Chemo-Kinematic Tracing of Old Populations using HBA stars

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Three Steps:

1. Study of 31 local HBA stars using available literature data and Hipparcos/Tycho 2 astrometry

2. A new and more homogenous set of full optical range high resolution high S/N data for our current sample

3. Using Gaia's results for this research, extending the scope from local to global

Why are HB stars such valuable tools for Galactic studies?

- RR Lyraes and BHB/EHB are easy to find
  - RR Lyr due to variability
  - BHB/EHB due to blueness (at medium to high galactic latitudes)
- Distances readily derivable
- luminous old stars, accessible beyond the boundaries of the Galaxy
- Genuinely old stars (descendants of sun-like & lower mass stars)

Why are HB stars such valuable tools for Galactic studies?

- Relatively numerous
- Very bright for old stars
- Abundance pattern appears to be pristine for T_{eff} <11,000 K
- globular clusters offer a testbed for issues concerning HBs
- long history of studies

→ *HB stars are an excellent tracer of old populations, eg. the Halo*

Why are HB stars such valuable tools for Galactic studies?

- Down-Sides and problems:
  - RHBs hard to distinguish from some other types
  - RR variability makes determination of distances and phys parameters more difficult
  - HBB+EHB (Teff>11,000 K): abundances severely altered!
  - HBA+especially HBB stars very similar to AV/BV stars (problem for solar neighbourhood)
  - high percentage of close binaries in sdB stars, these are RVV!

Kinematics & Abundances of local HBA stars

- study of kinematics and abundances of 30 local HBA stars to find objects within the ΩCen debris kinematics-abundance parameter space.
  - ΩCen is retrograde & has very distinct & unusual abundance pattern
  - Abundances, astrometric and astrophysical quantities for the stars from literature (Adelman & Philip (1986, 1990, 1992, 1994, 1996a,b), Altmann & de Boer (2000), Kinman (2000), Beers (2004), Hipparcos, Tycho2).

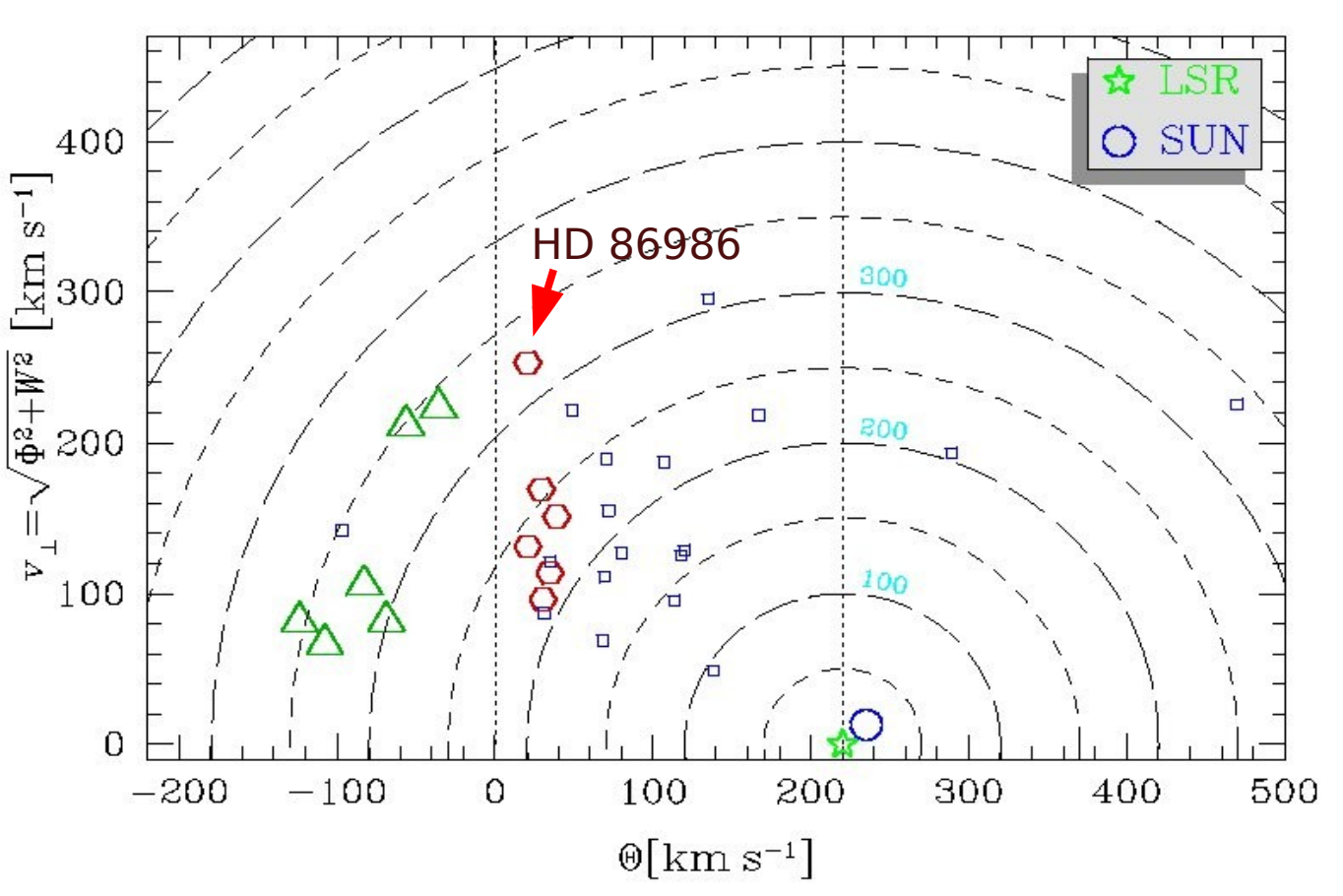
Kinematics & Abundances of local HBA stars

