A Search for Isolated Cool Magnetic White Dwarfs

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Abstract. We present the ongoing results of our search for new highly evolved (cool) isolated magnetic white dwarfs (MWDs) with extremely strong magnetic fields. The search was carried out using the broadband photopolarimeter of the 1 meter telescope of SAO RAS. Observations were conducted in circular polarization search mode, with typical values of -0.6% and higher in integrated light. A detailed study of 19 sources with temperatures less than 6000 K was carried out in a 100 pc volume. As a result, 3 new magnetic white dwarf candidates were found with fields of 10 MG and higher.

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1 Introduction

In this work we present the results of broadband polarimetric observations of white dwarfs. The aim of this study is to search for strongly-magnetic white dwarfs (MWDs) among cool white dwarfs. According to a series of papers (Liebert & Sion 1979; Valyavin & Fabrika 1999; Fabrika & Valyavin 1999; Liebert et al. 2003; Sion et al. 2014), the frequency of occurrence of MWDs with fields of several megagauss and higher increases as they cool with evolution. According to Valyavin et al. (2014) the process of this frequency increasing begins from the moment the convective stage develops. For the hydrogen DA white dwarfs, this amounts to temperatures of 14000 K and less (see Kepler et al. (2013)). Based on these and other observational facts we proposed a hypothesis (Valyavin et al. 2014) that the slowdown of convection in the outer layers of MWDs decreases their thermal evolution rate in the temperature region of less than 14000 K, thus

increasing their occurrence frequency in this temperature interval (see Fig. 1). It was also shown (Liebert et al. 2003; Sion et al. 2014) that the MWD occurrence frequency in the less-than-7000 K temperature interval is selectively biased and probably underestimated. We started our program of broadband polarimetric observations of white dwarfs in order to obtain a more accurate estimate of this frequency.

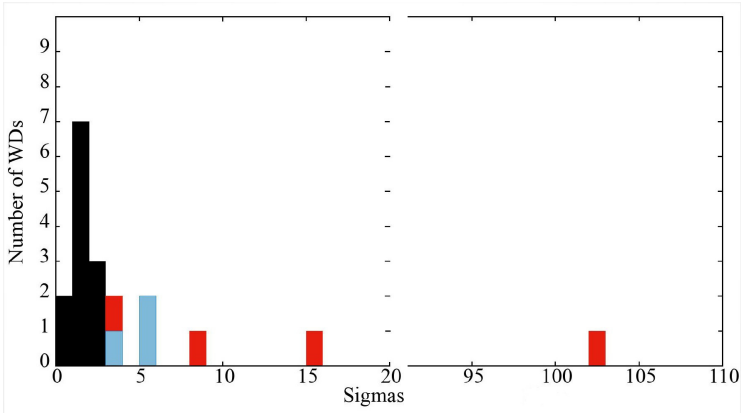

Fig. 1. From Valyavin et al. (2014). Frequency dependence of MWDs on temperatures. Filled circles are frequencies from the most recent survey (Kepler et al. 2013). Triangles are frequencies from other studies (Valyavin & Fabrika 1999; Liebert et al. 2003; Sion et al. 2014). Uncertainties are obtained by the Monte-Carlo method and taken from the literature (Valyavin & Fabrika 1999; Liebert et al. 2003; Sion et al. 2014). The solid and dashed lines are computations obtained assuming inhibition of convection only in the photosphere (dotted line); in the upper sub-photospheric layers and photosphere (solid line); and the entire convective zone (dashed line).

2 Observations

The observations were carried out with the 1 meter telescope of SAO RAS using the MMPP photometer-polarimeter in the circular polarization mode (Emelianov et al., in preparation) in integrated light (no filters). In its current release, it is a single-beam device, and one therefore needs to take two frames in order to obtain one circular polarization estimate – with the quarter-wave plate positioned at +45 and -45 degrees. In real practice, observations are carried out as a

continuous series of tens or even hundreds of such pairs with a total duration of one to 6 hours for each of the investigated sources. For each source, we obtained no less than three series of observations on different nights.

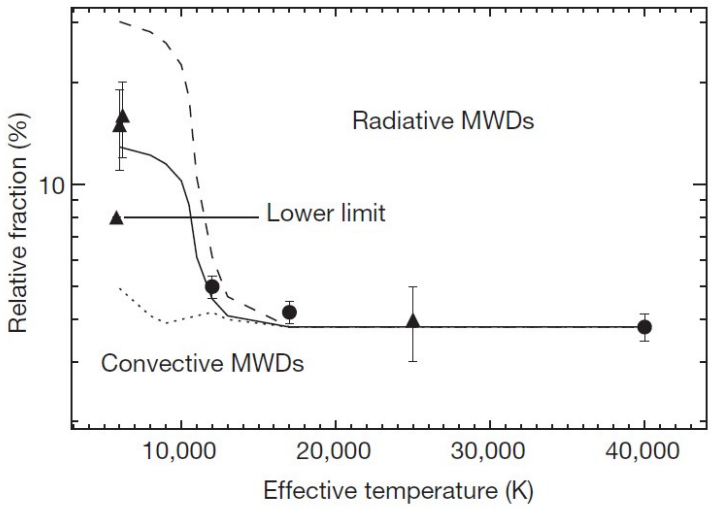

Fig. 2. Significance of the measured circular polarization in sigmas. The known magnetic white dwarfs are marked by red, the new strongly-magnetic white dwarf candidates are shown in blue, and black marks the sources that did not show significant polarization.

In order to standardize and test the capabilities of the new instrument we used 4 magnetic white dwarfs — GRW+708247, WD 1309+853, WD 1312+098, WD 1748+708. They all showed significant polarization of expected magnitudes, which illustrates the efficiency of the instrument. Our target sources consisted of white dwarfs within 25 pc with temperatures less than 7000 K. Fifteen such stars were selected for observations.

3 Results

In total, we obtained circular polarization values for 19 objects, including known magnetic sources. For all magnetic white dwarfs we derived polarization values

avaraged over their intrinsic rotation cycles with 4-sigma and higher significance levels. Among the 15 targeted sources, 3 new magnetic dwarf candidates were detected, with the following circular polarizations: 0.27% ± 0.09 for LP240-30, -0.39% ± 0.07 for WD1633+572, and -0.43% ± 0.08 for WD 0245+541. The histogram in Fig.2 shows the significance level of their circular polarization estimates in blue. Observations with the 2.6 meter Shajn telescope of Crao are planned for independent confirmation of the magnetic nature of these stars as well as surface magnetic field strength measurements. If all the candidates turn out to be magnetic, the occurrence frequency of magnetic white dwarfs in our sample will be 20%, which is significantly higher than the previous estimates.

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