HIPPARCOS OBSERVATIONS OF SYMBIOTIC STARS

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ABSTRACT

The Hipparcos results on symbiotic stars are presented and briefly discussed. In spite of the faintness of the targets and their distance at the very limit of the mission goals, the Hipparcos data are valuable because for the first time geometrically determined distances to at least a few symbiotic stars are provided. The Hipparcos results tend to support the notion from ground–based IR photometry and radial velocities that the bulk of symbiotic stars belong to the Bulge/thick–Disk population of the Galaxy, with implications for their energetics, their total number in the Galaxy and their link to SN Ia progenitors.

Key words: symbiotic stars, type Ia supernovae.

1. INTRODUCTION

Ground–based astrometry has so far failed to produce data on symbiotic stars of some relevance: very few objects have published proper motions (generally of some significance), and even fewer have published parallaxes (all however of no significance; see Kenyon 1986 and references therein). Distances to galactic symbiotic stars are currently obtained by indirect methods, particularly spectroscopic parallaxes in the IR. No symbiotic star is known to be associated with open or globular clusters and those belonging to the LMC, SMC or Draco dwarf galaxies harbor cool giants at the tip of the AGB (e.g. carbon stars), while very few symbiotics of this type are known in the Galaxy. Therefore, the inclusion of the brighter galactic symbiotic stars in the Hipparcos Input Catalogue (ESA 1992) appeared promising, offering for the first time the long waited for opportunity of geometrically determined distances. About 15 symbiotic stars were included in the observing list, and the results from the Hipparcos Catalogue (ESA 1997) are here briefly discussed.

2. THE DATA

The astrometric results are given in Table 1. They have been used to compile Tables 2 and 3 where the heights above the galactic plane and the absolute M_K magnitudes presented (the carbon symbiotic star NQ Gem has been ignored in the latter Tables due to the very large error on its parallax.) The spectral types and the luminosity classes in Table 3 are in a few cases still a matter of debate (see Kenyon & Fernandez-Castro 1987, Schulte-Ladbeck 1988, Huang et al. 1994).

A few individual notes seem appropriate. The absolute magnitude of Z And (the class prototype) argues for a partnership with the Bulge/thick-Disk galactic population, even if the association with a younger population (much brighter M_K) is inside the errors. The derived absolute magnitudes of symbiotics harboring a LPV cool component agree with the expectations for giants at the tip of the AGB, $M_K \sim -8$ (the inclusion of CH Cyg among the LPVs is justified by the large variability of its cool component, see Mikolajewski et al. 1996).

The absolute magnitude of EG And is more appropriate to a luminosity class II as originally suggested by Martini (1968). In BL Tel and HD 330036 the luminosity of the F supergiant is more appropriate to post-AGB stars than to massive stars evolving out of the main sequence (even accounting for the large error of HD 330036 parallax and the contribution by the M III companion in the case of BL Tel).

In the case of BL Tel the F supergiant could even simply be the expanded envelope of the white dwarf accreting at a rate exceeding the Eddington limit. The very faint absolute magnitude of AR Pav (with however a large error bar) may invite a careful investigation of the luminosity class of its cool component: taken at face value it would indicate a sub-giant luminosity.

3. THE DISTANCE SCALE AND THE GALACTIC POPULATION

Whitelock & Munari (1992) argued on the basis of the *UBVRI-JHKL* photometric catalogue by Munari *et al.* (1992) that S–type symbiotic stars (those containing a non pulsating M giant, ~ 75 per cent of the total), although different from the bright local M giants (belonging to the young galactic thin–Disk population), they are very similar to the M giants found in the Bulge/thick–Disk of the Galaxy. Their arguments were later reinforced by the results of extensive radial velocity monitoring (Munari 1994). The two galactic populations of younger and older M giants greatly differ in absolute magnitudes and intrinsic colors (Lee 1970, Frogel & Whitford 1987). These differences have a large impact on our understanding of symbiotic stars given the common practice of estimating distance, reddening and energetics from infrared spectrophotometry of the M giant. They testify on the importance of a careful investigation of the galactic population of symbiotic stars.

In Figure 1 the cumulative distribution in z (height above the galactic plane) of the target symbiotic stars from the original Allen (1984) catalogue (the first 10 in Table 1) is compared with that expected from the thin Disk population (scale height 100 pc, Freeman 1987) and that from the thick Disk (scale height 760 pc, Robin et al. 1996). All points lie *on the right* of the thin–disk distribution, and move further to the right when the lower limit to the distance is taken into account. There are some biases that if accounted for will move the points further to the right, i.e. toward the thick–Disk distribution: (a) symbiotic stars at distances in excess of $\sim$0.4 kpc are generally too faint to have been included in the Hipparcos Input Catalogue, and this is a net bias toward the objects laying closer to the galactic plane, and (b) as discussed by Munari & Renzini (1992), most symbiotic stars were discovered during searches for emission-line objects, which historically have been carried out at low galactic latitudes. Both facts translates into a net bias toward objects of low z.

