A KINE-CHEMICAL INVESTIGATION OF THE AB DOR MOVING GROUP “STREAM”

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ABSTRACT

The AB Dor Moving Group consists of a “nucleus” of ~10 stars at d ≃ 20 pc, along with dozens of purported “stream” members distributed across the sky. We perform a chemical and kinematic analysis of a subsample of AB Dor stream stars to test whether they constitute a physical stellar group. We use the NEMO Galactic kinematic code to investigate the orbits of the stream members, and perform a chemical abundance analysis using high resolution spectra taken with the Magellan Clay 6.5 m telescope. Using a χ² test with the measured abundances for 10 different elements, we find that only half of the purported AB Dor stream members could possibly constitute a statistically chemically homogeneous sample. Some stream members with three-dimensional velocities were hundreds of parsecs from the AB Dor nucleus ~10⁸ yr ago, and hence were unlikely to share a common origin. We conclude that the published lists of AB Dor moving group stream members are unlikely to represent the dispersed remnant of a single star formation episode. A subsample of the stream stars appears to be both statistically chemically homogeneous and in the vicinity of the AB Dor nucleus at birth. Their mean metallicity is [Fe/H] = 0.02 ± 0.02 dex, which we consider representative for the AB Dor group. Finally, we report a strong lower limit on the age of the AB Dor nucleus of >110 Myr based on the pre-main sequence contraction times for K-type members which have reached the main sequence.

Key words: open clusters and associations: individual (AB Dor Moving Group) – stars: abundances – stars: kinematics and dynamics – stars: late-type

1. INTRODUCTION

It has long been recognized that the solar neighborhood contains a population of young stars with ages and velocities similar to the Pleiades, including the famous star AB Dor (e.g., Jeffries 1995). More recently, Zuckerman et al. (2004) identified a concentration of stars associated with AB Dor at d ≃ 20 pc of apparently similar age and velocity. Using galactic three-dimensional (3D) space velocities and youth indicators such as Hα emission, strong Li absorption, strong X-ray emission, fast rotation, and color–magnitude diagram position, they identified 37 candidate member systems of the “AB Dor Moving Group,” of which appear to comprise a “nucleus,” including AB Dor itself. A detailed examination of the age indicators for AB Dor and its group members by Luhman et al. (2005) convincingly demonstrated that the color–magnitude diagram and Li depletion pattern for the group is suggestive of coevality with the Pleiades open cluster (hence a probable age of ~125 Myr). In the years since, additional members of the AB Dor moving group have been proposed (Torres et al. 2008; Viana Almeida et al. 2009; Schlieder et al. 2010; Zuckerman et al. 2011). da Silva et al. (2009) have tested the membership of these stars, and proposed new members, using an iterative method involving the proximity of candidate stars to each other in UVWXYZ space and to an adopted isochrone in absolute visual magnitude (see also Torres et al. 2006).

If the stars in a moving group are to have shared a common origin, then like open clusters, they should exhibit not only similar space velocity, but also similar chemical composition. De Silva et al. (2007b) and Bubar & King (2010) examined the HR 1614 and Wolf 630 moving groups, respectively, and have shown that using kinematics alone to group stars can be unreliable. These studies found that stars previously identified as group members based solely on their kinematics did not match the abundance patterns exhibited by the other stars in the group. Moving groups such as these with larger velocity spread (usually called “superclusters”) are now believed to be created by dynamical perturbations caused by, e.g., the Galactic bar. They clearly have a wide ranges of ages (Famaey et al. 2008; Bovy & Hogg 2010), and hence are not useful samples for age-related studies of stars. When adopting ages for stars based on their membership to a kinematic group, it is important to know whether the group is consistent with being coeval and co-chemical.

Considering the utility of moving groups for understanding galactic kinematic and chemical evolution, and their interest as targets for planet imaging and circumstellar disk evolution surveys, we have started a project to “chemically tag” some of the young, nearby stellar groups. In this contribution, we test whether purported members of the AB Dor moving group could have a shared origin. We present a detailed kinematic and spectroscopic study of 10 stars identified by Torres et al. (2008) and da Silva et al. (2009) as AB Dor members. These authors have already demonstrated that these stars have Li abundances consistent with other AB Dor members, so we do not discuss Li further. The 10 stars are a subsample of the “stream” members with low projected rotational velocity (v sin i < 20 km s⁻¹) that are outside of the “nucleus” identified by Zuckerman et al. (2004).

