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Spectral analysis of the stellar content of the North Ecliptic Pole Survey

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Abstract

We report the results (radial and rotational velocities and lithium abundances) of a high resolution spectroscopic analysis of 58 stars of the North Ecliptic Pole survey. The NEP survey with its moderately deep sensitivity (fluxes $\approx 10^{-14}$ erg cm^{-2}sec^{-1}) is the best survey, to date, able to sample the intermediate-age (10^8 - 10^9 years) nearby population. The identification process of NEP X-ray sources resulted in 152 X-ray sources having a normal star as counterpart, with an excess of yellow stars with respect to model predictions.

The radial velocities distribution we found is compatible with a young population comparable to field stars (4x10^9 yrs), or younger. From rotational velocity measurements our sample seems to be dominated by relatively young or intermediate-age stars, as is confirmed from lithium results. We state that most of the sample stars seems to belong to a young or intermediate age population. Nevertheless we hypothesize the presence, among the fastest K rotators, of possible old binary sistems with tidally locked rotation.

1 - Cross-Correlation Technique

We used the Fourier Cross-Correlation technique to derive precise radial and rotational velocities. We use a standard Local Thermodynamic Equilibrium (LTE) spectral analysis. To calibrate the relationship between the width of the cross-correlation peak and the $vsini$ values, we computed an extensive grid of synthetic spectra at different $vsini$, using the ATLAS9 Kurucz model atmospheres, assuming $\log g$=4.5 (cm sec^{-2}), microturbulent velocity ξ=1.0 km/sec and solar metallicity, which are the reasonable parameters of the template star.

The obtained synthetic spectra were cross-correlated with our template and the Full Width at Half Maximum (FWHM) of the cross-correlation peak was measured. The resultant relation between the FWHM of the cross-correlation peak and the corrisponding $vsini$, for the lowest ($T_{\rm eff}$ = 4000 K) and the highest ($T_{\rm eff}$ = 7500 K) values of the temperature range we explored, are shown in Fig. 1. A section of NEP spectra in the lithium region is shown in Fig. 2.

2 - Radial & Rotational Velocities

In Fig. 3 we show the histogram of the heliocentric radial velocities, and the superimposed gaussian radial velocity distribution for the target stars, with a standard deviation of 15 km/s and mean value of -13.5 km/s, that well agrees with the bulk of the data.

The Sun moves relative to the Local Standard of Rest (LSR) with a mean velocity of $|v_{LSR}|$=13.4 km/s. The gaussian radial velocity distribution, which represents a good fit for most of the targets reflects the motion of the Sun relative to the LSR. This distribution is compatible with a young population comparable to disk stars (4x10^9 yrs), or younger. Rotational velocity decreases with increasing age. Our sample seems to be dominated by relatively young or intermediate age stars. This statement is better explained by inspection of Fig. 4, which shows that most of the stars of our sample seems to have an age in range between 10^8 yrs (Pleiades age) and 4x10^9 yrs (field stars, as the Sun, 5x10^9 yrs old).

3 - Lithium Abundances

Of the 58 total observed stars, 25 show a prominent lithium feature, 5 of which are supposed to be binaries. Equivalent widths (EWs) of the Li I line were measured assuming a Gaussian profile of the blend formed by Fe I λ6707.4 and Li λ6708. Effective temperatures were derived from spectral type, as determined in Micela et al. (2007). EWs and $T_{\rm eff}$ were used to derive the Li abundances N(Li) from linear interpolation of the growth curves of Soderblom et al. (1993). In Fig. 5 binary system are flagged with a different symbol (red squares; blue squares for the two components of nep 5520 (SB2)). The lithium EWs of the Pleiades and Hyades clusters were also plotted for comparison (Soderblom et al., 1993, 1990). Fig. 6 shows N(Li), upper limits included, as a function of rotational velocity. Stars that show high N(Li) and low rotation are supposed to be young, and this theory is reinforced by the presence of emission in Hα and particularly in Na I D_1 and D_2 lines for most of them.

