Chemical Tagging the Hyades Supercluster as a consistency test of Stellar Kinematic Groups

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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 the chemical information survives. 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 and spectroscopic age determinations of this supercluster. This information has been derived from high-resolution echelle spectra. For a small subsample of the Hyades Supercluster, stellar atmospheric parameters (**T_{eff}**, log ***g***, **ξ** and **[Fe/H]**) have been determined using a own-developed automatic code which takes into account the sensibility of iron *EW*s 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.

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).

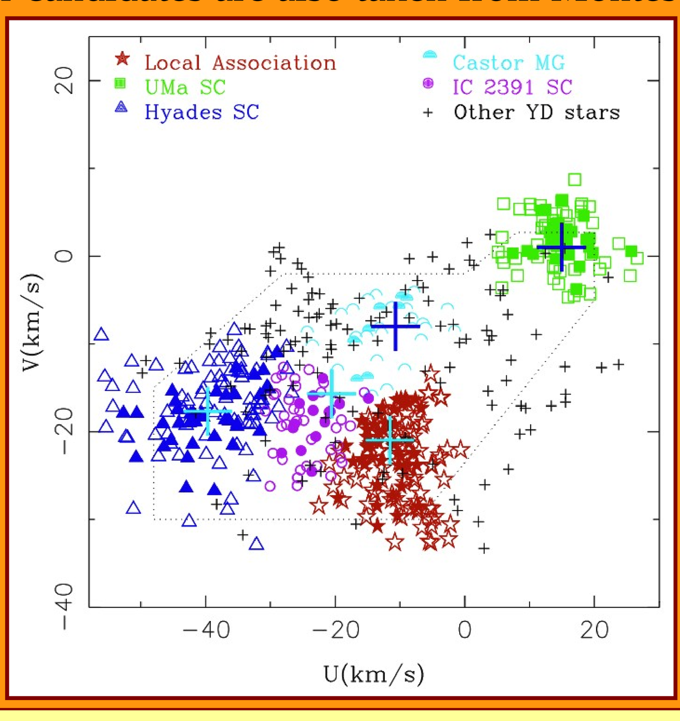

Fig. 1: *U*, *V* velocities for late-type stars possible member of young stellar kinematic groups (Montes et al. 2001). The blue triangles are the Hyades Supercluster candidates stars selected for this study.

Observations

The spectroscopic observations (see Fig. 2) were obtained at the 1.2 m *Mercator* Telescope in La Palma in January and May 2010 with *HERMES*, a high resolution echelle spectrograph. The spectral resolution is 85000, and the wavelength range covers from 3800 to 8750 Å. Our S/N ranges from 70 to 300 (120 on average) in the *V* band. A total of **61** stars were observed. In this contribution only single main sequence stars (from F7 to K4.) have been analyzed, being **42** in total.

