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LETTER

Letter to the Editor

Four magnetic DB white dwarfs discovered by the Hamburg/ESO survey*

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Abstract. We report on seven peculiar faint blue stars found in the course of the Hamburg/ESO survey (HES) which appear to be magnetic white dwarfs (WDs) with non-hydrogen spectra. We show in particular that four of them (HE 0338–3853, HE 0107–0158, HE 0026–2150, and HE 0003–5701) have He I lines split by magnetic fields of roughly 20 MG, since the π components of He I 5876 Å and He I 4929 Å can be identified unambiguously in their spectra, and the σ^+, σ^- components can be identified in the spectra of two of these stars (HE 0338–3853 and HE 0003–5701). Besides GD 229, these are the first magnetic DB white dwarfs discovered so far.

In addition, three further WDs with broad, unidentifiable features have been found: HE 1043–0502, HE 0236–2656, and HE 0330–0002. We argue that in all three of these stars H I can not be responsible for the broad features, and He I most probably not for the features in HE 0236–2656 and HE 0330–0002, while it still remains possible that the broad features of HE 1043–0502 are due to He I.

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

1. Introduction

Compact stars with strong magnetic fields are rewarding objects to study. They offer the opportunity to probe atoms under the influence of strong magnetic fields not available in laboratory experiments. Furthermore, magnetic WDs should give information on the origin and evolution of stellar magnetic fields from the main sequence (e.g. Ap stars) to the final evolutionary stages.

For reviews of the subject, cf. Angel (1978), Koester & Chanmugam (1990), Chanmugam (1992), Schmidt (1995), and Jordan (1997). Jordan lists 50 magnetic WDs, but only 15 with extemely high field strengths (> 100 MG). Nearly all magnetic WDs have pure hydrogen spectra, while, surprisingly, magnetic DBs have been missing so far. Until very recently, the only known magnetic WD with unambiguously identified He I lines was Feige 7, which shows strong, magnetically split hydrogen *and* He I lines (Achilleos et al. 1992). However, among the high magnetic field WDs there were two stars with strong unidentified features, namely GD 229 and LB 11146B. The latter has a broad absorption feature at 5500 Å, and in addition a Lyα σ component at 1340 Å and a stationary Hα component at $\sim$ 8500 Å, suggesting a high field strength of 670 MG (Liebert et al. 1993; Glenn at al. 1994). It was suggested that since the strong features in GD 229 and LB 11146B cannot be hydrogen, the next likely atmospheric constituent, namely He, is responsible for the broad features. Very recently Jordan et al. (1998) indeed have succeeded in identifying most of the GD 229 features as due to He I in fields between 300 and 700 MG.

The Hamburg/ESO survey for bright QSOs has turned out to be a rich source of magnetic WDs (Reimers et al. 1994, 1996). Due to the high spectral resolution ($\sim 10 \ldots 20$ Å FWHM) of the HES objective prism plates taken with the ESO Schmidt-telescope, the stellar component with identifiable features (H, He, Ca II,...) can be removed from the QSO candidate sample (Wisotzki et al. 1996; cf. Reimers & Wisotzki, 1997, for further references). The fraction of non-QSOs within the sample of quasar candidates for which follow-up spectroscopy is finally performed therefore contains considerable numbers of peculiar blue stars; in particular magnetic WDs, CVs, and binaries. In addition to the stars already published we have roughly 20 further magnetic WD candidates, most of them with hydrogen spectra.

In this letter we announce the discovery of seven new peculiar white dwarfs; four of them are magnetic DBs with detectable Zeeman lines.

2. Observations

Coordinates and magnitudes of the seven objects are given in Table 1. The coordinates are accurate to $\pm 0.5''$. No finding charts are given since the objects can be localized unambiguously using the *Digital Sky Survey*. Details of the spectroscopic follow-up observations are presented in Table 2. Spectra are

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* Based on observations at the European Southern Observatory, La Silla, Chile

Table 1. Coordindates and magnitudes of the objects. The B_J band is defined by the sensitivity curve of the hyper-sensitized Kodak IIIa–J emulsion, folded with the filter function of a Schott BG395 filter. B_J is roughly equal to B for objects around $B-V=0$. The listed B_J magnitudes are accurate to ± 0.1 mag.

