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THE CARINA-NEAR MOVING GROUP

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ABSTRACT

We identify a group of ∼20 comoving, mostly southern hemisphere, ∼200 Myr old stars near Earth. Of the stars likely to be members of this Carina-Near moving group, in either its nucleus (∼30 pc from Earth) or its surrounding stream, all but three are plausible members of a multiple star system. The nucleus is (coincidentally) located quite close to the nucleus of the AB Doradus moving group notwithstanding that the two groups have substantially different ages and Galactic space motions, *UVW*.

Subject headings: open clusters and associations: individual (HR 3070 moving group) — stars: evolution — stars: kinematics — stars: pre–main-sequence

1. INTRODUCTION

During the past decade, various young stellar associations and clusters have been identified within 100 pc of the Sun (see Zuckerman & Song 2004 for a review). These comoving groups can illuminate our understanding of the properties of low- and intermediate-mass stars at times that correspond to the long-ago era when planet building and heavy bombardment were occurring in our solar system. The *Spitzer* infrared observatory is targeting virtually all these young stars to determine if they are surrounded by dusty debris disks. And the stars are being observed at near-infrared wavelengths with the *Hubble Space Telescope* and with adaptive optics systems on most of the world's largest telescopes; the goal is to detect thermal emission from young massive planets.

In the present Letter, we add another example—the Carina-Near moving group—to the growing menagerie of nearby young associations. The nucleus—consisting of stars in the relatively narrow range of spectral type F–K0, of which HR 3070 (= HIP 38160) is the earliest spectral type and the brightest—is only ∼30 pc from Earth (Table 1). Some of the surrounding stream stars, whose group membership is therefore less secure than those in the nucleus, are even closer to Earth; for example, GJ 358 is within 10 pc. Based primarily on lithium abundance and X-ray flux (see § 3), we estimate the group to be somewhat older than the Pleiades.

Some nuclear stars in our proposed group were initially suggested as comoving by Eggen (1988). Later, Makarov & Urban (2000, hereafter MU2000) argued that they are part of a spatially very extensive, X-ray–bright, moving group they dubbed "Carina-Vela." However, other than X-ray luminosity, their choice of group membership was predicated entirely on kinematics, while lacking even radial velocity determinations. Our past experience (Song et al. 2002) with stars proposed (Makarov & Fabricius 2001) as members of the TW Hydrae association demonstrated that a purely convergent-point kinematic approach is insufficient to reliably pinpoint members of nearby young associations. Nonetheless, in the 5 years following publication of their paper, neither MU2000 nor any other astronomer has verified or denied their kinematic model. For example, both Cutispoto et al. (2002) and Wichmann et al. (2003) studied group member HIP 37563 without referencing the MU2000 paper. Indeed, unaware of the MU2000 paper, we independently stumbled on the nearer (to Earth) members of their proposed association while pursuing our research program of identification of young nearby stars. Apparently, in their young star program, Jensen et al. (2004) also find some overlap with the MU2000 sample. However, based on the few stars explicitly mentioned in the Jensen et al. abstract, the stars in their program appear, on average, to be about 3 times more distant from Earth than the stars in our Table 1.

Our investigations of radial velocities and youth indicators such as lithium abundance and Hα intensity are described in the following sections. The essence of our results may be summarized as follows: we confirm some of the MU2000-suggested members, deny others, and add some of our own. In addition, we think it is not helpful, and may even be wrong, to associate very nearby stars such as those listed in Table 1 with the much more distant stars that MU2000 place together into a single moving group. Specifically, as is evident from their Figure 5, the nearest members of their "Carina-Vela" group are 3 times closer to Earth than their proposed more distant members, with essentially no stars at intermediate distances. In view of these large spatial separations, lack of evidence that Galactic space velocities *UVW* are all similar, and lack of data on lithium abundances and activity indicators, at present we see no compelling reason to suppose the Carina-Vela group stars shared a common origin.

