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

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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 3.6m 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 TWA22 AB 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 \( V_{\text{rad}} = 14.8 \pm 2.1 \) km/s.

Conclusions. A kinematic analysis of TWA22 AB space motion and position implies that a membership of TWA22 AB to known young, nearby associations cannot be excluded except for the \( \beta \) 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 \( \beta \) 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: trigonometric parallaxes – Techniques: radial velocities – Stars: binaries, distances, fundamental parameters – Galaxy: open cluster and association

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), \( \beta \) Pictoris (hereafter \( \beta \) 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 \( \lambda 6708 \) absorption feature and its close proximity to TW A 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 that the strong lithium line seen at TWA22 is the same among other stars with similar spectral types, implying a probable membership to TWA or \( \beta \) Pic. 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 \( \beta \) 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 \( \beta \) 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
(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 ground-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 ≤ 0.5h). 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 alignment of CCD images, we used an I-band filter to minimize the differential color refraction effects (DCR), 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 ≤ 1 ≤ 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 motion, based on the Besançon Galaxy model (Robin et al. 2003, 2004), was derived (Δπ = 0.35 ± 0.01 mas, Δμcos(δ) = −5.43 ± 0.02 mas/yr, Δμsin(δ) = +2.98 ± 0.02 mas/yr). Both the final estimated TWA22 AB (α = 10°17′26.79", δ = −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.

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

| π  | d  | μx cos(δ) | μy | VRad |
|---|---|---|---|---|
| mas| pc| mas/yr| mas/yr| km/s|
| 57.0±0.7| 17.5±0.2| -175.8±0.8| -21.3±0.8| 14.8±2.1|

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

| m  | M  |
|---|---|
| (mag) | (mag) |
| 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:

\[
X_0 + \Delta X_0 + \mu_x (t - t_0) + \pi F_x(t) + \alpha Q_x = a_1 x(t) + a_2 y(t) + a_3 \tag{1}
\]

\[
Y_0 + \Delta Y_0 + \mu_y (t - t_0) + \pi F_y(t) + \alpha Q_y = b_1 x(t) + b_2 y(t) + b_3 \tag{2}
\]

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. \(\Delta X_0, \Delta Y_0, \mu_x, \mu_y, \pi, \) and \(\alpha\) are the unknown parameters.
stellar astrometric parameters. Both $\Delta X_0$ and $\Delta Y_0$ yield corrections of the standard coordinates of the star on the master frame, $\mu_X$ and $\mu_Y$ are projected proper motions in right ascension and declination, $\pi$ is the parallax, and $\alpha$ is a semi-major axis of the photocentric trajectory relative to a barycenter. Coefficients $(a, b)$ are unknown frame parameters that describe the transformation to the master frame system, $(F_\alpha, F_\delta)$ are the parallax factors, and $(Q_\alpha, Q_\delta)$ are known orbital factors (based on Bonnefoy et al. (2009) orbital data). The unknown coefficient $\alpha$ 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, $R = \frac{M_B}{M_A+M_B}$, $\beta$ is the fractional distance of the primary to the photocenter $\beta = \frac{1}{\Delta m+1}$ where $\Delta m$ is the magnitude difference between A and B.

Although it is impossible to include the parameter $\alpha$ 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 1-band adapted from Bonnefoy et al. (2009). $\Delta m = 0.46 - 0.87$ mag to determine $\alpha Q_\alpha$ and $\alpha Q_\delta$ and correct $X_0, Y_0$ from these quantities. The resulting astrometric parameters for TWA22 AB are then: $\pi = 56.4 \pm 0.7$ mas, $\mu_X \cos(\delta) = -178.2 \pm 0.7$ mas/yr, and $\mu_\delta = -9.4 \pm 0.8$ mas/yr.

We note that the parallax value obtained from this study is within $1\sigma$ 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 has a high-resolution (R = 115,000) fibered cross-dispersed echelle spectrograph functioning on the ESO/3.6m 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 $\leq 1$ 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 $V_r = 14.8 \pm 2.1$ 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, $\beta$ 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, $\beta$ 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. SSSPMJJ1102-3431 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 TWA01 and TWA9A, Torres et al. 1995 for TWA4; Reid 2003 for TWA11; and Mohanty et al. 2003 for 2M1207A). For $\beta$ 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 3 (only available in the electronic edition). Calculated mean space motions of TWA, $\beta$ 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, $\beta$ 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 results: (-10.1, -17.3, -5.0), (-10.8, -16.0, -9.1), and (-9.6, -20.8, -0.5), respectively, for TW A, β Pic, and Tuc-Hor.

To test the membership of TW A22 AB to TW A, β Pic, and Tuc-Hor, based on its space motion, we applied a χ² test with 3 degrees of freedom using their space motion measurements. We find the probabilities that TW A22 AB space motion be compatible with the mean space motion of β Pic, TW A 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 TW A22 to all members of these associations. Among the k nearest neighbors to TW A22, the fraction of members for a given association gives the membership probability for that group. This k-NN analysis corroborates that TW A22 is more likely a member of β Pic than TW A and Tuc-Hor. Both calculations tend to reject TW A and Tuc-Hor as a host association for TW A22 AB.

