A&A 503, 281–285 (2009)
DOI: 10.1051/0004-6361/200912173

Astronomy & Astrophysics

Kinematic analysis and membership status of TWA22 AB⋆,⋆⋆

R. Teixeira[1,2], C. Ducourant[2], G. Chauvin[3], A. Krone-Martins[1,2], M. Bonnefoy[3], and I. Song[4]

[1] Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, Rua do Matão, 1226 Cidade Universitária, 05508-900 São Paulo - SP, Brazil
e-mail: teixeira@astro.iag.usp.br
[2] Observatoire Aquitaine des Sciences de l'Univers, CNRS-UMR 5804, BP 89, 33270 Floirac, France
[3] Laboratoire d'Astrophysique, Observatoire de Grenoble, 414 rue de la piscine, 38400 Saint-Martin d'Hères, France
[4] Department of Physics & Astronomy, the University of Georgia, Athens, GA 30605, USA

Received 24 March 2009 / Accepted 29 April 2009

ABSTRACT

Context. TWA22 was initially regarded as a member of the TW Hydrae association (TWA). In addition to being one of the youngest (≈8 Myr) and nearest (≈20 pc) stars to Earth, TWA22 has proven to be very interesting after being resolved as a tight, very low-mass binary. This binary can serve as a very useful dynamical calibrator for pre-main sequence evolutionary models. However, its membership in the TWA has been recently questioned despite due to the lack of accurate kinematic measurements.
Aims. Based on proper motion, radial velocity, and trigonometric parallax measurements, we aim here to re-analyze the membership of TWA22 to young, nearby associations.
Methods. Using the ESO NTT/SUSI2 telescope, we observed TWA22 AB during 5 different observing runs over 1.2 years to measure its trigonometric parallax and proper motion. This is a part of a larger project measuring trigonometric parallaxes and proper motions of most known TWA members at a sub-milliarcsec level. HARPS at the ESO 3.6 m telescope was also used to measure the system's radial velocity over 2 years.
Results. We report an absolute trigonometric parallax of TWA22 AB, $\pi = 57.0 \pm 0.7$ mas, corresponding to a distance 17.5 ± 0.2 pc from Earth. Measured proper motions of TWA 22AB are $\mu_\alpha \cos(\delta) = -175.8 \pm 0.8$ mas/yr and $\mu_\delta = -21.3 \pm 0.8$ mas/yr. Finally, from HARPS measurements, we obtain a radial velocity $V_{\rm rad} = 14.8 \pm 2.1$ km s^{-1}.
Conclusions. A kinematic analysis of TWA22 AB space motion and position implies that a membership of TWA22 AB to known young, nearby associations can be excluded except for the β Pictoris and TW Hydrae associations. Membership probabilities based on the system's Galactic space motion and/or the trace-back technique support a higher chance of being a member to the β Pictoris association. Membership of TWA22 in the TWA cannot be fully excluded because of large uncertainties in parallax measurements and radial velocities and to the uncertain internal velocity dispersion of its members.

Key words. astrometry – stars: binaries: close – stars: distances – Galaxy: open clusters and associations: general – Galaxy: solar neighborhood – Galaxy: open clusters and associations: individual: TWA22AB

1. Introduction

Over the past decade, various coeval moving groups of stars have been discovered in the solar neighborhood, including three well-known associations, TW Hydrae (hereafter TWA, Kastner et al. 1997), β Pictoris (hereafter β Pic, Barrado y Navascués et al. 1999), and Tucana/Horologium (hereafter Tuc-Hor, Zuckerman & Webb 2000; Torres et al. 2000). These groups occupy an important astrophysical niche thanks to their proximity (≤100 pc) and youth (≤100 Myr). They offer the best targets for various studies, such as imaging searches for young brown dwarf and planetary mass companions, proto-planetary or debris disk-related programs, etc. Any young (sub)stellar binary members in tight orbits in these moving groups can serve as valuable calibrators for evolutionary models.

Song et al. (2003) identified the TWA22 system as a new member of TWA based essentially on the presence of a strong Li λ6708 absorption feature and its close proximity to TWA in the sky. A further proper motion analysis led Scholz et al. (2005) to conclude that TWA22 could indeed be the nearest TWA member to Earth. However, more recently, Mamajek (2005) has performed a convergent point analysis using several TWA members. He found that TWA22 has a low probability of membership in the TWA. This conclusion was refuted by Song et al. (2006) arguing a lack of reliable distance determinations for most TWA members to firmly reject TWA22's membership. Song et al. (2006) argued instead that the strong lithium line seen at TWA22, rarely seen among other stars with similar spectral types, implies a probable membership to TWA or β Pic.

During a VLT/NACO deep-imaging survey for close companions to stars in young associations, TWA22 was resolved as a tight (≈100 mas) binary with a projected physical separation of 1.76 ± 0.10 AU (see Bonnefoy et al. 2009).

Regardless of TWA22's membership in TWA or β Pic, TWA22 AB is a precious dynamical mass calibrator because of its young age (≈10 Myr) and the low masses of its components. A well-known age and a distance are crucial to the validity of calibrating evolutionary model calculations. Therefore, there is need for accurate observational data, such as the trigonometric parallax, proper motions, and radial velocity.

As a part of a larger project for the trigonometric parallax determination of all TWA members, we performed astrometric and photometric observations of TWA22 AB at ESO NTT/SUSI2

⋆ Based on observations performed at the European Southern Observatory, Chile (76.C-0543, 077.C-0112, 078.C-0158, 079.C-0229).
⋆⋆ Table 4 is only available in electronic form at http://www.aanda.org

Article published by EDP Sciences

Table 1. Absolute astrometric parameters for TWA22 AB and radial velocity derived in this work.