2. OBSERVATIONS AND REDUCTION

High resolution optical echelle spectra of the AB Dor stream stars listed in Table 1 were obtained on the nights of 2010 June 25 and 26 with the MIKE spectrograph at the 6.5 m Clay telescope at Las Campanas Observatory. Data was reduced using standard procedures in the IRAF echelle package. These include bias correction, flat fielding, scattered light removal, and wavelength calibration. The tilted slits were dealt with using the IRAF mtools.
package. In order to assure measurement of clean, unblended spectral features, we limited our abundance analysis to the red CCD, therefore the resultant spectra have wavelength coverage from 4850 to 8500 Å, with a resolution of R ~ 60,000 and typical S/N ~ 200–300 per resolution element. For reference, our analysis was carried out with respect to an extremely high S/N solar spectrum from reflected light from the asteroid Ceres, measured with the same telescope and setup.

3. ANALYSIS

3.1. Spectroscopic Analysis

We followed a standard excitation/ionization balance approach to determine basic physical parameters from our stellar spectra (Bubar & King 2010 and references therein). For our initial guesses of these parameters, we used photometric temperatures using the calibrations of Casagrande et al. (2010) and gravities from the tracks of Baraffe et al. (1998). Our input metallicity was assumed to be solar, and we calculated \( v_{	ext{int}} \) using Equation (2) from Allende Prieto et al. (2004).

The largest sources of error in our abundances were uncertainties in the final physical parameters and uncertainties in the line measurements themselves. Other sources of error, such as the \( \log(g_f) \) values used in the line lists, are eliminated (to first order) by our use of a differential abundance analysis. Uncertainties in \( \text{[Fe/H]} \) and the other physical parameters of each star were found using the method described in Bubar & King (2010). Because this method gave us unrealistically large uncertainties in \( \log(g_f) \), we adopted the \( \log(g_f) \) uncertainties using the Baraffe et al. (1998) evolutionary tracks. The physical parameters are given in Table 1. In addition, we include measurements of the equivalent widths of the lithium doublet at 6707 Å. Our measurements agree with those from da Silva et al. (2009).

We also measured lines of Na I, Mg I, Al I, Si I, Ca I, Cr I, Mn I, Ni I, and Ba I. Using the temperature, gravity, microturbulence, and metallicity solution for each star, we determined the abundances relative to the Sun, line by line. We used the mean abundance as our final value for each element and the standard error of the different line abundances as our uncertainty. When a single line was available, we adopted a conservative uncertainty of 0.10 dex. If more than one line was available, but all lines gave the same value (standard error of 0), we adopted a conservative uncertainty of 0.05 dex. The abundances are listed in Table 2.

3.2. Kinematics

For 5 of the 10 stars we studied spectroscopically, we calculated 3D velocities using published astrometry and radial velocities and the matrices of Johnson & Soderblom (1987). The other five stars are lacking Hipparcos trigonometric parallaxes (van Leeuwen 2007). The velocities are summarized in Table 3. We also include the mean velocity of
The three stars with thicker lines tracing their past separations are discussed in Section 4. They appear to be statistically chemically homogeneous with one another, and could have formed together with the AB Dor nucleus. Mean 1σ uncertainties in separation are plotted at 25 Myr intervals at top. The stars plotted here are, from top to bottom, HD 207278, HD 217343, HD 218860A, HD 6569, and HD 224228.

![Figure 1. Separations between the 5 AB Dor stream members with velocities listed in Table 3 and the AB Dor nucleus over the past 250 Myr. The hatched region corresponds to the plausible age range for the AB Dor nucleus (70–150 Myr, most likely near ~125 Myr; but see discussion in Section 3.3). The three stars with thicker lines tracing their past separations are discussed in Section 4. They appear to be statistically chemically homogeneous with one another, and could have formed together with the AB Dor nucleus. Mean 1σ uncertainties in separation are plotted at 25 Myr intervals at top. The stars plotted here are, from top to bottom, HD 207278, HD 217343, HD 218860A, HD 6569, and HD 224228.](image)