It is tempting to conclude that the Hipparcos data (whatever preliminary, biased, based on a small bunch of objects and affected by large errors) agree with the independent evidences from ground based photometric and radial velocity observations that the bulk of symbiotic stars belong of the Bulge/thick–Disk population of the Galaxy. From this partnership Munari & Renzini (1992) estimated in 3×10^5 the number of S–type symbiotics in the Galaxy. In their scenario it is enough that 2–4 per cent of them drive by accretion their WDs to the Chandrasekhar limit and C–deflagrate to account for the observed SN Ia rate. The recent theoretical models by Hachisu, Kato & Nomoto (1996) support the notion that carbon deflagration at the Chandrasekhar limit for WDs accreting from cool giants is the leading SN Ia explosion mechanism and therefore add support to the symbiotic stars as promising progenitors of type Ia Supernovae.

A deeper and more precise astrometric investigation of the galactic symbiotic stars will have to wait for the announced next generation of astrometric satellites.

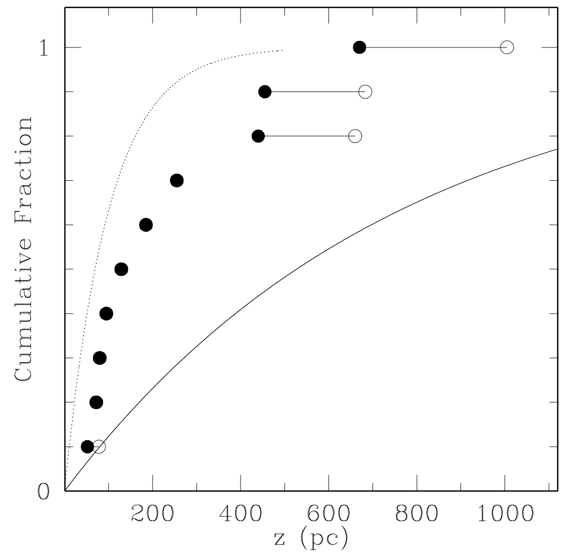

Figure 1. The observed cumulative distribution of heights above the galactic plane (z) for symbiotic stars is compared with those expected for the thin Disk (dashed line; scale height 100 pc) and for the thick Disk (solid lines; scale height 760 pc). The open circles show the relocation of the stars with a lower limit to z (Table 2) when their true height is taken 50 per cent higher than the reported lower limit.

REFERENCES

Allen, D.A. 1984, Proc. Astron. Soc. Aust. 5, 369

ESA, 1992, The Hipparcos Input Catalogue, ESA SP–1136

ESA, 1997, The Hipparcos Catalogue, ESA SP–1200

Freeman, K.C. 1987, ARA&A, 25, 603

Frogel, J.A., Whitford A.E., 1987, ApJ, 320, 199

Hachisu, I., Kato, M., Nomoto, K., 1996, ApJLett, 470, L97

Huang, C.C., Friedjung, M., Zhou, Z.X., 1994, A&AS, 106, 413

Kenyon, S.J., 1986, The Symbiotic Stars, Cambridge Univ. Press

Kenyon, S.J., Fernandez–Castro, T., 1987, AJ, 93, 938

Lee, T.A., 1970, ApJ, 162, 217

Martini, A., 1968, MemSAIt, 39, 633

Mikolajewski, M., Tomov, T.V., Kolev, D., 1996, IBVS4368

Munari, U., Renzini, A., 1992, ApJLett, 397, L87

Munari, U., Yudin, B.F., Taranova, O.G., Massone, G., Marang, F., Roberts, G., Winkler, H., Whitelock, P.A. 1992, A&AS, 93, 383

Munari, U., 1994, in Evolutionary Links in the Zoo of Interacting Binaries, MemSAIt, 65, 157

Robin, A.C., Haywood, M., Creze, M., Ojha, D.K., Bienayme, O. 1996, A&A, 305, 125

Schulte-Ladbeck, R.E., 1988, A&A, 189, 97

Whitelock, P.A., Munari, U., 1992, A&A, 255, 171

Table 1. Hipparcos positions, parallaxes and proper motions of symbiotic stars. Right ascension, α, and declination, δ, are expressed in degrees for the catalogue epoch J1991.25 and with respect to the reference system ICRS. The trigonometric parallax, π, is expressed in units of milliarcsec (a negative value arising when the true parallax is smaller than its error). The proper motion components, μ_δ and $\mu_{\alpha *} = \mu_\alpha \cos\delta$, are expressed in milliarcsec per Julian year (mas/yr), and are given with respect to the reference system ICRS. The standard errors of the equatorial coordinates (σ_δ and $\sigma_{\alpha *} = \sigma_\alpha \cos\delta$) are expressed in milliarcsec.