π mas	d pc	$\mu_\alpha \cos(\delta)$ mas/yr	μ_δ mas/yr	$V_{\rm rad}$ km s^{-1}
57.0 ±0.7	17.5 ± 0.2	−175.8 ± 0.8	−21.3 ± 0.8	14.8 ± 2.1

(La Silla – Chile). Radial velocity measurements were also obtained to complete the kinematic analysis of TWA22 AB. Using these new data, we performed a kinematic analysis to test the membership of TWA22 AB in TWA, β Pic, and Tuc-Hor. Our analysis uses only moving- group members with Hipparcos measured distances. In addition to Hipparcos moving-group members, we used 2M1207A whose accurate trigonometric distance was obtained from gound-based measurement (Ducourant et al. 2008). The possibility of TWA22 AB being a member of other nearby groups was investigated and discarded by more evident incompatibilities.

We present observation and data reduction in Sect. 2, and in Sect. 3, we discuss the membership of TWA22 in TWA, β Pic, and Tuc-Hor. The conclusion is provided in Sect. 4.

2. Observations and data treatment

2.1. Trigonometric parallax and proper motion

We used ESO NTT-SUSI2 which provides a good compromise between a large field of view (5.5′ × 5.5′) for a sufficient sampling of background stars and a small pixel size (80.5 mas) necessary for sub-milli arcsecond astrometry. Data were acquired over five observational epochs, and all observations were obtained around the meridian transit (hour angle ≤0.5 h). In our imaging, we used an I-band filter to minimize the differential color refraction effects (DCR). Residual DCR effects were removed from single observations following the method described in Ducourant et al. (2007). Multiple images were obtained at each epoch to reduce astrometric errors. The image of highest quality is selected as a master frame that will be used for cross-identification, alignement and scaling. The alignment of CCD axes and the plate scale were estimated using 2MASS catalog sources (Cutri et al. 2003).

A stellar point-spread function for each frame was fitted using the `DAOPHOT II` package (Stetson 1987). Then, we created catalogs of measured positions (x, y), internal magnitudes, and associated errors for all stars on each frame. Observational data were processed through a global treatment, as described in Ducourant et al. (2007, 2008), and a solution was derived for TWA22 AB relative to background stars ($14.5 \leq I \leq 18.5$ mag). In our astrometry data reduction and analysis, we ignore any influence of binarity. But, we assessed the effect of binarity in Sect. 2.2. Then, a statistical conversion from relative to absolute parallax and proper motions, based on the Besançon Galaxy model (Robin et al. 2003, 2004), was derived ($\Delta\pi = 0.35 \pm 0.01$ mas, $\Delta\mu_\alpha \cos(\delta) = -5.43 \pm 0.02$ mas/yr, $\Delta\mu_\delta = +2.98 \pm 0.02$ mas/yr). Both the final estimated TWA22 AB ($\alpha = 10^{\rm h}17^{\rm m}26.79^{\rm s}$, $\delta = -53°54'26.5''$, epoch = 2006.763 yr) proper motion and trigonometric parallax are given in Table 1. In a separate table (Table 2), apparent and absolute Bessel (V, R, I) and 2MASS (J, H, K) magnitudes (Cutri et al. 2003) are listed.

Figure 1 presents the apparent displacement of TWA22 AB relative to the background stars due to the parallax and proper motion.

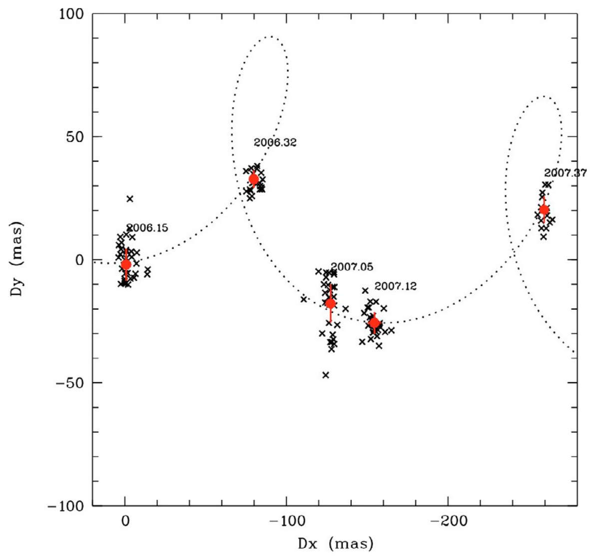

Fig. 1. Apparent astrometric displacement of TWA22 AB together with the best parallax and proper motion fit of the data. Blue dots correspond to weighted mean positions at each observational epoch.

Table 2. Apparent and absolute magnitudes of TWA22 AB: V, R, I Bessell filter data from this work and J, H, and K_s data from 2MASS.

	m (mag)	M
V	13.99 ± 0.02	12.77 ± 0.19
R	12.50 ± 0.14	11.28 ± 0.19
I	11.13 ± 0.23	9.91 ± 0.18
J	8.55 ± 0.01	7.33 ± 0.07
H	8.09 ± 0.04	6.87 ± 0.10
K	7.69 ± 0.02	6.47 ± 0.07

2.2. Impact of binarity onto the parallax determination

With ESO NTT/SUSI2, it is not possible to resolve two components of TWA22 AB. Therefore, with our astrometric observations we are measuring the photocenter of the system. This photocenter may not coincide with the center of mass because these two different positions depend on the ratio of mass and luminosity of the components. A photocenter of a binary should be affected by an elliptic, periodic movement with the same period as the binary orbit. The amplitude of this variation depends on the orbital parameters, mass, and luminosity ratios.

