**V348 And and V572 Per: Bright Triple Systems with Eccentric Eclipsing Binaries**

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**Abstract**

The eclipsing binaries are still important objects for our understanding of the universe. Especially these ones located within the more complex multiple systems can help us solving the problem of their origin and subsequent evolution of these higher order multiples. Photometry and spectroscopy spanning over more than 25 yr were used for the first complete analysis of the two bright triple systems, namely V348 And and V572 Per. The light curves in photometric filters were combined together with the radial velocities and analyzed simultaneously, yielding the precise physical parameters of the eclipsing components of these multiple systems. The system V348 And consists of two eclipsing components with its orbital period of about 27.7 days. The system is a very detached one, and both eclipses are rather narrow, lasting only about 0.016 of its period. The visual orbit of the wide pair has the period of about 87 yr. All three components of the system are probably of B8-9 spectral type, and the parallax of the system was slightly shifted to the value of 2.92 mas. On the other hand, the system V572 Per shows apsidal motion of its inner orbit, the orbital period being of about 1.2 days, while the apsidal motion of about 48 yr. The components are of A and F spectral types, while the motion with the third component around a common barycenter is only negligible. According to our modeling, this system is not a member of open cluster Alpha Persei.

**Key words:** binaries: eclipsing – binaries: spectroscopic – binaries: visual – stars: fundamental parameters – stars: individual (V348 And, V572 Per)

1. **Introduction**

The eclipsing binaries still represent the most general method how to derive the stellar masses, radii, and luminosities most precisely. The fruitful combination of the observational techniques like photometry and spectroscopy is still being used also for deriving the temperatures, surface gravities, or limb darkening, but also to compute the distances to these systems.

On the other hand, studying the binaries as parts of the higher order multiple systems can bring us new important results connected with the stellar origin and evolution. We can ask—how many multiple systems are there within the stellar population? What is the multiplicity fraction of the field stars, and is this number still the same? Or is it somehow evolving in time and the multiplicity fraction can be tracked as different between Population I and Population III stars? Is the mass ratio, period ratio, or eccentricity ratio the same for the low-mass as well as for the high-mass stars? What is the role of the Kozai cycles (see, e.g., Eggleton & Kiseleva-Eggleton 2001) Can the effects like synchronization or circularization predicted by the tidal theories (Zahn 2008) be traced in particular systems via deriving their orbital and physical parameters? These and many other still open questions play a crucial role in our theories of stellar formation and evolution, see, e.g., Halbwachs et al. (2003), Tokovinin (2008), or Tokovinin (2014). And of course, the models can be tested and verified only when using the real data, which can be obtained only via studying the particular system and deriving its parameters. The importance of dedicated studies of particular systems with higher hierarchies was presented, e.g., in the updated version of the Multiple Star Catalog (MSC; Tokovinin 2018). This is the main aim of the present paper, to bring new results on two new multiple systems never studied before. And moreover, both these systems are bright enough for subsequent follow-up observations.

Due to this reason, we have focused our effort on two systems for which their light curves (hereafter LC) and radial velocity curves were not studied yet (namely V348 And, and V572 Per). Besides the inner eclipsing pair, both of these systems also contain the distant third component detected via interferometry with its rather long orbital period. Moreover, both of these stars show eccentric orbits.

2. **The Analysis**

Our analysis uses a classical combination of the photometry and spectroscopy into one joint approach. If we combine these methods, we can obtain the physical parameters of both eclipsing components as well as the parameters of their mutual orbit. As a consequence, having the complete information about their masses, inclinations, periods, etc., we can also fill in the still quite incomplete statistics of the multiple (triple and quadruple) systems. All of these distributions of orbital and physical parameters are being used for discussions about the origin and subsequent evolution of such multiples (Tokovinin 2008, 2014).

All of our new spectroscopic observations were secured in the Ondřejov observatory in Czech Republic, using the 2 m telescope. The classical slit spectrograph has a resolution of \( R \sim 12,500 \). The individual exposure times were chosen

