COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4367

Konkoly Observatory
Budapest
26 August 1996

HU ISSN 0374 – 0676

NEW OBSERVATIONS OF FOUR GALACTIC CEPHEIDS

We have obtained CCD observations of a number of Cepheid variables which have been mostly ignored, probably because they are unreachable with moderate size telescopes and photoelectric equipment. We have employed 14-bit CCD systems to obtain results for several Cepheids which did not have photoelectric light curves or had not been observed during the past 30 years or so.

We have chosen a series of comparison stars for differential observations and we include here simple statistics on their variability. Finder charts for the fainter Cepheids are sometimes difficult to obtain and we have included CCD finder charts of these Cepheids and comparison stars. Our finder charts should facilitate identification for future observations of these stars.

CCD observations were obtained with the Virginia Military Institute's 0.5 m DFM telescope, with a 14-bit Photometrics CCD system, and the U.S. Air Force Academy's 0.4 m DFM telescope, also with a 14-bit Photometrics CCD system. V and R filters were chosen to match the Johnson standard system with the CCD spectral response (Bessell, 1990). We obtained CCD images of a standard field in M67 (Schild, 1983) and have obtained satisfactory transformations to the Johnson system. Our observations have been transformed to the Johnson V and R system. (We had problems with some of the early V observations because of a bad filter; therefore, we have more R observations than V observations.)

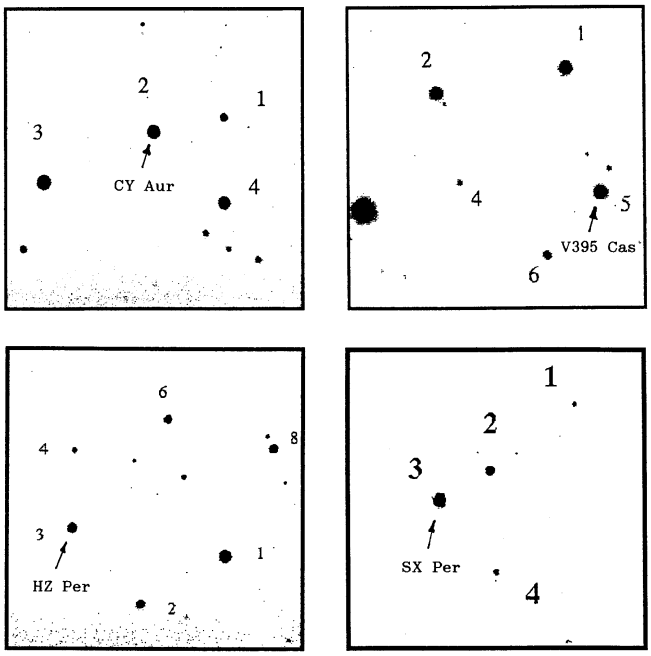

Figure 1. CCD finder chart for CY Aur, V395 Cas, HZ Per and SX Per. North is at top, east is at left. The image size is approximately 5' on each side

All CCD images have been flat fielded, and all but a couple of images have had bias and dark counts subtracted before flat fielding (no dark counts were discernible on the USAFA images). Exposures were standardized at four minutes for the VMI images, and six minutes for the USAFA images. Magnitudes were obtained at VMI with DAOPHOT, and at USAFA by summing counts inside a square aperture.

CCD finder charts for each of the Cepheids discussed below are shown in Figure 1. For some of these stars, we were unable to unambiguously identify the variable until we had a few images centered on the variable's coordinates, even using the Hubble Guide Star Catalog and GCVS positions. The R bandpass light curves are shown in Figures 2–5. The field of view of these finder charts (VMI images) is approximately 5 arcminutes; the original scale is 30"/mm. We found it difficult to compare our fields with some of the original finder charts from 30 or 40 years ago, since those finder fields (generally hand drawn or traced) often covered up to one degree and fainter stars were not shown. The effective bandpass was also generally different.

All stars on our images which were reasonably non-variable and bright enough for good statistics were used to form an average for each field (2 to 4 stars), which was then used to obtain a differential magnitude with the variable star.

Our light curves have been graphed at an arbitrary epoch to place maximum light at phase 0.0. The ephemeris used to calculate this phase is shown in the caption of each graph, where the zero epoch corresponds to the new normal maximum to aid in checking long-term period changes, or for comparison of peak light with other data. The periods used to calculate the phase in these graphs were obtained from the GCVS.

CY Aur. The finder chart appears to agree with that given in the GCVS. We could not find any photoelectric photometry of this Cepheid as we began this project, although we have now found observations from Berdnikov (1986) and Schmidt et al. (1995). A photographic light curve and the original finder chart are given in Kurochkin (1951). We graphed our R differential magnitudes in addition to R magnitudes from Berdnikov (these data were obtained from the Welch Cepheid database); see Figure 2. We shifted our differential measures arbitrarily (in magnitude) to correspond with his Johnson values. We found good agreement with his data, although some sections of the phase diagram are still inadequately covered.

V395 Cas. This Cepheid shows an exceptionally well-behaved light curve, especially in the R band. Although our light curve is poorly covered just before peak light, the rest of the curve is well defined. The comparison stars are also very stable. Our finder chart agrees with the original chart. We have also graphed the R data from Berdnikov (1992; data from Welch database); our differential data have been shifted by an arbitrary amount to coincide with Berdnikov's data. See Figure 3.

HZ Per. We located the original finder chart for HZ Per and there were no problems in identifying this star. We also graphed Berdnikov's (1993) data for comparison. The light curve is shown in Figure 4, and although the comparison stars we used are well behaved with a standard deviation of 0.″04 (in V), the light curve of the Cepheid is noisy, particularly on rising light on the red image.

