8.22 Chemical Tagging of Stellar Kinematic Groups: The Hyades Supercluster

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Abstract

Stellar Kinematic Groups are kinematical coherent groups of stars which may share a common origin. These groups spread through the Galaxy over time due to tidal effects caused by galactic rotation and disk heating, however some chemical information remains unchanged.

The aim of chemical tagging is to show that abundances of every element in the analysis must be homogeneous between members. We have studied the case of the Hyades Supercluster in order to compile a reliable list of members (FGK stars) based on chemical tagging information.

This information has been derived from high-resolution echelle spectra obtained during our surveys of late-type stars. For selected northern stars of the Hyades Supercluster, stellar atmospheric parameters (Teff, log(g), ξ and [Fe/H]) have been determined using an automatic code which takes into account the sensibility of iron EWs measured in the spectra.

We have derived absolute abundances consistent with galactic abundance trends reported in previous studies. The chemical tagging method has been applied with a carefully differential abundance analysis of each candidate star, using a well-known member of the Hyades cluster as reference.

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Abstract

Stellar Kinematic Groups are kinematical coherent groups of stars which might share a common origin. These groups spread through the Galaxy over time due to tidal effects caused by galactic rotation and disk heating, however the chemical information survives. The aim of chemical tagging is to show that abundances of every element in the analysis must be homogeneus between members. We have studied the case of the Hyades Supercluster in order to compile a reliable list of members (FGK stars) based on chemical tagging information. For a total of 61 stars from the Hyades Supercluster, stellar atmospheric parameters (T_{eff} , log g, ξ and [Fe/H]) have been determined using an own-implemented automatic code (*StePar*) which takes into account the sensibility of iron *EWs* measured in the spectra. We have derived absolute abundances consistent with galactic abundance trends reported in previous studies. The chemical tagging method has been applied with a carefully differential abundance analysis of each candidate member of the Hyades Supercluster, using a well-known member of the Hyades cluster as reference (vB 153). We find a **41 %** of membership candidates based on the differencial abundance analysis, proving that the Hyades Supercluster can not originate solely from the Hyades Cluster.

Sample selection

The sample was selected using kinematical criteria in *U*, *V* galactic velocities taking a dispersion of ≈10 km/s around the core velocity of the group (Montes et al. 2001). We had taken also additional candidates and spectroscopic information about some of these stars from López-Santiago et al. (2010), Martinéz-Arnáiz et al. (2010), and Maldonado et al. (2010). Some exoplanet host star candidates are also taken from Montes et al. (2010).

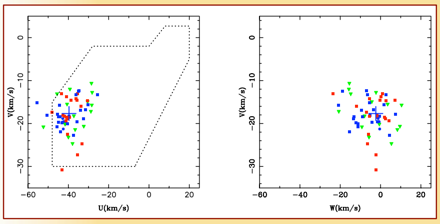

Fig. 1: *U*, *V*, *W* velocities for late-type stars candidate members of the Hyades Supercluster (Tabernero et al. 2011). Blue points are the final selected member stars. Red points are stars compatible with Hyades Fe abundance (but not for other elements), and the green ones not compatible. BZ Cet and V683 Per Hyades cluster members are denoted with circle blue points. The big blue cross indicates the core velocity of the Hyades Supercluster (Montes et al. 2001).

Observations

The spectroscopic observations (see Fig. 2) were obtained at the 1.2 m *Mercator* Telescope in La Palma in January, May and November 2010 with *HERMES*, a high resolution echelle spectrograph. The spectral resolution is 85000, the wavelength range covers from 3800 to 8750 Å. Our S/N ranges from 70 to 300 (160 on average) in the *V* band. A total of **92** stars have been observed. In this contribution only single stars (from F6 to K4.) have been analyzed, being **61** in total.

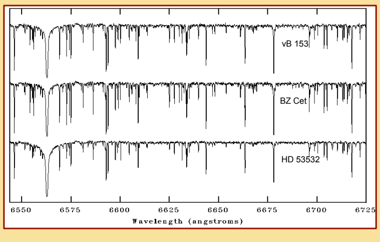

Fig. 2: High resolution spectra for some representative stars of our sample (see Table 1).

Stellar parameters

Stellar atmospheric parameters (**T_{eff}**, log **g**, ξ and **[Fe/H]**) have been determined with a own-developed code (*StePar*, see Tabernero et al. 2011) which iterates until the slopes of χ *vs* log(ϵ(Fe I)) and log(EW/λ) *vs* log(ϵ(Fe I)) where zero and imposing ionization equilibrium: log(ϵ(Fe I)) = log(ϵ(Fe II)). Fig. 3 shows the **T_{eff}** and log **g** histogram for the stars analyzed (The obtained values for representative stars are given in Table 1).

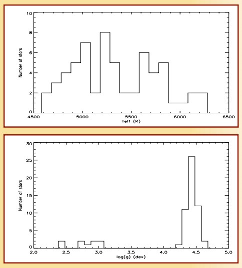

Fig. 3: T_{eff} and log$g$ histrogram of the sample.

Abundance determination

Absolute abundances have been calculated using the equivalent width (*EW*) method in a line-by-line basis. Line lists were taken from (González Hernández et al. 2010) and the *EW* measured with the *ARES* code (Sousa et al. 2007). Abundance analysis was carried out with the *MOOG* code (Sneden 1973) using our determined atmospheric parameters and a solar spectrum taken with the same instrumental configuration. Our abundance trends seem to be consistent with the thin disk solar analogs (González Hernández et al. 2010) as shown in Figs. 4 and 5. Representative abundances are given in Table 1.

