An Enigmatic Class of Isolated White Dwarfs with Magnetic Emission

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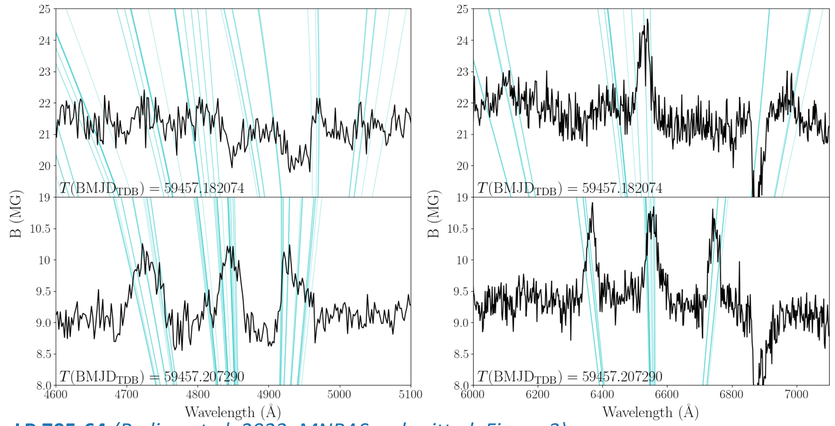
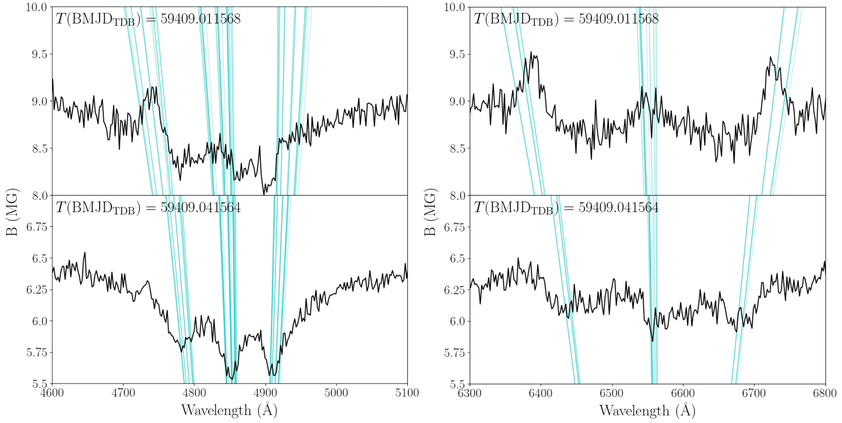
A new and mysterious class of variable star, the DAHe are hydrogen-atmosphere (DA) white dwarfs that display magnetic (DH) emission lines (De) without the apparent influence of a stellar companion. Li et al. 1998 (ApJ, 503, L151) invoked a unipolar inductor model for the activity, in which a rocky planet's orbit through the stellar magnetosphere excites the white dwarf atmosphere into emission, but such a planet has never been detected with targeted observation (Walters et al. 2021, MNRAS, 503, 3743). All members share remarkably similar physical characteristics as well, raising questions about how these objects form—their rapid rotation rates and strong magnetism suggest that they may result from binary mergers.



LP 705-64 *(Reding et al. 2023, MNRAS, submitted; Figure 3)*

G = 16.9, T_{eff} = 8440 K, M = 0.81 $M_\odot$, B = 9.4–22.2 MG, P_{rot} = 1.21 hr

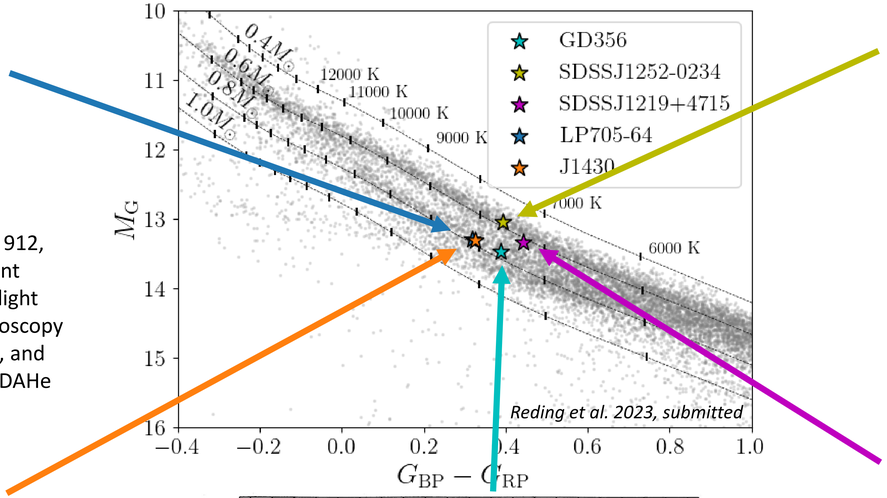
LP 705-64 was discovered using the *Gaia* DR2 VARINDEX metric (Guidry et al. 2021, ApJ, 912, 125), and stands distinct amongst the DAHe by displaying two emission phases of different magnetic field strengths, suggesting the presence of a multipole magnetic field. Its *TESS* light curve displays a dominant periodogram feature at 0.61 hours, but our time-series spectroscopy revealed that this signal reflects the time of transition between the two emission phases, and the true rotational period is double this value. This suggests value in revisiting the other DAHe with precise photometry to detect the presence of multiple magnetic poles.