- Preliminary result: Yes, some stars fit into the parameter space as defined by simulations (see Bekki & Freeman, 2003, Dinescu 2002) for ΩCen debris, more detailed studies required
- Surprise result: Among the prograde objects (about 75% of the sample) 5-6 share very similar abundances in several elements and very similar kinematics
  - These venture very close to the Galactic centre

→ ***Cometary orbit group (COG)***

Kinematics & Abundances of local HBA stars

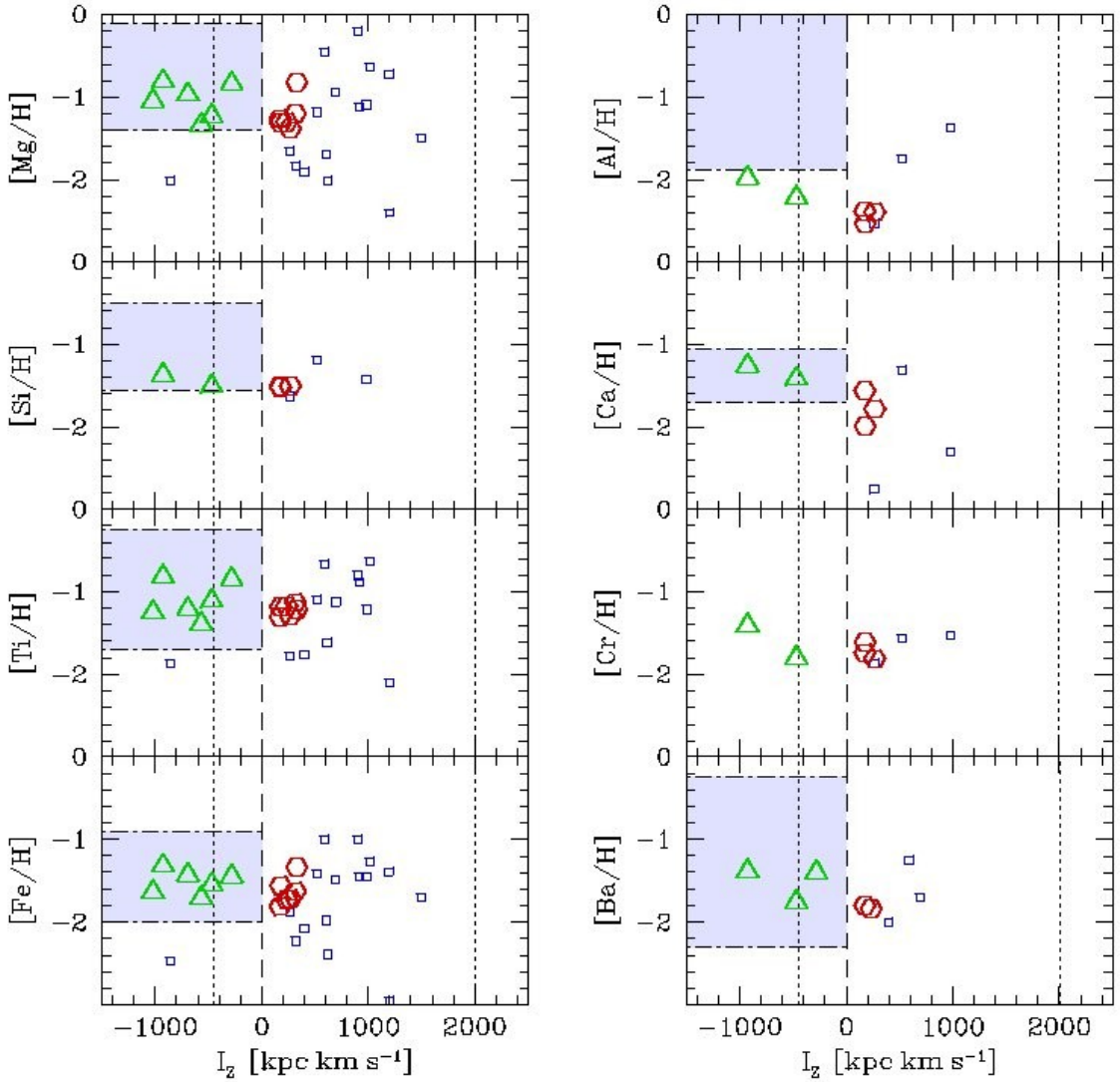
Toomre Diagram of 30 local HBA stars



green triangles: possible. ΩCen debris candi-dates

red symbols: COG stars

Kinematics & Abundances of local HBA stars



Abundance vs. angular momentum

Shaded: Ω Cen abundance range

green triangles: possible Ω Cen debris candidates

red symbols: COG stars

Note the close abundance range of the COGs!

Kinematics & Abundances of local HBA stars

- There is a clear indication of an overdensity of local HBA stars at very low prograde rotation and (Fe/H)=-1.6 - -1.7
- Further study required to substantiate this finding
  - new hi-res spectroscopy over the whole optical range to complete and extend the abundance measurements and verify the COGs and determine the nature of the Ocen debris candidates
    - data set acquired, evaluation currently in progress
  - extend study to larger samples, spanning a larger volume, e.g. those of Wilhelm et al., HQS, etc.

Kinematics & Abundances of local HBA stars

These results need a follow up with better and more homogenous data, more and better sampled star samples, however:

- published in Altmann et al., 2005, A&A 439, L5
- Results show that a galactochemical analysis (i.e. kinematics and differential abundances) can be a valuable tool in the study of old stars
- HBA stars are very suited tracers for this kind of work