SX Per. We have some misgivings about agreement with the original finder chart on this star, although there seems to be no doubt about having the correct star, since the period agrees. The light curve is shown in Figure 5. A light curve and finder chart are given by Kurochkin (1951); Henden (1980) also published photoelectric data for SX Per.

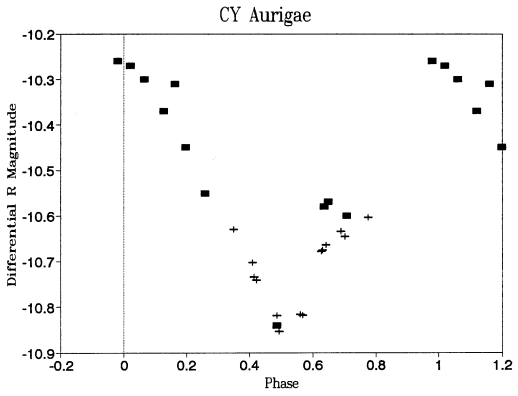

Figure 2. Light curve for CY Aur (R bandpass). Initial epoch is $\phi_0 = 2445643.0$ (Julian day), and the GCVS period is $13\overset{d}{.}85$. Squares are our data, plus marks denote Berdnikov's observations

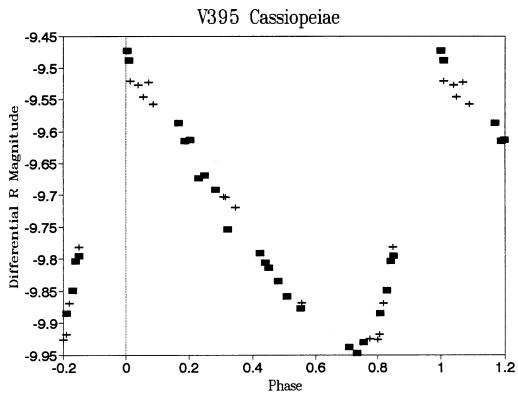

Figure 3. Light curve for V395 Cas (R bandpass). See Figure 2 for details. $\phi_0 = 2448099.0$ and GCVS period is $4\overset{d}{.}038$

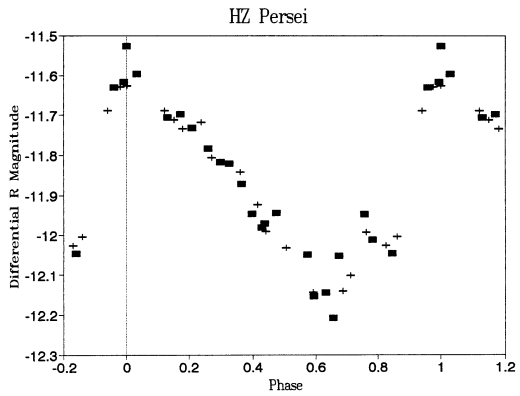

Figure 4. Light curve for HZ Per (R bandpass). See Figure 2 for details. $\phi_0 = 2448635.5$ and GCVS period is $11\overset{d}{.}28$

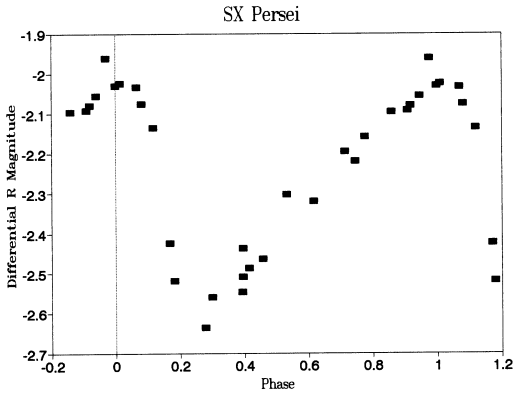

Figure 5. Light curve for SX Per (R bandpass). $\phi_0 = 2448646.0$ and GCVS period is $4\overset{d}{.}289967$

Table 1. Standard Deviations of Comparison Star Differences

CY Aur Stars #1,3,4,5,7		V395 Cas Stars #1,2,6		HZ Per Stars #1,2,4,6,8		SX Per Stars #1,2,4	
#1,3	$0\overset{m}{.}030$	#1,2	$0\overset{m}{.}006$	#1,2	$0\overset{m}{.}029$	#1,2	$0\overset{m}{.}048$
#1,4	0.029	#1,6	0.013	#1,4	0.023	#1,4	0.058
#1,5	0.092	#2,6	0.009	#1,6	0.015	#2,4	0.034
#1,7	0.102			#1,8	0.017		
#3,4	0.019			#2,4	0.044		
#3,5	0.084			#2,8	0.025		
#3,7	0.095			#4,6	0.021		
#4,5	0.075			#4,8	0.031		
#4,7	0.098			#6,8	0.023		
#5,7	0.124						

We have included a summary of our results with the comparison stars in our 5' CCD fields. In Table 1 is a listing of the standard deviations of our magnitude differences of comparison stars which we used to obtain differential magnitudes (R bandpass). We used the comparison stars shown in Table 1 to derive an average magnitude, which was then subtracted from the magnitude of the Cepheid. The V and R data have been deposited in the Welch Cepheid database (http://www.physics.mcmaster.ca/Cepheid/).

We wish to acknowledge the support of our two institutions in encouraging this research. D.L.D. acknowledges a sabbatical award and several V.M.I. Summer Research Grants in support of this work. R.H.B. acknowledges generous telescope time from the U.S. Air Force Academy. We also wish to acknowledge a National Science Foundation Research in Undergraduate Institutions grant (#AST-861373), which was used to purchase computer equipment for DAOPHOT data reduction, with matching funds from V.M.I. This research has made use of the SIMBAD database operated at CDS, Strasbourg, France.

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