Object	Type	R.A. (2000.0)	Decl.	B_J
HE 0338–3853	mag. DB	03:40:36.8	−38:43:43	16.7
HE 0107–0158	mag. DB	01:10:13.2	−01:42:03	16.4
HE 0026–2150	mag. DB	00:29:26.1	−21:33:42	16.6
HE 0003–5701	mag. DB	00:05:39.2	−56:44:41	15.8
HE 1043–0502	unid.	10:46:09.8	−05:18:17	17.0
HE 0236–2656	unid.	02:38:41.2	−26:43:24	16.7
HE 0330–0002	unid.	03:33:20.2	+00:07:20	16.8

Table 2. Journal of observations. U.T. is given for the start of the exposure. All objects have been observed with the B&C spectrograph attached to the ESO 1.52 m telescope, at a spectral resolution of ~ 15 Å.

Object	Date	U.T.	Exp. time
HE 0338–3853	02/11/95	6:31	20 min
HE 0107–0158	23/10/97	5:52	8 min
HE 0026–2150	23/10/97	1:52	10 min
HE 0003–5701	05/10/96	1:40	5 min
HE 1043–0502	05/02/97	5:20	20 min
HE 0236–2656	06/12/97	4:12	5 min
HE 0330–0002	04/12/97	4:57	5 min

shown in Fig. 1 and Fig. 2, together with a spectrum of GD 229 from Schmidt et al. (1996).

It should be emphasized that all spectra have been taken in the course of quasar candidate follow-up spectroscopy and that typically the spectrophotometry of these snapshot spectra is not sufficiently accurate for determining temperatures of the stars. We notice, however, that the apparent temperature sequence with HE 0338–3853 and HE 1043–0502 as being the hottest stars while HE 0236–2656 and HE 0330–0002 are the coolest among the seven stars is confirmed by the colours estimated from the digitized objective prism spectra.

3. Interpretation

3.1. Magnetic DB white dwarfs

Four of the new WDs have remarkably similar spectra (Fig. 1). In two of them (HE 0338–3853 and HE 0003–5701) the features can be identified with He I lines split under magnetic fields of roughly 20 MG. As in case of Feige 7 (Achilleos et al. 1992) the central π component of He I 5876 Å as well as the σ^+ and σ^- components are clearly detected. The broad feature between 5000 and 5200 Å consists of the five π components of He I 4929 Å. The corresponding blue shifted σ^- components are unresolved and are visible as broad absorption at ~ 4800 Å, while the two σ^+ components are seen at roughly 5270 Å and 5340 Å, respectively. Comparison with the tables of Kemic (1974), and also Fig. 3 in Achilleos et al. (1992), hints at field strengths in the range of 20 to 25 MG. The additional features between roughly 6200 Å and 7300 Å are probably due to the Zeeman-triplets of He I 6678 Å and He I 7065 Å. According to the new computations of Schmelcher (priv. comm.), the two triplets cover the range longward of 6200 Å at field strengths of 20 MG. These features are visible as a broad, shallow absorption trough with evidence for individual lines, e.g. at 7200 Å (Fig. 1). At 6200 Å there is a blending with the σ^+ component of He I 5876 Å. At higher spectral resolution and S/N the individual triplett components (6 lines) can probably identified. The features in the blue part of the spectra can also be attributed to He lines at similar field strengths; partly to He I 4471 Å. So far, there is no evidence for hydrogen lines.

The other two stars have quite similar spectra, although the features are weaker (HE 0026–2150), or the spectrum is too noisy to show narrow, weak features (HE 0107–0158). However, the gross appearance of the stronger features is rather similar: The shifted π components of He I 5876 Å and in particular of He I 4929 Å at 5100 Å are detected. Both stars apparently have He I spectra split by magnetic fields in the range of 10 to 30 MG. HE 0026–2150 has an additional strong, sharp Hα emission line and is probably a binary.