Following Van de Kamp (1967), our condition equations for TWA22 AB were modified to include the photocentric movement. The condition equations are written for each star on each of the N frames considered (including the master frame). These equations relate the measured coordinates to the stellar astrometric parameters:

$$X_0 + \Delta X_0 + \mu_X(t - t_0) + \pi F_X(t) + \alpha Q_\alpha = a_1 x(t) + a_2 y(t) + a_3 \quad (1)$$

$$Y_0 + \Delta Y_0 + \mu_Y(t - t_0) + \pi F_Y(t) + \alpha Q_\delta = b_1 x(t) + b_2 y(t) + b_3 \quad (2)$$

where (X_0, Y_0) are the known standard coordinate of the star at the central epoch t_0 and $(x(t), y(t))$ are the measured coordinates on the frame (epoch t) that need to be transformed into the master frame system. ΔX_0, ΔY_0, μ_X, μ_Y, π, and α are the unknown stellar astrometric parameters. Both ΔX_0 and ΔY_0 yield corrections of the standard coordinates of the star on the master frame, μ_X and μ_Y are projected proper motions in right ascension and

Table 3. Heliocentric coordinates (X, Y, Z) and Galactic velocities (U, V, W) of TWA22 AB together with mean values for TWA, β Pic and Tuc-Hor.

Name	X	Y	Z	U	V	W	Age	d
		pc			km s^{-1}		Myr	pc
TWA22	3.5 ± 0.2	–17.2 ± 0.2	0.7 ± 0.2	–8.0 ± 0.4	–17.1 ± 2.1	–9.0 ± 0.2	≤10(1)	17.5 ± 0.2
TWA	14.4 ± 8.7	–46.9 ± 5.3	22.5 ± 2.5	–10.0 ± 2.0	–17.6 ± 1.4	–4.8 ± 1.1	8(2)	55 ± 7
β Pic	9.2 ± 28.9	–7.5 ± 13.0	–13.2 ± 6.5	–10.9 ± 1.9	–16.1 ± 1.0	–9.0 ± 1.2	12 (3)	34 ± 14
Tuc-Hor	14.1 ± 17.7	–19.4 ± 8.0	–34.9 ± 3.5	–9.5 ± 1.7	–20.6 ± 1.7	–0.6 ± 2.6	27 (4)	46 ± 5

declination, π is the parallax, and α is a semi–major axis of the photocentric trajectory relative to a barycenter. Coefficients (a_i, b_i) are unknown frame parameters that describe the transformation to the master frame system, (F_α, F_δ) are the parallax factors, and (Q_α, Q_δ) are known orbital factors (based on Bonnefoy et al. (2009) orbital data). The unknown coefficient α is given by $\alpha = a(R - \beta)$ where a is the semi-major axis of TWA22 B's orbit around TWA22 A, R is a fractional mass, $R = \frac{M_B}{M_A+M_B}$, β is the fractional distance of the primary to the photocenter $\beta = \frac{1}{1+10^{-0.4\Delta m}}$ where Δm is the magnitude difference between A and B.

Although it is impossible to include the parameter α formally as a variable in our equations, we could externally determine its value to correct X_0, Y_0 for the orbital motion of photocenter around barycenter. For this, we assumed the mass-luminosity relations as: $M \propto (L)^{-2.5}$ and used the extrapolated magnitudes in the I-band adapted from Bonnefoy et al. (2009): $\Delta m_{\rm I}$ = 0.46–0.87 mag to determine αQ_α and αQ_δ and correct X_0, Y_0 from these quantities. The resulting astrometric parameters for TWA22 AB are then: π = 56.4 ± 0.7 mas, $\mu_\alpha \cos(\delta)$ = −178.2 ± 0.7 mas/yr, and μ_δ = −9.4 ± 0.8 mas/yr.

We note that the parallax value obtained from this study is within $1\sigma_\pi$ of the one given in Table 1 where it did not consider the effect of photocenter's periodic movement. On the other hand, we observe a large variation in the proper motion in declination. This suggests that our astrometric data may not cover a long enough time interval to properly account for the 5.144 yr, orbital periodic signal from Bonnefoy et al. (2009). The influence of this signal over 1.2 yr (duration of the observational program of TWA22 AB) is mainly equivalent to an offset of the proper motion in declination. We therefore conservatively stick to the values given in Table 1 as the best fit to our data.

2.3. Radial velocity

TWA22 AB was observed with HARPS (Mayor et al. 2003) over 2 years. HARPS is a high-resolution (R = 115 000) fiber-fed cross-dispersed echelle spectrograph functioning on the ESO/3.6 m telescope. For TWA22 AB (V = 13.99), we used 15 min exposures to obtain 60 spectra with SNR ranging from 6 to 10. The standard HARPS reduction pipeline was used to derive radial velocities from the cross-correlation of spectra with a mask for an M2 star. The instrument is generally stable over one night (nightly instrumental drifts ≤1 m s^{-1}), and we performed a precise nightly wavelength calibration from ThAr spectra (Lovis & Pepe 2007). Out of these measurements, we estimated a heliocentric radial velocity $V_{\rm r}$ = 14.8 ± 2.1 km s^{-1} for the system. This radial velocity is likely to be affected by the SB1 status of TWA22 AB. We took the binary nature into account in our uncertainty value by simulating expected amplitudes from the binary orbital motion based on the parameters from Bonnefoy et al. (2009).

3. Kinematic analysis

Based on new trigonometric parallax, proper motion, and radial velocity, we re-examine below the membership of TWA22 AB to TWA, β Pic, and Tuc–Hor. Membership in other young, nearby associations was rejected by more evident discrepancies in age, distances, etc.

