20th European White Dwarf Workshop
ASP Conference Series, Vol. 509
Tremblay, Gänsicke, and Marsh, eds.

Are All Magnetic White Dwarf Stars Massive?

Atsuko Nitta,[1,2] S. O. Kepler,[3] Baybars Kulebi,[4] Detlev Koester,[5] Scot J. Kleinman,[1] Don E. Winget,[6] Barbara G. Castanheira,[6] and Alejandro H. Corsico[7]

[1]*Gemini Observatory, Hilo, HI, U.S.A.;* anitta@gemini.edu, skleinman@gemini.edu

[2]*Subaru Telescope, Hilo, HI, U.S.A.;* anitta@gemini.edu

[3]*Universidade Federal do Rio Grande do Sul Porto Alegre, RS, Brazil;* kepler@if.ufrgs.br

[4]*Institut de Ciències de l'Espai, Barcelona, Spain*

[5]*Universität Kiel, Kiel, Germany;* koester@astrophysik.uni-kiel.de

[6]*University of Texas at Austin, Austin, TX, U.S.A.;* dew@astro.as.utexas.edu, barbara@astro.as.utexas.edu

[7]*University of La Plata, La Plata, Argentina;* acorsico@fcaglp.fcaglp.unlp.edu.ar

Abstract. We obtained follow-up spectra on 25 white dwarf stars identified in our white dwarf catalog of Sloan Digital Sky Survey (SDSS) as massive or magnetic. We identified over 300 magnetic white dwarf stars from SDSS with some uncertainties due to the low S/N of the spectra. With much higher S/N Gemini data, our sample should be able to help us confirm accuracy of our determinations. We present here our results so far from the follow up observations.

1. Overview

Our goal is to address the mystery of the origin of magnetic fields in white dwarf stars (WDs). One telling clue in this mystery is that spectroscopic mass determinations for magnetic WDs are consistently higher (averaging ~0.93 $M_\odot$ from Wickramasinghe & Ferrario 2005) than for non-magnetic WDs (averaging ~0.64 $M_\odot$ from Kepler et al. 2016). Through our WD catalog from Data Release 7 (Kleinman et al. 2013) of the Sloan Digital Sky Survey (SDSS), we have a statistically significant estimate of the distribution of over 300 magnetic WDs of different field strengths versus mass and temperature (Kepler et al. 2013). The low S/N SDSS spectra, however, leave some uncertainty in our identifications of magnetic fields and hamper our ability to simultaneously measure both the Zeeman-splitting and the Stark pressure broadening in these stars, meaning we cannot reliably measure both magnetic field and surface gravity. Obtaining S/N > 70 spectra at Gemini for a sample of low field massive magnetic WDs, we will test our low S/N determinations of magnetic fields, search for ways to measure magnetic field and surface gravity simultaneously, and ultimately determine if these magnetic fields are likely developed through the star's own surface convection zone, or inherited from massive Ap/Bp progenitors.

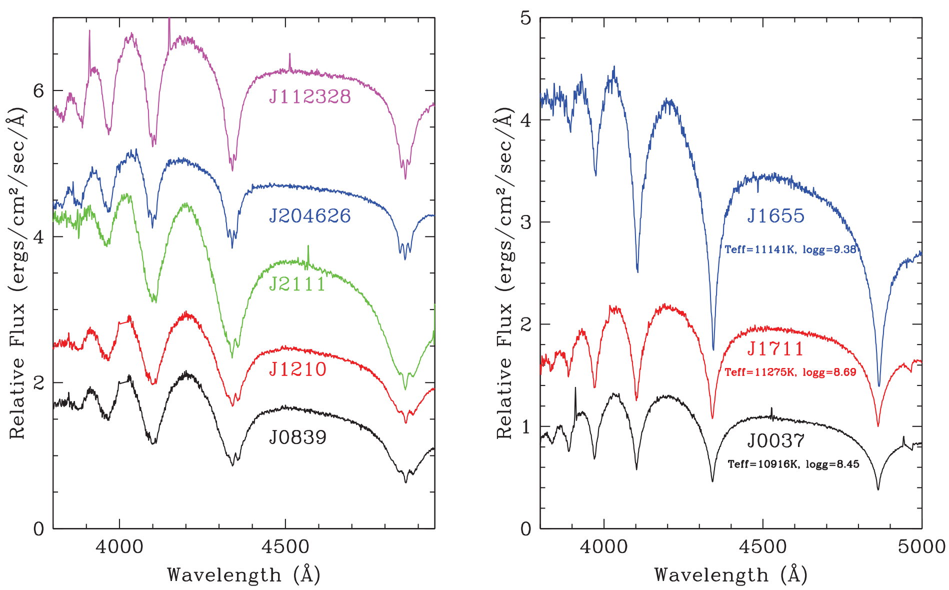

Figure 1. Gemini spectra of white dwarf stars. *Left:* Gemini spectra of WDs with detected Zeeman splitting seen in the hydrogen absorption lines. The spectra are, from the top, SDSS J112328.49+095619.39 (labeled as J1123 in the figure), SDSS J204626.15-071036.98 (labeled as J2046), SDSS J211125.84+110219.69 (labeled as J2111), SDSS J121033.24+221402.64 (labeld as J1210), and SDSS J083945.56+200015.76 (labeled as J0839). *Right:* Three Gemini spectra of white dwarf stars without any Zeeman splitting. Their full SDSS names are, from the top, SDSS J165538.93+253345.99, SDSS J171113.00+654158.3 (labeled as J1711), and SDSS J003719.12+003139.27. Their estimated effective temperature and surface gravity from their SDSS spectra are shown in a separate table. These three massive DAs physical parameters indicate they are good DAV candidates.

