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HIPPARCOS PARALLAXES OF CATACLYSMIC BINARIES AND THE QUEST FOR THEIR ABSOLUTE MAGNITUDES†

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HIPPARCOS proposal No. 67, submitted in 1982 by N. Vogt, Th. Schmidt-Kaler, and the present author, suggested several novae, novalike stars and dwarf novae for measurements of parallaxes and proper motions. Unfortunately, SS Cyg, the only dwarf nova of the proposal, was not observed due to a misidentification. A comparison between the Catalogue of Cataclysmic Variables (Downes, Shara and Webbink 1997) and the HIPPARCOS catalogue produced no additional cataclysmic variables, identified after completion of the HIPPARCOS Input Catalogue, that might have been included by chance in the target list.

Table 1: Parallaxes and distances of HIPPARCOS novae and novalike systems

HIP	Object	parallax π [″]	$\varepsilon\pi$ [″]	distance d ($\pm$ error) [pc]
Novae				
31481	RR Pic	−0.00246	0.00209	
78322	T CrB	−0.00161	0.00150	
92316	V603 Aql	+0.00421	0.00259	237 (+380, −90)
102190	HR Del	−0.00800	0.00357	
Novalike systems				
40430	IX Vel	+0.01038	0.00098	96 (+10, −8)
50581	RW Sex	+0.00346	0.00244	289 (+691, −120)
54226	QU Car	+0.00164	0.00150	610 (+6530, −292)
97394	V3885 Sgr	+0.00911	0.00195	110 (+30, −20)
101991	AE Aqr	+0.00980	0.00284	102 (+42, −23)

Table 1 lists the parallaxes in milli-arcseconds of the nine cataclysmic variables, as given in the HIPPARCOS catalogue (ESA 1997), and their derived distances. It should be noted that the objects were selected because of apparent brightness, not because of the potentially large parallax. Most cataclysmic variables at minimum light, even potentially near ones, are below the magnitude limit of the HIPPARCOS satellite. The following discussion confronts the HIPPARCOS results with other present-day information.

Novae: RR Pic: The Yale parallax catalog (van Altena, Lee and Hoffleit 1995) gives $\pi(\mathrm{abs}) = \overline{-0.0002} \pm 0.0101$ ($N = 2$) with the quality mark 'good agreement'. This is within the errors of the HIPPARCOS result.

†Based on data from the ESA HIPPARCOS astrometry satellite

V603 Aql: The Yale parallax catalog gives $\pi(\mathrm{abs}) = +0.0039 \pm 0.0057$ ($N = 7$) with the quality mark 'good agreement'. This is in excellent agreement with the HIPPARCOS result.

Novalike systems: IX Vel: Berriman, Szkody and Capps (1985) give a distance of 51 pc, while Eggen and Niemela (1984) derive 33 pc. Beuermann and Thomas (1990) carried out a careful analysis of this brightest UX UMa type system and derived the distance $d = 95 \pm 12$ pc from Bailey's method. This value is in excellent agreement with the HIPPARCOS result.

RW Sex: The Yale parallax catalog gives $\pi(\mathrm{abs}) = +0.0097 \pm 0.0069$ ($N = 2$) with the quality mark 'good agreement'. Beuermann, Stasiewski and Schwope (1992) use Bailey's method, which results in a rough estimate $d \approx 150$ pc, consistent with Osvald's trigonometric parallax $\pi = 0.007 \pm 0.04$, as quoted by Cowley, Crampton and Hesser (1977). The HIPPARCOS parallax is consistent with these statements; in spite of the large error, we assume that the true parallax is not much smaller than the value 0.00346 mas.

QU Car: Gilliland and Phillips (1982) derive $d > 500$ pc. They state that the spectrum is dominated by light from the accretion disk or the primary, and that the high rate of mass transfer indicates an old nova or novalike variable. The spectroscopic appearance, He II emission as strong as N III/C III 4640, supports this. The HIPPARCOS parallax is in agreement with the above distance estimate, without being able to improve it.

V3885 Sgr: A spectroscopic analysis by Haug and Drechsel (1985) shows anticyclic He I absorption which cannot be attributed to the secondary star. They assume an inclination $i = 70°$, which is likely too large. Warner (1987) gives $i = 30°$ and derives $M_V = 4.0$ from the surface brightness method; with $m_V = 10.4$ and $A_V = 0.16$, this results in the distance $d = 280$ pc. The HIPPARCOS parallax indicates that this distance is overestimated. An inclination $i > 30°$ would make the discrepancy even worse.

AE Aqr: The Yale parallax catalog gives $\pi(\mathrm{abs}) = +0.0352 \pm 0.0141$ ($N = 1$), i.e. $d = 28$ $(+19, -8)$ pc, which appears to be too small. The best distance estimate is that of Welsh, Horne and Oke (1993). The spectral type of the secondary is most likely K4-K5 V. It contributes between 64% and 86% to the light at 500 nm. Using the Barnes–Evans relation and the equivalent Roche lobe radius of the secondary, Welsh et al. estimate the distance $d \approx 95$ pc if the disk is hot, and ≈ 125 pc if the disk is cool. The HIPPARCOS distance lies comfortably in this range, without being of use in deciding between the two cases. An extensive discussion of the parallax of this system, and the question whether the secondary is a main sequence star, was given by Friedjung (1997).

Most trigonometric parallaxes of novae are small or vanishing; the positive result of V603 Aql is in agreement with the nebular expansion parallax, $d = 330$ pc (Duerbeck 1987).