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\(^{\dagger}\) Based on the data from 2 m telescope at the Ondřejov observatory in Czech Republic.
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Table 1
Parameters from the LC+RV Fitting of Both Systems

| Parameter          | V348 And       | V572 Per       |
|--------------------|----------------|----------------|
|                    | Primary        | Secondary      | Tertiary      |
| HJD$_0$            | 2455923.129 ± 0.025 | ...            | 2457007.3701 ± 0.0017 | ...            |
| P [days]           | 27.703514 ± 0.000325 | ...            | 1.2131789 ± 0.0000006 | ...            |
| a [R$_\odot$]     | 68.28 ± 0.87    | ...            | 7.01 ± 0.07     | ...            |
| v$_i$ [km s$^{-1}$]| −11.63 ± 0.52   | ...            | −0.05 ± 0.20    | ...            |
| $\epsilon$        | 0.116 ± 0.012   | ...            | 0.029 ± 0.002   | ...            |
| $\omega$ [deg]    | 95.6 ± 0.2      | ...            | 10.0 ± 0.1      | ...            |
| $\dot{\omega}$ [deg yr$^{-1}$]| ...            | ...            | 7.5 ± 0.9       | ...            |
| $q = M_2/M_1$      | 0.96 ± 0.02     | ...            | 0.79 ± 0.02     | ...            |
| $i$ [deg]          | 88.26 ± 0.02    | ...            | 80.7 ± 0.8      | ...            |
| $K$ [km s$^{-1}$]  | 61.22 ± 0.81    | 63.76 ± 0.85   | ...            | 126.73 ± 2.0   | 160.41 ± 2.3 | ... |
| $T$ [K]            | 10500 (fixed)   | 10412 ± 87     | ...            | 8000 (fixed)   | 6654 ± 112   | ... |
| $M$ [M$_\odot$]   | 2.81 ± 0.04     | 2.69 ± 0.04    | ...            | 1.76 ± 0.03    | 1.39 ± 0.03   | ... |
| $R$ [R$_\odot$]   | 2.42 ± 0.03     | 2.34 ± 0.03    | ...            | 1.68 ± 0.03    | 1.29 ± 0.04   | ... |
| $M$_{mag} [mag]   | 0.23 ± 0.01     | 0.33 ± 0.01    | ...            | 2.21 ± 0.05    | 3.57 ± 0.07   | ... |
| $L_4$ [%]          | 23.5 ± 0.6      | 21.6 ± 0.9     | 54.9 ± 1.3     | 68.5 ± 0.9     | 14.7 ± 0.5    | 16.7 ± 1.1 |
| $L_5$ [%]          | 22.3 ± 0.7      | 20.5 ± 0.8     | 57.2 ± 1.7     | 63.0 ± 1.0     | 17.0 ± 0.7    | 20.0 ± 0.8 |
| $L_6$ [%]          | 22.7 ± 0.6      | 20.9 ± 0.7     | 56.4 ± 1.0     | 60.4 ± 0.8     | 19.1 ± 0.5    | 20.5 ± 1.0 |
| $L_7$ [%]          | ...             | ...            | ...            | 55.2 ± 0.7     | 20.2 ± 0.6    | 24.6 ± 0.9 |

According to the quality of the particular night, typically 800–3600 s. All of the spectrograms were reduced in a standard way, the wavelength calibration was made via a ThAr comparison spectra obtained before and after the stellar ones. The flat fields were taken in the beginning and end of the night and their averages were then used for the reduction. After that, the radial velocities (RV) were derived with the program SPEFO (Horn et al. 1996, or Škoda 1996), on several absorption lines in the measured spectral region around H$_\alpha$ (usually Fe, Ca, or Si lines), with using the zero-point correction via measuring the telluric lines. All of these derived radial velocities are given in Table 4.

Owing to the relatively high brightness of these stars, only rather small telescopes were used for the photometric observations. The system V348 And was observed by (P. Svoboda) with only the 34 mm refractor at his private observatory in Brno, Czech Republic, using the SBIG ST-7 CCD camera. The second star V572 Per was monitored with the similar instrument at the private observatory (by R. Uhlar) in Jílové u Prahy, Czech Republic, using the SBIG ST-7 CCD camera. All of the measurements were reduced in a standard way using the program C-MUNIPACK, which is based on aperture photometry and uses the standard DAOPHOT procedures (Tody 1993). The photometric data were obtained during the time span of 2007–2018. Nevertheless, some of the older data were only used for the minima times derivation. All of these data were secured in the Johnson-Cousins photometric system (Bessell 1990), particularly the system V348 And was observed in $BV_R$, while the system V572 Per in $BVR$ filters.

