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Ap Stars

- Magnetic class of intermediate-mass CP stars
- Primarily dipole fields

Origin:

1. Fossil fields?
2. Stellar mergers?
3. ???

(Rusomarov et al. 2014)
Magnetic dichotomy: There may exist a critical $B_p$ below which fields decay.

Ultra-weak fields
($B_z < 1$ G)

- e.g. Vega (Lignières et al. 2009)
- e.g. Ursae Majoris (Blazère et al. 2015)

(Aurière et al. 2007)
1. Why study Ap stars?

2. Why do we need a volume-limited survey?
Ap Stars

~10% of hot stars are magnetic

MS Mass Distribution Within 100 pc
The Sample

Catalogue of Ap, HgMn, and Am Stars

(Renson & Manfroid 2009)

Candidate Ap/Bp Stars

1. Detected magnetic fields
2. Photometric variability
3. Photometric peculiarity index

Bona fide magnetic Ap/Bp star
The Sample

Hipparcos catalogue within 100 pc:

- ~19,000 stars
- ~2,000 MS A/B stars within 100 pc
## The Sample

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Known Ap/Bp Stars (d ≤ 100 pc)</td>
<td>51</td>
</tr>
<tr>
<td># of New ESPaDOnS Spectra Obtained</td>
<td>94</td>
</tr>
<tr>
<td># of Stars Observed</td>
<td>38</td>
</tr>
<tr>
<td># of Stars w/o High-Res. Spectropolarimetry (prior to this survey)</td>
<td>25</td>
</tr>
</tbody>
</table>

**Target $B_z$ Uncertainty:** ≤ 25 G
Fundamental Parameters

\( T_{\text{eff}} \) Calibrations:

Strömgren \( uvby\beta \)
- (Balona 1994, Stepien 1994)

Geneva
- (Hauck & North 1993)

Johnson \( UBV \)
- (Grey 2005)

BC Calibrations:
- (Landstreet et al. 2007)
Evolutionary Models:

- Non-rotating, Solar Metallicity
- (Ekström et al. 2012)

$M, R_p, \tau_{age}$
Magnetic Analysis

- Oblique Rotator Model (Stibbs 1950)

\[ i = 58^{+26}_{-12} \quad \beta = 61^{+10}_{-44} \quad B_p = 3.1^{+0.2}_{-0.1} \text{ kG} \]
Magnetic Analysis

- Oblique Rotator Model (Stibbs 1950)

\[ B_p = 1.0^{+0.3}_{-0.2} \, \text{kG} \]

\[ i = 56^{+19}_{-10} \, ^\circ \]

\[ \beta \geq 72^\circ \]
Magnetic Analysis

Inclination Angle

Obliquity Angle

Preliminary results!
Magnetic Analysis

Dipole Field Strength

... also very preliminary!
1. Calculate $T_{\text{eff}}$, $L$ photometrically
HR Diagram Within 100 pc

1. Calculate $T_{\text{eff}}, L$
2. Remove evolved stars
HR Diagram Within 100 pc

1. Calculate $T_{\text{eff}}$, L photometrically

2. Remove evolved stars

3. Compare the magnetic and non-magnetic samples
HR Diagram Within 100 pc

Spectroscopic Binaries:
Alpha Pisc.
(BRITE Survey, Neiner & Lèbre 2014)

Resolved multi-star systems:
(VAST Survey, De Rosa et al. 2014)

e.g.) HIP 82321

\[ \log P_{B-C} = 4.31 \]
\[ \log P_{A-BC} = 5.35 \]
(De Rosa et al. 2014)
Comparing the Populations

Non-Magnetic MS A/B Stars

Magnetic Ap/Bp Stars
Comparing the Populations

Fractional Incidence of Mag. Fields With Mass

Fractional Incidence

Mass (M_☉)

10^{-1}
10^{-2}
10^{-3}
1
2.0
2.5
3.0
3.5
4.0
Comparing the Populations

Non-Magnetic MS A/B Stars

Magnetic Ap/Bp Stars

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Comparing the Populations

Non-Magnetic MS A/B Stars

Magnetic Ap/Bp Stars
Summary/Future Work

- Newly obtained ESPaDOnS observations have increased volume-limited sample of precisely characterized Ap stars from 59% to ≥ 80%

- No detections from 20 candidate CP2 Ap stars:
  \[ 0.3 \leq \sigma_{\langle B_z \rangle} \leq 26 \text{ G} \quad \text{median}(\sigma_{\langle B_z \rangle}) = 9 \text{ G} \]

- Future Work: Spectral line modelling taking into account Zeeman broadening and binarity:
  - \( T_{\text{eff}} \)
  - \( \log(g) \)
  - \( v_{\text{sini}} \)
  - Chemical Abundances
The Sample

$B_z = 54 \pm 22 \text{ G}$