DYNAMICAL EVOLUTION AND SPECTRAL CHARACTERISTICS OF THE STELLAR GROUP MAMAJEK 2

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Received 2008 July 4; accepted 2008 September 19; published 2009 January 9

ABSTRACT

The dynamical evolution of the recently detected stellar group Mamajek 2 is studied by means of its past three-dimensional orbit. The past orbits of the open clusters NGC 2516 and α Persei, belonging to the so-called “Local Association,” were also computed in order to check for a possible common past dynamical evolution of these systems. To complete the data of the Mamajek 2 small group, we have obtained high-resolution FEROS spectra to measure the radial and also the projected rotational velocities of its members; an estimate of its metallicity was obtained as well. Two exceptionally low-rotating A-type stars turned out to be a strong magnetic Ap star in one case, and a normal A0 star with near-solar metallicity in the other. The dynamical results showed that NGC 2516 and Mamajek 2 may have had a common origin at the age of 135 ± 5 Myr. This dynamical age confirms the individual ages of 140 Myr for NGC 2516 and 120 ± 25 Myr for Mamajek 2 obtained independently by photometric methods. Both these groups appear to have the same solar metallicity giving support to a common birth scenario. The dynamical approach is showing that some bound open clusters can form in a coeval fashion with unbound stellar groups or with associations.

Key words: open clusters and associations: individual (NGC 2516, Mamajek 2) – stars: individual (HD 158450, HD 160142)

1. INTRODUCTION

The recent discoveries of young, loose stellar groups or unbound associations in the solar neighborhood, at distances up to about 100 pc (Zuckerman & Song 2004; Torres et al. 2008) motivated a deeper research of what is known as the Local Association or the Pleiades Supercluster (Eggen 1975, 1983). Historically, this supercluster has been conceived as a very large structure with a radius of a few hundred parsecs containing stars with space velocities similar to those of the Pleiades cluster. Considered in this way, the Local Association would contain different smaller structures, such as the Pleiades, NGC 2516, α Persei, NGC 1039, IC 2602 open clusters and the whole Scorpio-Centaurus (Sco–Cen) OB association.

In an attempt to visualize the structure/dynamics of the Pleiades Supercluster, Skuljan et al. (1999), based on Hipparcos astrometry, made a two-dimensional analysis and found among others, the existence of a “Pleiades branch” in the \( U, V \) space of velocities containing the separated Hyades and Pleiades groups. However, Skuljan et al. (1999) had difficulties in concluding whether this extended branch was due either to some special feature of the potential of the Galaxy or to the local spiral structure. Moreover, a complete mixture of ages was in play in this branch covering some few hundred million years.

Some years ago, we initiated a three-dimensional (3D) Galactic dynamical approach to study in detail the past evolution (ages and formation regions) of different young moving groups related to the Sco–Cen association. First, we studied the low-mass, loose stellar group β Pic, the \( \epsilon \) and \( \eta \) Chamaeleontis young cluster, and the TW Hya association (Ortega et al. 2002, 2004; Jilinski et al. 2005; de la Reza et al. 2006). All of these groups probably originated, along with the younger Sco–Cen component Upper Scorpius (US), in the mainstream of the older Sco–Cen subgroups, Lower Centaurus Crux (LCC) and Upper Centaurus Lupus (UCL), during the last 5–11 Myr.

In Ortega et al. (2007), we tackled the dynamical evolution of the Pleiades open cluster and the AB Dor group. Here, we investigate the common evolution of two further members of the Local Association: the open cluster NGC 2516, and Mamajek 2, a recent detected and studied stellar group (Mamajek 2006). Mamajek (2006) suggests that the Mamajek 2 group may have formed in the same star-forming region of the clusters Pleiades, NGC 2516 and α Persei, and the AB Dor group. In our previous work (Ortega et al. 2007), we found that while the Pleiades cluster and the AB Dor group could have, in fact, had the same origin, the α Persei cluster shows a completely different past dynamical evolution. In the present work, we show that the group Mamajek 2 and the open cluster NGC 2516 may have had a common origin, however, again quite distinct from that of the α Persei cluster.