Table 1 of MU2000, "Candidate members of the Carina-Vela moving group of young stars," contains 58 entries, most of which are not particularly near Earth. Of these 58, only five are included in our Table 1 as candidate members of the moving group of stars we are considering, and one MU2000 candidate is a definite nonmember of our proposed moving group. Rather than being spread out to distances >100 pc and with generally unknown *UVW* velocities (i.e., MU2000's Carina-Vela group), our Table 1A and B stars are characterized by proximity to

TABLE 1
The Carina-Near Moving Group

HIP	Other Name	R.A. (J2000)	Decl. (J2000)	SpT	*V* (mag)	*B*−*V*	*D* (pc)	RV (km s^{-1})	log (L_X/L_{bol})	Li (mÅ)	Hα (Å)	*U*, *V*, *W* (Uncertainty) (km s^{-1})
A. Members of the Nucleus of the Carina-Near Moving Group												
35564A ……..	…	07 20 21.4	−52 18 41	F2	6.05	0.48	34.8	18.6 ± 2	−4.99†	…	1.8	−26.2, −15.3, −4.6 (1.2, 1.9, 1.1)
35564B ……..	…	07 20 21.9	−52 18 33	G0	6.60	0.58	34.8	…	−4.99†	95	1.0	…
36414 ……….	HD 59704	07 29 31.4	−38 07 21	F7	7.75	0.52	52.5	28 ± 2	−4.39	80	1.3	−26.1, −20.7, −2.6 (0.9, 1.9, 0.5)
37563 ……….	HD 62850	07 42 36.1	−59 17 51	G2/3	7.19	0.62	33.3	17 ± 1	−4.44	135	1.1	−25.5, −18.0, −1.8 (0.5, 1.0, 0.4)
37635 ……….	HD 62848	07 43 21.5	−52 09 51	G0	6.70	0.55	30.2	20.5 ± 0.5	−4.60	60	1.2	−25.3, −18.4, −2.5 (0.4, 0.5, 0.2)
37918 ……….	HD 63581	07 46 14.8	−59 48 51	K0	8.15	0.77	36.2	17 ± 1	−4.34†	110	0.9	−26.0, −18.1, −2.4 (1.8, 1.0, 0.4)
37923 ……….	HD 63608	07 46 17.0	−59 48 34	K0	8.25	0.81	27.4	17 ± 1	−4.34†	76	0.9	−26.0, −18.1, −2.4 (1.8, 1.0, 0.4)
38160 ……….	HR 3070	07 49 12.9	−60 17 01	F1	5.79	0.43	34.9	15 ± 2	−5.38	…	2.1	−26.2, −16.6, −1.6 (0.5, 1.9, 0.6)
B. Probable and Possible Members of the Carina-Near Stream												
15844AB ……	GJ 140	03 24 06.5	+23 47 06	M1	10.4	1.45	19.8	19 ± 2	−3.52	0	−0.1	−24.3, −17.0, −6.0 (1.9, 2.1, 0.9)
15844C ……..	GJ 140C	03 24 12.7	+23 46 20	M2.5	11.9	…	19.8	18 ± 3	…	0	+0.3	−23.3, −15.0, −4.6 (2.7, 2.0, 1.4)
47425 ……….	GJ 358	09 39 46.4	−41 04 03	M2	10.77	1.52	9.5	18 ± 3	−3.71	0	−0.8	−28.8, −17.8, −0.9 (0.5, 3.0, 0.5)
58240 ……….	HD 103742	11 56 42.3	−32 16 05	G3	7.64	0.65	34.9	6 ± 0.4	−4.46†	111	1.1	−21.2, −17.1, −3.1 (3.3, 1.8, 0.9)
58241 ……….	HD 103743	11 56 43.8	−32 16 03	G3	7.81	0.70	29.2	6.7 ± 0.3	−4.46†	110	1.1	−21.0, −17.6, −2.8 (3.3, 1.8, 0.9)
60831 ……….	HD 108574	12 28 04.4	+44 47 39	(F7)	7.40	0.56	39.2	−1.8 ± 1	−4.70†	109	…	−28.5, −17.8, −4.4 (2.0, 1.2, 1.0)
60832 ……….	HD 108575	12 28 04.8	+44 47 30	(G0)	7.97	0.66	42.4	…	−4.70†	70	…	−30.9, −18.3, −1.5 (4.9, 3.0, 2.0)
116384 ……..	GJ 900	23 35 00.3	+01 36 19	M0	9.61	1.35	19.3	−10 ± 2	−3.53	6 ± 2	…	−29.1, −15.7, +0.9 (1.0, 1.2, 1.7)
117410 ……..	GJ 907.1	23 48 25.7	−12 59 15	K8	9.57	1.26	27.1	−8 ± 2	−3.44	…	…	−29.0, −14.0, +0.9 (1.8, 1.0, 1.9)
C. Nonmembers												
37718 ……….	HD 63008	07 44 12.5	−50 27 24	F8	6.64	0.53	30.8	8.5 ± 0.3	−4.60†	67	1.3	−26.4, −4.4, −6.2 (0.3, 0.3, 0.2)
37727 ……….	HD 63008B	07 44 16.5	−50 28 00	G0	7.55	0.70	30.1	9.0 ± 0.5	−4.60†	46	1.0	−26.5, −4.9, −6.4 (0.3, 0.5, 0.2)

