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PHOTOELECTRIC PHOTOMETRY OF β LYR IN 1971

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As part of the IAU Commission 42 second coordinated programme for the observation of β Lyr, narrow and intermediate band measurements have been obtained in the second half of 1971. The observations obtained are presented and briefly commented.

Key words: eclipsing binaries–photometry.

THE OBSERVATIONS

During the second international β Lyr campaign sponsored by Commission 42 of the IAU (Batten 1970a) and covering the intervals from 17 July to 2 August and from 10 to 23 August 1971, photoelectric observations were carried out at the Merate Observatory. In consequence of unfavourable weather conditions it was possible to obtain only few measurements during the proposed observing intervals; therefore the observations were continued outside the campaign limits up to late December 1971.

The photoelectric photometer, installed at the 102 cm Zeiss reflector, was equipped with an ice refrigerated Lallemand photomultiplier and with a Gardiner integrator. Owing to the S4 response of the phototube, only three blue out of the six interferential filters recommanded by the campaign coordinator (Batten 1970b) could be used. In addition to the narrow band filters, manufactured by Infrared Industries, Inc., an RG1 Schott filter was used. Taking into account the sensitivity curve of the photomultiplier, this filter allowed an intermediate width band in the red to be measured. The characteristics of the bands are summarized in table 1.

The variable star was observed differentially relative to the star HD 6997; check star was HR 7102 = 9 Lyr. In order to minimize the effects of possible rapid changes in sky transparency during the nights of moderate quality, β Lyr was usually bracketed in each colour between measurements of HR 6997. An automatic device permitted a quick alternative setting on the two stars. The integration time was typically set to 20 sec. The extinction coefficients were determined on seven nights and the average values of these measurements were used in the reduction of all observations.

The magnitude differences between the two comparison stars, average values calculated with the measurements related to seventeen nights, the corresponding standard errors and the number of individual observations are given in the first line of table 2. The standard deviation for a single observation therefore results to be respectively 0.019, 0.020, 0.016 and 0.011 mag in order of increasing filter wavelength and a similar internal accuracy can be expected for the measurements on β Lyr.

During the 1959 international campaign (Larsson-Leander 1969) Balazs-Detre observed in a band at $\lambda = 0.62\ \mu$, comparable to our red band ($\lambda = 0.63\ \mu$). The average Δm between comparison and check star resulted equal to $-0^{m}.235 \pm .002$ m.e. (from 37 measurements) and our observations gave $-0^{m}.241 \pm .002$ m.e. Therefore the relative brightness of the two comparison stars were the same during the two observing seasons.

Below in table 2 are listed the magnitude differences derived by comparing HR 6997 with some standard stars of the list proposed by E.H. Olson and K. Gyldenkerne (Batten 1971) in order to reduce the measurements obtained by different observers to an uniform system.

Altogether about 2100 individual differential magnitudes $\Delta m = m(\text{HR6997}) - m(\beta\ \text{Lyr})$ were obtained and from these measurements normal points have been calculated with observations made in short intervals of time.

THE RESULTS

After referring the normals to the same cycle by means of the period given by Herczeg (1973), the times of minima were determined for each lightcurve, fitting a parabola by least squares to the deeper part of the minima. Observations scattered along all the observing period were considered in computing the epoch of the primary minimum. On the contrary, only measurements out of the campaign limits were considered for the secondary eclipse because the lightcurves seem to be more unstable out of the primary eclipse, and moreover only one normal point within the secondary eclipse was obtained during the coordinated campaign. No significant differences were found between the instants derived from observations in the HeII emission region and the adjacent continuum.

The average instants and the corresponding errors of the normal minima are as follows:

Min I = Hel. JD 2441177.394	Min II = Hel. JD 2441248.42
±. 7 m.e.	±. 2 m.e.

The residuals $O-C$ calculated with respect to the ephemeris given by Herczeg (1973) give respectively: $-0^{d}.069$ and $-0^{d}.18$.

The normal points are listed in tables 3,4,5 and 6; n is the number of measurements in each normal, σ the corresponding standard error. The phases were calculated according to the period given by Herczeg (1973) and the epoch of Min I given above. The normal points are plotted versus phase in figure 1.

Looking over figure 1, the following features can be seen:

a) the maximum following the secondary eclipse (Max II) appears to be a little brighter in comparison with Max I;
b) the magnitudes pertaining to equal phases but to different cycles can differ systematically. The differences exceed the observational errors and witness the instability of the lightcurves of β Lyr. The changes are more evident out of the primary eclipse;
c) as our fragmentary measurements can prove, it appears that along the observing period the lightcurves changed out of primary eclipse whilst in Min I they were almost constant.