This paper is organized as follows: in Section 2, we present the main properties of the concerned stellar groups. Section 3 is devoted to the presentation of the observations of the stars of the Mamajek 2 group together with the measured radial and rotational velocities. Section 4 contains the dynamical aspects of the involved stellar groups. Section 5 presents the spectral analysis for two low-rotating A-type stars belonging to the Mamajek 2 group. Finally, Section 6 is devoted to the discussion and conclusions.

2. MAIN PROPERTIES OF THE OPEN CLUSTER NGC 2516 AND THE MAMAJEK 2 STELLAR GROUP

2.1. The NGC 2516 Open Cluster

NGC 2516, also called the “southern Pleiades” by Eggen (1972, 1983), is a rich, nearby, bright open cluster affected by small extinction. In studying possible large gravitational tidal effects (its present tidal radius is about 9 pc; Piskunov et al. 2008) on this cluster, Bergond et al. (2001) noted the regular circular geometry of its center from where two tails emerge almost perpendicular to the Galactic plane. The total mass of NGC 2516 is presently not well known. Values as low as 170 \( M_{\odot} \) have been proposed by Pandey et al. (1987) and as high as about 1000 \( M_{\odot} \) by Dachs & Kabus (1989). More recently a mass of
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∼250 $M_\odot$ for this cluster has been quoted by Piskunov et al. (2008). In contrast, its age appears to be quite well established. Recent literature adopts the age determined by Meynet et al. (1993) by fitting NGC 2516 with an isochrone at 140 Myr.

Concerning the metallicity of NGC 2516, the situation does not seem to be entirely clear. This is mainly due to the fact that bright F stars in NGC 2516, which would normally be used to derive the abundances, possess, in general, largely broadened spectral lines. Terndrup et al. (2002) present a quite thorough discussion of past and more recent metallicity determinations. Nevertheless, because of the importance of this parameter for the present study, some insights will be furnished. After an initial period where several authors (see Terndrup et al. 2002) found for NGC 2516 a metallicity of a few tenths dex below the solar, more recent analysis (Irwin et al. 2007; Jeffries et al. 2001; Sciortino et al. 2001; Sung et al. 2002) places NGC 2516 with a metallicity close to solar. This is in fact the conclusion of a careful spectroscopic analysis, albeit based on only two low-rotating, relatively hot stars, that gives $[\text{Fe/H}] = +0.01 \pm 0.17$. Also, a photometric determination yielded a value of $[\text{Fe/H}] = -0.05 \pm 0.14$. As commented by these authors, an analysis of faint G stars of NGC 2516 with larger telescopes will be necessary to settle the question.

In our discussion, we shall adopt a near solar metallicity for NGC 2516 which then will be compared with that estimated for Mamajek 2. In Section 4, we will see how a near solar abundance of NGC 2516 will be indirectly compatible with its dynamical age.

2.2. The Mamajek 2 Stellar Group

This new stellar aggregate was discovered by Mamajek (2006) based on the common parallel proper motions and similar trigonometric parallaxes of the stars. It contains the bright B8 giant $\mu$ Ophiuchus and eight further B- and A-type stars. This author proposes the coevality of this group located at a present distance of 170 pc and with an age of 120 ± 25 Myr. The scatter distance of the group members is ± 5 pc and the total mass is of the order of 24 $M_\odot$. According to Mamajek (2006), the half-maximum radius of this cluster is 0.4 pc while its tidal radius is of the order of 4 pc.

Adopting the canonical initial mass function (IMF) of Kroupa (2001), Mamajek (2006) proposes that the present existence of these nine stars would imply an initial population of ∼200 systems. So far the low-mass members of this group have not been detected. In this work, we have measured the radial velocities of the proposed members in order to confirm the reality of this stellar group. In fact, previously only two stars ($\mu$ Oph (HD 159975) and HD 158450) had their radial velocities measured (Mamajek 2006). No attempt is made here to detect other cooler and low-mass members.

3. OBSERVATIONS OF THE MAMAJEK 2 STELLAR GROUP

3.1. Radial Velocity Determinations

High-resolution spectra have been obtained for eight of the nine known members of the Mamajek 2 group. Unfortunately, for only one star (HD 159874) this was not possible because of bad weather conditions. There are no data concerning the radial velocity of this star in the literature. For these observations we used the FEROS spectograph attached to the 2.2 m telescope of ESO at La Silla, Chile. The spectra were obtained using a resolution of about $R = 48,000$ and covering a spectral range from 3800 to 9200 Å. The main objective of these observations was to measure the radial and projected rotational velocities and also to determine metallic abundances for some representative stars of the group. Standard FEROS pipeline resources for calibration purposes have been used.