3.2. Stars with unidentifiable features

Besides the magnetic DBs we have found three further stars with peculiar spectra (Fig. 2), probably also magnetic non-DAs. HE 1043–0502 has a strong feature at 4430 Å similar to the 4300 Å trough in GD 229. Further features can be seen roughly at 3400 Å and 4000 Å. In addition, there is an extremely broad, shallow trough between 5000 Å and 5800 Å.

Although the spectra of HE 1043–0502 and GD 229 look similar at first glance, Jordan et al. (1998) on the one hand have *succeeded* in identifying most of the features of GD 229 as stationary He I transitions in a field between 300 and 700 MG, while on the other hand there is *no* possible match of the features in the spectrum of HE 1043–0502 with He I in magnetic fields of up to $2 \cdot 10^3$ MG (Becken & Schmelcher, priv comm.; cf. Jordan et al. 1998). However, even in the case of GD 229 the strongest features at $4000-4200$ Å and at about 5280 Å can only be attributed to two line transitions ($2^1 0^+ \rightarrow 2^1 0^-$, $2^1 0^+ \rightarrow 2^1(-1)^+$), while other and weaker ones are produced by a superposition of several stationary components. Therefore, Jordan et al. (1998) speculated that additional stationary line components must be present which were not included in the current data sets for He I in a strong magnetic field. All available data are restricted to transitions with magnetic quantum numbers $|m| \leq 1$.

We have also no identification of the shallow features in the spectra of HE 0236–2656 (at 4650 Å and 5800 Å) and HE 0330–0002 (at 3900 Å, 4650 Å, and 6650 Å). In the former, the broad absorption troughs could be molecular bands according to their form, but we do not have an identification. Apart from missing identifications, the apparently low temperature of these two objects argues against the presence of He I lines. We tentatively

