CANDIDATES TO THE GLIESE CATALOGUE OF NEARBY STARS FROM TYCHO ASTROMETRY AND PHOTOMETRY

V.V. Makarov

Copenhagen University Observatory, Juliane Maries Vej 30, DK 2100 Copenhagen Ø, Denmark

ABSTRACT

A search for possible nearby stars, closer than 25 pc from the Sun, was carried out, based on the data in the Tycho Catalogue. Among the stars not given in the Hipparcos Catalogue, a total of 29 candidates to the Gliese catalogue of nearby stars were selected for further investigation and follow–up observations. Six stars in the Gliese catalogue, missed by the main Hipparcos instrument, are confirmed to be nearby by Tycho observations. The rather meagre result of this search indicates that the collection of nearby stars in the Hipparcos Catalogue is complete for stars brighter than about $M_V = 8$ mag.

Key words: space astrometry; trigonometric parallaxes; nearby stars.

1. INTRODUCTION

Before the Hipparcos mission, the Catalogue of Nearby Stars (CNS version 3, Gliese & Jahreiß 1991) was the most comprehensive and systematic compilation of observational data on stars in the close vicinity of the Sun. The catalogue contains 3803 entries with observed trigonometric parallaxes greater or equal to 39 mas. The catalogue served as a basis for numerous studies of, e.g. local stellar kinematics and luminosity function.

The Hipparcos Catalogue, with its unprecedented accuracy for 100 000 trigonometric parallaxes, provides an opportunity to critically revise the list of nearby stars. Already a provisional study of Hipparcos parallaxes by Perryman et al. (1995) showed that many of the CNS3 stars in fact lie beyond the range of 25 pc, and some of them very significantly so. At the same time, a good number of previously unknown nearby stars had been discovered. More details on the impact of Hipparcos parallaxes on the Catalogue of Nearby Stars are given by Jahreiß & Wielen (1997). Although the total number of known stars within 25 pc remains nearly the same, the contents of the sample changed drastically in some respects.

The Tycho Catalogue contains a million observed parallaxes. In spite of the poor astrometric precision for the vast majority of them, it seems interesting to do a search for possible nearby stars missing in the Hipparcos Catalogue. The Tycho Catalogue is complete to about $V = 10$ mag (Egret & Fabricius 1997), which is at least one magnitude fainter than the limit of completeness of the HIP. Tycho parallaxes may still be marginally useful at $V \approx 10$ mag. Hence, there might be a chance of finding previously unknown nearby stars among Tycho stars with large parallaxes and V in the range 8 to 10 mag.

2. SELECTION CRITERIA

The Tycho Catalogue contains 181 584 entries with parallaxes above 40.0 mas. At the same time, nearly the same number of negative parallaxes are below -40.0 mas (162 894). This shows that large parallaxes in the Tycho Catalogue are typically statistical outliers, populating the broad wings of the distribution of determined parallaxes, see Figure 16.17 in ESA SP–1200 1997, Volume 4. It is noted that the parallaxes in the Tycho Catalogue are of low significance for individual stars (see Chapter 18 of the same volume), and great caution must therefore be taken when individual parallaxes are selected and used for some purpose. The standard errors for parallaxes, given in the Tycho Catalogue, are probably underestimated for stars fainter than $V = 9$ mag, increasingly with growing magnitude. The majority of Tycho parallaxes, having external errors quite close to the chosen limit of 40 mas, are of no use for the purpose.

There are two main reasons for the excessive number of statistical outliers in the Tycho measurements:

- the influence of so-called 'parasitic' stars, typical for the Tycho instrument due to its long slits (see ESA SP–1200 1997, Volume 4);
- unresolved duplicity of stars.

For the faintest Tycho stars, besides, Tycho observations are statistically uncertain due to too low signal-to-noise ratio. A set of disturbed and scattered observations could then mimic a large positive or negative parallax.