The absolute magnitudes M_V of four novalike stars were derived from the HIPPARCOS parallaxes. Apparent magnitudes V were taken from the list of Bruch and Engel (1994), interstellar extinction A_V was estimated using the programme of Hakkila et al. (1997). Absolute magnitudes of three dwarf novae at maximum were calculated from the Hubble Space Telecope fine guidance sensor parallaxes of Harrison et al. (1999), and absolute magnitudes of 8 novae, in the interval of orbital periods of the dwarf novae and novalike systems considered here, were derived from nebular expansion parallaxes (Duerbeck 1999). Information on inclinations i and orbital periods P is taken from Ritter and Kolb (1998). All absolute magnitudes M_V were corrected for inclination effects using the prescription of Warner (1987), and listed as M_V^{corr} in Table 2. In the case of unknown inclination, i was assumed to be 44°.

Table 2: Absolute magnitudes of cataclysmic variables, as derived from trigonometric and nebular expansion parallaxes

Object	period [days]	V	d [pc]	A_V	M_V	i [°]	$M_V^{\rm corr}$
Dwarf novae at outburst							
SS Aur	0.1828	10.5	200	0.19	3.8	38	4.4
SS Cyg	0.2751	8.7	166	0.13	2.5	38	3.1
U Gem	0.1729	9.8	96	0.01	4.9	70	4.2
Novalike systems							
AE Aqr	0.4117	11.5	102	0.11	6.3	58	6.3
V3885 Sgr	0.2163	10.3	110	0.07	5.0	< 50	5.7
RW Sex	0.2451	10.6	290	0.05	3.3	34	4.0
IX Vel	0.1939	9.6	96	0.04	4.6	60	4.5
Novae at postoutburst minimum							
V603 Aql	0.1381	11.9	330	0.48	3.8	17	4.7
T Aur	0.2044	15.0	960	1.29	3.8	57	3.8
V1500 Cyg	0.1396	17.4	1500	1.85	4.7	?	5.1
HR Del	0.2142	12.2	760	0.34	2.5	40	3.0
DQ Her	0.1936	14.3	400	0.16	6.1	86	3.2
V533 Her	0.1469	14.9	560	0.94	5.2	?	5.6
BT Mon	0.3338	15.6	1800	0.89	3.4	82	1.4
RR Pic	0.1450	12.35	600	0.17	3.3	65	2.9

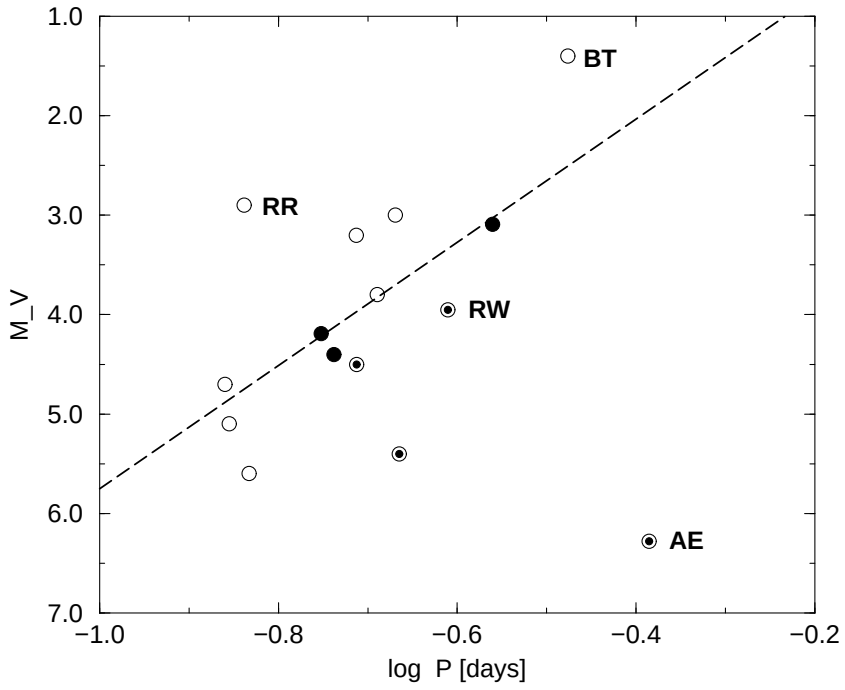

Figure 1. Absolute V-magnitudes as a function of orbital period (in days). Open circles: postnovae from expansion parallaxes; filled circles: dwarf novae at outburst from HST parallaxes; circles with central dot: novalike stars from HIPPARCOS parallaxes. A few systems are identified; the absolute magnitude of RW Sex is uncertain by more than $\pm 1^{\rm m}$. The regression line $M_V^{\rm corr} = -6.2 \log P - 0.45$ is shown.

The results are shown in Fig. 1. There is no obvious difference between the absolute magnitudes of dwarf novae *in outburst*, novalike stars, and novae a few decades after outburst. If the point in the lower right (the peculiar system AE Aqr, which has no fully developed accretion disk) is not taken into account, the remaining points indicate that systems with longer periods have brighter accretion disks. The data, however, are too scarce to draw definitive conclusions. We have omitted from our discussion "outlying" novae of very short as well as very long period: CP Pup and GK Per, which have absolute magnitudes $M_V^{\rm corr} = 3.5$ and 4.5, respectively, would mask this possible period dependence.

The conclusion is: In the interval 0.1 – 0.4 day, an absolute magnitude–orbital period relation $M_V^{\rm corr} = -6.2 \log P - 0.45$ seems to exist for all types of cataclysmic systems (novae at minimum, novalike systems, dwarf novae at outburst), where angular-momentum-loss controlled mass loss from the main sequence star feeds an accretion disk.

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