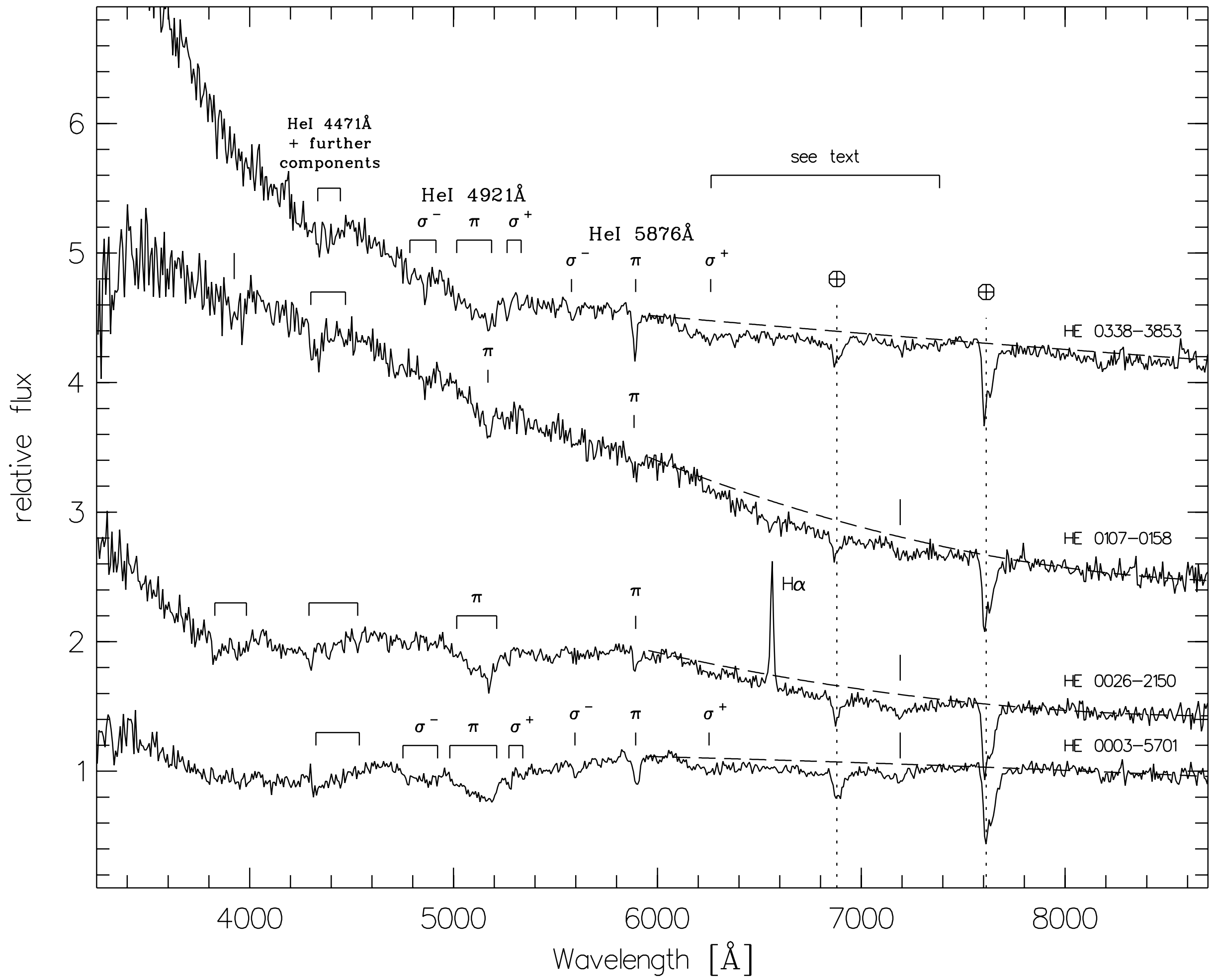

Fig. 1. Flux spectra f_λ of the four magnetic DBs taken with the ESO 1.52 m telescope, together with a rough continuum estimation in the red part of the spectra. The continua have been determined by fitting a second order polynomial through some high points, and are intended to make the shallow, broad absorption features in the red region noticeable. Atmospheric bands are labeled with '$\oplus$'. All spectra have been normalized to a mean flux of unity in the region 7000–7500 Å, and afterwards arbitrarily shifted in y-direction. Though these snapshot-spectra are nonphotometric, their apparent temperature sequence is consistent with colours estimated from the digitized objective prism spectra.

conclude that neither hydrogen nor helium give a plausible identification of the features.

4. Final remarks

Given the fact that except GD 229 there is no DB in the sample of 50 magnetic WDs known today (Jordan 1997), our discovery of four magnetic DBs appears surprising. The question is: Why have no magnetic DBs been discovered in the course of proper motion surveys or the PG survey, with exception of GD 229? The probable reason is the rareness of the phenomenon. With respect to the detection of peculiar blue stars, the HES should be complete to $B_J \sim 17$. The HES follow-up observations of candidates from 280 ESO/SRC fields, corresponding to an effective area of ~ 5000 square degrees, have revealed 4 magnetic DBs. Only HE 0003–5701 is significantly brighter than the PG magnitude limit ($B_J = 16.5$). On the same area roughly three dozens DBs have been found by the HES (unpublished). Although we are aware of the fact that this is still small number statistics, we tentatively conclude that the incidence of magnetism is not lower in DBs than in DAs.

Finally, we wish to point out that most of our results are preliminary. The main intention of this letter is to draw the attention of the white dwarf research community to these objects.