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REFERENCES

Batten, A.H.: 1970a, IAU Commission 42, 2nd β Lyr Campaign, Circular no. 1.
Batten, A.H.: 1970b, IAU Commission 42, 2nd β Lyr Campaign, Circular no. 2.
Batten, A.H.: 1971, IAU Commission 42, 2nd β Lyr Campaign, Circular no. 4.
Herczeg, T.J.: 1973, *Inform. Bull. Variable Stars* (IAU Commission 27) no. 820, 4.
Larsson-Leander G.: 1969, *Arkiv Astron.* **5**, 253.

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Table 1 Characteristics of the filters

Filter	Max	Half power bandwidth	Region
interferential	4057Å	35Å	emission-poor
interferential	4480Å	32Å	HeI triplet
interferential	4537Å	33Å	emission-poor
RG1 (2.5mm)	6300Å	360Å	---

Table 2 $\Delta m = m(\text{HR } 6997) - m(\text{HR } \ldots.)$

HR	λ 4057	4480	4537	6300
7102	-0.021 (42)	+0.077 (45)	+0.078 (46)	+0.241 (45)
	3	3	2	2 m.e.
6794	0.05 (2)	0.19 (1)	0.19 (1)	0.45 (1)
6845	-0.122 (5)	-0.141 (5)	-0.130 (6)	-0.196 (5)
	7	5	8	5
7171	-1.20 (1)	-1.15 (1)	-1.17 (2)	-1.09 (2)
7262	0.175 (6)	0.161 (5)	0.167 (5)	0.142 (5)
	10	8	9	7
7437	0.38 (1)	0.38 (2)	0.38 (1)	0.38 (1)
7731	-0.142 (6)	-0.001 (5)	-0.003 (5)	0.322 (5)
	13	9	10	10
7826	-0.413 (3)	-0.333 (3)	-0.339 (4)	-0.215 (3)
	22	12	12	12
7885	-1.61 (2)	-1.57 (2)	-1.58 (2)	-1.54 (2)
8217	-0.13 (2)	-0.06 (2)	-0.11 (2)	0.02 (2)
8266	-0.02 (2)	0.13 (2)	0.05 (2)	0.45 (2)
8338	-0.73 (2)	-0.73 (2)	-0.85 (2)	-0.74 (2)
8574	-0.31 (2)	-0.27 (2)	-0.29 (2)	-0.26 (2)

Table 3 Observations of β Lyr at λ = 4057 Å

JD 2441..	Phase	Δm	σ	n	JD 2441..	Phase	Δm	σ	n	JD 2441..	Phase	Δm	σ	n
162.395	.8404	1.780	.007	9	187.471	.7792	1.843	.004	4	246.293	.3270	1.832	.007	10
162.460	.8454	1.775	.002	9	191.380	.0814	1.454	.002	9	248.256	.4788	1.480	.003	8
162.545	.8520	1.815	.010	7	192.326	.1545	1.722	.004	8	248.307	.4827	1.470	.002	10
163.364	.9153	1.460	.022	3	196.359	.4663	1.498	.002	10	249.246	.5553	1.599	.005	8
165.365	.0700	1.341	.005	9	198.396	.6238	1.749	.002	9	249.333	.5620	1.637	.002	8
174.353	.7649	1.834	.003	5	212.350	.7027	1.843	.003	8	250.280	.6352	1.774	.009	9
174.417	.7699	1.830	.003	9	213.324	.7780	1.865	.005	8	260.236	.4050	1.702	.002	6
174.477	.7745	1.860	.006	7	217.336	.0882	1.539	.005	10	276.229	.6414	1.786	.003	6
174.533	.7789	1.851	.002	8	217.382	.0917	1.584	.012	6	281.235	.0285	1.064	.005	10
174.584	.7828	1.848	.010	6	225.280	.7024	1.866	.004	8	281.274	.0315	1.041	.008	10
176.352	.9194	1.409	.008	8	226.278	.7795	1.890	.006	10	282.227	.1052	1.627	.004	8
177.345	.9962	.910	.005	10	227.263	.8556	1.796	.003	9	290.230	.7240	1.930	.004	6
177.399	.0004	.908	.004	10	228.279	.9342	1.295	.004	10	291.234	.8016	1.872	.013	7
178.385	.0767	1.399	.002	9	231.274	.1657	1.759	.010	10	292.266	.8814	1.695	.002	10
179.372	.1530	1.694	.004	10	232.370	.2505	1.863	.004	7	293.262	.9583	1.112	.011	12
179.433	.1577	1.712	.004	7	233.328	.3245	1.864	.007	9	294.249	.0347	1.065	.007	5
179.518	.1642	1.760	.005	11	243.294	.0951	1.635	.007	7	295.235	.1109	1.662	.012	12
181.331	.3044	1.808	.004	10	243.307	.0960	1.642	.007	6	301.245	.5756	1.693	.012	10
182.350	.3832	1.690	.006	10	244.305	.1733	1.804	.006	12	303.230	.7290	1.864	.006	9
187.331	.7683	1.855	.003	8	245.269	.2478	1.916	.013	10	304.227	.8061	1.861	.005	8