| Star          | $U$ (km s$^{-1}$) | $V$ (km s$^{-1}$) | $W$ (km s$^{-1}$) | Ref. |
|---------------|------------------|------------------|------------------|-----|
| HD 6569       | $-7.9 \pm 1.2$   | $-28.9 \pm 1.2$  | $-10.0 \pm 1.2$  | 1,4 |
| HD 207278     | $-8.3 \pm 3.0$   | $-30.2 \pm 2.5$  | $-12.8 \pm 1.6$  | 2,4 |
| HD 217343     | $-3.2 \pm 0.4$   | $-25.4 \pm 0.4$  | $-13.6 \pm 0.3$  | 1,5 |
| HD 218860A    | $-8.3 \pm 1.2$   | $-28.3 \pm 0.9$  | $-10.3 \pm 0.7$  | 3,5 |
| HD 224228     | $-7.5 \pm 0.4$   | $-27.7 \pm 0.3$  | $-13.5 \pm 0.3$  | 1,4 |
| AB Dor nuc.   | $-7.6 \pm 0.4$   | $-27.3 \pm 1.1$  | $-14.9 \pm 0.3$  | 6   |
| Pleiades      | $-6.8 \pm 0.6$   | $-28.1 \pm 0.6$  | $-14.1 \pm 0.4$  | 7   |

**Notes.** All velocities calculated using parallaxes from van Leeuwen (2007). Proper motion and radial velocity references: (1) van Leeuwen (2007), (2) UCAC3 (Zacharias et al. 2010), (3) PPMX (Röser et al. 2008), (4) Torres et al. (2006), (5) Nordström et al. (2004), (6) Mamajek (2010) and E. E. Mamajek (in preparation). (7) Velocity for the Pleiades was calculated using the mean cluster proper motion from van Leeuwen (2007), parallax from Soderblom et al. (2005), and radial velocity from Robichon et al. (1999).

3.3. An Age Constraint on AB Dor

One can constrain the age of the AB Dor nucleus by searching for the main sequence turn-on point (e.g., Pecaut et al. 2012). Using the Zuckerman et al. (2004) sample of nucleus stars, we constructed a $V - K_\text{s}$ versus $M_\text{V}$ color–magnitude diagram (Figure 2) using $V$ magnitudes from Perryman & ESA (1997), $K_s$ photometry from the Two Micron All Sky Survey (2MASS; Skrutskie et al. 2006), and parallaxes from van Leeuwen (2007). We compare the positions of the AB Dor nucleus stars to the dereddened Pleiades color–magnitude sequence from Stauffer et al. (2007), and a main sequence constructed using the relations of Wright (2005) and a custom $B - V$ versus $V - K_s$ color–color fit for field stars.\(^7\)

The Pleiades and field star main sequence are in remarkable agreement for stars blueward of $V - K_s < 3.4$ ($T_{\text{eff}} \approx 4000$ K; using calibration of Casagrande et al. 2008) and $M_V < 8.3$ ($\log(L/L_\odot) > -1.02$). Using the Baraffe et al. (1998) tracks, this zero-age main sequence (ZAMS) turn-on position corresponds to a 0.65 $M_\odot$ star. It takes such a star 120 Myr to contract as a pre-MS star before reaching within 0.01 dex luminosity of the ZAMS. This agrees remarkably well with other modern turnoff and Li depletion ages for the Pleiades (~125 Myr; e.g., Stauffer et al. 1998; Barrado y Navascués et al. 2004; Kharchenko et al. 2005).

\(^6\) The AB Dor nucleus contains roughly ~8 $M_\odot$ of stars within a volume of ~2500 pc$^3$, for a density of ~0.003 $M_\odot$ pc$^{-3}$ (Mamajek 2010), which is a factor of ~40 lower than the local disk density ($\rho_\odot \approx 0.12 M_\odot$ pc$^{-3}$; van Leeuwen 2007). It is unclear whether this subset of members constitutes a true “nucleus” or whether it is a chance over-density of stream members.

\(^7\) http://www.pas.rochester.edu/~emamajek/EEM_dwarf_UBVRIHK_colors_Teff.dat.
For the AB Dor nucleus, there is a well-defined clump of late K-type members which appear to be on the ZAMS, including HIP 25283 \((V - K_2), M_V = 3.16, 7.84\), HIP 26369 \((V - K_2), M_V = 3.23, 7.92\), and HIP 31878 \((V - K_2), M_V = 3.21, 8.00\). The color–magnitude diagram is sparse redward of this; however, the known nucleus members redward of \(V - K_s > 4.78\) \((T_{\text{eff}} < 3180 K; HIP 22738 A, B, AB Dor Ba/Bb)\) are certainly pre-MS. Considering its color–magnitude position with respect to pre-MS, as commonly quoted \(\chi^2\) values in parentheses are 1σ uncertainties in final digits.

