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UBV OBSERVATIONS OF THE Be STAR γ Cas (1983-87)

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The Be star γ Cassiopeiae is ejecting rings of gas due to its rapid rotation, therefore this is also a shell star. Its visual magnitude varies between about 3.0 and 1.6, although usually it stays around 2.5. This star is one of ROSAT's bright sources and also an IRAS source.

Over six years of 1982-1988, i.e. in the period of an international campaign (see Horaguchi et al., 1994), the Be star, γ Cas has been observed at Yonsei University Observatory (YUO). As comparison HR113 was observed (see Table 1). During that period we used the 40-cm (at Campus Station) and the 61-cm (at Ilsan Station) reflectors of YUO which were equipped with PMT photometers and *UBV* filters, and with a chart recorder. The Campus Station is at the downtown and the Ilsan Station is in the suburb of Seoul. One or more standard stars were observed continuously throughout the nights, and extinction coefficients at each observing station were determined, some of them are listed in Table 2.

Table 1. Some information on γ Cas as program star and HR113 as comparison.

Star	BD	HD	R.A. (1950.0)	Dec. (1950.0)	Sp.	<i>V</i>	(<i>B</i> – <i>V</i>)	(<i>U</i> – <i>B</i>)	Ref.*
γ Cas	+59°0144	5394	00 ^h 53 ^m 40 ^s	+60°26'47''	BOIVe	2.47	+2.47	–0.15	1
HR113	+59°0068	2626	00 ^h 27 ^m 32 ^s	+59°42'05''	B9IIIIn	5.94	+0.01	–0.36	1, 2

* 1: Hoffleit (1982), 2: Harmanec et al. (1981)

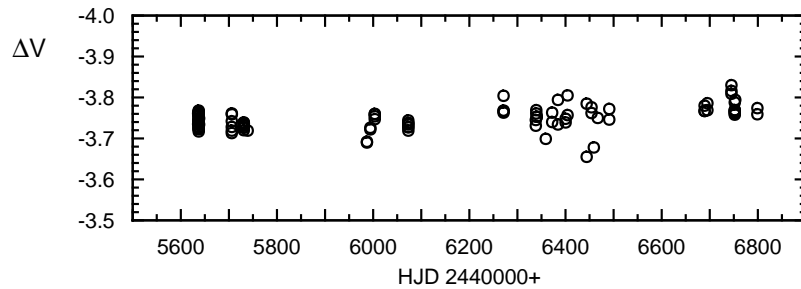
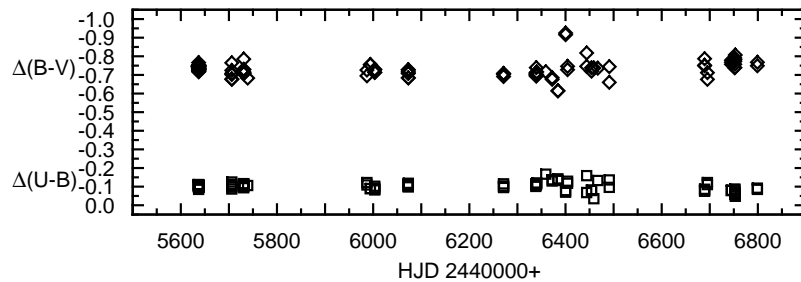
Table 2. *UBV* extinction coefficients at YUO.

<i>JD</i> _⊙ 2440000+	<i>k_v</i>	<i>k_b</i>	<i>k_u</i>	<i>JD</i> _⊙ 2440000+	<i>k_v</i>	<i>k_b</i>	<i>k_u</i>
5635.5	0.32	0.505	0.88	6340.5	0.261	0.327	0.50
5709.5	0.327	0.533	0.93	6359.5	0.372	0.507	0.87
5731.5	0.380	0.547	0.90	6372.5	0.176	0.395	
5740.5	0.257	0.433	0.78	6384.5	0.240	0.349	0.78
5987.5	0.540	0.800		6400.5	0.289	0.396	0.62
5987.5	0.540	0.800		6404.5	0.407	0.481	0.71
5994.5	0.181	0.362	0.70	6444.5	0.194	0.336	0.69
6003.5	0.298	0.505	0.89	6444.5	0.194	0.336	0.69
6072.5	0.163	0.357	0.74	6454.5	0.358	0.559	0.93
6271.5	0.604	0.770	1.35	6459.5	0.373	0.564	0.91
6338.5	0.235	0.417		6467.5	0.308	0.500	0.82
6339.5	0.324	0.435	0.65	6491.5	0.432	0.633	0.97

Table 3. Constants for *UBV* standardization in 1982-1988 at YUO.