3.1. Space motion

To test the membership of TWA22 AB, our first approach is to statistically compare its galactic space motion with the mean UVW values for TWA, β Pic, and Tuc-Hor members. Only stars with known trigonometric parallaxes were considered here because accurate distances are crucial in the UVW calculation. For TWA, our sample set includes TWA 01, TWA 04, TWA 09, and TWA 11 with trigonometric parallaxes from the Hipparcos catalog (ESA 1997)and 2M1207A from Ducourant et al. (2008). Although TWA19 has a Hipparcos parallax, we did not consider it here because Mamajek (2005) classified it as non TWA member. SSSPMJ1102-3431 TWA member (Teixeira et al. 2008) has also been excluded from our study because no radial velocity was available. Their radial velocities were extracted from Table 1 of Mamajek (2005) (Torres et al. 2003, data for TWA 01 and TWA9A; Torres et al. 1995, for TWA4; Reid 2003, for TWA11; and Mohanty et al. 2003, for 2M1207A). For β Pic, we used the list of suggested members by Torres et al. (2006). Astrometric measurements and radial velocities were respectively obtained from the Hipparcos catalog (ESA 1997) and the Table 6 of Torres et al. (2006). Finally, for Tuc-Hor, astrometric measurements and radial velocities were respectively obtained from the Hipparcos catalog (ESA 1997) and Kharchenko et al. (2007) for suggested members by Zuckerman & Song (2004) and Torres et al. (2008). The selection of stars and the original data used in our analysis are presented in Table 4 (only available in the electronic edition). Calculated mean space motions of TWA, β Pic, and Tuc-Hor are reported in Table 3, together with their spatial heliocentric coordinates and velocities for TWA22 AB. In this Table positive X(U) points to the Galactic center, Y(V) is positive in the direction of Galactic rotation and Z(W) is positive toward the north Galactic pole. Ages are from (1) Song et al. (2003); (2) De la Reza et al. (2006); (3) Ortega et al. (2004); (4) Makarov (2007).

The mean values derived here (Table 3) for TWA, β Pic, and Tuc-Hor are in good agreement with published values: (–11, –18, –5), (–11, –16, –9), and (–11, –21, 0) from Table 7 of Zuckerman & Song (2004) and (−10.5 ± 0.9, −18.0 ± 1.5, −4.9 ± 0.9), (−10.1±2.1, −15.9±0.8, −9.2±1.0), and (−9.9±1.5, −20.9± 0.0, −1.4 ± 0.9) from Table 1 of Torres et al. (2008).

Since Hipparcos proper motions were derived from observations covering only a small time interval, we also calculated mean spatial motions of these associations using Tycho-2 proper motions (Hoeg et al. 2000) and we obtained nearly the same

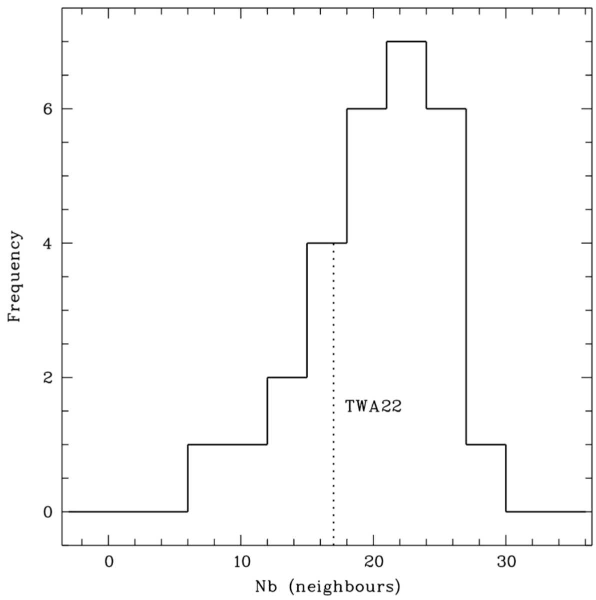

Fig. 2. Number of β Pic members in a sphere of 2σ radius in the UVW space around each member. Sigma is the velocity dispersion for this association.

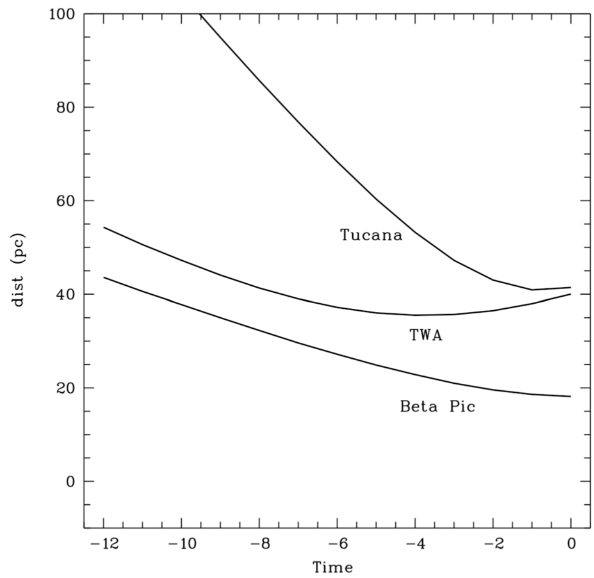

Fig. 3. Distances between TWA22 AB and three moving groups (TWA, β Pictoris, and Tucana-Horologium moving groups) for the past 12 Myr.

results: (–10.1, –17.3, –5.0), (–10.8, –16.0, –9.1), and (–9.6, –20.8, –0.5), respectively, for TWA, β Pic, and Tuc-Hor.

To test the membership of TWA22 AB to TWA, β Pic, and Tuc-Hor, based on its space motion, we applied a χ^2 test with 3 degrees of freedom using their space motion measurements. We find the probabilities that TWA22 AB space motion be compatible with the mean space motion of β Pic, TWA and Tuc-Hor are 50%, 1% and 0.5% respectively. An alternative approach is to perform a k-NN analysis in the UVW space (implemented by Venables & Ripley 2002, R Development Core Team 2008) where we computed the distance of TWA22 to all members of these associations. Among the k nearest neighbors to TWA22, the fraction of members for a given association gives the membership probability for that group. This k-NN analysis corroborates that TWA22 is more likely a member of β Pic than TWA and Tuc-Hor. Both calculations tend to reject TWA and Tuc-Hor as a host association for TWA22 AB.