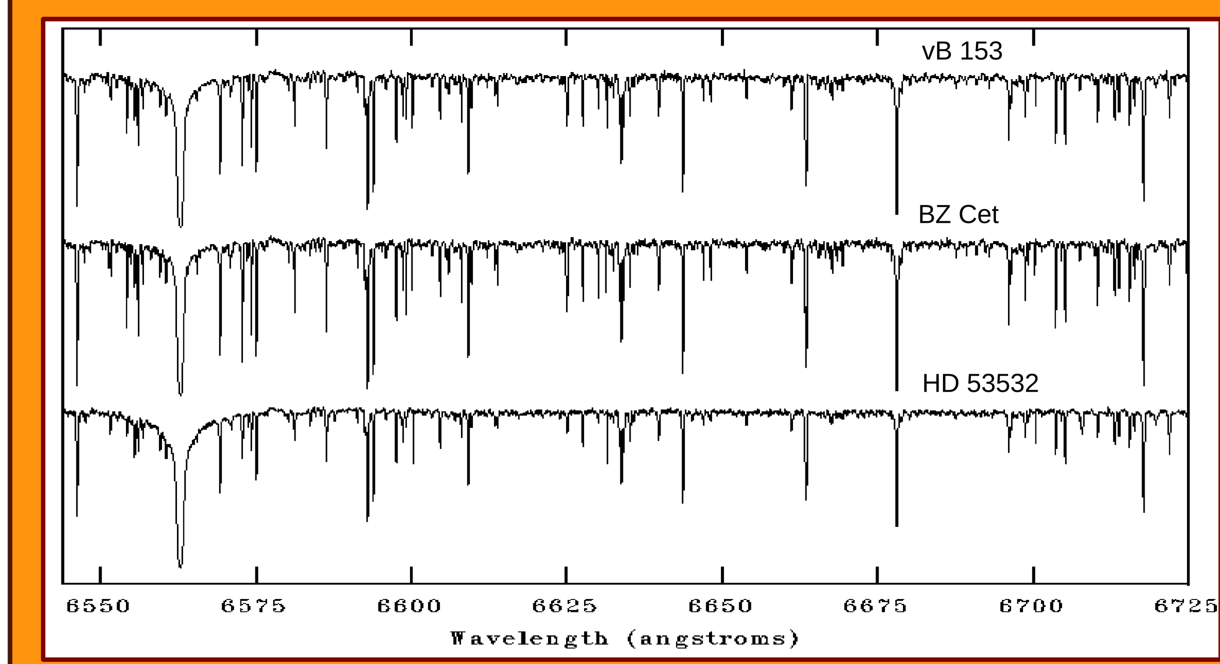

Fig. 2: High resolution spectra for some representative stars of our sample (see Table 1).

Stellar parameters

Stellar atmospheric parameters (**T_{eff}**, log ***g***, **ξ** and **[Fe/H]**) were determined with a own-developed code that 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 show the **T_{eff}** and log***g*** histogram for the stars analyzed. The obtained values for representative stars are given in Table 1).

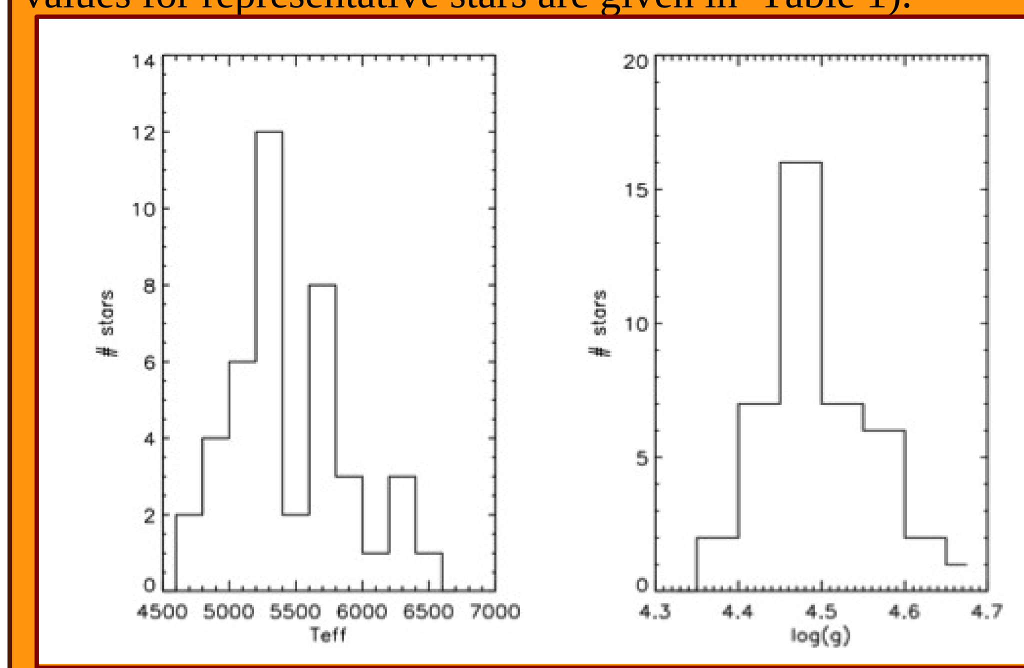

Fig. 3: T_{eff} and log*g* histrogram of the sample.

Abundance determination

Absolute abundances were 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.