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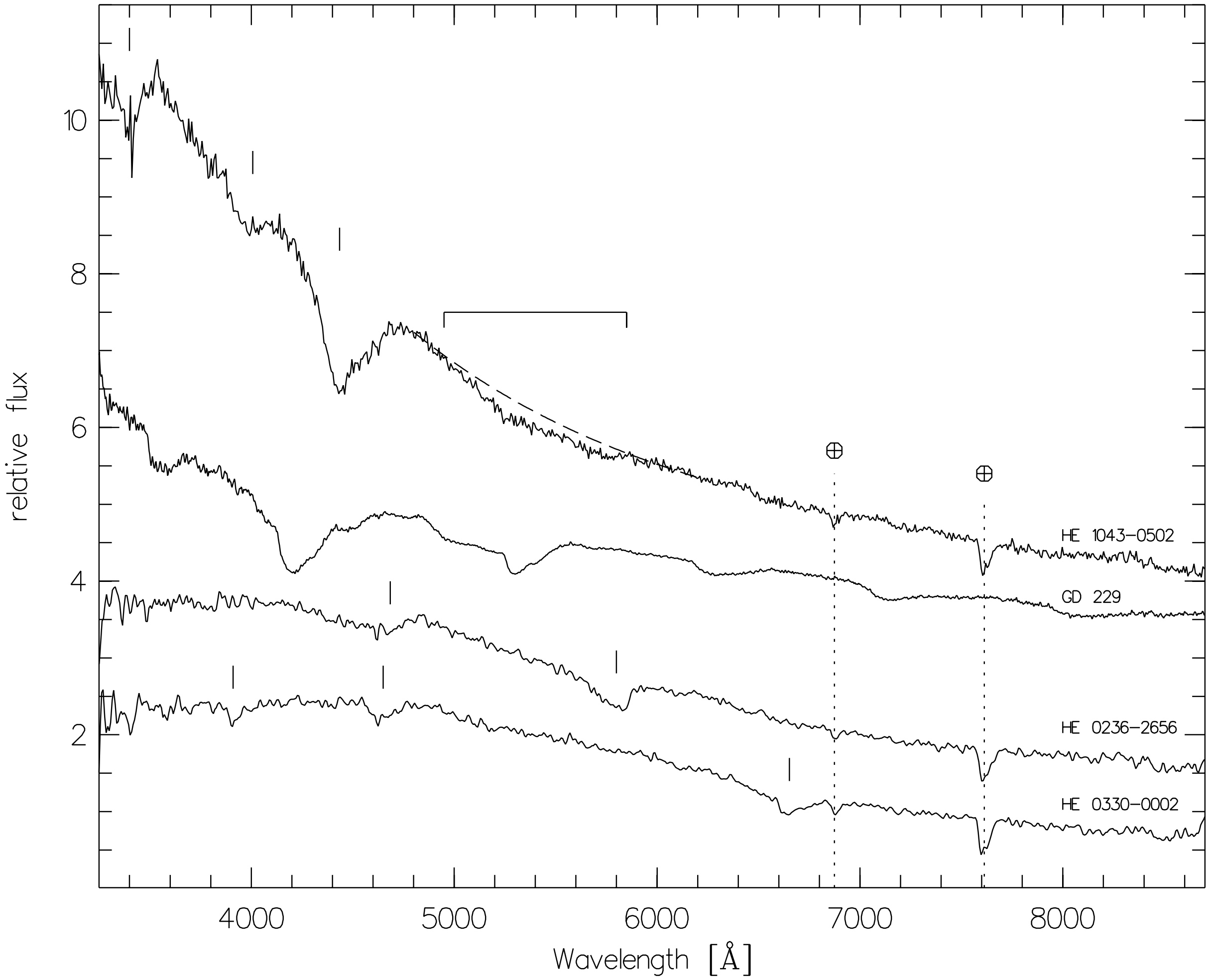

Fig. 2. Flux spectra of three WDs with unidentifiable features in comparison with a spectrum of GD 229. The latter is the same as in Schmidt et al. (1996) and was kindly provided by G. Schmidt. The spectra have been treated in the same way as descripted in the caption of Fig. 1. The spectra of HE 0236–2656 and HE 0330–0002 have been smoothed with a gaussian filter of 15 Å FWHM. A rough continuum estimation of the 5000–5800 Å region by a third order polynomial is given for HE 1043–0502 to visualize the shallow, broad absorption feature. Telluric bands are labeled with '⊕'. As for the spectra shown in Fig. 1, the apparent temperature sequence is consistent with colours estimated from the digitized objective prism spectra.

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