Observing Season	C_1	C_2	C_3	C_4	C_5	C_6	Observatory*
82 09 0183 08 31	1.506	-0.069	0.415	0.867	-0.625	1.167	C
83 09 0184 05 31	1.545	-0.015	0.320	0.916	-0.361	1.092	C
86 06 0187 01 06	0.200	-0.050	0.350	0.890	0.050	1.150	C
87 01 2987 08 31	1.265	-0.015	-0.375	0.891	-0.560	1.230	C
87 09 0188 05 31	0.865	-0.047	0.375	0.890	-0.395	1.200	C
82 10 0183 08 31	1.040	-0.050	0.330	0.890	-0.480	1.095	I
83 09 0184 09 20	0.850	-0.050	0.330	0.895	-0.490	1.135	I
84 09 2184 12 05	-0.512	-0.038	0.355	0.890	-0.460	1.118	I
84 12 0685 08 31	1.100	-0.069	0.345	0.900	-0.535	1.123	I
85 09 0185 11 30	1.290	-0.050	0.320	0.863	-0.345	1.128	I
85 12 0186 08 31	0.935	-0.042	0.285	0.895	-0.395	1.195	I
86 09 0186 10 30	0.865	-0.103	0.295	0.880	-0.450	1.130	I
86 11 0186 11 10	2.700	0.000	0.192	0.808	-0.125	1.175	I
86 11 1187 02 25	1.242	0.035	-0.350	0.835	-0.395	1.140	I
87 02 2687 08 16	0.885	-0.065	0.275	0.920	-0.475	1.120	I
87 08 1787 10 25	0.808	-0.060	0.368	0.887	-0.395	1.105	I
87 10 2687 11 03	0.808	-0.060	0.368	0.887	-0.558	1.105	I
87 11 0488 02 31	0.450	-0.060	0.368	0.887	-0.395	1.105	I

* C: Campus Station, I: Iلسan Station

**Figure 1.** ΔV light curve of γ Cas in 1983-1987.**Figure 2.** Color index curves of γ Cas in 1983-1987.

The *UBV* observation sequence of the program star for one observation point is approximately same as that suggested by Harmanec et al. (1977). Recorded tracings on the chart paper at a given time for each filter are determined with the sky brightness subtracted. For the comparison star the readings in the three filters were determined at different time, but for the program star the observing time is fixed as the epoch of observation with the middle filter. For standardization the usual equations

$$V - v = C_1 + C_2(B - V), \quad B - V = C_3 + C_4(b - v), \quad U - B = C_5 + C_6(u - b)$$

Table 4. *UBV* Observations of γ Cas (1983-1987).

