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CCD PHOTOMETRY OF CN Tau, V427 Lyr, V926 Cyg, AND GS Lyr

CCD observations of the variable stars CN Tau, V427 Lyr, V926 Cyg, and GS Lyr using the CCD/Transit Instrument (CTI) and Capilla Peak Observatory are reported. The CTI is a stationary, meridian pointing optical telescope that images a narrow strip of the sky at all right ascensions (McGraw et al. 1980, 1983, 1986, Wetterer 1995). The 1.8 meter, f/2.2 telescope is rigidly mounted to point at a single declination and relies on the Earth's rotation to bring different parts of the sky into view. The photometry of a selection of nonvariable stars distributed throughout the survey area and acquired during several nights throughout the year were used to calibrate the data from all nights of observations (Cawson et al. 1986, Wetterer 1995). All stars in the CTI survey are calibrated in this consistent instrumental magnitude system and so any variable star within the CTI survey will have many nearby calibrated comparison stars. To establish the conversion between instrumental and standard magnitudes, a number of stars within the CTI survey were also calibrated to the standard Johnson magnitude system (McGraw et al. 1989).

The photometric data for all stars within the survey area were analyzed to discover RR Lyrae variable stars (Wetterer et al. 1996). In this search, we excluded the portion of the CTI survey area near the Galactic plane due to the excessive and unknown reddening caused by dust in the Galactic disk. Three stars previously classified as RR Lyrae stars (CN Tau, V427 Lyr, and V926 Cyg) within the excluded region were observed by the CTI. We included these stars in subsequent CCD observations with Capilla Peak Observatory's 61-cm telescope (Laubscher et al. 1988). Despite being listed as a slow irregular type variable star, we also included GS Lyr in the observation program because, upon initial inspection, its light curve had RR Lyrae characteristics. Table 1 lists the name, right ascension and declination (epoch 1987.5), the number of CTI and the number of Capilla Peak (CAP) observations through the V filter for each star.

Table 2 summarizes the results. After the star's name, the next five columns list the maximum, minimum, and flux averaged standard V magnitudes; the amplitude of variation in V (ΔV), and; the B$-$V at minimum light. Wetterer et al. (1996) details the transformation from instrumental to standard magnitudes and how the flux averaged magnitude was calculated. The final four columns list the rise time in fraction of a period (m$-$M); the period in days (found using a standard period finding algorithm); the heliocentric Julian Date of maximum light (minus 2440000 days), and the type of variability for each star. Finder charts, light curves and photometry for these stars can be found in Wetterer (1995).

Table 1. Variable Stars

Star	α	δ	CTI	CAP
CN Tau	$05^{h}57^{m}22.1^{s}$	$28°02'31''.0$	50	32
GS Lyr	19 03 50.3	28 00 44.9	23	94
V427 Lyr	19 13 11.8	28 00 51.5	24	21
V926 Cyg	19 38 06.6	27 59 09.9	25	22

Table 2. Photometry results

Star	V_{Max}	V_{Min}	V_{Mean}	ΔV	B−V	m−M	Period	HJD	Type
CN Tau	12.56	12.92	12.755	0.35	0.89	0.25	1.79325	9366.384	Cδs
GS Lyr	12.57	13.51	13.076	0.96	1.70	-	-	-	L
V427 Lyr	15.90	17.44	16.694	1.54	0.69	0.20	0.424599	9540.933	RRab
V926 Cyg	15.03	15.63	15.258	0.60	0.69	0.45	0.306999	9554.837	RRc

Table 3. V observations of GS Lyr

HJD	V	HJD	V	HJD	V	HJD	V
7303.93896	12.528	9194.94816	13.018	9275.71731	12.880	9546.96366	13.130
7320.89075	12.651	9194.95419	13.019	9277.56787	12.847	9547.95647	13.197
7321.88855	12.646	9240.64127	12.674	9277.57821	12.881	9547.96141	13.203
7323.88245	12.713	9240.64459	12.689	9283.57228	12.855	9553.96097	13.363
7324.88000	12.744	9240.70824	12.689	9283.57512	12.835	9553.96652	13.359
7329.86572	12.822	9240.71076	12.690	9289.57200	12.871	9554.94510	13.383
7335.84888	12.897	9240.76854	12.689	9289.57500	12.866	9554.95063	13.369
7358.78589	12.749	9240.77112	12.686	9297.53984	12.835	9582.85203	13.315
7383.71802	12.793	9241.65927	12.694	9297.54227	12.819	9582.85844	13.313
7678.91113	12.904	9241.66198	12.698	9311.55296	12.777	9605.81082	13.363
7679.90930	12.895	9241.71331	12.689	9311.55541	12.780	9605.81365	13.327
7681.90247	12.886	9241.71667	12.684	9328.54604	12.791	9606.75402	13.315
7682.89990	12.957	9247.63738	12.763	9328.54909	12.807	9606.75642	13.334
7683.89697	12.963	9247.64028	12.758	9519.95773	12.909	9611.75561	13.361
7686.88916	12.960	9253.76846	12.848	9519.96034	12.932	9611.75803	13.366
7687.88599	12.939	9253.77245	12.840	9529.95193	13.040	9612.60463	13.409
7689.88123	13.011	9260.61109	12.972	9529.95450	13.013	9612.64065	13.372
8063.85669	13.003	9260.61510	12.961	9530.92060	13.023	9629.59566	13.348
8101.75195	12.472	9261.58742	12.981	9530.92308	13.014	9629.60124	13.345
8102.74902	12.511	9261.59162	12.980	9531.93816	13.041	9635.56156	13.385
8123.69263	12.956	9267.61190	13.001	9531.94073	13.037	9635.56748	13.400
8127.68188	12.993	9267.61491	12.984	9534.94858	13.041	9672.53446	13.232
8128.67920	12.976	9269.63775	12.965	9534.95112	13.044	9672.54005	13.221
9163.80752	12.800	9270.58464	12.939	9535.85637	13.112	9673.52934	13.246
9192.94201	13.018	9270.58787	12.944	9535.85890	13.044	9673.53528	13.205
9192.94794	13.001	9271.61973	12.914	9539.96199	13.064	9688.52802	12.829
9192.95542	13.011	9271.62303	12.913	9539.96472	13.075	9688.53510	12.836
9194.90031	13.045	9272.58091	12.922	9540.95876	13.055		
9194.90653	13.042	9272.58347	12.906	9540.96377	13.045		
9194.94182	13.023	9275.70890	12.875	9546.95883	13.129		