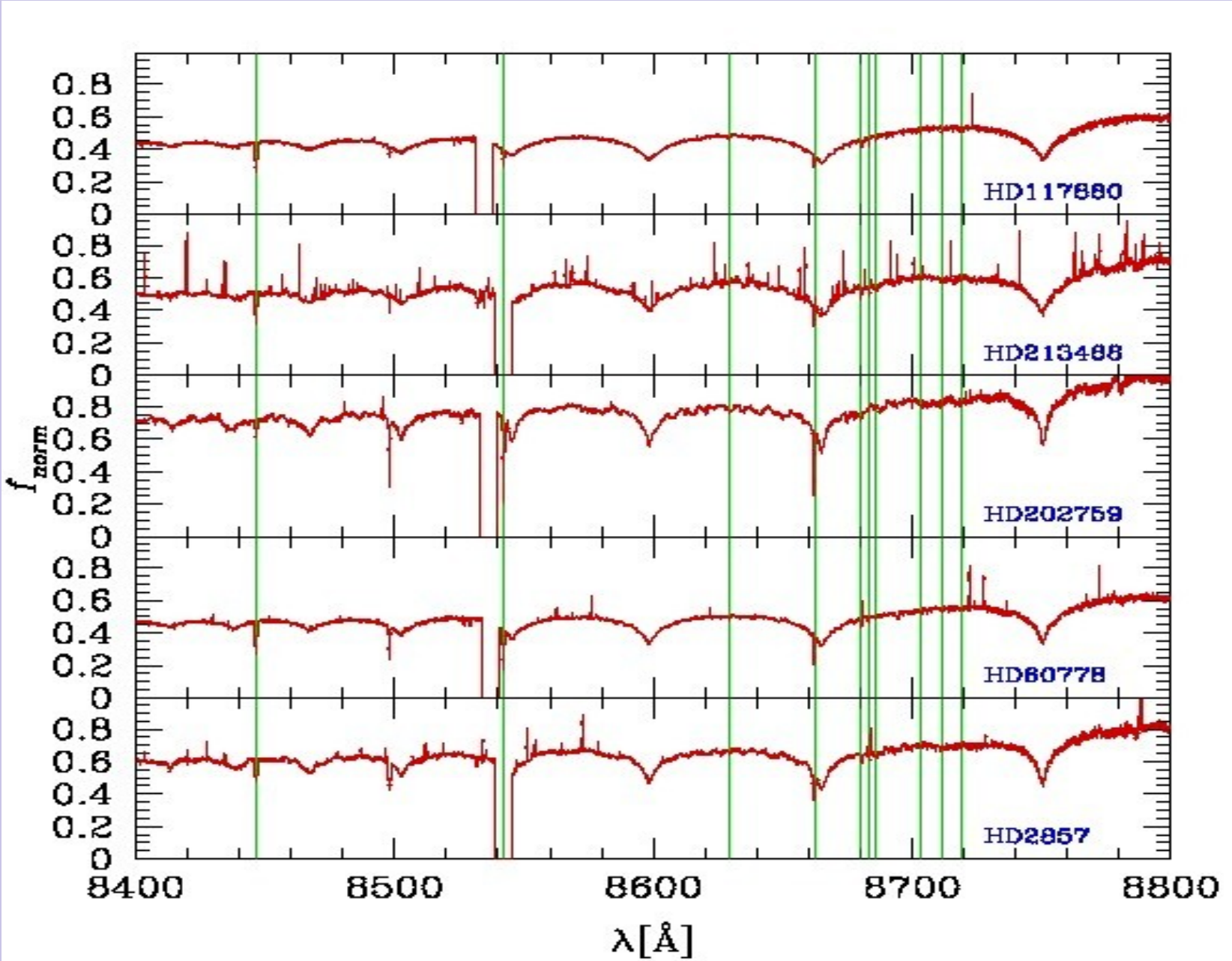
Kinematics & Abundances of local HBA stars

A complete high resolution set of data for most of The 31 stars was taken during 2005-7 using FEROS (ESO-La Silla), FOCES (CAHA), SARG (TNG).

- Data in process of being evaluated.
- For most stars data we have good data
- First Results expected during 2010 (depending on GAIA workload)

- RVS spectral region of 5 randomly selected star spectra shown

Kinematics & Abundances of local HBA stars



Kinematics & Abundances of local HBA stars

This will give us a much better understanding of the origin of the local HBA stars including the nature of the COGs, and the ΩCen question, however:

- Local sample of HBA stars ***very*** incomplete
- Hipparcos (H>7.3 mag) very incomplete – input list driven
- Local HBAs only allow studying the Sun's neighbourhood (d<1.5kpc)

To make statements about the whole Galactic Population of HB stars, we need a larger, more Complete sample with better kinematics!

Enter Gaia:

- **GAIA** will give us a complete sample of ~10^5-10^6 HBA stars
- Significantly improved kinematics
- Will measure HBA stars to ~65 kpc
- Far better Luminosity calibration and hence distance determination
- Limited abundances for the ~10000 brightest stars

Kinematic census of HBA stars for a large part of the Galaxy (except far outer Halo)

Gaia&friends (earth bound telescopes):

- **GAIA** data can be enhanced by earthbound studies:
  - RVs and abundances for stars fainter than Gaia's spectroscopic limit (17 mag)
  - Extension of spectral analysis to the whole optical spectrum, i.e. beyond the GSW of 847-874 nm.
    - Access to more elements
  - Better (higher S/N) spectra

Gaia enhanced by earthbound observations will allow us to really disentangle the origin of different groups of HBA stars, standing as a tracer for stellar populations (especially in the Halo) at large

Outlook

- **Gaia** will certainly revolutionise our view of the Milky Way in an unprecedented way

- **HB(A)** stars can significantly contribute to this "revolution"

- Combining **Gaia** and **groundbased** observations in a sensible way (especially hires spectroscopy in the faint regime) will boost our understanding of the Galaxy and its populations even more.