JD_{\odot}	ΔV	$\Delta(B-V)$	$\Delta(U-B)$	JD_{\odot}	ΔV	$\Delta(B-V)$	$\Delta(U-B)$
2440000+				2440000+			
5636.0554	-3.725	-3.829	-4.576	6072.9921	-3.724	-3.828	-4.556
5636.0676	-3.751	-3.862	-4.609	6073.0042	-3.734	-3.836	-4.563
5636.9679	-3.738	-3.833	-4.579	6073.0141	-3.728	-3.828	-4.545
5636.9800	-3.746	-3.847	-4.600	6073.0253	-3.726	-3.839	-4.547
5637.0050	-3.756	-3.841	-4.607	6073.0749	-3.718	-3.817	-4.527
5637.0405	-3.745	-3.846	-4.598	6073.0860	-3.717	-3.828	-4.512
5637.0503	-3.737	-3.838	-4.582	6073.1002	-3.709	-3.827	-4.511
5637.0635	-3.752	-3.850	-4.593	6073.0042	-3.734	-3.836	-4.563
5637.0718	-3.758	-3.856	-4.609	6271.1281	-3.757	-3.872	-4.563
5637.0773	-3.754	-3.854	-4.607	6271.1416	-3.794	-3.896	-4.604
5637.1087	-3.749	-3.860	-4.600	6271.1547	-3.758	-3.860	-4.563
5637.1177	-3.734	-3.843	-4.584	6338.2612	-3.721	-3.834	-4.544
5637.1198	-3.728	-3.831	-4.563	6338.2752	-3.735	-3.836	-4.536
5637.1312	-3.732	-3.828	-4.568	6339.2005	-3.759	-3.867	-4.560
5637.1335	-3.730	-3.831	-4.566	6339.2175	-3.751	-3.864	-4.603
5637.1460	-3.728	-3.825	-4.573	6340.1858	-3.743	-3.858	-4.574
5637.1564	-3.732	-3.834	-4.579	6340.1946	-3.743	-3.863	-4.563
5637.1640	-3.723	-3.832	-4.574	6358.9883	-3.689	-3.856	-4.573
5637.1724	-3.717	-3.823	-4.560	6372.2259	-3.730	-3.867	-4.543
5637.1748	-3.718	-3.814	-4.562	6372.2403	-3.753	-3.883	-4.568
5637.1828	-3.747	-3.848	-4.582	6384.2264	-3.724	-3.857	-4.472
5637.1854	-3.740	-3.845	-4.579	6384.2660	-3.784	-3.926	-4.540
5637.1953	-3.713	-3.815	-4.532	6400.2058	-3.738	-3.808	-4.733
5637.2048	-3.713	-3.817	-4.541	6400.2198	-3.729	-3.808	-4.724
5637.2074	-3.707	-3.816	-4.534	6404.1937	-3.747	-3.876	-4.604
5637.2165	-3.733	-3.837	-4.560	6404.2076	-3.795	-3.913	-4.659
5637.2167	-3.713	-3.816	-4.546	6443.9570	-3.645	-3.804	-4.550
5638.1064	-3.739	-3.845	-4.595	6443.9658	-3.775	-3.843	-4.661
5638.1193	-3.724	-3.825	-4.554	6454.1053	-3.766	-3.848	-4.568
5706.0032	-3.751	-3.848	-4.572	6454.1155	-3.752	-3.831	-4.569
5706.0158	-3.703	-3.790	-4.555	6458.9173	-3.668	-3.703	-4.440
5706.0243	-3.718	-3.820	-4.522	6467.0148	-3.740	-3.873	-4.609
5706.0342	-3.732	-3.839	-4.547	6490.9468	-3.736	-3.872	-4.532
5706.0520	-3.749	-3.862	-4.540	6490.9692	-3.762	-3.858	-4.602
5706.0616	-3.709	-3.834	-4.510	6689.2299	-3.757	-3.843	-4.630
5730.9149	-3.729	-3.823	-4.608	6689.2599	-3.757	-3.832	-4.584
5730.9238	-3.721	-3.828	-4.556	6689.2698	-3.770	-3.850	-4.599
5730.9338	-3.725	-3.826	-4.556	6659.0916	-3.776	-3.898	-4.574
5730.9506	-3.726	-3.839	-4.548	6695.1009	-3.759	-3.870	-4.582
5730.9591	-3.728	-3.834	-4.542	6744.9829	-3.820	-3.900	-4.679
5730.9661	-3.716	-3.823	-4.532	6744.9930	-3.806	-3.885	-4.642
5730.9965	-3.710	-3.826	-4.542	6745.0002	-3.799	-3.879	-4.647
5731.0073	-3.717	-3.824	-4.537	6751.9196	-3.751	-3.838	-4.577
5739.0278	-3.709	-3.815	-4.498	6751.9274	-3.755	-3.836	-4.593
5987.0062	-3.680	-3.789	-4.515	6751.9354	-3.778	-3.841	-4.622
5987.0144	-3.682	-3.804	-4.499	6751.9429	-3.755	-3.825	-4.597
5994.1260	-3.712	-3.801	-4.557	6751.9606	-3.748	-3.806	-4.597
5994.1350	-3.716	-3.806	-4.560	6751.9680	-3.759	-3.824	-4.608
6003.2645	-3.750	-3.852	-4.565	6751.9752	-3.759	-3.843	-4.582
6003.2848	-3.744	-3.826	-4.556	6752.9983	-3.784	-3.832	-4.639
6003.2947	-3.737	-3.823	-4.551	6798.9658	-3.749	-3.841	-4.590
6003.3091	-3.749	-3.841	-4.555	6798.9755	-3.764	-3.849	-4.617

are used where ubv , UBV and C_i stand for instrumental magnitudes, standard UBV magnitudes, conversion constants, respectively. C_i s listed in Table 3 are applied for each observing season. Details about observing and reducing procedures including the procedure of standardization to Johnson UBV system were described by Nha et al. (1986) and Jeong (1988).

In this period we obtained 312 observations (104 in U , 104 in B , 104 in V) as listed in

Table 4 and stored as electronic file available at the IBVS website as 5392-t4.txt. (These data had been already published by Jeong (1988), but are not easily available to the community because it was written in Korean and this is one aim of this paper to publish in IBVS.) Table 4 lists the observed data with respect to HR113. ΔV , $\Delta(B - V)$, and $\Delta(U - B)$ light and color index curves constructed with the data are shown in Figure 1 and Figure 2. Some light curves constructed using these (Jeong, 1988) data had been reported by Jeong & Lee (1988) and Horaguchi et al. (1994).

In 1965-1987 the visual magnitude of γ Cas has gradually increased. Jeong & Lee (1988) shows that its V magnitude of 2.20-2.15 in 1983-1987 slightly exceeded the level of its pre-outburst in the 1930s. They found that the V light of γ Cas reached its minimum three times during the 1969-1987 period when V/R was at maximum. Such a light behavior is also discussed by Jeong and Lee (1988) and Horaguchi et al. (1994), especially in connection with $B - V$ changes, V/R variations of $H\alpha$ and $H\beta$, high velocity narrow absorption component exhibited in the far UV.

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