Both photometric and spectroscopic observations were studied in the standard approach. Hence, the program PHOEBE (Prša & Zwitter 2005), which uses the classical Wilson-Devvinney algorithm (Wilson & Devvinney 1971; and its later modifications), was used for the analysis. It allows us to fit the relevant physical parameters of the eclipsing components, as well as their relative orbit. For the analysis, we used several assumptions. At first, the primary temperature was set to the value corresponding to the particular spectral type (see calibrations by Pecaut & Mamajek 2013 and the more updated website). The coefficients of the limb darkening were interpolated from the tables of van Hamme (1993). The coefficients of albedo $A_1$ and the gravity darkening coefficients $g_i$ were fixed at their suggested values. And finally, the third light was also computed because we deal with the triple systems and the additional light can easily be attributed to this distant component.

The errors of individual parameters were derived via a combined approach using PHOEBE as well as the code PYTERPOL (Nemravová et al. 2016). It derives the radiative and kinematic parameters of components via comparison of observed spectra to the synthetic ones.

For the fitting of apsidal motion and visual orbit (see below) our own codes were used. These programs use the weighted least-squares method and the simplex algorithm. For error estimation the boot-strapping method was used.

3. V348 And

The first system is the northern hemisphere star V348 And (=HIP 1233, HD 1082, $V_{\text{max}} = 6.6$ mag). Since Dyson (1935), its spectral type is usually classified as B9. Despite its brightness and northern decl., its detailed analysis is still missing. The star was classified as an eclipsing binary based on the Hipparcos data (Perryman & ESA 1997), having the supposed orbital period of about 5.5 days. However, according to our observations obtained during 2007–2008, we found there no evidence of an eclipse. Hence, we prematurely stated that the star was incorrectly classified as an eclipsing binary, see our previous paper on this star in Zasche & Svoboda (2008).

According to our new findings presented in this paper, we found that the star is eclipsing, but with a much longer orbital period. Moreover, the star is also known as a visual binary, having the distant component of about 02″ away from the

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8. See http://c-munipack.sourceforge.net/.

7. www.pas.rochester.edu/~enemajek/EEM_dwarf_UBVJHK_colors_Teff.txt

8. https://github.com/chrysante87/pyterpol/wiki
primary. However, its orbital period is still rather uncertain (see below). The parallax of the system was derived as 3.02 mas (van Leeuwen 2007), while more recently by GAIA (Gaia Collaboration et al. 2018) as 2.16 mas.

After several years of observations, a photometric decrease was detected, indicating that the star is really an eclipsing one. And finally after many other nights of observations we found out that its period is much longer than previously assumed, being of about 27.7 days. However, these eclipses are very narrow (lasting about only 0.016 of the phase, which is of about 10.4 hr), but relatively deep, of about 0.14 mag in the R filter.

The combined analysis of LC+RV provides an insight into the basic physical parameters of both components. The system is composed of two very similar stars. The primary and secondary components are both of the B9V spectral type. The results of our analysis are given in Table 1, while the plots of the RV curve as well as the light curves are given in Figure 1. The third component is even more luminous than the eclipsing pair itself, and according to the spectra, its spectral type should be similar, of about B8V. As one can see, the eccentricity of the orbit is only small, while the $\omega$ angle remains practically the same, hence the apsidal motion is only very slow (longer than 1000 yr). For this eclipse-time analysis of the apsidal motion we collected all of the available times of eclipses, including our new observed ones as well as those derived from photometry by Hipparcos (Perryman & ESA 1997), International Gamma-Ray Astrophysics Laboratory (INTEGRAL) and its optical monitoring camera (OMC) instrument (Mas-Hesse et al. 2003), and Multi-site All-Sky CAmeRA (MASCARA; Burggraaff et al. 2018). All of these are given below in Table 2.

Thanks to its brightness and period, both the masses and radii can be derived very precisely at the level of 2% only. Hence, we can state that there is no other similar long-period ($P > 20$ days) system with main-sequence components in our Galaxy with such well-derived parameters (see the DEBCat catalog by Southworth 2015).

Besides the photometry and spectroscopy, the visual orbit of V348 And (i.e., WDS J00153+4412AB) was also recomputed. Our new solution (see Table 3 and Figure 2) differs from the

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**Figure 1.** Results of our LC+RV analysis of V348 And as based on the PHOEBE fitting. Left: for the RVs, the primary is plotted as a solid line (and full dots), while secondary as a dashed line (and open circles). Right: photometry the data collected during more than 10 yr. Individual curves were shifted in the y-axis for better brevity of the picture. Typical precision of the individual observations are also plotted as the short error bars on the left.

