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Microturbulent velocities and abundances for A and F dwarfs in open clusters

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Abstract. The current status of microturbulent velocity and abundance determinations for A and F dwarfs in open clusters is reviewed. A programme to observe several tens of A and F dwarfs in open clusters of various ages was initiated several years ago. We have performed high resolution high signal-to-noise spectroscopy of stars well distributed in mass along the Main Sequence. Microturbulent velocities and abundances of several chemical elements have been derived iteratively by fitting grids of synthetic spectra calculated in LTE to the observed spectra. Curve of growths were used in a few instances as well. The results obtained are reviewed for Coma Berenices, the Pleiades, Alpha Persei and the Ursa Major moving group.

The microturbulent velocities exhibit a broad maximum in the range A5V to about F0V as indicated in Smalley (2004).

Keywords. Turbulence, stars: abundances, (Galaxy:) open clusters and associations: general

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1. Introduction

In the analysis of stellar spectra, microturbulent velocity usually refers to turbulent elements whose size is small compared to unit optical depths. Its value is usually adjusted so that abundances derived from lines of different equivalent widths be equal.

A possible dependence of the microturbulent velocity versus effective temperature was searched (Smith 1973, Coupry & Burkhart 1992, Gray *et al.* 2001). Recently, Smalley (2004) summarized the situation for tepid stars: microturbulent velocities rise from 2 km/s for early A-type stars up to 2–4 km/s for late A-type stars, and then back to 1–2 km/s for mid F-types stars. In this paper, we report on microturbulent velocities determined in the analysis of high dispersion spectra of A and F stars in open clusters, our major goal having been the derivation of elemental abundances.

2. Programme stars, observations and data reduction

Fifteen stars (ten members of Alpha Persei and five members of Coma Berenices) were observed with the AURELIE spectrometer placed at the coudé focus of the 152 cm telescope of the Haute Provence Observatory (OHP)(Tab. 1). Thirty two stars (twenty two members of Coma Berenices and ten members of the Pleiades) were observed with the ELODIE echelle spectrograph attached to the 193 cm telescope of the OHP (Tab. 1).

The IRAF software was used to reduce all spectra following the standard procedure for the mono-order (offset removal, division by flat field and wavelength calibration) and the echelle spectra (bias substraction, finding and centering the orders, removal of the diffuse light, division by the flat field, extracting the spectra, wavelength calibration and merging the orders). The normalization was done with IRAF (we computed synthetic spectra using SYNSPEC, Hubeny & Lanz 1992, to help establish the position of the continuum in each order).

Table 1. Stars and open clusters

Number of stars	Open cluster	Age (Myr)	metallicity $[\frac{Fe}{H}]$	Date of observation	Spectrograph used	Wavelength range (Å)
10	Alpha Persei	70	0.1	October 2005	AURELIE	4450-4600
5	Coma Berenices	450	-0.052	March 2004	AURELIE	4450-4600
22	Coma Berenices	450	-0.052	April 2004	ELODIE	3800-6800
10	Pleiades	140	-0.03	January 2004	ELODIE	3800-6800

3. Microturbulent velocities and abundances analysis

3.1. *Fundamental atmospheric parameters*

The effective temperatures (T_{eff}) and surface gravities (log g) were determined using the Napiwotzki *et al.* (1993) UVBYBETA code based on Strömgren $uvby\beta$ photometry. The routine dereddens the observed photometric indices $(b-y)_1$, m_1 and c_1, then derives T_{eff} and log g from the dereddened indices and the β-index.

3.2. *The method*

Synthetic spectra were computed using Takeda's iterative procedure (Takeda 1995). This code requires two input data, a line list and model atmospheres. LTE model atmospheres were computed using Kurucz' ATLAS9 (Kurucz 1992) code, assuming a plane parallel geometry, hydrostatic equilibrium, radiative equilibrium and depth independent microturbulence. The line list was constructed from Kurucz's gfall.dat list (http://kurucz.harvard.edu), the oscillator strengths were checked using more accurate values from the literature and from the NIST database.