### Table 4

A Chemically Homogeneous Subsample of AB Dor Stream Stars

| HD      | \(T_{\text{eff}}\) (K) | [Na/H] | [Mg/H] | [Al/H] | [Si/H] | [Ca/H] | [Cr/H] | [Mn/H] | [Ni/H] | [Ba/H] | [Fe/H] | \(\chi^2\) |
|--------|------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| 317617 | 4870(63)               | 0.01(9)| -0.04(7)| -0.04(4)| -0.10(3)| 0.11(9) | 0.10(5) | -0.09(1) | -0.08(1) | 0.10(5) | -0.03(3) | 8.6     |
| 224228 | 4953(52)               | -0.08(8)| -0.12(3)| -0.14(10)| -0.09(3)| 0.07(8) | 0.07(1) | -0.04(1) | -0.09(2) | 0.12(2) | -0.04(3) | 11.3    |
| 217343 | 5830(59)               | -0.08(4)| -0.15(4)| 0.08(10)| -0.04(3)| -0.01(3) | 0.17(18) | -0.18(4) | -0.11(3) | 0.18(3) | -0.04(4) | 8.9     |
| 199058 | 5737(71)               | -0.08(3)| -0.15(12)| -0.14(1) | -0.06(3)| 0.01(4) | 0.00(10) | -0.09(4) | -0.13(2) | 0.19(2) | -0.03(5) | 7.2     |
| 189285 | 5557(56)               | -0.12(5)| -0.11(7) | -0.05(3) | -0.07(3) | 0.03(3) | 0.00(10) | -0.12(2) | -0.12(3) | 0.11(1) | -0.03(4) | 9.7     |

### Note.
Values in parentheses are 1σ uncertainties in final digits.

For the AB Dor nucleus, there is a well-defined clump of late K-type members which appear to be on the ZAMS, including HIP 25283 \((V - K_s), M_V = 3.16, 7.84\), HIP 26369 \((V - K_s), M_V = 3.23, 7.92\), and HIP 31878 \((V - K_s), M_V = 3.21, 8.00\). The color–magnitude diagram is sparse redward of this; however, the known nucleus members redward of \(V - K_s > 4.78\) \((T_{\text{eff}} < 3180 K; HIP 22738 A, B, AB Dor Ba/Bb)\) are certainly pre-MS. Considering its color–magnitude position with respect to other nucleus members, AB Dor itself is clearly ZAMS, not pre-MS, as commonly quoted \(\chi^2\) values in parentheses are 1σ uncertainties in final digits.

Hence, the use of pre-MS evolutionary tracks for AB Dor A is inappropriate. The stars blueward of \(V - K_s < 3.25 \,(T_{\text{eff}} > 4140 K)\) and brighter than \(M_V < 8.0 \,(\log(L/L_\odot) > -0.96)\) are definitely on the MS. Using the Baraffe et al. (1998) tracks, this corresponds to stars of mass >0.67 \(M_\odot\). It takes a 0.67 \(M_\odot\) star 110 Myr to contract to the ZAMS, hence we can take 110 Myr as a strong lower limit on the age of the AB Dor nucleus.

The cooler AB Dor nucleus members HIP 22738 A \((V - K_s = 4.78, M_V = 10.89)\) and HIP 22738 B \((V - K_s = 5.13, M_V = 11.79)\) have color–magnitude positions nearly coincident with the single-star Pleiades sequence of Stauffer et al. (2007), when one adopts the Hubble Space Telescope Pleiades distance from Soderblom et al. (2005). The location of ZAMS stars with \(V - K_s \approx 3.2\) is at odds with previous younger age estimates \(\sim 50–70\) Myr; Zuckerman et al. 2004; Torres et al. 2008; da Silva et al. 2009, and with recent age estimates for the AB Dor system of \(40–50\) Myr (Guirado et al. 2011)\(^9\) and \(50–100\) Myr (Janson et al. 2007). Our results further corroborate the findings of Luhman et al. (2005) that the AB Dor group is coeval with the Pleiades \((\sim 125\) Myr).