Precise radial velocity measurements for B- and A-type stars are intrinsically difficult. This is partly due to effects of their high temperatures and large or very large rotational velocities, especially of B stars. The few lines available for both types of stars make the measurements difficult. These difficulties are reflected in the fact that there are no appropriate radial velocities for standard stars (again especially for B-type stars). Nevertheless, the high stability of FEROS and its large spectral dispersion, make this instrument one of the best available for radial velocity measurements. To measure these velocities we have followed the same methodology as previously used with hot stars of the Sco–Cen OB association (Jilinski et al. 2006). The cross-correlation technique, which is used for precise radial velocities determinations in later-type stars, can be problematic when applied to the hotter BA stars because early-type stars’ spectra show few absorption lines, which are in many cases intrinsically broad (up to a few hundreds km s$^{-1}$) due to stellar rotation. Because of this, we determine the doppler shift for each measurable unblended spectral line of He i, C ii, N ii, O ii, Mg ii, Si ii and S i, Fe i and Fe ii, and Ti i and Ti ii relative to their rest wavelengths. The measured radial velocities with their error bars are listed in Table 1.

3.2. Projected Rotational Velocities

Projected rotational velocities were determined by the synthetic spectra method, the most accurate method for $v \sin i$ determination consisting in computing the synthetic spectra and comparing them with the observed one (de Medeiros et al. 2006). To select the appropriate atmospheric models, we used the $(B-V)_0$ versus $T_{\text{eff}}$ calibrations from Kenyon & Hartmann (1995) to determine the effective temperature. The observed values of the color indexes $B-V$ and color excesses $E_{B-V}$ were taken from Table 2 of Mamajek (2006). For the star $\mu$ Oph we used $T_{\text{eff}} = 12,020$ K taken from Glagolevsky (1994). A value of the surface gravity equal to $\log g = 4.0$ was adopted for the synthetic spectra calculations.

In general, in order to determine $v \sin i$, we selected two spectral regions: 7770–7780 Å containing the O i infrared triplet and 4470–4490 Å containing the Mg ii 4481.2 line. The values of $v \sin i$ obtained for the Mamajek 2 group are presented in Table 1. Six stars of the group have high rotation compatible with their spectral types (Royer et al. 2002, 2004; Abt & Morrell 1995) and two stars, HD 158450 and HD 160142, show low projected rotation velocities. Star HD 158450 is a peculiar
A-type star with an important magnetic field (Kudryavtsev et al. 2006) believed to be responsible for its low rotation. Star HD 160142, is a normal A0 star, probably seen pole-on. For HD 160142, besides the above-mentioned spectral lines, we consider also the spectral synthesis of the Fe\textsc{ii} line at 4489.183, 4491.405, and 6147.741 Å as well as the Ti\textsc{ii} lines at 4464.449, 4468.507, and 4488.325 Å, which allowed us to determine the projected rotation velocity of this star with an even higher precision. In the case of the chemically peculiar star HD 158450, which has spectral lines broadened by the magnetic field effects, we performed an analysis of the magnetically split Fe\textsc{ii} line at 6149.258 Å.

4. DYNAMICAL EVOLUTION CALCULATIONS

To study the dynamical evolution of stellar groups it is necessary to integrate back in time the 3D orbits of the stars. Beginning with the present distance or initial XYZ positions relative to the Sun and with the presently observed spatial velocities (U V W), the 3D past orbits are calculated using a modeled Galactic potential. More details of the adopted methodology can be found in previous works (Ortega et al. 2002, 2004, 2007; Jilinski et al. 2005; de la Reza et al. 2006).

For small stellar groups and stellar associations, with ages less than ~12 Myr, it was possible to find the dynamical ages and the respective birthplaces by determining the first maximum confinement of the individual orbits. This was the case for the \( \beta \) Pic and TW Hya associations (Ortega et al. 2002, 2004; de la Reza et al. 2006). For clusters, instead, it is advantageous to work with the mean values of the velocities of the stars in order to minimize input errors, especially in the case of a relatively large age of the system. In this case, we evolve the group with unknown age together with another system, preferentially a cluster, having a reasonably well determined age. If both stellar systems attain a maximum approach at some time and if such approach occurs with low relative velocity, we consider this time as the age of the first group. This technique was employed by us in a study of the Pleiades open cluster and the AB Dor association (Ortega et al. 2007). We shall use this methodology in the present work.