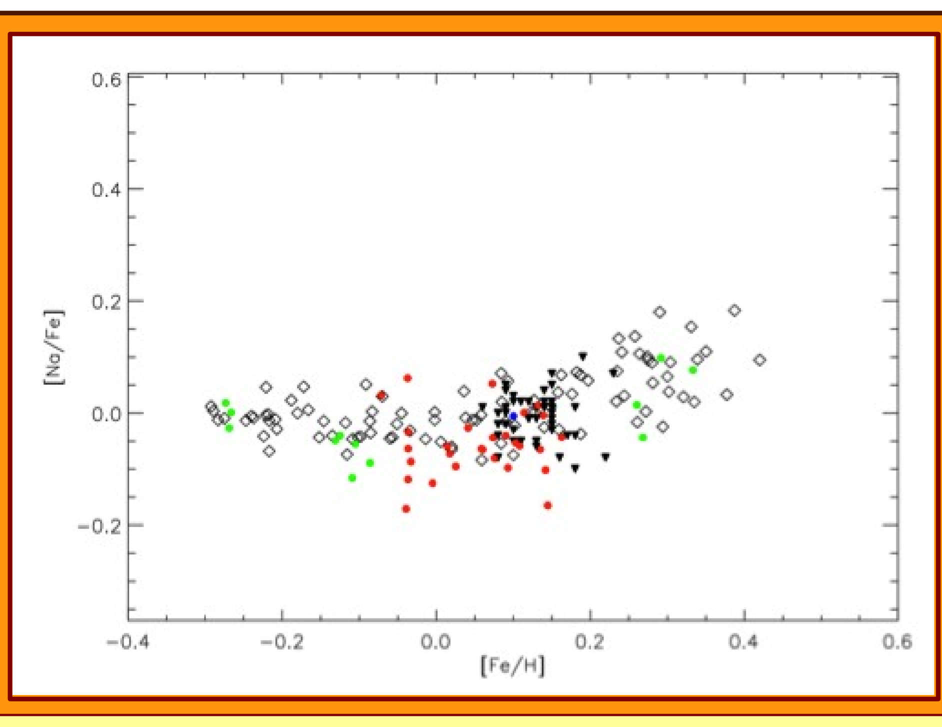

Fig. 4: [Na/Fe] vs. [Fe/H]: open diamonds represent the thin disk data (González Hernández et al. 2010), black filled triangles represent Hyades cluster data (Paulson et al. 2003), red points are our stars compatible with Hyades Fe abundance, and the green ones not compatible. The BZ Cet Hyades cluster member star is marked in blue.

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	5036 ±45	4.39 ±0.12	1.01 ± 0.11	0.10	0.10	0.05	0.17	0.09
HD 53532	5677 ±22	4.53 ±0.07	1.14±0.04	0.09	-0.01	0.03	0.09	0.06

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.

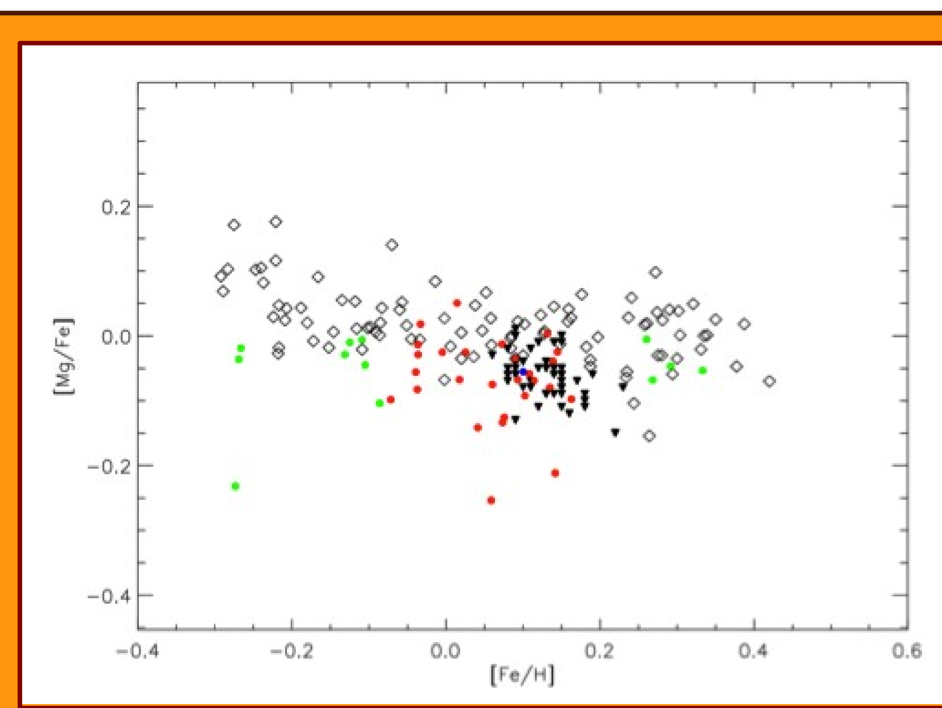

Fig. 5: Same as Fig. 4, but for [Mg/Fe] vs. [Fe/H]

Differential abundances

Differential abundances **Δ[X/H]** have been determined by comparison with the reference star **vB 153**, a known Hyades cluster member, 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 3σ rejection for the **Fe** standard deviation in the Hyades cluster (0.05 dex, Paulson et al. 2003, see Fig. 6). In this subsample another 2.5σ diagnostic has been applied in order to prove homogeneity in each element (see Figs. 7 to 10).