The microturbulent velocity (ξ_t) and the rotational velocity ($v_e \sin i$) were simultaneously determined as explained by Takeda (1995) by fitting the line profile of the Mg II line around 4481 Å and the unblended Fe II lines at 4491.405 Å and 4508.288 Å. The Fe II lines are more sensitive to rotational velocity while the Mg II line is sensitive to both parameters (ξ_t and $v_e \sin i$). Each line gives a set of values for these parameters (usually comparable) and the mean values are adopted. These values were then fixed when modelling all other lines in order to determine the abundances.

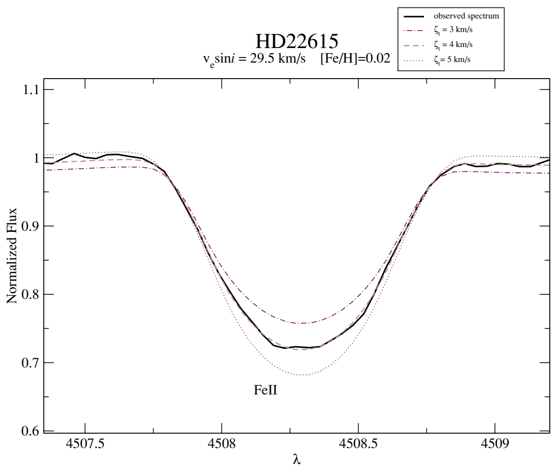

Figure 1. The effect of ξ_t on the shape of the line: the long-dashed line corresponds to a value of ξ_t of 3 km/s, the dotted one corresponds to a ξ_t of 5 km/s while the best agreement (dashed line) corresponds to $\xi_t = 4$ km/s. Observations are shown as solid line.

4. Results and conclusion

We confirm that the microturbulent velocity reaches its maximum around mid A-type stars ($\xi_t \sim 2-4$ km/s), then it decreases to $1-2$ km/s for F stars in agreement with previous authors (Coupry & Burkhart 1992, Smalley 2004, ...).

Our results appear in figure 2 (left). A compilation of microturbulent velocities determined by various authors for the Pleiades, Alpha Persei, Coma Berenices and the Ursa Major moving group appears in figure 2 (right). The broad increase of ξ_t with $T_{\rm eff}$ around 8000 K agrees well with Smalley's (2004) prescriptions.

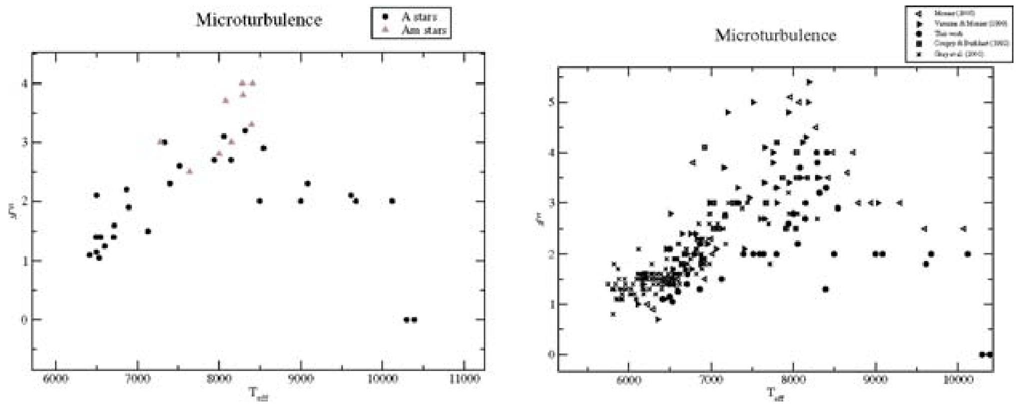

Figure 2. (Left) Plot of ξ_t versus $T_{\rm eff}$ (deduced from this work) for the stars of the Pleiades, Alpha Persei and Coma Berenices. (Right) Plot of ξ_t versus $T_{\rm eff}$ for the stars of this work, Varenne & Monier (1999) and Monier (2005). We added the A-F stars of Coupry & Burkhart (1992) and Gray *et al.* (2001).

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