Our final approach is to count the number of β Pic, TWA, and Tuc-Hor members (or neighbors) within a sphere of fixed radius in the UVW space, centered at TWA22's value and at each individual member of these associations. Radii are selected proportional to the velocity dispersions of the associations. We found that UVW spatial densities of TWA and Tuc-Hor members around TWA22 are significantly lower than the averaged one found in both associations. In contrary, the UVW spatial density of β Pic members around TWA22 (within 2σ) is similar to the average density in β Pic (see Fig. 2).

Membership probabilities and association member density around TWA22 support a possible membership in the β Pic association. The membership of TWA22 in TWA cannot be firmly evaluated because of the paucity of high-quality kinematic data for most of its members.

3.2. Trace-back

Another way to test the membership of TWA22 AB to TWA, β Pic, and Tuc-Hor is to use the trace-back technique to compare the Galactic space position of TWA22 AB and TWA, β Pic, and Tuc-Hor backward in time. To avoid using any uncertain values for the solar peculiar motion (Mihalas & Binney 1981; Dehnen & Binney 1998; Makarov 2007) by transforming heliocentric velocities into LSR velocities, we decided to work in a reference system centered, along time, on TWA22 AB instead. We present, in Fig. 3, the distance between TWA22 AB and the center of each association in time. We note that TWA22 is always closer to β Pic than to TWA and Tuc-Hor. Since the mean motions of the associations derived here are in good agreement with values from the literature, the few TWA members considered here may not have seriously affected the result.

4. Conclusions

Motivated by the importance of the young, very low-mass astrometric binary TWA22 AB as an important calibration point for stellar theoretical calculations, we measured its precise trigonometric parallax (57.0 ± 0.7 mas), proper motions (−175.8 ± 0.8 mas/yr,−21.3 ± 0.8 mas/yr), and radial velocity (V_{rad} = 14.8 ± 2.1 km s^{-1}). These parameters are fundamentals for determin the physical properties of the tight binary system (Bonnefoy et al. 2009).

Our high-quality astrometric measurements along with HARPS radial velocity measurement allow us to discuss the membership of TWA22 AB to nearby associations. Our kinematical study shows that membership by TWA22 AB in known young, nearby associations can be excluded except for the β Pictoris and TW Hydrae associations. Membership probabilities based on the system space motion or the use of trace-back technique also support possible membership of TWA22 AB in the β Pictoris association. Membership in the TWA cannot be fully excluded because of the current lack of precise parallax measurements for most of its members. Our results are, to some extent, inconclusive about the membership of TWA22 AB in TWA or β Pic, but they are consistent with that from an age analysis. The location of TWA22 AB on a color-magnitude diagram supports its age being about 10 Myr but cannot be determined precisely enough to distinguish from 8 (TWA age) and 12 Myr (β Pic moving group age). Precisely known trigonometric distances of many more TWA members, an aim of our larger astrometric program of observing all known TWA members, should improve the situation soon.

Acknowledgements. We thank Michel Rapaport for helpful comments. We also acknowledge partial financial support from the *Programmes Nationaux de Planétologie et de Physique Stellaire* (PNP & PNPS) (in France), the Brazilian organization FAPESP and CAPES, and the French organization COFECUB.

References

Barrado y Navascués, D., Stauffer, J. R., Song, I., & Caillault, J. P. 1999, ApJ, 520, L123
Bonnefoy, M., Chauvin, G., Dumas, C., et al. 2009, to be published in A&A
de Bruijne, J. H. J. 1999, MNRAS, 306, 381
Cutri, R. M., Skrustskie, M. F., Van Dyk, S., et al. 2003, *2MASS All Sky Catalog of Point Sources* (Pasadena:IPAC/Caltech)
Dehnen, W., & Binney, J. J. 1998, MNRAS, 298, 387
De la Reza, R., Jilinski, E., & Ortega, V. G. 2006, AJ, 131, 2609
Ducourant, C., Teixeira, R., Hambly, N., et al. 2007, A&A, 470, 387
Ducourant, C., Teixeira, R., Chauvin, G., et al. 2008, A&A, 477, L1
ESA 1997, HIPPARCOS and Tycho catalogues, ESA-SP-1200
Fernández, D., Figueras, F., & Torra, J. 2008, A&A, 480, 735
Hoeg, E., Fabricius, C., Makarov, V. V., et al. 2000, A&A, 363, 385
Kastner, J. H., Zuckerman, B., Weintraub, D. A., & Forveille, T. 1997, Science, 277, 67
Kharchenko, N. V., Scholz, R. D., Piskunov, A. E., et al. 2007, AN, 328, 889
Lovis, C., & Pepe, F. 2007, A&A, 468, 1115
Makarov, V. V. 2007, ApJS, 169, 105
Mamajek, E. 2005, ApJ, 634, 1385
Mayor, M., Pepe, F., Queloz, D., et al. 2003, The Messenger, 114, 20
Mihalas, D., Binney, J., Galactic Astronomy, Structure and Kinematics
Mohanty, S., Jayawardhana, R., & Barrado y Navascués, D. 2003, ApJ, 593, L109
Mohanty, S., Jayawardhana, R., Huélamo, N., & Mamajek, E. 2007, ApJ, 657, 1064
Ortega, V. G., de la Reza, R., Jilinski, E., & Bazzanella, B. 2002, ApJ, 575L, 75
Ortega, V. G., de la Reza, R., Jilinski, E., & Bazzanella, B. 2004, ApJ, 609, 243
Robin, A. C., Reyle, C., Derriere, S., & Picaud, S. 2003, A&A, 409, 523
R Development Core Team 2008, R: A language and environment for statistical computing, reference index version 2.6.2, R Foundation for Statistical Computing, Vienna, Austria, URL http://www.R-project.org
Reid, N. 2003, MNRAS, 342, 837
Robin, A. C., Reyle, C., Derriere, S., & Picaud, S. 2004, A&A, 416, 157
Scholz, R. D., McCaughream, M. J., Zinnecker, H., & Lodieu, N. 2005, A&A, 430, L49
Setiawan, J., Henning, Th., Launhardt R., et al. 2008, Nature, 451, 7174, 38
Song, I., Zuckerman, B., & Bessel, M. S. 2003, AJ, 599, 342
Song, I., Schneider, G., Zuckerman, B., et al. 2006, ApJ, 652, 1, 724
Sterzik, M. F., Pascucci, I., Apai, D., van der Bliek, N., & Dullemond, C. P. 2004, A&A, 427, 245
Stetson, P. B. 1987, PASP, 99, 191
Teixeira, R., Ducourant, C., Chauvin, G., et al. 2008, A&A, 489, 825
Torres, G., Stefanik, R. P., Lathan, D. W., & Mazeh, T. 1995, ApJ, 452, 870
Torres, C. A. O., da Silva, L., Quast, G. R., de la Reza, R., & Jilinski, E. 2000, AJ, 120, 2, 1410
Torres, G., Guenther, E. W., Marschall, L. A., et al. 2003, AJ, 125, 2, 825
Torres, C. A. O., Quast, G. R., da Silva, L., et al. 2006, A&A, 460, 695
Torres, C. A. O., Quast, G. R., Melo, C. H. F., & Sterzik, M. F. 2008 [arXiv:0808.3362]
Venables, W. N., & Ripley, B. D. 2002, Modern Applied Statistics with ed. S. Fourth Edition (New York: Springer)
Van de Kamp, P. 1967, Principle of Astrometry, ed. R. A. Rosenbaum, & G. Philip Johnson
Webb, R. A., Zuckerman, B., Platais, I., et al. 1999, ApJ, 512, L63
Zuckerman, B., & Song, I. 2004, ARA&A, 42, 685
Zuckerman, B., & Webb, R. A. 2000, ApJ, 535, 959