**Figure 2.** Visual orbit of V348 And. The individual observations are connected with their theoretical positions on the orbit, while the dotted line stands for the line of the apsides and the dashed line stands for the line of the nodes.
already published solutions. Both Seymour et al. (2002) and Olevic et al. (2003) presented much longer orbits. But according to our modeling, there is a need for a tighter orbit due to its total mass. As one can compute from both eclipsing components, and using the Hipparcos parallax, the total mass of the system is of about 8.1 \( M_e \). Subtracting the masses of the primary and secondary, the tertiary mass should be about 2.6 \( M_e \). But such a small mass is unrealistic for such a luminous body. Hence, our final conclusion is that the total mass of the system is about 8.9 \( M_e \) (i.e., 2.8 + 2.7 + 3.4), but the system is located slightly further away, i.e., having the parallax of 2.92 mas. Such a value is still within the error interval of the Hipparcos value, but outside of the new GAIA parallax. We can only speculate that there may be a problem with deriving the parallax value when the instrument is not able to resolve the double into two separate targets and this can shift the true value of parallax.

4. V572 Per

The second system in our study is called V572 Per (\textit{=HIP} 15193, HD 20096, \( V_{\text{max}} = 6.7 \) mag). It is also a detached binary, but it was never studied before. Its photometric variability was also recognized by Hipparcos (Perryman & ESA 1997), having an orbital period of about 1.21 days. Similarly to V348 And it also contains a close visual component. However, this component (being of about 1″5) is not moving noticeably on the sky, hence any reliable third-body orbit cannot be derived. Moreover, the star was also proven as a member of the close open cluster Alpha Persei (Zuckerman et al. 2012). The GAIA survey (Gaia Collaboration et al. 2018) provided new measurements of its parallax, however it gives two numbers for two close sources. The brighter one is 8.07 \( \pm \) 0.05 mas, while the fainter one is 7.97 \( \pm \) 0.06 mas (i.e., the distance is 123–126 pc).

Results of our LC+RV fitting are given in Table 1, while the plots of RV and light curve are presented in Figure 3. Moreover, besides the LC+RV fitting, we also performed an analysis of the minima times of V572 Per, which revealed that the system shows an apsidal motion of its eccentric orbit. Such a movement is plotted in Figure 4, where the apsidal motion during almost 30 yr is clearly visible. Its period is only about 48 yr, hence the system deserves special attention and new photometric observations in the upcoming years to confirm this apsidal motion. Relativistic contribution to the total apsidal motion rate is about 4%. An internal structure constant resulted in \( \log k_2 = -2.37 \), which can be compared with the tables, e.g., by Claret (2004). The results indicate that the system is still rather young, having an age of about only 20 Myr.

From the combined analysis of LC+RV the results indicate that the third component in the light curve contributes about 20% to its total luminosity (depending on the photometric filter). This yielded a magnitude difference between the combined light of an eclipsing pair and this third component of about 1.5 mag. Such a result is in perfect agreement with the values given in the Fourth Catalog of Interferometric...
Table 2

| Star Name | HJD—2400000 (days) | Error (days) | Type | Filter | References |
|-----------|---------------------|--------------|------|--------|------------|
| V348 And  | 48498.65119         | 0.00627      | P    | Hp     | Hipparcos  |
| V348 And  | 54842.66675         | 0.04519      | P    | V      | OMC/INTEGRAL |
| V348 And  | 57142.16495         | 0.00016      | P    | C      | MASCARA    |
| V348 And  | 57155.82545         | 0.00834      | S    | C      | MASCARA    |
| V348 And  | 57252.99676         | 0.00107      | P    | C      | MASCARA    |
| V348 And  | 57266.64006         | 0.00222      | S    | C      | MASCARA    |
| V348 And  | 57308.37787         | 0.00742      | P    | C      | MASCARA    |
| V348 And  | 57391.48638         | 0.00540      | P    | C      | MASCARA    |
| V348 And  | 56269.31277         | 0.02211      | S    | R      | This study |
| V348 And  | 56560.38780         | 0.00064      | P    | V      | This study |
| V348 And  | 56629.45404         | 0.00092      | S    | RC     | This study |
| V348 And  | 56629.45582         | 0.00102      | S    | R      | This study |
| V348 And  | 56906.50226         | 0.00626      | S    | BVR    | This study |
| V348 And  | 56920.54223         | 0.00290      | P    | R      | This study |
| V348 And  | 56934.20656         | 0.00149      | S    | R      | This study |
| V348 And  | 57017.30505         | 0.00101      | S    | R      | This study |
| V348 And  | 57031.37299         | 0.00169      | P    | C      | This study |
| V348 And  | 57266.63076         | 0.00192      | P    | R      | This study |
| V348 And  | 57280.69077         | 0.00202      | P    | R      | This study |
| V348 And  | 57294.34885         | 0.00453      | S    | R      | This study |
| V348 And  | 57308.39410         | 0.00389      | P    | BVR    | This study |
| V348 And  | 57626.77573         | 0.00414      | S    | R      | This study |
| V348 And  | 57696.24057         | 0.00211      | P    | BVR    | This study |
| V348 And  | 57751.65673         | 0.00088      | P    | R      | This study |
| V348 And  | 58028.68835         | 0.00571      | P    | R      | This study |
| V348 And  | 58042.34567         | 0.00301      | S    | BVR    | This study |
| V348 And  | 58056.38505         | 0.01229      | S    | R      | This study |
| V348 And  | 58402.47455         | 0.00145      | S    | I      | This study |
| V348 And  | 58416.43209         | 0.00800      | P    | R      | This study |

