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THE AB DORADUS MOVING GROUP

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ABSTRACT

From radio to X-ray wavelengths, AB Doradus has been an intensively studied star. We have identified ∼30 nearby star systems, each with one or more characteristics of youth, that are moving through space together with AB Dor. This diverse set of ∼50 million year old star systems is the comoving, youthful group closest to Earth. The group's nucleus is a clustering of a dozen stars ∼20 pc from Earth that includes AB Dor itself. The AB Dor moving group joins the previously known and somewhat younger and more distant Tucana/Horologium and TW Hydrae associations and the β Pictoris moving group as excellent laboratories for investigations of forming planetary systems.

Subject headings: open clusters and associations: individual (AB Doradus moving group) — stars: kinematics — stars: pre–main-sequence

1. INTRODUCTION

The past few years have seen the identification of a variety of comoving stellar groups near the Sun with ages in the range 8–30 Myr, which is characteristic of the period during which the planets of the solar system were forming (see Jacobsen 2003, Kasting & Catling 2003, and references therein). The first such group to be identified was the TW Hydrae association, ∼55 pc from Earth. Then the somewhat nearer Tucana/Horologium association was discovered, followed soon after by the even closer β Pictoris moving group whose stars are typically ∼35 pc from Earth. With but a few exceptions, all stars in these groups and the somewhat more distant (97 pc) η Chamaeleontis cluster are located deep in the southern hemisphere (see Zuckerman & Song 2004 for a recent review).

Given that nearby main-sequence stars are brighter and thus more prominent and easier to study than more distant ones, we anticipated that no substantial stellar association closer than the β Pictoris group would ever be identified. But we were wrong. We have identified the ultrarapid rotator, quintessential active binary star, AB Doradus, only 15 pc from Earth, as the most famous member of a young, comoving, stellar group that partially surrounds the Sun (Table 1). Many AB Dor group stars are found in the northern hemisphere.

Current adaptive optics (AO) systems on large telescopes and the Near-Infrared Camera and Multi-Object Spectrometer on the *Hubble Space Telescope* (*HST*) become sensitive to faint objects near bright ones at separations larger than about 1″. As may be seen in Table 1, about half the stars in the AB Dor moving group are sufficiently close to Earth that planets within 30 AU of these stars are accessible to AO and *HST*. Such systems can be probed for warm (self-luminous) planets of a few Jupiter masses having semimajor axes comparable to those of the giant planets of the solar system.

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2. OBSERVATIONS

In 2001 we began a spectroscopic search for young stars near the Sun using the double-beam grating and echelle spectrographs on the two Nasmyth foci of the Australian National University's 2.3 m telescope (see, e.g., Zuckerman et al. 2001 for a few early results) and the Hamilton echelle spectrograph at the coudé focus of the 3 m telescope at Lick Observatory. Some spectra have also been obtained with the High Resolution Echelle Spectrometer (Vogt et al. 1994) at the 10 m Keck telescope and with an echelle spectrometer on the 2.5 m telescope at Las Campanas Observatory. The primary goal of these observations is the measurement of radial velocity and $v \sin i$ along with the equivalent widths of the Hα and Li λ6708 lines. Radial velocity, in conjunction with proper motion and parallax, enables us to calculate the three-dimensional Galactic space motions U, V, W that are essential for the identification of individual moving groups. Details of our observations and results can and will be found in Song et al. (2003) and I. Song et al. (2004, in preparation).

The spectral types in parentheses listed in the fifth column of Table 1 are based on $V-K$ colors in preference to SIMBAD-listed spectral types. Most of these stars have been little investigated previously (few references in SIMBAD), and catalog spectral types are not necessarily reliable. Some, for example, HIP 26369 and 31878, are members of binary systems where a companion with consistent spectral type and $V-K$ can be used as a fiducial point. In addition, we can classify some of the stars based on our own grating spectrometer data (I. Song et al. 2004, in preparation).

Entries for radial velocity, lithium, Hα, and $v \sin i$ in Table 1 are our own measurements. Additional measurements of some of these quantities may be found in the papers listed in the references/notes column, i.e., the last column of Table 1. A question mark in this column indicates questionable membership; for example, one component of U, V, W may differ by a few kilometers per second from the group mean, or the lithium equivalent width or X-ray luminosity may be somewhat low for a typical star of age 50 Myr. We have not observed PW And or LO Peg.