Our final approach is to count the number of β Pic, TW A, and Tuc-Hor members (or neighbors) within a sphere of fixed radius in the UVW space, centered at TW A22’s value and at each individual member of these associations. Radii are selected proportional to the velocity dispersions of the associations. We find that UVW spatial densities of β Pic members around TW A22 are significantly lower than the averaged one found in both associations. In contrary, the UVW spatial density of β Pic members around TW A22 (within 2σ) is similar to the average density in β Pic (see Fig. 2).

Membership probabilities and association member density around TW A22 support a possible membership in the β Pic association. The membership of TW A22 in TW A 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 TW A22 AB to TW A, β Pic, and Tuc-Hor is to use the trace-back technique to compare the Galactic space position of TW A22 AB and TW A, 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 TW A22 AB instead. We present, in Figure 3, the distance between TW A22 AB and the center of each association in time. We note that TW A22 is always closer to β Pic than to TW A and Tuc-Hor. Since the mean motions of the associations derived here are in good agreement with values from the literature, the few TW A members considered here may not have seriously affected the result.

4. Conclusions

Motivated by the importance of the young, very low-mass astrometric binary TW A22 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). These parameters are fundamentals for determining 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 TW A22 AB to nearby associations. Our kinematical study shows that membership by TW A22 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 TW A22 AB in the β Pictoris association. Membership in the TW A 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 TW A22 AB in TW A.
or β Pic, but they are consistent with that from an age analysis. The location of TW A22 AB on a color-magnitude diagram supports its age being about 10 Myr but cannot be determined precisely enough to distinguish from 8 (TW A age) and 12 Myr (β Pic moving group age). Precisely known trigonometric distances of many more TW A members, an aim of our larger astrometric program of observing all known TW A members, should improve the situation soon.

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Table 4. Original data for $\beta$ Pictoris, TWA, and Tucana/Horologium members used in our kinematical analysis from LSSA 1997, Manjake 2005, Ibañez et al. 2006, and Fontan et al. 2006. Together with the derived heliocentric spatial coordinates and velocities derived in this work.

| Identifier | $\beta$ (hms) | $\delta$ (mas) | $V_r$ (Km/s) | $V_x$ (Km/s) | $V_y$ (Km/s) | $V_z$ (Km/s) | $\mu_x$ (mas/yr) | $\mu_y$ (mas/yr) | $\mu_z$ (mas/yr) |
|------------|---------------|---------------|--------------|--------------|--------------|--------------|----------------|----------------|----------------|
| HIP10779   | 02 17 24.63   | +28 44 31.0   | 7.75         | 29 40 55.30  | 98.15 49.66  | -71.45 11.75 | 5.04 ± 2.40   | 16.9 ± 1.62   | -12.6 ± 1.9   |
| HIP4082    | 02 27 20.20   | +28 44 31.0   | 11.99        | 23 37 33.30  | 97.89 49.66  | -70.08 11.45 | 3.32 ± 1.84   | 14.9 ± 1.62   | -12.6 ± 1.9   |
| BD +59 578  | 02 27 20.20   | +28 44 31.0   | 11.99        | 23 37 33.30  | 97.89 49.66  | -70.08 11.45 | 3.32 ± 1.84   | 14.9 ± 1.62   | -12.6 ± 1.9   |
| HIP8920    | 04 11 30.11   | +28 44 31.0   | 11.99        | 23 37 33.30  | 97.89 49.66  | -70.08 11.45 | 3.32 ± 1.84   | 14.9 ± 1.62   | -12.6 ± 1.9   |
| HIP2471    | 04 59 31.01   | +28 44 31.0   | 11.99        | 23 37 33.30  | 97.89 49.66  | -70.08 11.45 | 3.32 ± 1.84   | 14.9 ± 1.62   | -12.6 ± 1.9   |
| HIP2054    | 05 01 57.49   | +28 44 31.0   | 11.99        | 23 37 33.30  | 97.89 49.66  | -70.08 11.45 | 3.32 ± 1.84   | 14.9 ± 1.62   | -12.6 ± 1.9   |
| ident  | alpha (hms) | delta (″′′) | V (mag) | $\pi$ (mas) | $\mu_\alpha \cos(\delta)$ (mas/yr) | $\mu_\delta$ (mas/yr) | Vt (Km/s) | X (pc) | Y (pc) | Z (pc) | U (Km/s) | V (Km/s) | W (Km/s) |
|--------|-------------|-------------|--------|------------|------------------|-----------------|----------|------|------|------|--------|--------|--------|
| HIP2484 | 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 |
| HIP2487 | 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 |
| HIP2578 | 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 |
| HIP2729 | 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 |
| HIP9141 | 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 |
| HIP12394| 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 |
| HIP16853| 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 |
| HIP21965| 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 |
| HIP100751| 02 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 |
| HIP105388| 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 |
| HIP107947| 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 |
| HIP108195| 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 |
| HIP116748| 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 |