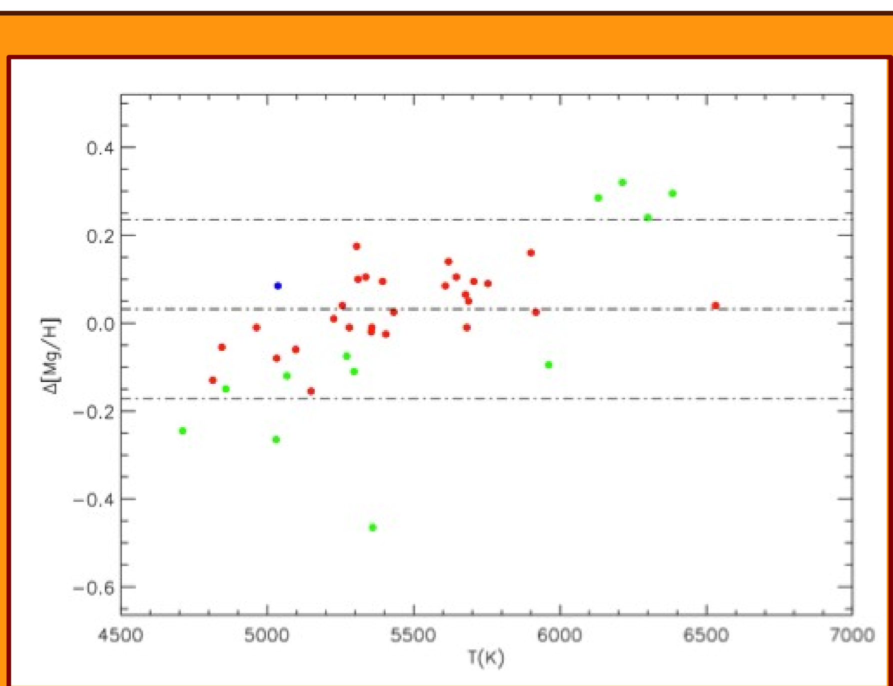

Fig. 7: Same as Fig. 6, but for Δ[Mg/H] vs. T_{eff}

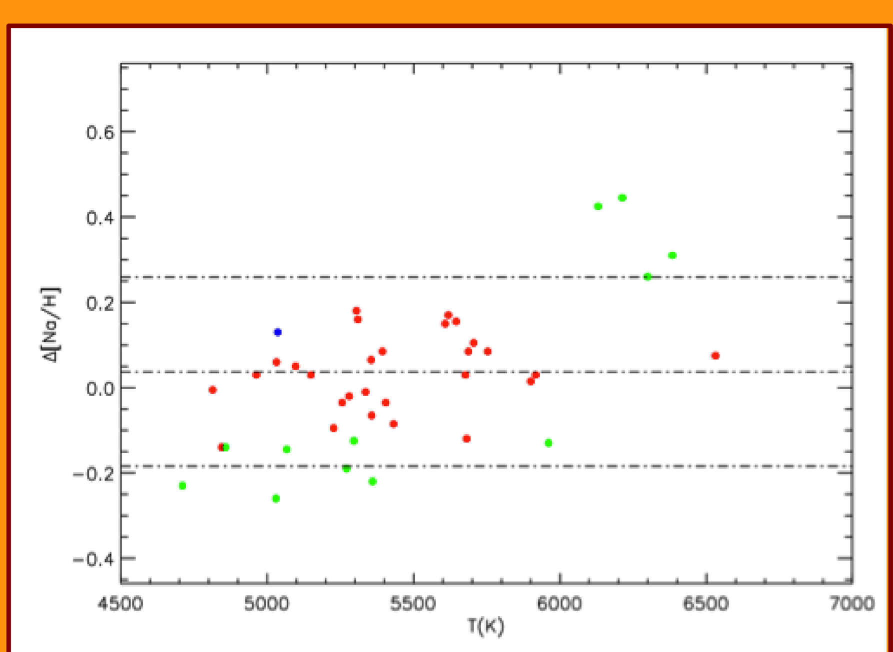

Fig. 8: Same as Fig. 6, but for Δ[Na/H] vs. T_{eff}

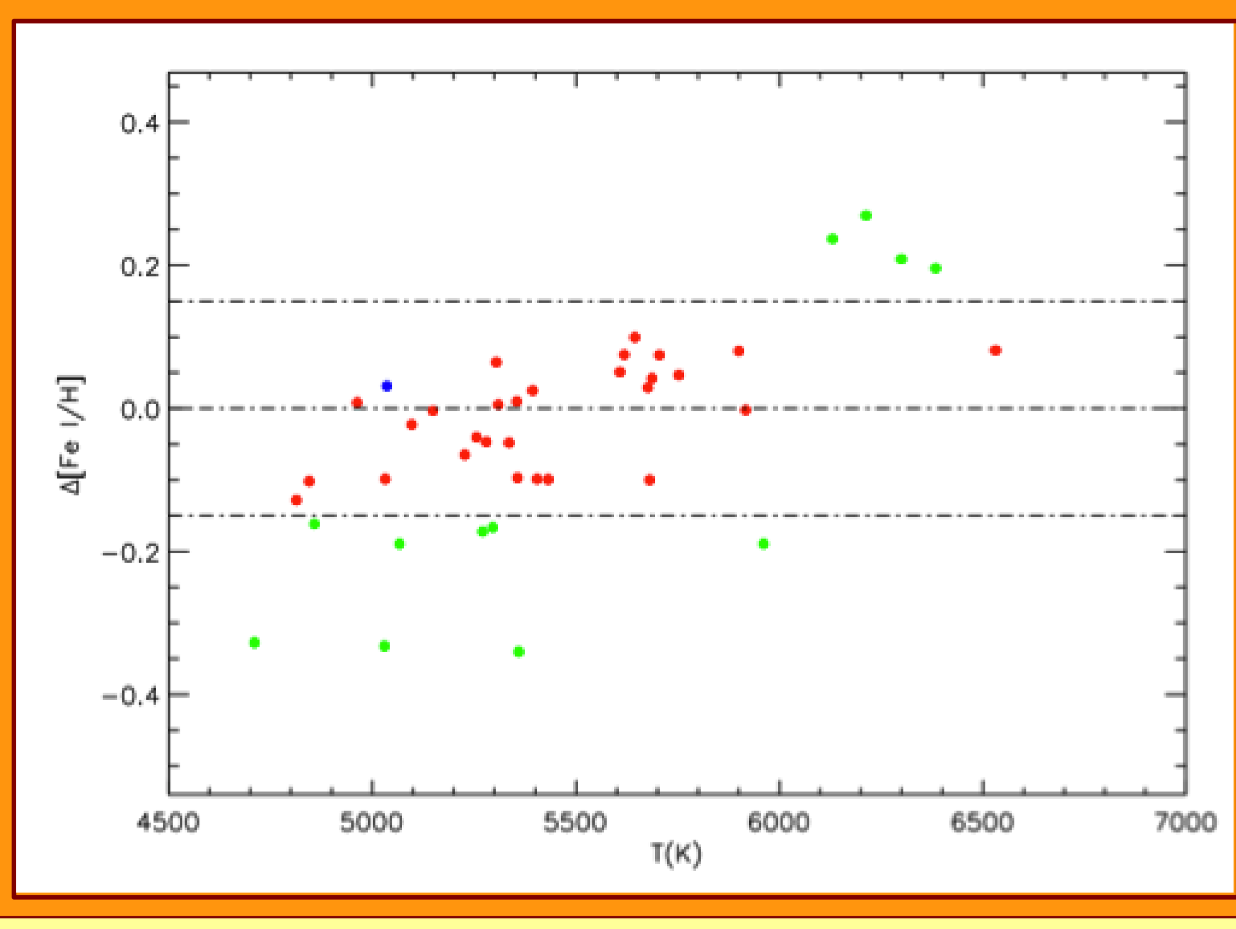

Fig. 6: Δ[Fe/H] differential abundance vs. T_{eff}. Dashed lines represent 3σ level for the Hyades cluster. Red points are accepted as a preliminary selection of candidates, while green ones are rejected. The Hyades cluster member BZ Cet is marked in blue.