Table 4 Observations of β Lyr at λ = 4480 Å

JD 2441..	Phase	Δm	σ	n	JD 2441..	Phase	Δm	σ	n	JD 2441..	Phase	Δm	σ	n
162.395	.8404	1.830	.007	12	198.370	.6218	1.833	.004	8	249.315	.5606	1.720	.002	5
162.494	.8480	1.839	.003	10	201.315	.8495	1.848	.009	9	249.350	.5633	1.733	.005	6
165.393	.0722	1.432	.008	4	202.311	.9265	1.369	.018	2	250.255	.6333	1.882	.004	14
174.341	.7640	1.932	.002	8	212.350	.7026	1.910	.003	8	254.259	.9429	1.322	.007	8
174.416	.7698	1.924	.003	10	213.306	.7766	1.911	.004	10	260.223	.4040	1.796	.005	6
174.477	.7745	1.936	.003	9	217.320	.0869	1.590	.012	8	276.228	.6414	1.869	.003	6
174.533	.7789	1.941	.001	8	217.401	.0932	1.654	.006	9	281.233	.0284	1.112	.004	11
174.583	.7827	1.929	.010	5	225.296	.7036	1.948	.003	9	281.272	.0314	1.104	.007	11
176.336	.9182	1.509	.004	9	226.291	.7805	1.956	.004	10	282.227	.1052	1.677	.005	8
177.329	.9950	.999	.006	9	227.280	.8570	1.842	.002	9	290.230	.7240	2.008	.004	6
177.398	.0004	.997	.004	8	228.263	.9330	1.351	.002	8	291.233	.8015	1.956	.009	7
178.369	.0755	1.450	.003	9	231.260	.1647	1.833	.006	8	292.247	.8799	1.760	.002	10
179.350	.1513	1.765	.004	11	232.347	.2487	1.921	.003	9	293.246	.9571	1.174	.003	7
179.433	.1577	1.784	.004	7	233.307	.3229	1.916	.005	8	293.274	.9593	1.147	.012	6
179.496	.1625	1.819	.004	8	243.277	.0938	1.671	.003	8	294.249	.0347	1.121	.020	5
181.315	.3032	1.890	.003	8	244.274	.1709	1.875	.003	6	295.235	.1109	1.724	.013	12
182.332	.3818	1.781	.004	9	245.252	.2465	1.936	.016	8	300.249	.4986	1.631	.022	3
187.323	.7677	1.921	.003	8	246.274	.3255	1.942	.005	13	301.214	.5732	1.789	.011	7
187.482	.7800	1.901	.003	4	248.242	.4777	1.589	.001	8	301.234	.5745	1.798	.014	8
191.380	.0814	1.515	.002	10	248.295	.4817	1.587	.003	8	303.229	.7290	1.956	.003	9
192.325	.1545	1.798	.003	8	249.233	.5543	1.696	.002	6	304.226	.8061	1.941	.004	8
196.334	.4644	1.603	.004	10	249.285	.5583	1.712	.004	6					

