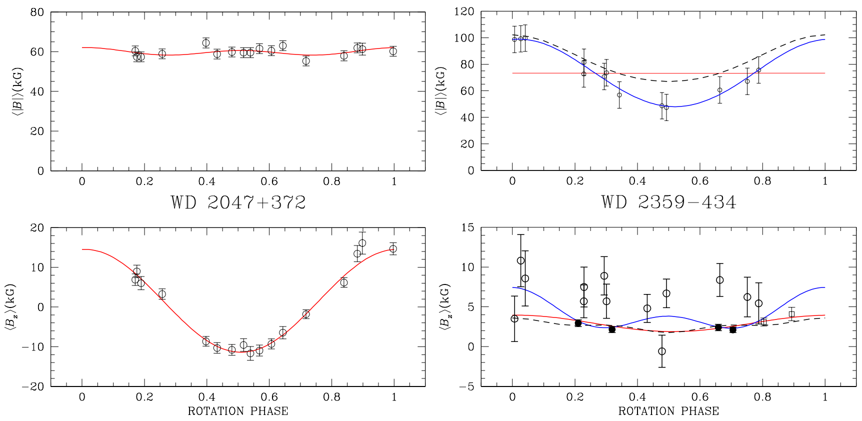

Figure 1. *Left panel:* WD 2047+372: Observed variation of $\langle B_z \rangle$ and $\langle |B| \rangle$ fit by a simple dipolar model. *Right panel:* WD 2359-434: Observed variation of $\langle B_z \rangle$ and $\langle |B| \rangle$ fit by a simple dipolar model (thin red lines), a co-linear dipole-quadrupole-octupole model (dashed black lines) and by a model including the superposition of a dipole with a non linear quadrupole (thick blue lines).

for WD2359-434 do not appear consistent with a simple dipole-like geometry. Red lines in Fig. 1 (right) show the best simple dipole fit found. A better fit is obtained using a combination of a dipole and quadrupole with different axes (blue lines). A model fit to $\langle B_z \rangle$ and $\langle |B| \rangle$ is shown in Fig. 1 (right), and a map of this fit is illustrated in Fig. 2 (thanks to Oleg Kochukhov for the plot routine).

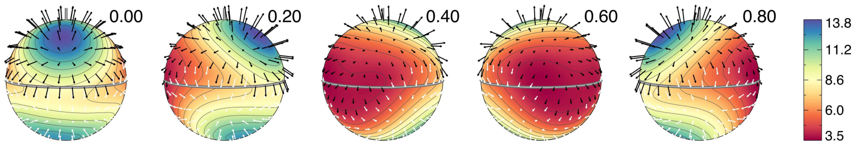

Figure 2. The distribution of magnetic field over the surface the dipole-non-aligned quadrupole model of WD 2359-434, as seen at five successive phases. Black arrows represent outward field, white arrows inward field. The axis of rotation is a small white line segment close to the top of each sphere. The scale at right is in units of Tesla (1 T = 10 kG).

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