Table 4. Original data for β Pictoris, TWA and Tucana/Horologium members used in our kinematical analysis from ESA 1997, Mamajek (2005), Torres et al. (2006) and Ducourant et al. (2008) together with the derived heliocentric spatial coordinates and velocities derived in this work.

Ident	Alpha	Delta	V	π	$\mu_\alpha \cos(\delta)$	μ_δ	V_r	X	Y	Z	U	V	W
	(hms)	(°′″)	mag	(mas)	(mas/yr)		(km s^{-1})		(pc)			(km s^{-1})	
HIP 10 679	02 17 24.68	+28 44 31.0	7.75	29.40 ± 5.39	98.15 ± 6.96	−67.41 ± 5.77	5.0 ± 0.4	−24.0	16.9	−17.2	−12.6 ± 1.9	−14.0 ± 3.2	−6.0± 1.1
HD 14 082	02 17 25.23	+28 44 42.8	6.99	25.37 ± 2.84	94.34 ± 3.00	−72.17 ± 2.83	4.6 ± 0.3	−27.8	19.6	−20.0	−13.2 ± 1.2	−16.9 ± 2.2	−7.3 ± 0.7
AG Tri	02 27 29.20	+30 58 25.2	10.12	23.66 ± 2.04	79.50 ± 2.26	−70.09 ± 1.54	7.0 ± 1.1	−31.1	20.9	−19.5	−14.0 ± 1.0	−15.0 ± 1.7	−8.8 ± 0.8
BD+05 378	02 41 25.84	+05 59 18.9	10.28	24.67 ± 2.41	82.32 ± 4.30	−55.14 ± 2.72	10.0 ± 0.0	−26.5	6.7	−29.9	−12.1 ± 0.8	−16.5 ± 1.9	−6.6± 0.4
HD 29 391	04 37 36.11	−02 28 24.2	5.22	33.60 ± 0.91	43.32 ± 0.81	−64.23 ± 0.61	21.0 ± 0.0	−24.3	−8.2	−15.2	−14.0 ± 0.1	−16.2 ± 0.3	-10.1 ± 0.1
GJ 3305*	04 37 36.11	−02 28 24.2	5.22	33.60 ± 0.91	43.32 ± 0.81	−64.23±0.61	20.1 ± 0.0	−24.3	−8.2	−15.2	−13.2 ± 0.1	−16.0 ± 0.3	−9.6 ± 0.1
V1005 Ori	04 59 34.81	+01 47 01.5	10.05	37.50 ± 2.56	37.15 ± 2.18	−93.94 ± 1.48	18.7 ± 0.0	−23.3	−7.4	−10.7	−11.7 ± 0.3	−16.9 ± 0.8	−9.4 ± 0.3
CD-57 1054	05 00 47.09	-57 15 26.1	10.02	38.08 ± 1.07	35.64 ± 1.09	72.80 ± 0.98	19.4 ± 0.3	−1.5	−20.8	−15.9	−10.8 ± 0.3	−16.7 ± 0.3	−9.2 ± 0.2
HIP 23418	05 01 58.79	+09 58 59.9	11.45	31.20 ± 8.56	17.18 ± 8.75	−81.96 ± 5.42	17.3 ± 0.0	-29.8	−5.5	−10.4	−12.4 ± 1.1	−14.4 ± 3.3	−10.0± 1.7
HD 35 850	05 27 04.75	−11 54 03.0	6.30	37.26 ± 0.84	17.19 ± 0.69	−49.30 ± 0.64	22.8 ± 0.0	-20.2	−13.8	−10.9	−13.2 ± 0.1	−17.1 ± 0.1	−9.9 ± 0.1
Beta Pic	05 47 17.08	−51 04 00.2	3.85	51.87 ± 0.51	4.65 ± 0.53	81.96 ± 0.61	20.2 ± 0.4	−3.3	−16.3	−9.8	−10.9 ± 0.1	−16.2 ± 0.3	−9.2 ± 0.2
AO Men	06 18 28.22	−72 02 42.1	9.95	25.99 ± 1.02	−8.14 ± 0.98	71.42 ± 1.15	16.3 ± 0.0	7.4	−33.1	−18.2	−9.7± 0.5	−16.3 ± 0.1	−8.8± 0.2
HD 139 084B	15 38 57.60	−57 42 26.4	8.14	25.15 ± 1.09	−52.87 ± 1.11	−105.99 ± 1.03	0.1 ± 2.0	32.1	−23.5	−1.3	−11.9 ± 1.7	−15.9 ± 1.4	-10.1 ± 0.5
V343 Nor*	15 38 57.60	−57 42 26.4	8.14	25.15 ± 1.09	−52.87 ± 1.11	−105.99 ± 1.03	4.2 ± 1.4	32.1	−23.5	−1.3	−8.6 ± 1.2	−18.3 ± 1.1	−10.3 ± 0.5