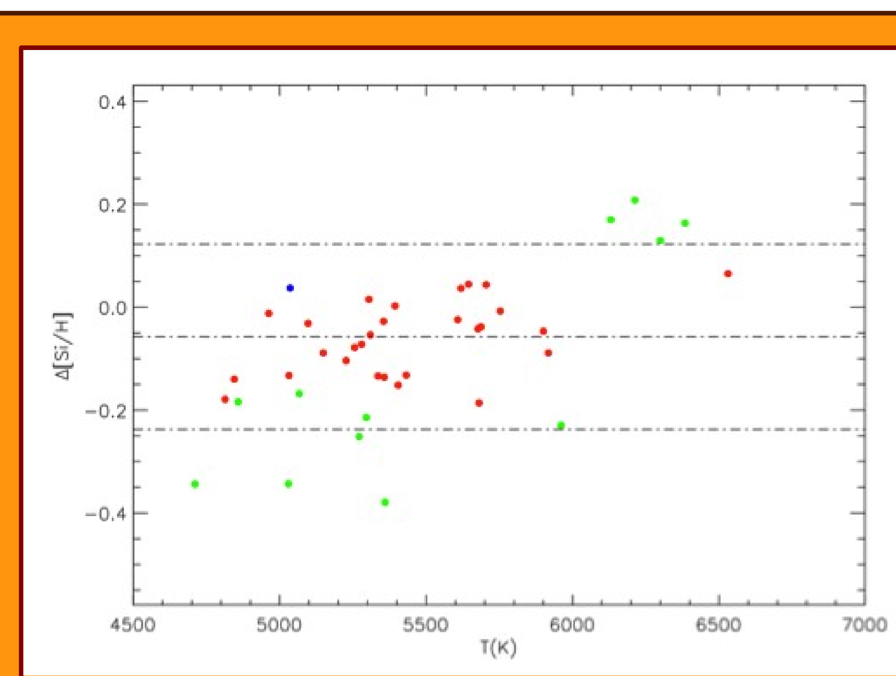

Fig. 9: Same as Fig. 6, but for Δ[Si/H] vs. T_{eff}

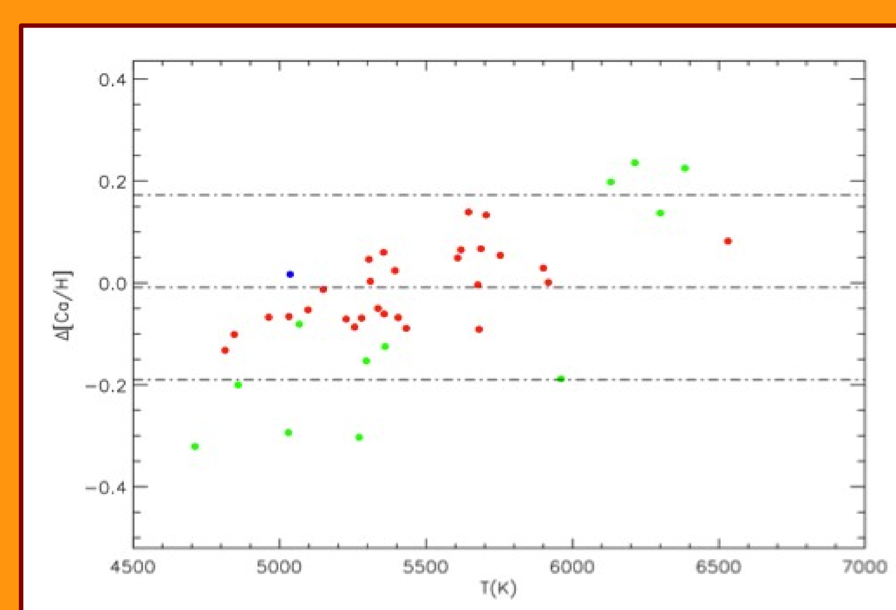

Fig. 10: Same as Fig. 6, but for Δ[Ca/H] vs. T_{eff}

Conclusions

We have computed the stellar parameters and their uncertainties for 42 single main sequence 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 27 stars from the original sample are homogeneous in abundances for all the elements we have considered (a **64%** of the sample), 3 stars fail to be homogeneous in one element. A more detailed analysis to check the consistency between the different age indicators and the chemical homogeneity is in progress.

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