Quite a few different sets of selection criteria were tried, the condition $|\pi| > 40$ mas being always included. The reliability of the resulting samples was estimated by the fraction of negative ($\pi < -40$ mas)

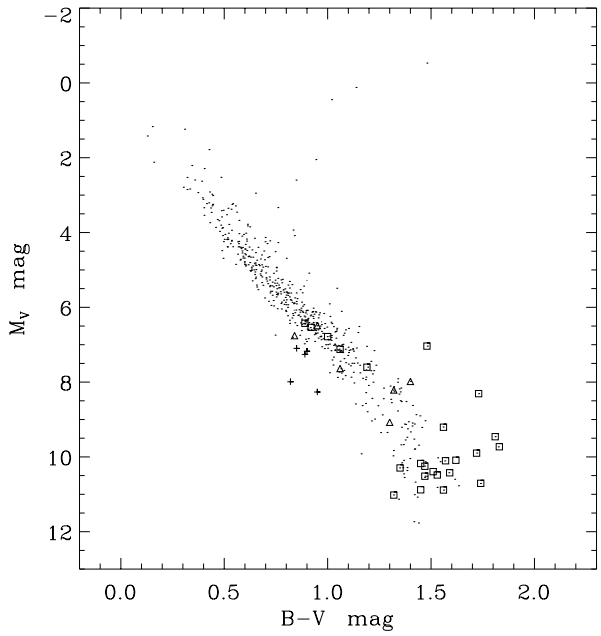

Figure 1. The observational HR diagram constructed from the Tycho Catalogue, for the 'wide' selection of probable stars nearer than 25 pc. All the stars, including those in common with HIP, are marked with dots, the Tycho candidates from the top section of Table 1 are shown with open squares, those from the middle section with plus symbols and the confirmed CNS3 stars from the bottom section with triangles.

parallaxes. It was, for example, found that this fraction becomes 0 when only stars with standard errors σ_π well below 10 mas are included, but that hardly leaves any candidates beyond the Hipparcos Catalogue collection. In order to obtain a bigger sample of Tycho-only candidates, a looser condition on σ_π should be used, taking the risk of contaminating the sample with gross statistical errors. Eventually, a set of selection criteria was found, which gives an acceptable reliability of the resulting sample:

1. $|\pi| > 40$ mas
2. standard error $\sigma_\pi < 30$ mas
3. solution quality $Q = 1$ to 6
4. relative error $\sigma_\pi/|\pi| < 0.22$
5. magnitude $V_T < 10.4$
6. colour $B - V \in [0.0, 2.0]$
7. variability flag T48 is not set

The size of the resulting sample, called hereafter the 'wide' sample, is 822, with 36 parallaxes smaller than −40 mas. When restricted to stars only present in the Tycho Catalogue, the size is down to 161, with 34 negative parallaxes.

The HR diagram for the wide sample, constructed entirely from the data available in the Tycho Catalogue, is shown in Figure 1. For clarity, 266 stars are not included in the diagram, which fall below and to the left of the main sequence. Since nearby subdwarfs are very rare, and Tycho photometry is believed to be quite accurate, those deviating dots must be due to erroneous parallaxes, resulting in too faint absolute magnitudes. Assuming the same proportion for the sample of 161 Tycho-only stars, the fraction of false candidates would be about 32 per cent. The actual fraction can still be larger, for the 161 stars in the narrow sample are mostly fainter than the median magnitude of the wide sample.

3. PROBABLE NEARBY STARS

Some additional tests were made on the original sample of 161 stars, taking into account other available Tycho and on-ground observational data. The three main tests were:

- consistency of the position on the HR diagram as derived from the Tycho observational data, with the assumption of a main sequence star;
- consistency of the observed Tycho parallax with other available observations, e.g. CNS3, Yale catalogue (Van Altena et al. 1995);
- Consistency of the observed Tycho proper motion with other available data, e.g. PPM (Röser & Bastian 1991, Bastian et al. 1993 and Röser et al. 1994) and the Lowell Survey (Giclas et al. 1971).