### 4. DISCUSSION

A stellar group that formed simultaneously within a molecular cloud is expected to be chemically homogeneous, except for elements potentially depleted as the stars age (e.g., Li, Be). To test for chemical homogeneity within our sample, we developed an abundance \(\chi^2\) test. We calculated a \(\chi^2\) value for each star individually, using \(\chi^2_{\text{obs}} = \Sigma(X_i - \bar{X_i})^2/\sigma^2\), where \(X_i\) is the measured abundance of the \(i\)th element, \(\sigma_i\) is the uncertainty in this measurement, and \(\bar{X_i}\) is the expected abundance of the star, obtained by a weighted linear least squares fit to the abundance versus \(T_{\text{eff}}\) trend for each element. The \(\chi^2\) values of the individual stars were then summed to obtain a total \(\chi^2_{\text{tot}}\).

We compared \(\chi^2_{\text{tot}}\) to the 95% significance critical values. If our stars constitute a chemically homogeneous sample, \(\chi^2_{\text{tot}}\) should be less than the critical value. If \(\chi^2_{\text{tot}}\) was too high, we rejected the star with the highest individual \(\chi^2\), and repeated the above calculations with the remaining stars. We continued this iterative procedure until a statistically homogeneous subsample was found. Out of our original sample of 10 stars, we found only 5 to be consistent with being chemically homogeneous: HD 189285, 224228, 217343, 199058, and 317617 (Table 4). Our results suggest that roughly half of the purported AB Dor stream stars have dissimilar chemical compositions.

To quantify the degree of chemical heterogeneity of the stream sample, we also calculated the intrinsic abundance scatter necessary to generate the observed scatter for each element in our sample. We mirrored the approach of De Silva et al. (2006), in that \(\sigma_{\text{obs}} = \sigma_{\text{int}} + \sigma_{\text{err}}\), where \(\sigma_{\text{obs}}\) is our observed standard deviation from the mean abundance of each element, \(\sigma_{\text{err}}\) is the average measurement uncertainty we have for the abundance of each element, and \(\sigma_{\text{int}}\) is the intrinsic scatter we are solving for. We find intrinsic 1σ dispersions of 0.02 (Na, Mg), 0.03 (Fe), 0.04 (Cr, Ni), 0.06 (Al, Mn), 0.08 (Ba), and 0.11 (Si). The observed scatter in the Ca abundances is consistent with no intrinsic dispersion for the sample. De Silva et al. (2006) found that the intrinsic dispersion (rms) in abundances for Hyades cluster members was typically <0.03 dex, and most notably only 0.014 dex for Ba (compared to 0.08 dex seen for AB Dor stream stars) and scatter consistent with no intrinsic dispersion for Si (compared to 0.11 dex seen for AB Dor stream stars). This scatter is also consistent with the HR diagram for the Hyades, which Quillen (2002) found yields an intrinsic scatter in \([\text{Fe/H}]\) of <0.03 dex rms. The intrinsic scatter in abundances for AB Dor stream stars is larger than that for a typical open cluster like the Hyades.

We also compare our abundance results to abundances of field stars within 15 pc of the Sun from the S\(^N\) survey of Allende Prieto et al. (2004). In Figure 3, we plot \([\text{Fe/H}]\) versus \([\text{Ba/H}]\) for our stars and the S\(^N\) field stars. Our stars qualitatively match the abundance trends of the field stars. The other elements our sample has in common with the S\(^N\) survey show similar results. Our results suggest that the AB Dor stream stars comprise a sample of young stars with a range of chemical compositions.

One possible explanation for the observed scatter in our abundances is stellar activity (e.g., Schuler et al. 2010). All of the stars have X-ray counterparts in the ROSAT All-Sky Survey (Voges et al. 1999), so we calculate X-ray fluxes following Fleming et al. (1995) and quote the coronal activity of the stars as \(log(L_x/L_{\text{bol}})\) in Table 1. We calculate Spearman correlation coefficients for coronal activity \((log(L_x/L_{\text{bol}}))\) versus abundances for the 10 elements we investigated among the AB Dor stream stars (see Table 5). None of the trends are statistically significant (adopting \(\alpha = 0.05\) significance level), as determined using a critical value table (Zar 1972). We also test whether abundance trends exist versus chromospheric activity as quantified using Hα emission. We calculate residual Hα equivalent widths by subtracting normalized spectra of similar resolution of stars of similar temperature and approximately solar metallicity from...
the Montes & Martin (1998) library of echelle spectra. These residuals are listed in Table 1. In Table 6, we list the Spearman rank order correlation coefficients for residual Hα emission equivalent widths versus elemental abundances. [Mg/H] and [Fe/H] show ～2σ correlations, while our other abundances show no significant correlations with Hα residuals.