Table 3

| Parameter | Our Solution | (2002) | Olevic et al. (2003) |
|-----------|--------------|--------|---------------------|
| $P_1$ [yr] | 86.9 ± 0.3  | 330    | 137.958 ± 1.657    |
| $T_0$ | 2451501 ± 96 | 2449900 | 2450734.4 ± 43.8 |
| $e$ | 0.559 ± 0.015 | 0.715 | 0.7238 ± 0.0096 |
| $a$ [arcsec] | 0.118 ± 0.013 | 0.29 | 0.527 ± 0.0008 |
| $i$ [deg] | 66.0 ± 3.9 | 73.8 | 62.9 ± 0.3 |
| $\Omega$ [deg] | 61.1 ± 2.4 | 64.3 | 68.4 ± 1.0 |
| $\omega$ [deg] | 139.7 ± 10.2 | 78 | 118.14 ± 0.02 |

Measurements of Binary Stars (Hartkopf et al. 2001), which are in the range from 1.48 to 1.65 mag.

We can also compute the photometric distance to the system using our derived values. At this point we found a problem. According to different published papers on the open cluster Alpha Persei (e.g., Robichon et al. 1999; Jackson & Jeffries 2010, or Pisonneault et al. 1998), its distance modulus is probably in between 6.0 and 6.5 mag (i.e., the distance is 158–200 pc), and according to Makarov (2006) the star is a member of that cluster. However, as one can check from its proper motion and distance, it is a quite disputable member of such a cluster. According to our result, the distance modulus resulted in about 5.0 mag (i.e., 100 pc distant), which means that the star is much closer to the Sun than the cluster itself, and is probably not connected with it. The value of the GAIA parallax provides a distance in between these two distances.

5. Discussion and Conclusions

In the era of huge surveys both on photometry and spectroscopy, one can ask whether a dedicated study on one particular binary is still worth the effort. However, as was presented quite recently (Kim et al. 2018), the catalog of eclipsing binaries with eccentric orbits and apsidal motion is still only sparsely populated with stars having the complete LC+RV solution (hence with precisely derived masses) with periods longer than 20 days. Our study of V348 And can serve as a good example. Moreover, its parameters were derived with high precision at a level of about 2%. The other system V572 Per can enrich a still limited group of short eccentric systems with fast apsidal motion ($U < 50$ yr), which nowadays comprises only 21 systems (Kim et al. 2018). Hence any new
contribution, moreover with derived masses, is welcome. And, as was mentioned in many other publications (like, e.g., Claret & Giménez 2010), their role for testing the stellar structure theories is still undisputable.

Moreover, besides the eccentric inner orbit, the fact that we deal with hierarchical triple systems is also of high importance. As was presented recently, e.g., by Tokovinin (2014), there is an excess of tight inner binaries within the triples, probably caused by tidal evolution and Kozai cycles.

It also should be noted that both of these stars are of high brightness and are also located on the northern sky. One would expect that almost all of the interesting systems here are known and were studied before. But, as we have pointed out, also some interesting results still can be obtained with very small photometric instruments (all photometry for our study was obtained using only small telescopes having an aperture of less than 8 cm).