V824 Ara	17 17 25.54	−66 57 02.5	6.87	31.83 ± 0.74	−21.84 ± 0.58	−136.47 ± 0.64	5.9 ± 0.0	24.7	−17.3	−8.8	−8.1 ± 0.3	−17.5 ± 0.3	−9.3 ± 0.2
HD 155 555C*	17 17 25.54	−66 57 02.5	6.87	31.83 ± 0.74	−21.84 ± 0.58	−136.47 ± 0.64	2.7 ± 1.8	24.7	−17.3	−8.8	−10.6 ± 1.4	−15.8 ± 1.1	−8.4 ± 0.5
HD 164 249	18 03 03.41	−51 38 55.7	7.01	21.34 ± 0.86	3.46 ± 0.86	−86.46 ± 0.56	0.5 ± 0.4	43.2	−14.3	−11.3	−7.0 ± 0.5	−15.5 ± 0.6	−9.0 ± 0.4
HD 164 249B*	18 03 03.41	−51 38 55.7	7.01	21.34 ± 0.86	3.46 ± 0.86	−86.46 ± 0.56	-2.4 ± 1.3	43.2	−14.3	−11.3	−9.6 ± 1.2	−14.6 ± 0.7	−8.3 ± 0.5
HD 168 210	18 19 52.21	−29 16 32.4	8.72	13.25 ± 1.41	2.84 ± 1.83	−47.16 ± 1.17	−7.0 ± 2.6	74.8	4.4	−8.8	−7.1 ± 2.6	−15.0 ± 1.6	−7.8 ± 1.1
HD 172 555	18 45 26.86	−64 52 15.2	4.78	34.21 ± 0.68	32.67 ± 0.51	−148.72 ± 0.45	3.8 ± 0.0	23.3	−13.1	−11.8	−9.5 ± 0.3	−16.4 ± 0.3	−10.0 ± 0.2
CD-64 1208*	18 45 26.86	−64 52 15.2	4.78	34.21 ± 0.68	32.67 ± 0.51	−148.72 ± 0.45	1.0 ± 3.0	23.3	−13.1	−11.8	−11.8 ± 2.4	−15.1 ± 1.4	−8.9 ± 1.2
PZ Tel	18 53 05.86	−50 10 49.1	8.43	20.14 ± 1.18	16.64 ± 1.32	−83.58 ± 0.87	−3.4 ± 0.7	45.1	−11.1	−17.6	−10.6 ± 0.8	−15.4 ± 1.0	−7.9 ± 0.7
Eta Tel	19 22 51.18	−54 25 25.4	5.03	20.98 ± 0.68	25.57 ± 0.75	−83.03 ± 0.49	0.0 ± 0.0	40.9	−12.6	−21.1	−9.0 ± 0.3	−15.4 ± 0.5	−8.2 ± 0.3
HD 181327	19 22 58.92	−54 32 16.3	7.04	19.77 ± 0.81	23.84 ± 0.89	−81.77 ± 0.57	−0.7 ± 0.0	43.3	−13.4	−22.4	−9.9 ± 0.4	−16.0 ± 0.7	−8.0 ± 0.4
AT MicN	20 41 50.97	−32 26 03.6	10.27	97.80 ± 4.65	269.32 ± 6.55	−365.69 ± 4.65	−4.5 ± 0.0	8.1	1.6	−6.1	−10.2 ± 0.4	−17.0 ± 0.8	−10.5 ± 0.7
AT MicS	20 41 50.97	−32 26 03.6	10.27	97.80 ± 4.65	269.32 ± 6.55	−365.69 ± 4.65	−5.2 ± 0.0	8.1	1.6	−6.1	−10.8 ± 0.4	−17.1 ± 0.8	−10.1 ± 0.7
AU Mic	20 45 09.34	−31 20 24.1	8.81	100.59 ± 1.35	280.37 ± 1.58	−360.09 ± 0.98	−6.0 ± 1.7	7.8	1.7	−6.0	−11.3 ± 1.3	−16.7 ± 0.4	−9.6 ± 1.0
WW PsA	22 44 57.84	−33 15 00.7	11.70	42.35 ± 3.37	183.12 ± 2.50	−118.87 ± 2.21	2.2 ± 0.0	10.8	2.4	−20.9	−12.6 ± 1.1	−17.9 ± 1.5	-11.1 ± 0.7
TWA01	11 01 51.95	−34 42 16.9	10.92	17.72 ± 2.21	−66.90 ± 1.78	−12.36 ± 1.42	12.7 ± 0.2	7.8	−51.4	22.0	−12.0 ± 1.8	−18.0 ± 0.8	−5.1 ± 1.3
TWA04	11 22 05.34	−24 46 39.5	8.89	21.43 ± 2.86	−85.45 ± 1.89	−33.37 ± 2.12	9.3 ± 1.0	5.7	−38.4	26.0	−11.8 ± 1.8	−17.7 ± 1.6	−6.8 ± 1.7
TWA09A	11 48 24.26	−37 28 49.0	11.13	19.87 ± 2.38	−54.10 ± 2.12	−19.97 ± 1.54	9.5 ± 0.4	15.2	−43.5	20.2	−6.6 ± 1.2	−14.9 ± 0.9	−3.5 ± 1.0
TWA11	12 36 01.07	−39 52 10.0	5.78	14.91 ± 0.75	−55.92 ± 0.70	−24.00 ± 0.52	6.9 ± 1.0	30.6	−53.7	26.1	−10.1 ± 0.8	−17.0 ± 1.0	−5.4 ± 0.6