HIC	Name	α	$\sigma_{\alpha *}$	δ	σ_δ	π	σ_π	$\mu_{\alpha *}$	$\sigma_{\mu_{\alpha *}}$	μ_δ	σ_{μ_δ}
3494	EG And	011.15491629	0.62	+40.67939958	0.68	1.48	0.97	9.12	0.74	−15.05	0.74
77662	HD 330036	237.81638625	6.32	−48.74959149	3.92	0.93	3.07	−1.86	2.85	−0.25	2.31
78322	T CrB	239.87568752	0.89	+25.92014087	0.97	−1.61	1.63	−5.93	1.18	10.73	1.40
78512	AG Dra	240.42092763	0.88	+66.80282974	0.96	−1.72	0.98	−6.18	0.92	−5.47	1.08
89886	AR Pav	275.11617608	1.18	−66.07857718	1.44	3.37	2.47	−0.98	1.49	−11.31	2.07
95413	CH Cyg	291.13780926	0.79	+50.24147258	0.75	3.73	0.85	−6.77	0.92	−19.75	1.14
97594	CI Cyg	297.54931678	1.08	+35.68417458	1.31	−0.36	1.58	−2.88	1.47	−2.92	1.54
107848	AG Peg	327.75822786	1.09	+12.62559362	0.83	−0.30	1.17	0.26	1.82	−2.72	0.92
116287	Z And	353.41648545	1.58	+48.81833360	1.84	2.34	2.91	−6.72	2.22	−6.21	2.14
117054	R Aqr	355.95600683	2.52	−15.28442126	1.00	5.07	3.15	32.98	1.37	−32.61	1.24
36623	NQ Gem	112.97719480	1.15	+24.50350014	0.78	0.11	1.37	−9.52	1.64	−3.83	0.63
52562	RT Car	161.19648645	0.78	−59.41337477	0.70	1.49	0.90	−7.71	1.03	3.26	0.78
83714	HD 154791	256.64384548	0.40	+23.97183394	0.62	2.57	0.86	−7.30	0.48	−5.47	0.83
93844	BL Tel	286.65880929	0.73	−51.41756176	0.51	1.61	0.83	−5.29	0.89	0.71	0.66

Table 2. Distances and heights above the galactic plane (z) of symbiotic stars from Hipparcos observations. $\triangle d$ is the range of distances according to the error in the parallax of the program star, and b is the galactic latitude.

HIC	Name	d (pc)	error (%)	$\triangle d$ (pc)	b (°)	z (pc)
3494	EG And	675	66	(408/1960)	−22.17	255
77662	HD 330036	1075	330	(250/∞)	4.15	78
78322	T CrB	$\geq$ 613			48.16	$\geq$455
78512	AG Dra	$\geq$1020			40.97	$\geq$670
89886	AR Pav	297	73	(170/1110)	−21.60	109
95413	CH Cyg	268	23	(218/347)	15.58	72
97594	CI Cyg	$\geq$ 633			4.74	$\geq$52
107848	AG Peg	$\geq$ 855			−30.89	$\geq$440
116287	Z And	427	124	(190/∞)	−12.09	89
117054	R Aqr	197	62	(122/521)	−70.32	185
83714	HD 154791	389	33	(292/585)	32.99	212
52562	RT Car	671	60	(418/1695)	−0.41	5
93844	BL Tel	621	52	(410/1282)	−23.16	244

Table 3. Absolute K magnitudes of symbiotic stars. K magnitude and A_K extinction are from ground based observations. M_K and its range are derived from the Hipparcos parallax and its associated error. LPV = long period variable.

HIC	Name	K	A_K	spectrum	M_K	M_K range min	max
3494	EG And	2.6	0.2	M2 II	−6.7	−5.6	−9.1
77662	HD 330036	7.6	1.0	F5 Ia	−3.6	−0.4	
78322	T CrB	4.8	0.0	M4 III	$\leq$−4.1		
78512	AG Dra	6.2	0.0	K4 III–II	$\leq$−3.8		
89886	AR Pav	7.2	0.0	M3 III	−0.2	+1.0	−3.0
95413	CH Cyg	−0.6	0.4	LPV	−8.1	−7.7	−8.7
97594	CI Cyg	4.5	0.2	M5 II	$\leq$−4.7		
107848	AG Peg	3.8	0.0	M3-4 III-II	$\leq$−5.9		
116287	Z And	5.0	0.3	M3 III	−3.4	−1.7	
117054	R Aqr	−1.0	0.1	LPV	−7.6	−6.5	−9.7
83714	HD 154791	3.3	0.2	M3 III	−4.8	−4.2	−5.7
52562	RT Car	1.9	0.2	M2 Ia	−7.4	−6.4	−9.4
93844	BL Tel	4.8	0.2	F5 Ib + MIII	−4.4	−3.5	−5.9