Dynamical calculations can give good results only if present positions and space velocities of cluster members have the most precise values as possible. For this reason stars with Hipparcos (ESA, 1997) astrometric data are preferentially used in this work. Likewise, radial velocities of high quality are important. For the Mamajek 2 group we used the mean value of the \( v_{\text{rad}} \) of the Hipparcos stellar members which were measured in this work. These measurements are shown in Table 1. Concerning the mean radial velocities for NGC 2516, we considered the following data: 23.8±0.3 km s\(^{-1}\) obtained for 24 members by Jeffries et al. (1998); 22.0 ± 0.2 km s\(^{-1}\) for 22 members (González & Lapasset 2000); 22.7 ± 0.4 km s\(^{-1}\) for 14 members (Robichon et al. 1999), and finally 24.2±0.2 km s\(^{-1}\) for 57 members by Terndrup et al. (2002). We also check the possibility of common evolution of the Mamajek 2 group with the \( \alpha \) Persei cluster, as suggested by Mamajek (2006). For the \( \alpha \) Persei cluster we used the published U VW values of Robichon et al. (1999) obtained using 46 Hipparcos star members. Spatial velocities given by Makarov (2006) were also considered for this cluster, noting however, that in this case the distances were kinematically determined.

For NGC 2516, the use of a set of different mean radial velocities resulted in different past orbits, clearly indicating that the dynamical calculations are sensitive to this quantity, especially for ages larger than 100 Myr. The sample of Terndrup et al. (2002) contains the largest number of stars. The mean radial velocity quoted by these authors were obtained combining their own observed velocities (33 determinations) with those in Jeffries et al. (1998) for six common members. This also allowed an estimate of the systematical error. The best result indicating a very probable common origin of NGC 2516 and Mamajek 2 groups is that obtained using the data of Terndrup et al. (2002). This can be appreciated in Figure 1 where the past 3D distance between these two groups is shown as a function of time in the past. A maximum approach or a minimum distance of nearly 20 pc is obtained at \(-135 ± 5\) Myr. The uncertainty in the age was estimated through Monte Carlo simulations using 1000 realizations. In Figure 1 (lower panel), we show the past evolution of their relative velocity and angle of approximation.

In Figure 2, we show a similar analysis for the past evolution of the \( \alpha \) Persei cluster and the Mamajek 2 stellar group. It shows that, for both cases Robichon et al. (1999) and Makarov (2006), these systems do not achieve any approach in their evolution. Dynamically there is no relation between them.

Figure 3 shows the mean 3D orbits of Mamajek 2 and the cluster NGC 2516 projected on to the Galactic plane (XY) and on the plane (YZ) perpendicular to the Galactic plane.

5. THE MAGNETIC CHEMICALLY PECULIAR STAR HD 158450

One of the stars of Mamajek 2 group, HD 158450, shows a highly peculiar spectrum. This star was included in the list of "the brighter stars of astrophysical interest in the southern sky" by Bidelman & MacConnell (1973) based on the Michigan blue objective-prism survey of the southern sky as a peculiar A star of the Sr-Cr-Eu type. The presence of a magnetic field on the surface of this star was recently discovered by Kudryavtsev et al. (2006) from spectropolarimetric observations of a sample of chemically peculiar stars at the 6 m telescope of the Special Astrophysical Observatory (Russian Academy of Sciences).