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| Star Name | HJD—2400000 (days) | RV$_1$ (km s$^{-1}$) | Error (km s$^{-1}$) | RV$_2$ (km s$^{-1}$) | Error (km s$^{-1}$) |
|-----------|-------------------|---------------------|---------------------|---------------------|---------------------|
| V348 And  | 56041.5766        | −69.91              | 1.65                | 50.77               | 0.39                |
| V348 And  | 56357.2585        | 37.68               | 2.01                | −59.13              | 0.48                |
| V348 And  | 56400.6903        | −76.20              | 1.66                | 53.01               | 7.92                |
| V348 And  | 56534.5871        | −46.54              | 0.87                | 21.13               | 1.16                |
| V348 And  | 56563.6216        | −61.96              | 2.66                | 37.55               | 2.48                |
| V348 And  | 56572.5450        | −23.97              | 0.98                | 9.45                | 1.28                |
| V348 And  | 56590.2923        | −48.02              | 1.12                | 22.40               | 4.06                |
| V348 And  | 56590.5739        | −50.89              | 1.48                | 31.41               | 3.09                |
| V348 And  | 56592.3997        | −72.36              | 1.36                | 52.12               | 1.45                |
| V348 And  | 56596.6362        | −63.08              | 2.15                | 40.61               | 1.12                |
| V348 And  | 56665.1968        | 46.17               | 2.10                | −76.87              | 1.93                |
| V348 And  | 56665.4144        | 46.11               | 2.66                | −74.71              | 2.50                |
| V348 And  | 56862.4588        | 29.47               | 0.38                | −55.96              | 2.47                |
| V348 And  | 56924.4092        | −67.61              | 2.05                | 46.82               | 4.51                |
| V348 And  | 57084.2744        | 23.89               | 2.60                | −50.82              | 3.06                |
| V348 And  | 57248.4857        | 45.88               | 7.34                | −68.68              | 5.07                |
| V348 And  | 57260.5891        | −69.17              | 2.55                | 48.80               | 0.80                |
| V348 And  | 57275.5356        | 46.09               | 4.10                | −74.11              | 2.39                |
| V348 And  | 57323.5005        | 1.75                | 6.28                | −24.11              | 6.24                |
| V348 And  | 57328.5228        | 45.15               | 1.43                | −70.60              | 3.27                |
| V348 And  | 57868.5572        | −76.57              | 0.80                | 54.89               | 1.93                |
| V348 And  | 57876.5621        | −7.49               | 2.37                | ...                 | ...                 |
| V348 And  | 57954.5020        | −61.05              | 2.28                | 38.25               | 2.76                |
| V572 Per  | 56571.4889        | 122.65              | 3.51                | −163.36             | 4.32                |
| V572 Per  | 56572.5780        | 77.87               | 3.10                | −104.99             | 2.56                |
| V572 Per  | 56590.3078        | −118.92             | 2.72                | 152.61              | 6.22                |
| V572 Per  | 56590.4916        | −90.88              | 3.93                | 117.60              | 5.50                |
| V572 Per  | 56592.3713        | 56.92               | 3.98                | −73.27              | 8.75                |
| V572 Per  | 56862.5158        | 72.87               | 2.78                | −88.93              | 2.63                |
| V572 Per  | 56862.5837        | 108.78              | 1.93                | −127.26             | 3.57                |
| V572 Per  | 56924.3582        | 59.83               | 6.17                | −71.36              | 4.16                |
| V572 Per  | 57079.3053        | −120.45             | 0.99                | 148.18              | 4.86                |
| V572 Per  | 57084.3023        | −65.68              | 1.30                | 81.68               | 5.05                |
| V572 Per  | 57084.3527        | −41.35              | 2.59                | 39.24               | 3.78                |
| V572 Per  | 57126.3372        | −56.04              | 4.50                | 64.81               | 6.40                |
| V572 Per  | 57260.6045        | 130.68              | 4.84                | −165.72             | 5.07                |
| V572 Per  | 57294.4578        | 91.56               | 1.81                | −119.09             | 2.75                |
| V572 Per  | 57323.4676        | 36.29               | 6.17                | −39.45              | 2.40                |
| V572 Per  | 57328.5854        | 128.18              | 4.15                | −165.25             | 4.62                |
| V572 Per  | 57330.3089        | −117.55             | 3.29                | 145.97              | 6.57                |
| V572 Per  | 57332.4880        | 15.51               | 2.24                | −14.78              | 1.54                |
| V572 Per  | 57410.4423        | −124.74             | 2.91                | 155.86              | 3.00                |
| V572 Per  | 57443.3294        | −99.99              | 4.43                | 127.98              | 4.09                |
| V572 Per  | 57876.3165        | −127.74             | 3.29                | 159.44              | 4.39                |
This research has made use of the SIMBAD and VIZIER databases, operated at CDS, Strasbourg, France and of NASA’s Astrophysics Data System Bibliographic Services.

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