The first condition was the most crucial one, leaving only some 30 objects out of the 161. The candidates situated below and to the left of the main sequence, suggesting large positive errors in their parallaxes, were mostly discarded. A few stars of this kind are however kept for further investigation, which are relatively bright and show additional supporting evidence, e.g. a significant proper motion. These are given in the middle section of Table 1. The available MK spectral classification for the HD stars in the southern sky (Houk 1975–1988) was also used.

Six stars turned out to be already present in the CNS3, but for some reason missing in the Hipparcos Catalogue. They are given in the bottom section of Table 1, along with their cross-identifications in the notes. The proximity of these stars is confirmed by Tycho data.

A few stars were discarded due to huge inconsistencies in the on-ground and Tycho proper motions or parallaxes. These objects are likely Tycho statistical outliers. At the same time, a few other objects were added to the list, in spite of an indication of variability/duplicity in field T48, violating condition 7 of the above selection criteria. The resulting list of candidates is given in the top section of Table 1, with additional relevant information summarized in the notes.

It is noted, for example, that one object is certainly eligible for the Catalogue of Nearby Stars (833–134–1). Quite a few objects are noted with 3 or 6, meaning

that their proper motion is known to be slow (less or similar to 25 mas/yr). One would not expect many nearby stars to move slowly relative to the Sun. Yet, there are two facts encouraging further investigation of these stars. Firstly, there must be a strong selection effect, tending to a more thorough representation of high proper motion stars in the CNS3. A high proper motion is easier to detect than a big parallax, and some real faint and slow nearby star could elude the attention of the observers making on-ground parallax determinations. Secondly, proximate stars with low or moderate proper motion are present in somewhat surprising abundance in the Hipparcos Catalogue, as is noted by Murray et al. (1997). At least three stars in the Hipparcos Catalogue within 30 pc of the Sun have space velocities below 5 km/s with respect to the Sun.

4. CONCLUSIONS

The search for unknown nearby stars in the Tycho Catalogue beyond the Hipparcos sample resulted in a rather modest group of 29 candidates, which still require follow-up observations to be confirmed or ruled out. It is difficult to say, how many of them are indeed nearer than 25 pc, and how many real nearby stars remain hidden in the Tycho Catalogue. It is noted, however, that only some 8 of the selected objects appear brighter than $M_V = 8$ mag. They conform better to the main sequence than the scatter of fainter stars, which tends to concentrate around $M_V = 10$ mag. More candidate objects can be obtained by loosing some of the selection criteria, but they would also bunch up around magnitude 10. It seems hardly possible to find further reasonable candidates brighter than $V = 10$ mag (corresponding roughly to $M_V = 8$ mag at 25 pc), where the Tycho Catalogue is complete.

This strongly suggests that the Hipparcos sample of nearby stars, with possibly the present small addition, is virtually complete down to absolute visual magnitude 8. Whether it is complete down to $M_V = 9$ mag, as stated by Jahreiß & Wielen (1997), can not be concluded from an analysis of individual Tycho data of the present kind. Perhaps, a careful statistical analysis of the bulk of Tycho Catalogue parallaxes will answer that question.

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Table 1. Suspected and confirmed nearby stars.

