

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

J. D. Landstreet<sup>1,2</sup>, S. Bagnulo<sup>2</sup> and G. Valyavin<sup>3</sup>

<sup>1</sup> *Dept. of Physics & Astronomy, University of Western Ontario, London,  
Ontario N6A 3K7, Canada*

<sup>2</sup> *Armagh Observatory and Planetarium, College Hill, Armagh BT61 9DG,  
Northern Ireland, UK*

<sup>3</sup> *Special Astrophysical Observatory, RAS, Nizhnij Arkhiz, Zelenchukskij  
Region, 369167 Karachai-Cherkessian Republic, Russia*

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.

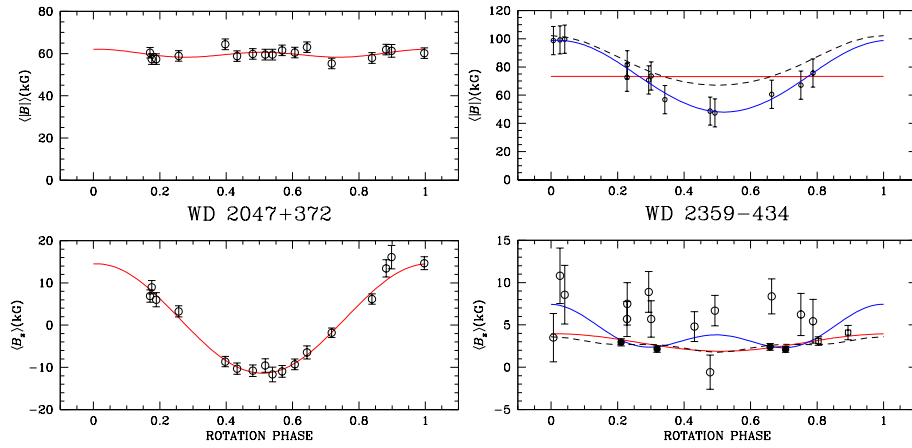
**Key words:** white dwarfs – magnetic fields

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 ( $T_{\text{eff}} = 14710$  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,  $T_{\text{eff}} = 8540$  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 H $\alpha$ . These measured values are then searched for periodic variability due to rotation of the underlying WD.

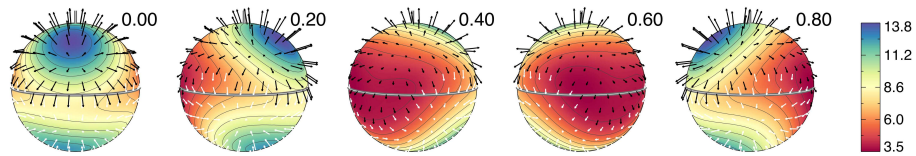
The results are as follows. WD2047+372:  $\langle B_z \rangle$  varies periodically, +15 to -11 kG,  $P = 0.243$  d;  $\langle |B| \rangle \approx 60$  kG  $\approx$  constant. WD2359-434:  $\langle B_z \rangle$  is almost constant at +5 kG; H $\alpha$  core equivalent width varies strongly with  $P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

Modelling is difficult because (1) the intrinsic width of the H $\alpha$  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 H $\alpha$  line cores of DA stars. Our data for WD2047+372 are consistent with a simple dipole model,  $i = 27^\circ$ ,  $\beta = 86.5^\circ$ ,  $B_d = 92$  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).

## References

- Bagnulo, S., Fossati, L., Landstreet, J. D., & Izzo, C. 2015, *Astron. Astrophys.*, **583**, A115
- Landstreet, J. D., Bagnulo, S., Martin, A., & Valyavin, G. 2016, *Astron. Astrophys.*, **591**, A80
- Landstreet, J. D., Bagnulo, S., Valyavin, G., & Valeev, A. F. 2017, *Astron. Astrophys.*, **607**, A92,
- Landstreet, J. D., Bagnulo, S., Valyavin, G. G., et al. 2012, *Astron. Astrophys.*, **545**, A30
- Landstreet, J. D., Bagnulo, S., Valyavin, G. G., et al. 2015, *Astron. Astrophys.*, **580**, A120



John Landstreet