We have only one high-resolution spectrum of HD 158450 obtained on 2007 June 2 (MJD = 54253.31316). Analysis of this spectrum indicated the presence of a strong magnetic field resulting in the magnetic splitting of some spectral lines. The most prominent spectral feature is the Fe\textsc{ii} line 6149.258 Å line, commonly used for magnetic field strength determination due to the specific Zeeman pattern of this line consisting of two \( \pi \)- and two \( \sigma \)-components with the same wavelength shift (Mathys et al. 1997). In unpolarized light the profile of this line in the presence of a magnetic field is a simple doublet (see Figure 4).
The wavelength shift between the red and blue components of the Fe II 6149.258 Å line in our spectrum of HD 158450 is
\[ \Delta \lambda_Z = \lambda_r - \lambda_b = 0.530 \pm 0.010 \text{ Å}. \]
The mean magnetic field modulus (the line-intensity weighted average over the visible stellar hemisphere of the modulus of the magnetic vector) can be estimated by the equation (Stütz et al. 2003)
\[ \frac{\Delta \lambda_Z}{2} = 4.67 \times 10^{-13} \cdot g_{\text{eff}} \cdot \lambda^2 \cdot \langle H \rangle, \]
where \( \Delta \lambda_Z \) is the measured Zeeman splitting in Å, \( g_{\text{eff}} = 1.35 \) is the effective Landé factor, \( \lambda \) is the central wavelength of the unshifted line in Å, and \( \langle H \rangle \) is the mean magnetic field modulus in Gauss. Using this formula we find the mean magnetic field modulus \( \langle H \rangle = 11100 \pm 200 \text{ G} \).

In Kudryavtsev et al. (2006) the mean longitudinal component of the magnetic field was determined to be \( \langle B_l \rangle \parallel = 1570 \pm 180 \text{ G} \), whereas the individual values of the longitudinal magnetic field vary for different dates from \(-2920 \pm 200 \text{ G} \) to \(+810 \pm 240 \text{ G} \), indicating strong variation of the magnetic field strength with stellar rotation.

The high-resolution spectrum obtained by us allowed us to measure the projected rotational velocity of HD 158450 with high precision. Kudryavtsev et al. (2007) determined \( v \sin i = 20 \pm 2 \text{ km s}^{-1} \), a value close to the lower limit for a projected rotational velocity of \( 18 \text{ km s}^{-1} \), which can be achieved with moderate-resolution spectra \( (R = 15000) \) used in the above-mentioned paper. Kudryavtsev et al. (2007) note in their article that rotational velocities of magnetic stars have to be determined using high-resolution spectra and by the comparison of observed spectra with the synthetic ones.

However, the rotational velocities in Kudryavtsev et al. were estimated by the FWHM measurements of two Fe II lines \( (4508.280 \text{ and } 4491.401 \text{ Å}) \) having low Landé factors. The approximation of the Fe II 6149.258 Å magnetically split line by a synthetic spectrum showed that this star has a significantly lower projected rotational velocity of \( v \sin i = 9 \pm 1 \text{ km s}^{-1} \).

Our determination of the radial velocity of this star \( (v_{\text{rad}} = -17.3 \text{ km s}^{-1}) \) is in perfect agreement with the value of \( v_{\text{rad}} = -17.2 \pm 1.4 \text{ km s}^{-1} \) obtained by Kudryavtsev et al. (2007). Previously, Grenier et al. (1999) found the value of \(-22.0 \pm 4.2 \text{ km s}^{-1} \) for the radial velocity of this star. Although the difference in radial velocity is rather large, we note that
Figure 3. Past orbits of NGC 2516 cluster and Mamajek 2 group. The orbit of NGC 2516 was calculated with radial velocities from Terndrup et al. (2002). Each interval between the symbols corresponds to 10 Myr time interval. The first (left) points on the orbits correspond to the current situation and the last (right) ones to the age of \(-135\) Myr. The upper panel shows the orbits projected on the Galactic equatorial plane (XY) and the lower panel on the perpendicular (YZ) plane.

Grenier et al. (1999) measured the radial velocity of this star by correlation with template of the same spectral class. The peculiar nature of the spectrum of HD 158450 could lead to some discrepancy. That is why the double, or multiple nature of this star, as pointed out in the SIMBAD database, needs further investigation by monitoring its radial velocity.

We detected resolved magnetically split lines in this chemically peculiar star. However, a careful determination of the atmospheric parameters and a detailed abundance analysis of this star is beyond the scope of this paper. We emphasize that HD 158450 is a member of the Mamajek 2 stellar group which has a quite well-determined age. A detailed study of this star would then be very important for the understanding of the origin and evolution of stellar magnetic fields, a problem not clarified until now.

6. A CHEMICAL ANALYSIS OF HD 160142

The star HD 158450, being an Ap star, is not appropriate for the metallicity estimation of the Mamajek 2 group. We invested then in an analysis of the normal low-rotating A0 star HD 160142 using the last version of the well-known MOOG program (Sneden 1973). In order to determine the atmospheric parameters of HD 160142, we measured the equivalent widths of neutral and ionized iron lines whose oscillator strength values (\(\log g_f\)) were analyzed by Lambert et al. (1996).

