Chemical tagging of stellar kinematic groups

Hugo Tabernero¹
David Montes¹
Jonay I. González Hernández²

¹Departamento de Astrofísica, Universidad Complutense de Madrid (UCM), Spain.
²Instituto de Astrofísica de Canarias (IAC), Spain.
Moving Groups

- Coherent kinematic streams of stars (Eggen 1958).
- These streams might share a common origin.
- Kinematics dilutes over time.
- Chemical information is preserved.

Young kinematic groups (Montes et al. 2001a)
Chemical Tagging

- Kinematical information is diluted.
- Chemical information is preserved.
- Open clusters have homogeneous abundances.
- Dispersed open clusters should preserve their chemical composition.
- HR 1614 is a true moving group.
- Some moving groups are not dispersed clusters (Williams et al. 2009, Arcturus MG).

De Silva et al. 2009

Two clusters: Hyades, Collinder 261

A Moving Group: HR1614
Summary

- Sample selection
- Observations
- Stellar parameters
- Elemental abundances
- Differential abundances
- Testing ages: log(T)-log(g) diagram
- U, V, and W Galactic velocities
- Conclusions
We will centre on the Hyades Supercluster (maybe originated from the Hyades cluster, see De Silva et al. 2011, Pompéia et al. 2011, Tabernero et al. 2012).

Stars are selected attending to their $U$, $V$, and $W$ galactic velocities.

Stars that lie within approximately 10 km/s around the core velocity of the group are taken as candidates.

All the sample stars were taken from:

Montes et al. (2001a)
López-Santiago et al. (2010)
Maldonado et al. (2010)
Martínez-Arnáiz et al. (2010)
Observations

- HERMES at 1.2 m MERCATOR telescope at La Palma.
- High-resolution echelle spectrograph. (R=86000)
- Wavelength range: 3600-9000 Å
- 90 stars observed: 61 analyzed.
Stellar Parameters (StePar)

- **Automated determination** of: $T_{\text{eff}}$, $\log g$, $\xi$, and [Fe/H] (StePar, Tabernero et al. 2012)

- Based on $EW$ determination of 300 Fe I-II lines with the ARES code (Sousa et al. 2007).

- Iteration until nullify the slopes of $\log(\varepsilon(\text{Fe I}))$ vs $\chi$, $\log(EW/\lambda)$, and $\log(\varepsilon(\text{Fe I})) = \log(\varepsilon(\text{Fe II}))$

- 2002 version of the MOOG code (Sneden 1973)

- Kurucz ATLAS9 plane-parallel model atmospheres (Kurucz 1993).

- **Limitations**: spectral types F6 to K4, slow rotators (< 15 km/s), no veiling.

See Poster number ... (StePar: An automatic code for stellar parameter determination)
Elemental abundances I

- Line lists and atomic parameters from:
  
  Neves et al. (2009)
  González Hernández et al. (2010)
  Pompéia et al. (2011).

- Automated EW determination (ARES, Sousa et al. 2007).

- 20 chemical elements treated:
  - α-peak elements (Mg, Si, Ca, and Ti)
  - Fe-peak elements (Cr, Mn, Co, and Ni)
  - odd-Z elements (Na, Al, Sc, and V)
  - s-process elements: (Cu, Zn, Y, Zr, Ba, Ce, and Nd).

- Elemental abundances are referred to a solar reference (spectrum of the asteroid Vesta)

Blue points: Selected candidates.
Red points: Similar [Fe/H] only.
Green points: Discarded stars.
Orange points: Hyades cluster stars.
Stars: Giants.
Asterik: De Silva et al. (2011) candidates.
Some giants deviate from the galactic trend.

Our stellar parameter determination is adequate for giants?

Lets try another Fe I-II line list

---

Blue points: Selected candidates.
Red points: Similar [Fe/H] only.
Green points: Discarded stars.
Orange points: Hyades cluster stars.
Stars: Giants.
Black Triangles: Hyades cluster stars (Paulson et al. 2003)
Asteriks: De Silva et al. (2011) candidates.
Croses: Pompéia et al. (2011) candidates.
Elemental abundances III

- Fe I-II line list comparison Sousa et al. (2008) vs Hekker & Melendez (2007)

\[ T_{\text{eff}} \text{ offset} \approx 70 \text{ K} \]

Small but negative \( \log(g) \) offset
Testing the variation of $[X/Fe]$ for the new stellar parameter set.

Small differences for $[Ni/Fe]$.

Offset around 0.05 dex, it does not explain why giants deviate so much from the trend.
We employ the reference star (vB 153).

This reference star is the same as in Paulson et al. (2003)

Line-by-line differences are computed for each element.

This treatment minimizes the errors introduced by the atomic parameters (i.e. loggf's)

We apply an rms criterion to select candidates: at least 18 elements at 1-rms, 2 at 1.5-rms.

Blue points: Selected candidates.
Red points: Similar [Fe/H] only.
Green points: Discarded stars.
Orange points: Hyades cluster stars.
Stars: Giants.
Blue points: Selected candidates.
Red points: Similar $[\text{Fe/H}]$ only.
Green points: Discarded stars.
Stars: Giants.
Orange points: Hyades cluster stars.

A pure 1-rms criterium
- 15/61 candidates (25%)

18 elements (1-rms), 2 (1.5-rms):
- 28/61 candidates (56%)
The coolest stars deviate from all the ischrones (systematic offset and a large error).

We find that our stars are consistent with the Hyades Isochrone (700 Myr, Perryman et al. 1998).

Same age does not guarantee membership: both ages and composition are required.
Selected candidates: dispersion in V decreases.

This Moving Group contains both field stars and candidates that may originate from Hyades cluster.

Blue points: Selected candidates.
Red points: Similar [Fe/H] only.
Green points: Discarded stars.
Orange points: Hyades cluster stars.
Conclusions

- We find 28 candidate members (26 dwarfs, 2 giants).
- Other authors (Pompéia et al. 2011, De Silva et al. 2011) find much lower membership numbers (10, 15 % respectively).
- Hyades Supercluster can not originate entirely on the Hyades cluster.
- Until more complete samples are analyzed no clear constraints on the contamination levels can be derived.
- It is still possible to identify members that can be originated from the original cluster.
- More details for the Hyades Supercluster study (Tabernero et al. 2012a, in press)
- Similar study for the Ursa Mayor moving group (Tabernero et al. 2012b, in preparation)
The End