TYC id	RA(J2000) deg	Dec(J2000) deg	$\pi \pm \sigma_\pi$ mas	$B_T \pm \sigma_{B_T}$ mag	$V_T \pm \sigma_{V_T}$ mag	$B-V \pm \sigma_{B-V}$ mag	Note
712–1986–1	80.86423229	13.70032581	158.5 ± 29.2	11.59 ± 0.11	10.02 ± 0.04	1.32 ± 0.10	1
833– 134–1	152.05393124	11.99694017	48.0 ± 8.1	9.20 ± 0.03	8.13 ± 0.02	0.92 ± 0.03	2
1011– 690–1	268.26348591	10.49546361	124.4 ± 27.4	11.84 ± 0.11	10.01 ± 0.03	1.53 ± 0.10	
1373– 783–1	114.11335804	22.02970458	135.2 ± 27.1	11.67 ± 0.10	9.77 ± 0.03	1.59 ± 0.10	3
1951–1445–1	136.82532230	22.87281825	46.7 ± 8.3	9.11 ± 0.02	8.08 ± 0.01	0.89 ± 0.02	4
2064– 930–1	256.90491725	24.77417352	99.8 ± 21.8	11.92 ± 0.08	10.18 ± 0.03	1.45 ± 0.07	6
2681–1259–1	297.78977101	36.65899220	130.3 ± 28.2	12.19 ± 0.17	10.31 ± 0.05	1.56 ± 0.18	3
2703– 676–1	320.90592595	31.26272448	115.0 ± 23.9	11.91 ± 0.11	10.09 ± 0.03	1.51 ± 0.10	3
2829–1713–1	30.72277414	38.10967026	123.0 ± 24.5	11.56 ± 0.09	9.80 ± 0.03	1.47 ± 0.08	3
2855–1062–1	46.39218802	42.19742512	51.6 ± 8.7	9.39 ± 0.02	8.22 ± 0.01	1.00 ± 0.02	4
3102– 69–1	271.93503239	39.07483449	50.6 ± 9.1	10.49 ± 0.03	9.08 ± 0.02	1.19 ± 0.03	5
3566–1040–1	298.43655065	50.39657024	61.6 ± 13.6	11.43 ± 0.08	9.36 ± 0.02	1.73 ± 0.07	6
3576–1273–1	306.02889398	47.72883735	137.4 ± 28.2	11.93 ± 0.16	10.19 ± 0.05	1.45 ± 0.15	
3904–1517–1	273.44654877	53.68614845	42.0 ± 9.0	10.70 ± 0.05	8.92 ± 0.02	1.48 ± 0.04	6
4006– 889–1	348.24094395	56.94431847	100.4 ± 21.2	11.91 ± 0.12	9.72 ± 0.03	1.83 ± 0.12	3
4486– 726–1	352.89731967	72.64957569	110.9 ± 23.2	12.06 ± 0.12	10.29 ± 0.04	1.47 ± 0.12	3
4650–1536–1	355.24068653	82.87214411	53.8 ± 6.1	9.71 ± 0.02	8.47 ± 0.01	1.06 ± 0.02	7,8
6462– 940–1	62.66351998	-29.59229257	78.9 ± 16.1	11.59 ± 0.07	9.72 ± 0.02	1.56 ± 0.06	6
6478– 948–1	79.20087628	-24.74301442	97.2 ± 21.2	12.09 ± 0.10	10.15 ± 0.03	1.62 ± 0.09	6,9
7652– 957–1	113.82879883	-42.40265772	135.3 ± 22.8	12.14 ± 0.16	10.05 ± 0.03	1.74 ± 0.16	6
8194–1609–1	151.15974631	-51.31037169	91.2 ± 20.1	11.83 ± 0.12	9.66 ± 0.03	1.81 ± 0.12	3
8583– 418–1	139.57295920	-52.53107776	107.6 ± 22.1	11.80 ± 0.14	9.74 ± 0.03	1.72 ± 0.14	6
9450– 327–1	241.55619943	-79.49092339	106.8 ± 21.6	11.84 ± 0.10	9.96 ± 0.03	1.57 ± 0.09	
9459–1622–1	292.38612569	-76.01217892	109.4 ± 23.2	11.71 ± 0.09	10.10 ± 0.03	1.35 ± 0.08	
263– 982–1	169.44628660	00.79149185	44.3 ± 9.2	9.98 ± 0.03	8.94 ± 0.02	0.90 ± 0.03	10
2441–1542–1	104.06917375	32.44487165	49.4 ± 9.9	9.61 ± 0.03	8.63 ± 0.02	0.85 ± 0.03	11
2897–1624–1	70.73873154	40.38624866	64.6 ± 13.1	9.89 ± 0.03	8.94 ± 0.02	0.82 ± 0.03	12
4162– 626–1	190.88926117	60.01479232	56.6 ± 12.1	10.61 ± 0.04	9.50 ± 0.02	0.95 ± 0.04	
6667– 738–1	181.53740779	-23.60218317	51.5 ± 10.9	9.74 ± 0.02	8.70 ± 0.02	0.89 ± 0.02	13
232–1982–1	137.47567085	5.20353866	67.8 ± 10.7	9.73 ± 0.02	8.48 ± 0.01	1.06 ± 0.02	14
3478– 418–1	214.05126174	51.37609369	46.3 ± 6.7	9.40 ± 0.03	8.43 ± 0.02	0.84 ± 0.03	15
3819–1043–1	157.60624333	55.99920490	72.8 ± 9.8	10.48 ± 0.04	8.90 ± 0.02	1.32 ± 0.04	16
4378–2162–1	133.86348281	70.79503606	84.8 ± 9.8	10.01 ± 0.02	8.34 ± 0.01	1.40 ± 0.02	17
4835– 774–1	115.01192970	-3.60297679	100.2 ± 15.2	10.63 ± 0.04	9.07 ± 0.02	1.30 ± 0.04	18
5930–2196–1	86.11137392	-22.42098198	111.1 ± 4.6	7.37 ± 0.01	6.26 ± 0.01	0.95 ± 0.01	19