2M1207	12 07 33.46	−39 32 53.9	20.15	19.10 ± 0.40	−64.20 ± 0.40	−22.60 ± 0.40	11.2 ± 2.0	19.5	−44.2	20.1	−7.9 ± 0.8	−18.3 ± 1.7	−3.5 ± 0.8
HIP 490	00 05 52.47	−41 45 10.4	7.51	24.85 ± 0.92	97.62 ± 0.59	−76.40 ± 0.73	1.6 ± 1.3	10.6	−5.5	−38.4	−9.8 ± 0.5	−21.5 ± 0.8	−1.3 ± 1.2
HIP 1113	00 13 52.83	−74 41 17.4	8.76	22.86 ± 0.87	84.14 ± 0.81	−47.52 ± 0.78	8.8 ± 0.2	19.2	−26.1	−29.4	−9.0 ± 0.5	−19.9 ± 0.6	−1.3 ± 0.3
HIP 1481	00 18 26.01	−63 28 38.5	7.46	24.42 ± 0.68	90.37 ± 0.60	−58.98 ± 0.67	6.6 ± 0.3	15.4	−19.0	−32.8	−9.0 ± 0.4	−20.0 ± 0.5	−0.8 ± 0.3
HIP 2484	00 31 32.56	−62 57 29.1	4.36	23.35 ± 0.52	82.48 ± 0.42	−54.37 ± 0.47	14.0 ± 3.0	15.1	−20.2	−34.7	−5.3 ± 1.1	−23.1 ± 1.5	−6.2 ± 2.4
HIP 2487	00 31 33.36	−62 57 55.6	4.53	18.95 ± 4.35	87.95 ± 4.06	−45.79 ± 3.96	9.8 ± 0.0	18.6	−24.8	−42.7	−11.1 ± 3.5	−24.1 ± 4.6	−3.0 ± 1.3
HIP 2578	00 32 43.79	−63 01 53.0	5.07	21.52 ± 0.49	86.15 ± 0.39	−49.85 ± 0.46	5.0 ± 1.2	16.3	−22.0	−37.6	−10.4 ± 0.5	−19.9 ± 0.7	1.0 ± 1.0
HIP 2729	00 34 51.09	−61 54 57.7	9.56	21.78 ± 1.01	87.33 ± 0.89	−53.14 ± 0.96	−1.0 ± 3.0	15.6	−21.2	−37.7	−12.1 ± 1.2	−17.7 ± 1.6	6.2 ± 2.5
HIP 9141	01 57 48.91	−21 54 04.9	8.07	23.61 ± 1.03	103.86 ± 0.98	−50.89 ± 0.75	5.7 ± 0.3	−11.1	−3.5	−40.7	−10.4 ± 0.4	−21.5 ± 0.9	−1.3 ± 0.3
HIP 12 394	02 39 35.22	−68 16 01.0	4.12	21.27 ± 0.50	87.40 ± 0.42	0.56 ± 0.50	6.4 ± 2.2	10.6	−31.0	−33.7	−11.0 ± 0.6	−17.0 ± 1.5	3.2 ± 1.6
HIP 16 853	03 36 53.32	−49 57 28.9	7.62	24.00 ± 0.66	89.96 ± 0.66	1.82 ± 0.70	14.4 ± 0.9	−4.4	−25.8	−32.5	−10.1 ± 0.3	−20.5 ± 0.6	−0.8 ± 0.8
HIP 21 965	04 43 17.17	−23 37 41.9	7.12	17.17 ± 1.24	50.00 ± 0.81	−13.28 ± 0.93	19.3 ± 2.9	−33.7	−31.2	−35.8	−11.5 ± 1.7	−20.9 ± 1.7	−2.3 ± 1.9
HIP 100 751	20 25 38.85	−56 44 05.6	1.94	17.80 ± 0.70	7.71 ± 0.58	−86.15 ± 0.45	2.0 ± 3.0	43.4	−15.0	−32.4	−6.4 ± 2.3	−22.2 ± 1.2	−1.7 ± 1.7
HIP 105 388	21 20 49.93	−53 02 02.3	8.65	21.81 ± 1.17	30.00 ± 1.16	−94.36 ± 0.60	−1.6 ± 0.2	32.0	−9.0	−31.6	−8.2 ± 0.4	−20.0 ± 1.1	−0.3 ± 0.2
HIP 107 947	21 52 09.67	−62 03 07.7	7.22	22.18 ± 0.80	43.57 ± 0.47	−91.84 ± 0.49	1.4 ± 0.6	28.1	−15.9	−31.5	−9.1 ± 0.5	−19.8 ± 0.7	−0.1 ± 0.4
HIP 108 195	21 55 11.34	−61 53 11.0	5.92	21.49 ± 0.67	43.53 ± 0.38	−90.56 ± 0.42	1.0 ± 3.0	28.8	−16.3	−32.7	−9.4 ± 1.9	−20.1 ± 1.2	0.3 ± 2.1
HIP 116 748	23 39 39.35	−69 11 44.1	8.17	21.64 ± 1.32	79.04 ± 1.15	−67.11 ± 1.20	7.4 ± 0.2	21.3	−23.5	−33.6	−9.5 ± 0.8	−21.9 ± 1.1	−0.9 ± 0.4