Notes.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds. *UVW* velocities are defined with respect to the Sun, with *U* positive toward the Galactic center, *V* positive in the direction of Galactic rotation, and *W* positive toward the north Galactic pole. The average *UVW* velocity for the nucleus of the Carina-Near moving group is (−25.9, −18.1, −2.3) km s^{-1}.
For HIP 35564B, we measured the radial velocity (RV) to be 59 and 32 km s^{-1} in 2006 January and April, respectively; therefore, this star may be a spectroscopic binary.
For HIP 37563, we measured 125 mÅ for Li λ6708. Wichmann et al. (2003) and Cutispoto et al. (2002) each measured 145 mÅ.
For HIP 37718 and 37727, the parallax we used for calculation of their *UVW* velocities is 32.8 ± 0.4 mas. Proper motion = (−110.8 ± 1.0, +143.0 ± 1.0) mas yr^{-1}.
For HIP 37918 and 37923, the parallax we used is 29.2 ± 2.0 mas. Proper motion = (−58.0 ± 1.5, +155 ± 1.5) mas yr^{-1}.
For HIP 47425, García-Sánchez et al. (2001) list RV = 142 ± 21 km s^{-1}.
For HIP 58240 and 58241, the parallax we used is 31.45 ± 4.5 mas. Proper motion = (−177.4 ± 2.0, −5.3 ± 2.0) mas yr^{-1}.
For HIP 60831 and 60832, the listed spectral types are estimated from *V* − *K* color.
For HIP 116384, the listed Li λ6708 equivalent width is from Zboril et al. (1997); it is a triple system (Martín 2003).
HIP 117410 is a 1″ *Hipparcos* binary.
The dagger indicates that the *ROSAT* X-ray positional uncertainty circle covers both stars in the four indicated binary systems. To calculate the fractional X-ray luminosity in each case, we "shared" the X-ray flux between the two stars.

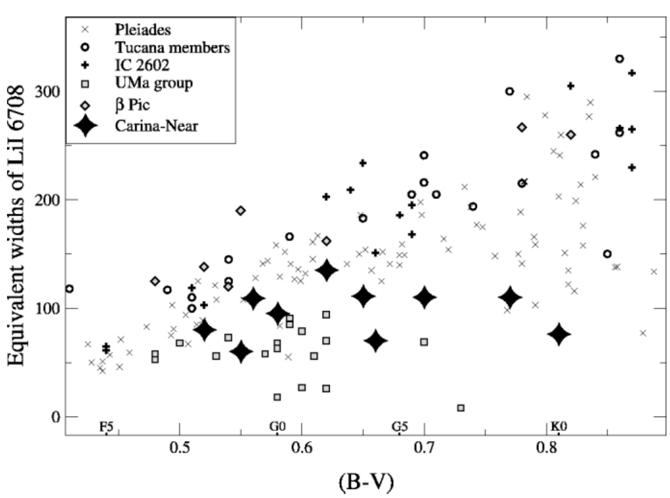

Fig. 1.—Equivalent width of Li i λ6708 as a function of *B* − *V*. Displayed equivalent widths are not corrected for possible contamination by Fe i λ6707.44, and measurement uncertainty of equivalent widths is ~20 mÅ. *B* − *V* values for Carina-Near group stars are calculated from Tycho-2 B_T and V_T magnitudes using the relation given in Bessell (2000).