TABLE 1
THE AB DOR MOVING GROUP

HIP	Other Name	R.A. (J2000)	Decl. (J2000)	Sp.	V (mag)	D (pc)	RV (km s^{-1})	Li (mÅ)	Hα (Å)	$v \sin i$ (km s^{-1})	U, V, W (km s^{-1})	Refs./Notes
	PW And	00 18 20.9	+30 57 22	K2 V	8.6	(28)	…	…	…	…	−4.4, −27.1, −16.1	1–4
3589	HD 4277	00 45 50.9	+54 58 40	F8 V+K3	7.8	48.5	−15.4 ± 0.5	119	+0.91	24	−8.9, −26.6, −15.8	3″.8 binary
5191	HD 6569	01 06 26.1	−14 17 47	K1 V	9.5	50.0	+6.0 ± 1.2	150	+0.72	10	−8.6, −31.1, −9.3	?; 23″ binary
6276		01 20 32.3	−11 28 04	(G8)	8.4	35.1	+9.9 ± 1.0	145	+0.76	10	−4.7, −27.8, −13.6	
10272	HD 13482	02 12 15.4	+23 57 29	K1+K5	7.8	32.3	−1.3 ± 0.3	110	+0.80	<10	−7.1, −28.3, −11.8	?; 3; 1″.8 binary
12635		02 42 20.9	+38 37 22	(K3.5)	10.2	49.6	−4.1 ± 0.3	146	+0.23	6	−8.7, −28.7, −13.1	
12638	HD 16760	02 42 21.3	+38 37 08	G5	8.7	49.6	−3.3 ± 0.2	158	+1.09	27??	−9.3, −28.3, −13.4	
13027	HD 17332	02 47 27.4	+19 22 18	G0+G5	6.9	32.6	+4.1 ± 1.3	155	+0.90	13	−8.5, −28.5, −12.9	5, 6; 3″.6 binary
14807		03 11 12.3	+22 25 24	(K6)	10.6	49.8	+4.1 ± 0.3	34	+0.10	…	−5.1, −28.6, −16.1	
14809		03 11 13.8	+22 24 58	G5	8.5	49.8	+5.2 ± 0.2	145	+0.87	…	−6.0, −28.3, −16.7	
16563A	V577 Per	03 33 13.5	+46 15 26	(G5)	8.2	33.8	−6.0 ± 0.3	200	+0.70	7	−6.5, −25.6, −15.7	1, 7, 8
16563B		03 33 14.0	+46 15 19	M0	11.2	33.8	−6.1 ± 1.1	30	−2.50	20	−6.5, −25.6, −15.7	
17695		03 47 23.3	−01 58 20	M3	11.6	16.3	+16.0 ± 1.7	0?	−2.20	18	−7.4, −27.1, −10.6	
18859	GJ 159	04 02 36.7	−00 16 08	F5 V	5.4	19.2	+17.0 ± 0.3	100	+1.08	14	−7.2, −28.6, −11.6	1, 9, 10
19183	HD 25953	04 06 41.5	+01 41 03	F5	7.8	55.3	+17.6 ± 0.6	120	+1.20	…	−6.9, −27.8, −14.3	
25283	HD 35650	05 24 30.2	−38 58 11	(K7)	9.1	17.7	+30.9 ± 1.0	0	+0.28	6	−7.1, −27.0, −14.5	
25647	AB Dor	05 28 44.8	−65 26 55	K1	6.9	14.9	+33.0 ± 3.0	295	+0.10	80	−7.5, −29.8, −16.0	1, 3, 8, 11; 9″ binary
26369		05 36 55.1	−47 57 48	(K7)	9.8	23.9	+31.1 ± 1.1	30	−0.80	44	−7.2, −27.0, −13.9	
26373	UY Pic	05 36 56.8	−47 57 53	K0 V	7.9	23.9	+31.0 ± 1.0	240	+0.54	9	−7.2, −26.9, −13.9	1, 3
30314	HD 45270	06 22 30.9	−60 13 07	G1 V	6.5	23.5	+30.0 ± 0.7	135	+1.05	16	−7.6, −26.7, −13.6	3, 6, 12
	GSC 8894-426	06 25 55.9	−60 03 28	M2	11.7	(22)	+31.8 ± 2.0	0	−3.90	…	−10.3, −27.7, −15.6	
31711	HR 2468	06 38 00.4	−61 32 00	G1.5 V	6.2	21.7	+33.4 ± 1.0	120	+0.84	15	−7.1, −28.5, −15.0	1, 3, 12–14; 0″.8 binary
31878		06 39 50.0	−61 28 41	(K7)	9.7	21.9	+30.5 ± 0.7	50	+0.26	12	−7.2, −27.4, −13.9	
36349	V372 Pup	07 28 51.4	−30 14 48	(M3)	10.0	15.6	+26.6 ± 1.0	0	−2.35	20	−7.4, −24.4, −15.7	0″.3 binary
63742	HD 113449	13 03 49.7	−05 09 42	(K1)	7.7	22.1	+2.0 ± 0.5	142	+0.74	6	−5.0, −28.8, −9.8	1, 3, 4, 15
76768	HD 139751	15 40 28.4	−18 41 46	(K7)	10.1	42.6	−8.9 ± 0.4	110	−0.55	8	−7.5, −31.9, −15.6	?; 0″.9 binary
81084		16 33 41.6	−09 33 12	M0.5	11.3	31.9	−15.0 ± 0.4	0	−0.60	7	−7.0, −28.7, −13.4	?
82688	HD 152555	16 54 08.1	−04 20 25	G0	7.8	47.6	−17.1 ± 0.5	133	+1.18	15	−6.1, −28.8, −12.6	3
86346	HD 160934	17 38 39.6	+61 14 16	M0	10.2	24.0	−35.6 ± 0.7	40	−1.09	17	−5.3, −27.6, −14.5	?; 1, 4
106231	LO Peg	21 31 01.7	+23 20 07	K8	9.2	25.1	…	…	…	…	−5.7, −27.3, −15.0	1, 3, 8
110526	GJ 856A	22 23 29.1	+32 27 34	M3	11	16.0	−20.6 ± 2.1	0	−3.60	16	−6.8, −27.8, −15.0	1; 1″.8 binary
113579	HD 217343	23 00 19.3	−26 09 13	G3 V	7.5	32.1	+6.3 ± 1.5	167	+0.96	8	−3.1, −26.8, −14.1	?; 3, 6
113597	HD 217379	23 00 27.9	−26 18 43	(K8)	9.8	30.0	+8.4 ± 1.5	0	+0.18	7	−2.0, −24.5, −15.4	1″.8 binary
114066		23 06 04.8	+63 55 34	(M1)	10.9	24.9	−23.7 ± 0.8	30	−1.60	8	−6.8, −27.3, −15.9	1
114530	HD 218860	23 11 52.0	−45 08 11	(G5)	8.8	50.5	+10.3 ± 1.2	220	+0.88	3	−7.9, −29.1, −11.3	?
115162		23 19 39.5	+42 15 10	(G4)	8.9	49.4	−19.7 ± 0.2	160	+0.90	…	−4.8, −27.5, −14.3	
118008	HD 224228	23 56 10.7	−39 03 08	K3 V	8.2	22.1	+12.1 ± 0.5	76	+0.78	6	−7.6, −27.9, −12.3	?; 3