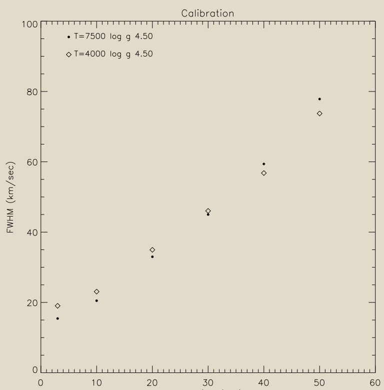

Figure 1: *Calibration curve used for the $vsini$ estimation from the width of the cross-correlation peak. The curve was created by cross-correlating the original spectrum of the template star against a set of artificial versions of the spectrum at different rotational velocities.*

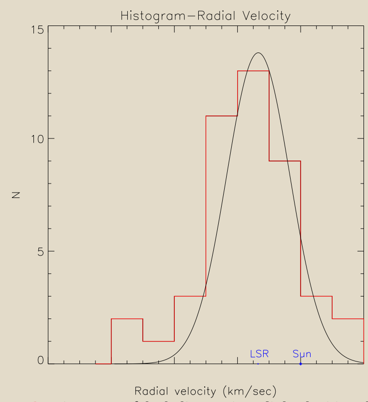

Figure 3: *Histogram of the heliocentric radial velocities, the Sun velocity with respect to the LSR is indicated ($|v_{LSR}|$ =13.4 km/s). The superimposed gaussian radial velocity distribution for the targets with a standard deviation of 15 km/s, is shown.*

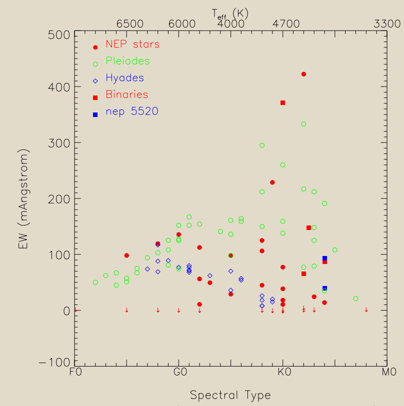

Figure 5: *Distribution of lithium equivalent widths of single NEP stars (red dots) and binary stars (red squares; blue squares for nep 5520 (SB2)), with respect to spectral type, compared to Pleiades (green dots) and Hyades (blue rhombs) distributions. Red arrows indicate EW upper limits for those stars in which no lithium line was visible in the spectrum.*

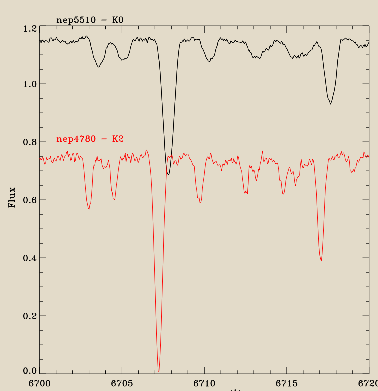

Figure 2: *Normalized spectra in the lithium region for two NEP sources which show a prominent line. These spectra are not corrected for the radial velocity.*

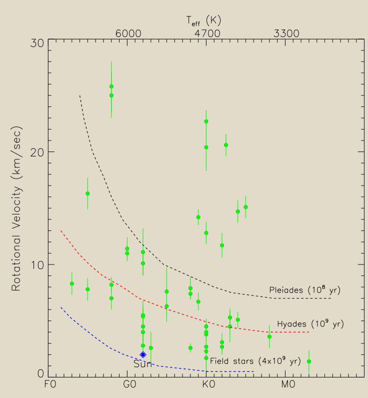

Figure 4: *Rotational velocity distribution with respect to spectral type (temperature); average trends of rotational velocity of Pleiades, Hyades and field stars, are shown.*

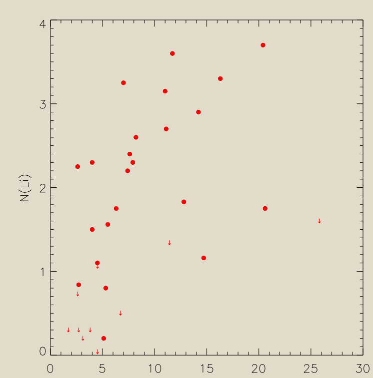

Figure 6: *Lithium abundances with respect to rotational velocity, the arrows indicates upper limits of Lithium abundances.*

Conclusions

We confirmed the presence of an excess of yellow stars in the NEP survey. The most plausible explaination of such excess could be the presence of a young population, that may be due to a recent event of star formation.

We find that the excess is concentrated at high rotations (among K-stars) and that most of the sample stars seems to belong to a young or intermediate age population. Nevertheless we hypothesize the presence, among the fastest K rotators, of possible old binary sistems with tidally locked rotation.

Next step, regarding the detailed abundance analysis, becomes necessary to definitely assess the nature of this population.

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