Our analysis was somewhat hampered by the relatively noisy observed spectrum of this star, which makes the measurement of faint Fe i lines with equivalent widths lower than \(10-15\) mÅ difficult. After eliminating suspected blends and very weak lines whose equivalent widths could not be measured in our spectrum with high precision, we used 25 Fe i and 17 Fe ii lines. Following the usual iterative procedure, we derived the effective temperature and microturbulent velocity by requiring the iron abundance to be independent of the excitation potential and the equivalent width (Figure 5). The surface gravity was derived from the ionization equilibrium by finding the value for which the iron abundances from Fe i and Fe ii coincide. The Kurucz’s (1993) grid of atmospheric models was used in the calculations. The following atmospheric parameters (effective temperature, surface gravity, and microturbulent velocity) were derived: \(T_{\text{eff}} = 9320\) K, \(\log g = 3.8\), and \(\xi_m = 2.07\) km s\(^{-1}\), respectively. In this case, the metallicity of HD 160142 is \(\log [\text{Fe/H}] = 7.62 \pm 0.05\), i.e., [Fe/H] = +0.10.

We must note however, that even if the \(T_{\text{eff}}\) value coincides with the photometric temperature based on the \(T_{\text{eff}}\) versus (\(B-V\)) diagram, the obtained value of the surface gravity (\(\log g = 3.8\)) is too low for a star of such a temperature and age.

A different method was then explored to estimate the surface gravity of HD 160142 by analyzing its position on the HR diagram. Knowing the effective temperature \(T_{\text{eff}} = 9320\) K from the photometric data, the surface gravity can be inferred from internal structure models. Using isochrones from the models of Lejeune & Schaerer (2001) for solar metallicity (\(Z = 0.02\)) and...
assuming an age of $\log t = 8.10$ or 126 Myr (similar to the age of the Mamajek 2 group) for HD 160142, we obtained for the surface gravity the value $\log g = 4.27$, resulting in a solar iron abundance for the Fe i lines ($\log\epsilon(\text{Fe}) = 7.51 \pm 0.05$) and a higher abundance for the Fe ii lines ($\log\epsilon(\text{Fe}) = 7.69 \pm 0.08$).

This discrepancy between the iron abundances derived from the Fe i and Fe ii lines may be due to different reasons. Problems with the Fe i/Fe ii ionization balance have been reported for a wide range of stars (e.g., Allende Prieto et al. 1999). Recently Yoon et al. (2008), analyzing a high-resolution spectrum of the known A-type star Vega, have demonstrated the effects of rotation on the derived abundances. They found that, in the case of Vega, the rotation induces an iron ionization imbalance amounting to $\sim 0.35$ dex, but in the opposite sense of that induced by departures from LTE. Thus, if HD 160142 is a high-rotating star seen nearly pole-on, we have to use the model with a lower value of the surface-gravity forcing to achieve the ionization balance, i.e., equality between the iron abundance derived from Fe i lines and that derived from Fe ii lines. We also note that in the case of HD 160142 the microturbulent velocity ($\xi = 2.07$ km s$^{-1}$) was determined using the relatively weak Fe i lines, and may be different for the more intense Fe ii lines. On the other hand, noise can somehow perturb a proper determination of the continuum, introducing an error in the equivalent width measurements of the weak Fe i lines.

Error estimates of the derived atmospheric parameters are not straightforward. An uncertainty of $\pm 0.02$ mag in the correction for interstellar reddening of the observed $(B-V)$ index results in an uncertainty of about $\pm 200$ K in the “photometric” temperature. The typical uncertainty in the microturbulent velocity, obtained in the usual way by finding the value which provides iron abundance independent of the equivalent width of the Fe i lines, is about $\pm 0.2$ km s$^{-1}$. Taking into account uncertainties in the atmospheric parameters, equivalent width determinations, non-LTE effects, and possible effects of rotation (if HD 160142 is indeed highly rotating A star seen nearly pole-on), we estimate that HD 160142 has near solar metallicity $\log\epsilon(\text{Fe}) = 7.62 \pm 0.10$. Nevertheless, taking into consideration all possible sources of uncertainties, we have to note that the real value of the error can be somewhat greater than $0.10$ dex.