2. Observations and Results So Far

We were awarded GMOS-N time in 2012A, 2013A, 2013B semesters for this program. We obtained data for 25 targets. We present here our initial results. So far there are 6 magnetic DAs, 13 massive DAs which did not show sign of magnetic fields and data on 6 more objects to reduce. The 6 magnetic DAs were correctly identified as magnetic DAs in our catalog. Two of the non-magnetic WDs were identified as magnetic in our catalog. One object identified as possible DQ in our catalog turned out to be a DA. We also found 10 massive DA spectra from earlier programs. They were originally targeted to confirm their masses and we plan to search for any sign of magnetic fields in these DAs as well.

Fig. 1 shows the Gemini spectra of WDs with and without detected Zeeman splitting seen in the hydrogen absorption lines. The physical parameters of the three non-

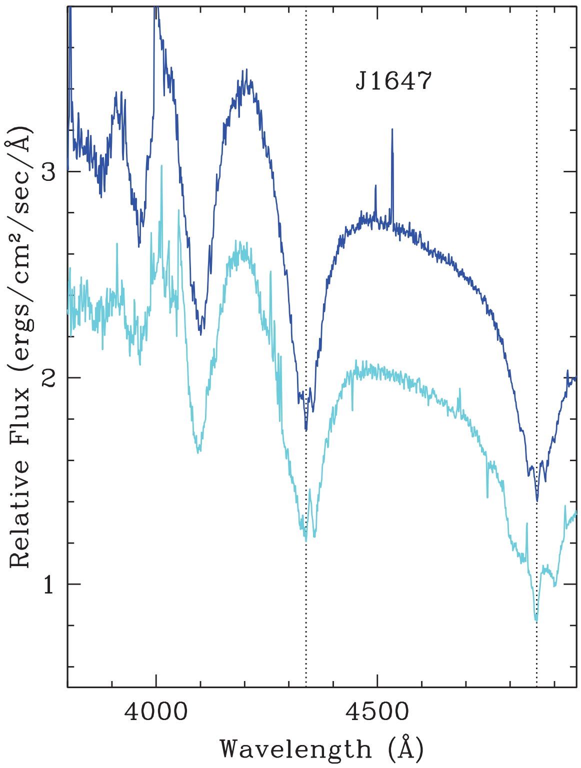

Figure 2. J164703.24+370910.29, labeled as J1647 in the figure, showed variation between different exposures. Here is an example of spectra, each with 20min exposure time, taken one after another.

magnetic WDs in the figure are listed in Table 1. They are taken from the SDSS catalogue (Kleinman et al. 2013). Their physical parameters indicate they are good massive DAV candidates and hopefully will be followed up soon to find out if they are massive DAVs. Fig. 2 shows spectra of J164703.24+370910.29 which showed variations between different exposures, indicating variations at the timescale of minutes. So far this is the only observed object that showed any variations.

When fully analyzed, the new Gemini spectra will help us provide better realistic limits on the number of magnetic field stars (vs. field strength) we identified with the noisier SDSS spectra (Kleinman et al. 2013; Kepler, et al. 2013; Kepler et al. 2015; Kepler et al. 2016). We can then better explore the full SDSS sample with an accurate statistical understanding of our ability to detect magnetic fields (particularly low strength) in the SDSS spectra.

Acknowledgments. Based on observations obtained (processed using the Gemini IRAF package) at the Gemini Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under a cooperative agreement with the NSF on behalf of the Gemini partnership: the National Science Foundation (United States), the National Research Council (Canada), CONICYT (Chile), Ministerio de

Table 1. Physical Parameters of three Massive DAV in Fig. 1. The parameters are those from their SDSS spectra.

Handle Used in Fig. 1	Object Name (SDSS)	$T_{\rm eff}$ (K)	log g
J1655	J165538.93+253345.99	11 141	9.38
J1711	J171113.00+654158.3	11 275	8.69
J0037	J003719.12+003139.27	10 916	8.45

Ciencia, Tecnología e Innovación Productiva (Argentina), and Ministério da Ciência, Tecnologia e Inovação (Brazil).

References

Kepler, S. O., Pelisoli, I., Jordan, S., et al. 2013, MNRAS, 429, 2934
Kepler, S. O., Pelisoli, I., Koester, D., et al. 2015, MNRAS, 446, 4078
Kepler, S. O., Pelisoli, I., Koester, D., et al. 2016, MNRAS, 455, 3413
Kleinman, S. J., Kepler, S. O., Koester, D., et al. 2013, ApJS, 204, 5
Wickramasinghe D. T., & Ferrario L. 2005, MNRAS, 356, 1576