NOTE.—We have not observed PW And and LO Peg; data are available in the listed references. For HIP 63742, radial velocities in the literature range from 11.5 to −6.3 km s^{-1}. Thus, this star may be a spectroscopic binary. If, for example, the systemic radial velocity is 2 km s^{-1}, then U, V, W = (−6.6, −26.8, −12.9) km s^{-1}. Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds. Sp. = spectral type; D = distance; and RV = radial velocity. The method described in the next to last paragraph of § 3 was used to calculate the listed distances to PW And and GSC 8894-426.

REFERENCES.—(1) Montes et al. 2001b; (2) Montes et al. 2001a; (3) Wichmann et al. 2003; (4) Fekel 1997; (5) Nidever et al. 2002; (6) Cutispoto et al. 2002; (7) Christian & Mathioudakis 2002; (8) Jeffries 1995; (9) Chen et al. 2001; (10) Reiners & Schmidt 2003; (11) Vilhu et al. 1987; (12) Torres et al. 2000; (13) Cutispoto et al. 1999; (14) Favata et al. 1995; (15) Gaidos et al. 2000.

TABLE 2
NEARBY YOUNG STELLAR GROUPS

Group Name	Spectral Type Range	Age (Myr)	*U*, *V*, *W* (km s^{-1})
TW Hydrae association	A–M	8	−11, −18, −5
Tucana/Horologium	B–M	30	−11, −21, 0
β Pictoris moving group	A–M	12	−11, −16, −9
AB Dor moving group	F–M	50	−8, −27, −14
η Cha cluster	B–M	8	−12, −19, −10
Cha-near	A–M	10?	−11, −16, −8

NOTE.—See tables in Zuckerman & Song (2004) for a listing of members of these associations.