Earth and rather tight constraints (a few kilometers per second) on measured *UVW* velocities. In addition, stars listed in part B of our Table 1 are not in the Carina-Vela direction. Finally, based on our Figures 1 and 2 and the discussion in § 3, we believe that the Carina-Near stars must be older than the Pleiades, whereas IC 2391, which belongs to the Carina-Vela moving group proposed by MU2000, is generally regarded as younger than the Pleiades. In view of these many differences, we designate the stars we are considering to be the "Carina-Near moving group."

2. OBSERVATIONS

In 2006 January, we obtained spectra of Table 1 stars with the double-beam grating and echelle spectrographs on the two Nasmyth foci of the Australian National University's 2.3 m telescope at Siding Spring Observatory. The primary goal of these observations is the measurement of stellar radial velocity along with the equivalent widths of the Hα and Li λ6708 lines. Radial velocity, in conjunction with proper motion and parallax, enables one to calculate the three-dimensional Galactic space

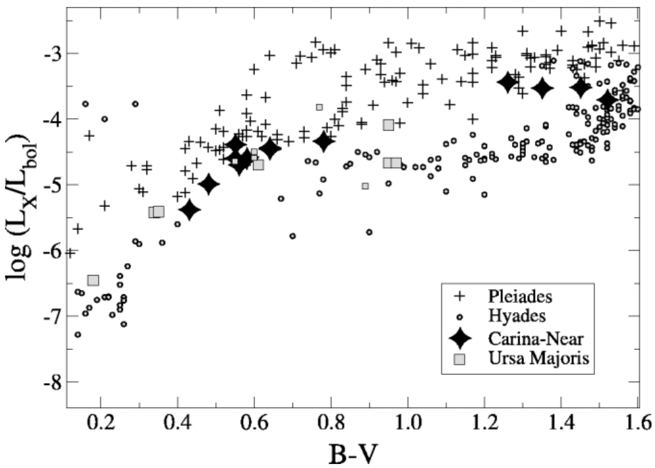

FIG. 2.—Ratio of X-ray to bolometric luminosity as a function $B-V$. $B-V$ values for Carina-Near group stars are calculated from Tycho-2 B_T and V_T magnitudes as in Fig. 1. Ursa Majoris moving group (estimated age of 500 ± 100 Myr; King et al. 2003) stars are plotted as squares (large squares for nucleus members). Based on the relative position in this plot of UMa and Hyades member stars, if the Hyades age is ∼600 Myr as is usually quoted, then the UMa stars are probably ∼400 Myr old. The $B-V$ color of a multiple system was calculated to reproduce a single color for matching the composite L_X/L_{bol} value of the system.

motions *U*, *V*, *W* that are essential for identification of individual moving groups.

Entries for radial velocity, lithium, and Hα in Table 1 are a mix of our own measurements and those of others. The *UVW* velocities were calculated using weighted averages of proper motions from the PPM and Tycho catalogs, and occasionally a third catalog, and of radial velocities measured by us and by others. For stars that are obviously binaries based on their small separation in the plane of the sky, e.g., HIP 37918 and 37923, we used the weighted mean of their *Hipparcos*-measured distances to calculate the *UVW* velocities listed in Table 1.