Notes:

1 A significant proper motion for this star of $(+91.6, -120.0)$ mas/yr is found in TYC, in fair agreement with a proper motion derived by comparison of TYC and GSC 1.2 positions.

2 There is a confidence that this star is nearby. It is a component of Regulus, and therefore is included in the Yale catalogue, but without individual parallax. Regulus itself was not included in CNS3, because the Yale parallax for it was 37.5 mas. Since the parallax of Regulus is 42.09 mas in HIP, and 42.4 mas in TYC, it must be included in the list of nearby stars, along with this component.

3 A low proper motion star, as confirmed by comparison of the GSC 1.2 and TYC positions.

4 A moderate proper motion for this star in TYC is in statistical agreement with PPM.

5 A high proper motion star, found also in the Lowell Proper Motion Survey. The proper motion in TYC $(+47.6, -270.7)$ mas/yr is consistent with PPM.

6 A low proper motion given in PPM.

7 A proper motion of $(-9.1, -38.0)$ mas/yr is given in PPM.

8 A large discrepancy between TYC and PPM proper motions.

9 Suspected to be double/variable from Tycho photometric analysis.

10 A proper motion $(-106.5, -79.0)$ mas/yr is found in PPM

11 A parallax of 35.2 ± 11.9 and a proper motion of $(-167.0, -152.0)$ mas/yr are given in the Yale catalogue. A spectral type G5 is given in the SIMBAD data base.

12 A moderate proper motion in PPM of (-44.6,-32.0) mas/yr.

13 The PPM proper motion for this star $(68.7, -99.0)$ mas/yr is in fair agreement with the observed TYC proper motion. A spectral type of K1V is however given in the Michigan Spectral Survey, in agreement with the observed TYC colour, but in disagreement with the observed parallax.

14 Unnamed (NN) star in CNS3 = PPM 155494 = HD 78727.

15 Wo 9474B in CNS3 = PPM 34433 = HD 234121. It can in fact be more distant than 25 pc, for the component A of this double system has $\pi = 33.54$ mas in HIP and 29.3 mas in TYC.

16 GJ 394 in CNS3 = PPM 32667 = HD 237903.

17 GJ 325 in CNS3, A and B components in one unresolved TYC entry.

18 GJ 282B in CNS3 = PPM 190510.

19 GJ 216B in CNS3 = PPM 249306 = HD 38392.