U, *V*, *W* was calculated using weighted averages of proper motions from the PPM Star and Tycho catalogs and of radial velocities measured by us and by others.

3. DISCUSSION

After combining our observations with those of other astronomers and with astrometric catalogs, especially *Hipparcos*, it became apparent that Table 1 stars have a similar motion through the Galaxy. The stars also have at least one indicator of youth, usually multiple indicators. These include Hα emission, strong lithium 6708 Å absorption, large $v \sin i$, large X-ray flux, and a location above the main sequence on an M_K versus $V-K$ color-magnitude diagram (see Zuckerman & Song 2004 for extensive considerations of age diagnostics).

A key to identifying youthful moving groups near the Sun is the careful measurement of *U*, *V*, *W* because differences among the groups are not large (Table 2). The space motion of the AB Dor group is clearly distinguished from that of the other young groups by its more negative *V* and *W* components. The existence of distinguishable proximate kinematic groups in addition to those listed in Table 2 will be discussed by I. Song et al. (2004, in preparation).

We estimate the age of the AB Dor moving group in two ways. First, we compare the intensity of Hα emission (and absorption) of the late K- and early M-type stars in the Tucana association with those in the AB Dor group. For similar spectral types, the Hα lines are more strongly in emission in Tucana. Second, we plot three M-type members of the AB Dor group on an M_K versus $V-K$ diagram (Fig. 1). As can be seen, they lie slightly above the main sequence. If Tucana is ~30 Myr old, as seems likely (e.g., Stelzer & Neuhauser 2000), then the AB Dor stars are probably ~50 Myr old, but with at least 10 Myr uncertainty.

Assuming an age of 50 Myr, one may use Figure 1, or, better, Figure 2 in Zuckerman & Song (2004), and a measured radial velocity to determine the *U*, *V*, *W* of stars with indications of youth but lacking accurate (*Hipparcos*) parallaxes. Specifically, one may read M_K from Figure 1 for a 50 Myr old star with known $V-K$. Then with known m_K, and accurate proper motions from, say, the Tycho catalog, one can calculate the *U*, *V*, *W* of the star. The *U*, *V*, *W* of PW And and GSC 8894-426 match those of AB Dor group members that have *Hipparcos*-determined distances.

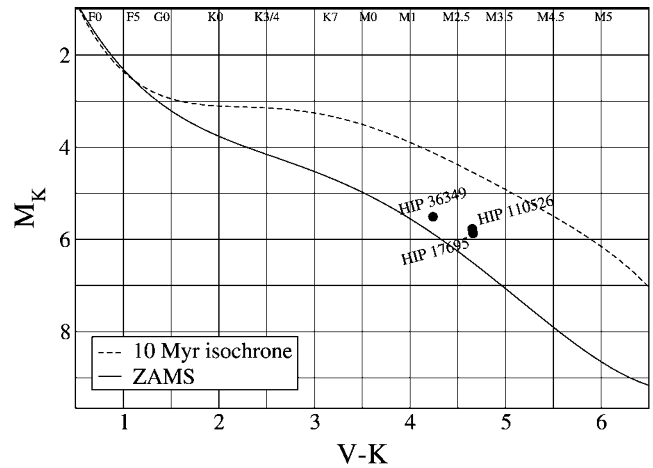

FIG. 1.—Mid–M-type members of the AB Dor moving group. The indicated 10 Myr and zero-age main-sequence (ZAMS) isochrones are empirically determined (see Song et al. 2003 for additional details).

The Ursa Majoris and Tucana moving groups are each characterized by a nuclear cluster of ~10 stars and a surrounding stream of many more stars. The structure of the AB Dor group appears similar. The stars listed in Table 1 from HIP 25283 to 36349 can be regarded as the nucleus and the other Table 1 stars as stream stars. The nuclear group, which contains AB Dor itself, is deep in the southern hemisphere and at an average distance from Earth of ~20 pc. These nuclear stars are contained in a region only ~10 pc on a side.

4. CONCLUSIONS

We have identified a group of comoving ~50 Myr old stars that partially surround the Sun. Spectral types range from late F-type to mid–M-type stars. A similar range of spectral types is seen in previously discovered nearby moving groups with ages in the range 8–30 Myr (Table 2; Zuckerman & Song 2004). As instrumentation improves, this ensemble of stellar associations will enable astronomers to follow the process of planetary formation over a range of stellar masses during the critical age interval from 8 to 50 Myr.

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