However, before making conclusions regarding the intrinsic scatter in the elemental abundances and trends of abundances versus activity, we note that two stars (BD-03 4778 and TYC 486-4943-1) are substantially more active than the other stars in our sample (both in terms of coronal X-ray emission and chromospheric Hα emission; see Table 1). When these three stars are removed from the calculation of the Spearman correlation coefficients for Hα emission versus abundance, we do not see any statistically significant correlations. To examine the influence of these two stars on our results, we repeat our calculation of the intrinsic elemental abundance scatters without these two stars. We find intrinsic 1σ dispersions of 0.01 dex (Fe, Mg), 0.02 dex (Si), 0.04 dex (Ni), 0.05 dex (Cr), 0.06 dex (Mn, Ba), 0.07 dex (Al), and again negligible scatter for the Ca and Na abundances. The intrinsic scatter for [Si/H] dropped significantly when the two active stars are removed from the sample. While the scatter is negligible for some elements, it is measurably higher for others (e.g., Cr, Mn, Ba, Al) than one would expect for a cluster sample. We thus conclude that activity alone is unlikely to explain the observed heterogeneity in abundances among the AB Dor stream stars.

Besides the five stars listed in Table 4, we found that another subsample of three stars (HD 6569, HD 224228, and HD 218860A) is also consistent with chemical homogeneity. Interestingly, these three stars also stay within 200 pc of each other in the past (well closer than any other pairs of stars). These three stars, displayed in Table 7 and shown in bold in Figure 1, are also the three closest stars to the AB Dor nucleus in the past. This combination of chemical and kinematic homogeneity indicates that these three stars could have formed together in the same birthsite, along with AB Dor. Their weighted mean metallicity is [Fe/H] = 0.02 ± 0.02 dex, and if one places the 10 elements on equal footing, one derives a mean metallicity of [M/H] = 0.01 ± 0.02 dex. This is nearly identical to a previous mean estimate for the AB Dor group by Ortega et al. (2007) ([Fe/H] = −0.02±0.02 dex), and the average quoted metallicity [Fe/H] for the Pleiades (+0.04 ± 0.02 dex; Soderblom et al. 2009). Our combined chemical and kinematic results suggest that these values are most representative of the true AB Dor group. Thus, we find that a subsample of the AB Dor stream stars may constitute a kinematically and chemically coherent population, but that one should not assume that all stream stars have a common origin with one another or the AB Dor nucleus.

The nature of the group of 5 chemically homogeneous stars in Table 4 is more difficult to determine. Only two of these stars have Hipparcos parallaxes, so we could not run all five through our kinematic tests. It is possible that some or all of these stars could represent their own stream, distinct from AB Dor, but we cannot say this definitively without more precise kinematic data.

### 5. SUMMARY

We have obtained high-resolution spectra of 10 purported AB Dor moving group “stream” members. Using measured abundances for 10 elements (including Fe) we show that our sample of stream stars is statistically inconsistent with being chemically homogeneous. The abundance trends of these stars are consistent with field star trends, and our results suggest that perhaps half of the stream stars can be considered statistically chemically homogeneous, whereas the other half show slightly different chemical compositions which could reflect birth in regions other than AB Dor’s birthsite. Due to the lack of statistical correlations between stellar activity indicators (log(Lₜ/Lₜ, bol) and Hα emission) and the individual stellar abundances, we surmise that stellar activity alone is unable to explain the observed spread in abundances. Kinematically, only five of our stars have well determined 3D velocities, but we find that two of these were ～400–600 pc away from the AB Dor nucleus when it was born, whereas three of them (which also appear to be statistically chemically homogeneous) could have

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**Table 5**

| Log(Lₜ/Lₜ, bol) vs. Abundance | \( \rho \) |
|-----------------------------|----------|
| [Na/H]                      | 0.48     |
| [Mg/H]                      | 0.28     |
| [Al/H]                      | 0.12     |
| [Cr/H]                      | 0.18     |
| [Mn/H]                      | 0.33     |
| [Fe/H]                      | 0.06     |

**Note.** For the two-tailed test and sample of 10 objects, the \( \alpha = 0.05 \) level of significance corresponds to \( \rho = ±0.648 \) (Zar 1972).
formed in AB Dor’s vicinity at the group’s birth. This kinematically and chemically coherent group has mean metallicity of \[ [\text{Fe/H}] = 0.02 \pm 0.02 \text{ dex}, \] which we think is representative of the AB Dor group. While there does appear to be an AB Dor “nucleus” (Zuckerman et al. 2004), it appears that a significant fraction of the outlying stream members found in Torres et al. (2008) and da Silva et al. (2009) do not constitute a chemically homogeneous or kinematically coherent sample.