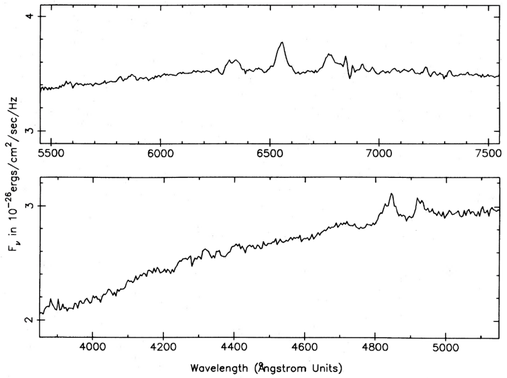


WD J143019.29−562358.33 *(Reding et al. 2023, MNRAS, submitted; Figure 3)*

G = 17.4, T_{eff} = 8500 K, M = 0.83 $M_\odot$, B = 5.8–8.9 MG, P_{rot} = 1.44 hr

WD J1430-5623, like LP 705-64, was discovered using the *Gaia* DR2 VARINDEX metric and presents an evolving magnetic field with rotational phase. It and SDSS J1252-0234 both fully transition between emission and absorption, though WD J1430-5623 appears to superimpose these phases at Hβ, suggesting a potential multipole field like in LP 705-64.

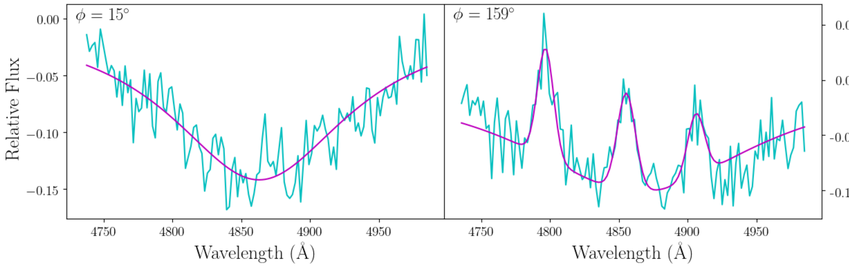




GD 356 *(Greenstein & McCarthy 1985, ApJ, 239, 732; Figure 3)*

G = 15.0, T_{eff} = 7698 K, M = 0.74 $M_\odot$, B = 11.0 MG, P_{rot} = 1.93 hr

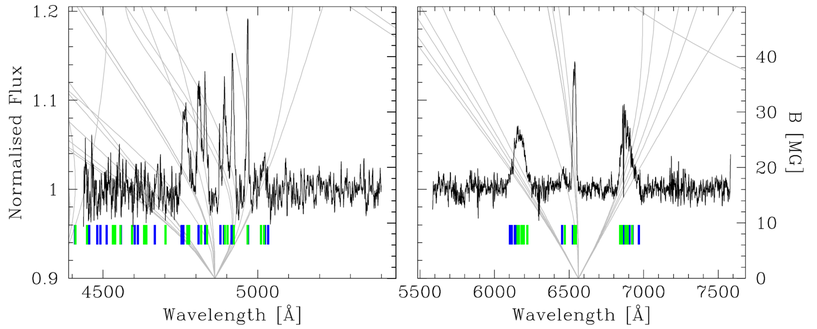
GD 356 is the foundational object of the DAHe class. Its spectrum features only the Balmer series in weakly variable (0.2%; Brinkworth et al. 2003, MNRAS, 348, L33) Zeeman-split emission due to a rotation axis orientation which never fully obscures its magnetic spot.



SDSS J125230.93-023417.72 *(Reding et al. 2020, ApJ, 894, 19; Figure 4)*

G = 17.5, T_{eff} = 8237 K, M = 0.65 $M_\odot$, B = 5.0 MG, P_{rot} = 0.09 hr

Thirty-five years after finding GD 356, the discovery of SDSS J1252-0234 established the DAHe as a new class of variable white dwarf. It is among the fastest-rotating white dwarfs known, and its Balmer features, particularly at Hβ, transition between absorption and Zeeman-split emission across a rotation cycle. Its photometric variability amplitudes increase towards blue wavelengths as well (SDSS-g = 5.0%, SDSS-i = 2.2%), though its near-ultraviolet photometry is fainter than white dwarf models predict, suggesting the presence of yet-unobserved UV activity. This may be attributable to magnetic spots suppressing convection on the stellar surface (Gentile Fusillo et al. 2018, MNRAS, 473, 3693), though SDSS J1252-0234 apparently stands alone in experiencing this phenomenon, as all other members fit well to their near-UV photometry despite hosting stronger magnetic fields. We encourage future UV spectroscopy of the DAHe white dwarfs to better understand their variability mechanisms.



SDSS J121929.45+471522.8 *(Gänsicke et al. 2020, MNRAS, 499, 2564; Figure 2)*

G = 17.6, T_{eff} = 7500 K, M = 0.65 $M_\odot$, B = 18.5 MG, P_{rot} = 15.26 hr

SDSS J1219+4715 was discovered shortly after SDSS J1252-0234 and resembles GD 356 with its spectrum never fully transitioning into absorption, though the emission line strengths vary more than those of its predecessor (2.7%). This object also has the longest rotation period of the confirmed DAHe, though still spins faster than average for white dwarfs (<P_{rot}> = 35±28 hr; Hermes et al. 2017, ApJS, 232, 23).