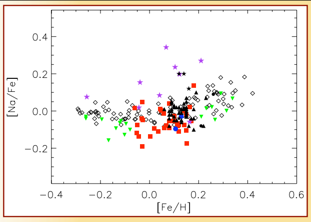

Fig. 4: [Na/Fe] vs [Fe/H]: open diamonds represent the thin disk data (González Hernández et al. 2010), black filled triangles represent Hyades cluster data (Paulson et al. 2003). Red points are our stars compatible with Hyades Fe abundance, and the green ones not compatible. BZ Cet and V683 Per Hyades cluster members are marked with blue circles. Purple starred points represent the giant stars. Black starred points are the candidates selected stars in De Silva et al. (2011), black circles are those selected in Pompéia et al. (2011).

Name	T_{eff}(K)	log g	ξ (km/s)	[Fe/H]	[Na/H]	[Mg/H]	[Si/H]	[Ca/H]
vB 153	5235 ± 36	4.45 ± 0.11	1.14 ± 0.06	0.06	-0.04	-0.04	0.13	0.09
BZ Cet	5035 ± 37	4.38 ± 0.11	0.98 ± 0.08	0.11	0.09	0.09	0.25	0.15
HD 53532	5698 ± 17	4.56 ± 0.05	1.10 ± 0.03	0.12	0.08	0.03	0.18	0.22

Table 1: Example table of determined **parameters** and **abundances** as well as the typical parameter errors. **vB 153** is the Hyades cluster reference star used in the differential analysis, **BZ Cet** is a Hyades cluster confirmed member, and **HD 53532** is a Hyades Supercluster candidate star that satisfies chemical homogeneity.

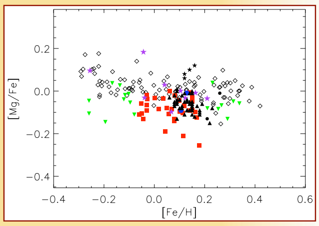

Fig. 5: As Fig. 4, for [Mg/Fe] vs [Fe/H].

Differential abundances

Differential abundances **Δ[X/H]** have been determined by comparison with a reference star known to be member of the Hyades cluster (**vB 153**) in a line-by-line basis (see Paulson et al. 2003 and De Silva et al. 2006). We have computed the differential abundances for the following elements: **Fe**, **Na**, **Mg**, **Al**, **Si**, **Ca**, **Sc**, **Ti**, **V**, **Cr**, **Mn**, **Co**, and **Ni**, the most representative of them are shown in Figs. 6 to 10. A first candidate selection within the sample has been determined by applying a 1-rms rejection for the **Fe** abundance results. In this subsample another 1-rms diagnostic has been applied in order to prove homogeneity in each element (see Figs. 7 to 10).

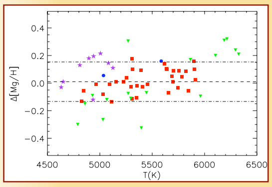

Fig. 7: As Fig. 6, for Δ[Mg/H] vs T_{eff}

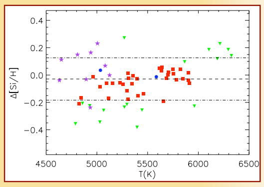

Fig. 9: As Fig. 6, for Δ[Si/H] vs T_{eff}

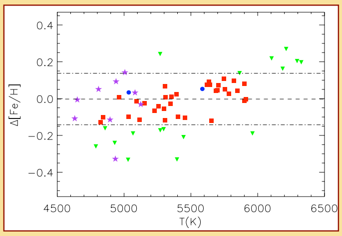

Fig. 6: Δ[Fe/H] differential abundance vs T_{eff}. Dashed-dotted lines represent 1-rms level for the Hyades cluster. The dashed line represents the median abundance. Red points are accepted as a preliminary selection of candidates, while green ones are rejected. The Hyades cluster member BZ Cet and V683 Per are marked with **blue points**. Purple starred points represent the giant stars.

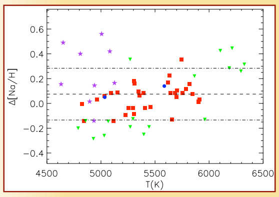

Fig. 8: As Fig. 6, for Δ[Na/H] vs T_{eff}

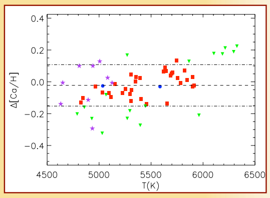

Fig. 10: As Fig. 6, for Δ[Ca/H] vs T_{eff}

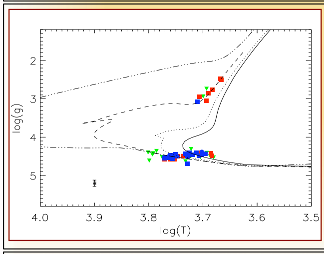

Fig. 11: Spectroscopic log **T_{eff}** vs log **g** for the candidate stars. We have employed the Yale-Yondale ischrones (Demarque et al. 2004) for Z=0.025 and 0.1, 0.7, 4 and 13 Gyr (from left to right). Mean error bars are represented at the right bottom. Blue points are the final selected member stars. Red points are stars compatible with Hyades Fe abundance (but not for other elements), and the green ones not compatible. BZ Cet and V683 Per Hyades cluster members are denoted with circle blue points.

Conclusions

We have computed the stellar parameters and their uncertainties for 61 single Hyades Supercluster candidate stars, after that we have obtained the chemical abundances of 12 elements, and the differential abundances. From the chemical tagging analysis we have found that 25 stars from the original sample are homogeneous in abundances for all the elements we have considered (a **41 %** of the sample), 5 stars fail to be homogeneous in one element. The selected stars are consistent (within the error bars) with the Hyades age (0.7 Gyr, see Fig. 11). A more detailed analysis to check consistency between the different age indicators and the chemical homogeneity is in progress.

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