The calculated period for CN Tau is significantly different than that listed in the General Catalog of Variable Stars (GCVS) (Kholopov et al. 1985-88). The GCVS period turns out to be a sidereal day alias of the true period. In light of the longer period calculated from CTI and Capilla Peak data and the star's location near the Galactic plane, it is likely that CN Tau is actually a short period Cepheid instead of an RR Lyrae variable star.

The calculated period for V427 Lyr using the CTI and Capilla Peak data is nearly identical (0.26 s shorter) to that listed in the GCVS. The current classification as an RR Lyrae type ab is confirmed. Due to the image scale, V427 Lyr was combined with two other fainter stars during CTI photometry. The Capilla Peak data was used to estimate the magnitudes of these stars ($V = 18.008 \pm 0.056$ and $V = 19.497 \pm 0.133$). The standard magnitudes in Table 2 reflect the fact that the contribution from these fainter stars were removed.

Table 4. B observations of GS Lyr

HJD	B	HJD	B	HJD	B	HJD	B
7303.94080	14.201	8037.93078	14.369	9553.96339	15.053	9635.56748	14.974
7334.85551	14.604	8039.92555	14.409	9554.94750	14.979	9672.53693	14.844
7686.89238	14.601	9540.96142	14.691	9582.85529	14.930	9673.53213	14.492
7711.82418	14.779	9546.96122	14.770	9612.60797	14.968	9688.53169	14.113
7712.82087	14.816	9547.95896	14.781	9629.59840	14.955		

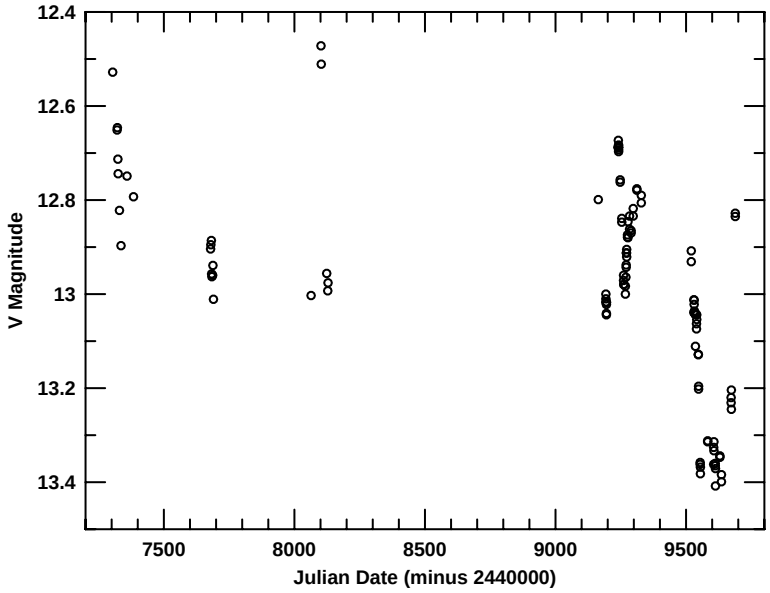

Figure 1. V magnitude of GS Lyr versus HJD

The calculated period for V926 Cyg using the CTI and Capilla Peak data is approximately 2 seconds longer than that listed in the GCVS. The light curve has a slight asymmetry, and with its current period and color, a classification as an RR Lyrae type c seems reasonable. Again, due to the image scale, V926 Cyg was combined with two other stars during CTI photometry. As in the previous case, the Capilla Peak data was used to estimate the magnitudes of these stars (V = 18.273 ± 0.040 and V = 18.093 ± 0.025) which we took into account when calculating the standard magnitudes in Table 2.

With the additional observations at Capilla Peak, it became quickly apparent that the RR Lyrae-like light curve for GS Lyr was due to the limited number of CTI observations and the sidereal day aliasing present in the CTI data. Further observations, however, were conducted in an attempt to obtain an accurate classification. Tables 3 and 4 list the heliocentric Julian date (minus 2440000 days) and the instrumental V and B magnitudes respectively for all observations of GS Lyr.

Data before JD 2449000 is from the CTI while data after is from Capilla Peak. The Capilla Peak data has been transformed to CTI instrumental magnitudes. The average error in the CTI V magnitude is 0.004 while the average error in the Capilla Peak V magnitude is 0.012. The average error for both the CTI and Capilla Peak B magnitudes is 0.020. Figure 1 plots the instrumental V magnitude as a function of time for all observations. The instrumental $B - V \approx 1\overset{\mathrm{m}}{.}6$, resulting in standard V magnitudes 0.1 fainter than the instrumental magnitudes. GS Lyr was previously classified as a slow irregular variable in the GCVS. This classification remains appropriate in view of the fact that variations took place over several days and no periodicity could be found in the present data.

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