A HIGH-PRECISION SURVEY OF MAGNETIC WHITE DWARFS

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The White Dwarf Zoo

- DA  Only H
- DB  Only He
- DC  Only Continuum
- DO  He II + maybe HeI and/or H
- DZ  Only metal lines
- DQ  Carbon features

Sion et al. (1983)
• $|B| > 50 \text{ MG}$: Magnetic force ~ Coulomb force; polarisation of the continuum + spectral upheaval

• $1\text{ MG} < |B| < 50 \text{ MG}$: Line polarisation & splitting, quadratic Zeeman regime

• $50 \text{ kG} < |B| < 1\text{ MG} \rightarrow$ Line polarisation & splitting linear Zeeman regime

• $1\text{ kG} < |B| < 50 \text{ kG} \rightarrow$ Line polarisation; field detectable only through spectropolarimetry

See Putney (1997)
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<table>
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<th>n^l m_\ell</th>
<th>n^l' m'_\ell</th>
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<th>7 \times 10^6</th>
<th>B(\text{gauss})</th>
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**50 kG < |B| < 1MG —> Line polarisation & splitting linear Zeeman regime**

**1kG < |B| < 50 kG —> Line polarisation; field detectable only through spectropolarimetry**

We do not have an instrument that optimally covers at best all these regimes
**S, M, L, XL, XXL surveys**

- **S** Kemp et al. (1970): first field detection in a WD, followed by various BBCP surveys
- **L** Schmidt & Smith (1995): specpol survey of 170 DA WDs; $\sigma \sim 8.6\, \text{kG}$ (4% detections rate)
- **M** Putney (1997): specpol survey of 46 WDs, $\sigma > 10\, \text{kG}$ (15-20% detection rate)
- **M** Koester et al. (1998): high-res spec survey of 30 stars, (16% detection rate)
- **S** Aznar-Cuadrado (2004) + Jordan et al. (2005): FORS circular specpol of 12+10 stars, $\sigma < 1\, \text{kG}$ (25% + 10% detection rate, respectively)
- **XL** Koester et al. (2009): UVES high-res spec survey of 1000 isolated and WD+dM (1.6% detection rate)
- **S** Landstreet et al. (2012): FORS specpol survey of 8 WDs; $\sigma \sim 1\, \text{kG}$ (12% detection rate). Reassessment of previous surveys
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About statistics

- Sample size
- Signal-to-noise ratio
- Bias from the instrument used for the survey
- Re—observations of known or suspected magnetic stars
- Misleading language, e.g., “… 50 WDs have a field strength less than 10 kG …” (when 10 kG is the detection threshold), or “field was detected at 2σ level”
- Morphology and geometry relative to the observer
- Magnetic fields in WDs with featureless spectra (DC) can be detected only if |B| > 50 MG
- Non featureless WDs with field strength |B| > 50G may be not easily recognised/classified
OUR NEW SURVEY

~ 60 WDs observed in low and/or medium and/or high resolution spectro-polarimetric mode using three different instruments

Most of the targets were never observed before with high precision polarimetric techniques (or never observed at all in polarimetric mode)

Roughly magnitude-limited, but certainly not optimised (yet) for unbiased statistics
FORS @ VLT
\[ \frac{V}{I} = -4.67 \times 10^{-13} \left( \frac{1}{\lambda^2} \right) \left( \frac{1}{I} \right) \left( \frac{dI}{d\lambda} \right) \langle B_z \rangle \]
Flexures are much more likely to produce spurious detections than hiding a magnetic field.
ESPaDONs @ CHFT
Landstreet et al. (2015)
WD1350-090 MWD
Esp spectra 2017-01, binned to 0.5 Å (blk, red, blu), avg ESO spec, binned 0.2 Å (grn)
The graph shows a histogram of $\sigma_{B_\ast} (G)$ with the number of measurements on the y-axis and $\sigma_{B_\ast} (G)$ on the x-axis. The histogram is shaded and includes bars at intervals of 0 to 2000 G, with a peak concentration in the 500-1000 G range.
• In our high precision (σ ~0.5kG) survey of 60 WDs, we have discovered 1 new magnetic WD, and re-observed a small number of previously known magnetic or suspected magnetic WDs for monitoring purpose.

• Combining our new survey with 20 stars previously observed by Aznar-Cuadrado et al. (2004), Jordan et al. (2007), and Landstreet et al. (2012) we have 80 WDs observed in circular polarisation with very high precision (< 1kG). —> x 4!

...of which:

• 4 WDs have |<Bz>| < 10 kG
• 1 WD has |<Bz>| ~35 kG, and
• 1 has a 100+ MG field (Grw+70 8247)

• **THIS DOES NOT TRANSLATE INTO STATISTICS IN A STRAIGHTFORWARD WAY (e.g., 7.5%)!**

• With the current telescopes it will be very hard to detect any dipolar field weaker than 3 kG.
Pushing the precision to the limits of the current instrumentation has not led to a substantial increase of the incidence of magnetic fields (rather the opposite)

(We cannot push the precision much further down...)

The results of our (and K&V) high-precision spectro-polarimetric survey supports the idea that magnetic WDs are pretty rare objects
MODELLING OF MWDs

- WD 2047+372: younger and simpler (dipolar) field
- WD 2359-434: older and more complex field