It is then fair to conclude that until other cooler stars of Mamajek 2 are discovered and analyzed, a solar abundance for the A0-type star HD 160142 may be adopted as representative of the metallicity of this stellar group.

7. DISCUSSION AND CONCLUSIONS

Calculations of the dynamical history of young stellar groups are a new source of astrophysical knowledge. In the present work, we have investigated the past evolution of three stellar groups, belonging to what historically has been known as the Local Association or the Pleiades Supercluster, with the aim of disentangling the dynamical evolution of their components and making evident possible relations existing between them. These three groups are the open clusters NGC 2516 and α Persei, and the recently detected small group called Mamajek 2 (Mamajek 2006).

We have obtained new data for eight of the nine known members of the Mamajek 2 group by means of high-resolution FEROS spectra. This allows us to measure the radial velocities with a method especially devised for hot stars of spectral types B and A (Jilinski et al. 2006; see Section 3.1). Taking advantage of the high quality of the data, rotational, projected velocities as well as information concerning the nature and chemical abundances of some stars have been obtained. Among the A-type stars of Mamajek 2, we have found only two systems with low values of $v\sin i$. One of them, HD 158450 turned out to be a magnetic Ap star while the other, HD 160142, is a normal A0 star, probably observed in a pole-on orientation. The mean magnetic field modulus of HD 158450 measured by us is $(H) = 11100$ G, confirming the strong field previously found by Kudryavtsev et al. (2006) for this star. However, it is important to note that knowing the value of the magnetic field of a star of known age can be an important ingredient in solving the puzzle of the origin and evolution of stellar magnetic fields.

The chemical analysis of the normal A-type star HD 160142 belonging to the Mamajek 2 group indicates that it has a near solar metallicity.

The new measured radial velocities of Mamajek 2 members were used as input to calculate the $UVW$ components of the spatial velocity of each star and with them the mean 3D past orbit of the group. All these stars have $\text{Hipparcos}$ astrometry. The dynamical calculations produced the following results: the open cluster NGC 2516 and the Mamajek 2 group approached to a minimal distance of about 20 pc at $-135 \pm 5$ Myr. This approach took place in such a way that the angle between the velocity vectors of these two stellar systems was of only 20° and their relative velocity was fairly low ($\sim 12$ km s$^{-1}$). Taken together, all these factors point to a probable common origin of these two structures. We note that the obtained dynamical age of $-135 \pm 5$ Myr for both groups is consistent with the ages found for them in the literature, and obtained independently using photometric isochrones. Furthermore, both groups appear to have similar solar metallicities, supporting a common birth scenario. Another more indirect confirmation, at least for NGC 2516, is the fact that if the metallicity of NGC 2516 was lower than the solar one, as previously suggested by some authors, the photometric age of this cluster would be larger, of the order of 180 Myr (see Tern-Drup et al. 2002). A solar metallicity of NGC 2516, presently more accepted, supports then the dynamical age found in this work.

Contrary to the case of NGC 2516, the past orbit of the star cluster α Persei does not show any indication of a past approach with the Mamajek 2 group (Figure 2).
On the basis of age and kinematics similarities, Mamajek (2006) suggested that the group Mamajek 2, the open clusters Pleiades and α Persei, and the AB Dor association could have formed in the same star-forming complex. Our dynamical studies are showing a different scenario in which the AB Dor group can be considered to be associated with the Pleiades cluster (Ortega et al. 2007), whereas the Mamajek 2 group is associated with the open cluster NGC 2516 but not with Pleiades nor with the α Persei cluster. So the dynamical studies carried out by us point to common formation of a bound structure and a small or large unbound star aggregate. Such a scenario has some resemblance with the model proposed by Kroupa et al. (2001). This model is based on N-body numerical calculations designed to study the formation of open clusters despite the expected gas expulsion resulting from the presence of O-type stars. Starting from a configuration of the Orion Nebular Cluster type, the resulting one resembles the Pleiades open cluster. According to the model, the cluster so formed should be surrounded by an expanding stellar group of the same age as the cluster.

We thank the referee for the valuable remarks and comments that helped to improve this paper. E.G.J. thanks FAPERJ for the financial support under the contract E-26/153.045/2006. We also thank Dr. Licio da Silva who realized the spectral observations.

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