We also demonstrate that the AB Dor nucleus must be \( > 110 \text{ Myr} \) based on the presence of three late K-type members which are clearly on the ZAMS. Taking into account the findings of Luhman et al. (2005), the data are strongly in favor of coevality of the AB Dor nucleus with the Pleiades (\( \sim 125 \text{ Myr} \)).

Our survey shows that kinematics, color–magnitude positions, and stellar youth indicators alone are not necessarily sufficient for testing whether a kinematic group of stars actually shares a common origin. Chemical tagging of purported members of moving groups provides an additional diagnostic for testing group membership, and holds promise for piecing together the recent chemo-kinematic history of star-formation in the solar vicinity.

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Table 6
Spearman Rank Order Correlation Coefficients for \( \Delta \text{EW(H\alpha)} \) versus Abundance

| \( \Delta \text{EW(H\alpha)} \) vs. | Full Sample | \( \Delta \text{EW(H\alpha)} \) vs. | TYC 486-4943-1 and BD-03 4778 Removed |
|---------------------------------|-------------|---------------------------------|---------------------------------|
| [Na/H]                          | -0.30       | [Na/H]                          | 0.05                            |
| [Mg/H]                          | 0.62        | [Mg/H]                          | 0.26                            |
| [Al/H]                          | -0.12       | [Al/H]                          | -0.07                           |
| [Si/H]                          | 0.45        | [Si/H]                          | 0.07                            |
| [Ca/H]                          | 0.27        | [Ca/H]                          | 0.43                            |
| [Cr/H]                          | -0.04       | [Cr/H]                          | -0.40                           |
| [Mn/H]                          | 0.30        | [Mn/H]                          | -0.19                           |
| [Ni/H]                          | 0.25        | [Ni/H]                          | -0.14                           |
| [Ba/H]                          | 0.50        | [Ba/H]                          | 0.02                            |
| [Fe/H]                          | 0.58        | [Fe/H]                          | 0.12                            |

Notes. \( \Delta \text{EW(H\alpha)} \) is the estimated chromospheric H\alpha emission (see Table 1 and Section 4). For the two-tailed test and sample of 10 objects, the \( \alpha = 0.05 \) level of significance corresponds to \( \rho = \pm 0.648 \) (Zar 1972). Whether or not the two active stars TYC 486-4943-1 and BD-03 4778 are included in the sample, none of the activity versus abundance correlations have significance beyond \( \alpha = 0.05 \).

Table 7
A Chemically and Kinematically Coherent Population of AB Dor Stream Stars

| HD    | \( T_{\text{eff}} \) (K) | [Na/H] | [Mg/H] | [Al/H] | [Si/H] | [Ca/H] | [Cr/H] | [Mn/H] | [Ni/H] | [Ba/H] | [Fe/H] | \( \chi^2 \) |
|-------|--------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|
| 224228| 4953(52)                 | -0.08(8)| -0.12(3)| -0.14(10)| -0.09(3)| 0.07(8)| 0.07(1)| -0.04(1)| -0.09(2)| 0.12(2)| -0.04(3)| 5.0       |
| 218860A| 5543(49)                 | -0.06(4)| 0.00(8)| 0.02(6)| 0.02(2)| 0.09(4)| 0.14(5)| -0.01(3)| -0.02(2)| 0.26(2)| 0.05(3)| 7.5       |
| 6569  | 5170(59)                 | -0.05(5)| -0.02(6)| 0.01(2)| -0.04(3)| 0.04(2)| 0.20(2)| 0.02(3)| 0.08(3)| 0.22(2)| 0.06(3)| 17.5      |
| Wt. Mean | ...                        | -0.06(3)| -0.09(3)| 0.01(2)| -0.02(1)| 0.05(2)| 0.10(1)| -0.03(1)| -0.04(1)| 0.20(1)| 0.02(2)| ...       |

Note. Values in parentheses are 1\( \sigma \) uncertainties in final digits.

Facilities: Magellan:Clay (MIKE spectrograph), HIPPARCOS, ROSAT, CTIO:2MASS

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