We have divided Table 1 into three parts: (A) nuclear members of the Carina-Near moving group, (B) suggested "stream" members associated with the group, and (C) stars suggested in MU2000 as comoving but rejected by us as group members based on *UVW* velocities. For moving groups with ages <50 Myr, mid and late M-type stars located above the main sequence are probably the most reliable way to establish age (see, e.g., discussion and Fig. 2 in Zuckerman & Song 2004). However, we could identify no stars noticeably above the main sequence among our proposed group members. The absence of such pre–main-sequence stars is consistent with our ∼200 Myr age estimate for the group (§ 3).

3. DISCUSSION

Lacking any M-type stars that lie above the main sequence, we estimate the age of the Carina-Near group using lithium abundance plus activity indicators. Figure 1 displays the Li λ6708 equivalent width (EW) versus spectral type of Carina-Near group stars overplotted on Figure 3 from Zuckerman & Song (2004). The Carina-Near stars are seen to lie near the bottom envelope of the lithium EW for Pleiades stars. Figure 2 shows the X-ray luminosity of Carina-Near stars, normalized by their bolometric luminosities, overplotted on Figure 4 of Zuckerman & Song (2004). Again, the Carina-Near stars lie near the bottom envelope of Pleiades stars. Finally, we measured the EW of Hα lines in the early M-type stars HIP 47425 and 15844AB and C (all of which have $B-V\sim 1.5$) to be −0.77, −0.14, and +0.29, respectively, where a negative sign denotes emission. Comparison with Hα line activity in stars with similar $B-V$ (see Fig. 5 in Zuckerman & Song 2004 and Fig. 5 in Gizis et al. 2002) suggests that these stars are young but not dramatically so.

With adaptive optics imaging, Martín (2003) found that GJ 900 (HIP 116384) is a triple system. Martín notes that his referee, J. Stauffer, argues that the age of GJ 900 is 100 Myr or older based on its position in a *V* versus $V-I$ color-magnitude diagram and comparison with low-mass members of the IC 2391, IC 2602, and Pleiades clusters.

Our measurements, as indicated in Figures 1 and 2, are consistent with J. Stauffer's assessment, and we assign an age of 200 ± 50 Myr to the Carina-Near moving group.

A remarkable aspect of the stars listed in parts A and B of Table 1 is the dominance of multiple star systems. Only HIP 36414, 37635, and 47425 appear, at this time, to be likely single stars. The situation regarding HIP 37563 and 38160 is unclear. While HIP 37563 and 38160 might be single stars (they are fairly far from each other in the plane of the sky), it is possible that either one or both might comprise a very wide multiple system with the binary star HIP 37918/37923. Specifically, HIP 37563 and 38160 are each separated in the plane of the sky by about 1 lt-yr from HIP 37918 and 37923. If the separation along the line of sight is comparable (or less), then HIP 37563 or 38160, or both, could be, with HIP 37918 and 37923, a very wide triple or quadruple system.

In their § 5, MU2000 comment that "surprisingly many" of their proposed Carina-Vela group stars are members of binaries; this trait, they note, may be characteristic of stellar youth. If so, then such youthful affinity for multiplicity has been preserved for ∼200 Myr in the Carina-Near group.

4. CONCLUSIONS

We have identified a group of comoving ∼200 Myr old stars that partially surround the Sun. At least four of these stars are close enough to Earth to have been included in the original Gliese catalog of nearby stars (1969): GJ 140, 358, 900, and 907.1. Like all previously discovered and younger associations of stars within 100 pc of Earth—TW Hydrae, Tucana/Horologium, β Pictoris, AB Doradus, η Cha, Cha-Near—the nucleus of the Carina-Near moving group is located deep in the southern hemisphere. This nucleus is (coincidentally) located quite close to the nucleus of the AB Doradus moving group notwithstanding that the two groups have substantially different ages and Galactic space motions, *UVW*: AB Dor (−8, −27, −14); Carina-Near (−26, −18, −2). Indeed, the *U* velocity of the Carina-Near group is substantially more negative than the *U* velocities of all the other groups listed here. In any event, identification of this nearby group of stars, many of which have masses similar to the Sun, extends the time line covered by these other groups to older ages. As instrumentation capabilities improve, astronomers will be able to follow the planetary formation process over the age interval from 8 to 200 Myr.

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