Table 5 Observations of β Lyr at λ = 4537 Å

JD 2441..	Phase	Δm	σ	n	JD 2441..	Phase	Δm	σ	n	JD 2441..	Phase	Δm	σ	n
162.393	.8402	1.811	.005	11	198.370	.6218	1.772	.003	8	249.315	.5606	1.651	.002	6
162.495	.8481	1.825	.002	11	201.314	.8494	1.838	.008	11	249.346	.5630	1.663	.006	7
165.391	.0720	1.392	.020	4	202.311	.9265	1.381	.006	2	250.255	.6333	1.831	.003	14
174.342	.7640	1.878	.002	8	212.350	.7027	1.892	.003	9	254.259	.9429	1.318	.004	7
174.417	.7698	1.875	.002	9	213.306	.7766	1.903	.004	10	260.223	.4039	1.730	.004	6
174.478	.7746	1.886	.003	7	217.320	.0869	1.566	.011	8	276.228	.6414	1.825	.002	6
174.534	.7789	1.890	.002	8	217.401	.0932	1.643	.005	9	281.236	.0286	1.110	.004	11
174.584	.7828	1.875	.008	6	225.296	.7036	1.906	.004	9	281.274	.0315	1.094	.006	10
176.336	.9183	1.482	.006	9	226.290	.7805	1.930	.004	10	282.226	.1051	1.669	.005	8
177.327	.9949	.957	.004	8	227.280	.8569	1.844	.003	8	290.231	.7240	1.987	.004	7
177.399	.0004	.950	.004	10	228.263	.9330	1.345	.002	8	291.233	.8015	1.926	.008	7
178.368	.0753	1.418	.003	9	231.260	.1647	1.827	.008	8	292.247	.8799	1.758	.003	10
179.350	.1513	1.746	.003	11	232.347	.2487	1.901	.003	9	293.245	.9571	1.175	.009	7
179.432	.1576	1.767	.003	7	233.307	.3230	1.886	.003	8	293.274	.9593	1.144	.013	6
179.496	.1625	1.794	.006	8	243.278	.0938	1.660	.003	8	294.250	.0348	1.121	.015	6
181.315	.3032	1.854	.002	8	244.274	.1709	1.848	.002	6	295.235	.1109	1.716	.013	12
182.332	.3818	1.725	.004	9	245.252	.2465	1.935	.006	8	300.249	.4986	1.534	.026	3
187.323	.7677	1.894	.002	8	246.275	.3256	1.892	.004	13	301.217	.5734	1.700	.009	8
187.481	.7799	1.857	.005	4	248.246	.4780	1.516	.003	9	301.232	.5746	1.724	.016	7
191.380	.0814	1.489	.004	10	248.293	.4816	1.505	.004	9	303.229	.7290	1.919	.005	9
192.325	.1544	1.768	.003	8	249.233	.5543	1.619	.008	6	304.226	.8060	1.908	.004	8
196.335	.4645	1.535	.005	9	249.284	.5582	1.647	.005	6					

Table 6 Observations of β Lyr at λ = 6300 Å

JD 2441..	Phase	Δm	σ	n	ID 2441..	Phase	Δm	σ	n	JD 2441..	Phase	Δm	σ	n
162.390	.8400	2.031	.002	10	191.366	.0802	1.738	.002	8	248.281	.4807	1.717	.003	10
162.456	.8451	2.043	.006	10	192.317	.1538	1.992	.002	8	249.229	.5539	1.826	.004	6
162.545	.8520	2.055	.005	7	195.344	.3878	1.975	.005	6	249.293	.5589	1.849	.003	9
163.381	.9166	1.760	.005	11	196.312	.4627	1.759	.002	11	249.339	.5625	1.867	.005	9
165.352	.0690	1.613	.003	7	198.356	.6207	1.989	.002	10	250.235	.6318	2.048	.002	8
174.326	.7628	2.102	.002	8	198.465	.6291	2.024	.002	7	254.235	.9410	1.594	.002	6
174.417	.7698	2.097	.003	9	201.305	.8487	2.034	.004	8	258.221	.2492	2.127	.005	11
174.478	.7746	2.091	.005	7	202.320	.9272	1.675	.006	12	260.213	.4032	1.964	.002	6
174.534	.7789	2.107	.004	9	212.349	.7025	2.101	.002	8	276.228	.6414	2.042	.003	6
174.584	.7828	2.097	.004	6	213.284	.7749	2.105	.002	14	281.234	.0284	1.417	.002	10
176.319	.9169	1.752	.002	8	217.305	.0358	1.783	.003	8	281.273	.0314	1.408	.005	10
177.314	.9939	1.277	.002	8	217.381	.0916	1.822	.005	6	282.224	.1050	1.897	.004	9
177.400	.0005	1.271	.003	9	225.271	.7017	2.132	.003	8	290.230	.7239	2.190	.002	6
178.351	.0740	1.641	.002	8	226.266	.7786	2.128	.001	8	291.232	.8015	2.137	.006	7
178.437	.0806	1.700	.006	8	227.263	.8557	2.047	.001	8	292.247	.8799	1.972	.003	10
179.327	.1495	1.956	.002	11	228.247	.9317	1.624	.002	8	293.245	.9571	1.467	.004	7
179.441	.1583	1.987	.003	9	231.246	.1636	2.028	.005	8	293.273	.9592	1.434	.012	6
179.481	.1614	1.995	.005	9	232.324	.2469	2.111	.003	10	294.251	.0348	1.425	.005	7
180.321	.2263	2.087	.006	9	233.293	.3218	2.110	.003	8	295.234	.1109	1.942	.007	12
180.335	.2274	2.079	.008	9	243.265	.0928	1.876	.002	8	300.248	.4985	1.733	.017	3
181.299	.3020	2.060	.001	8	244.271	.1706	2.063	.003	8	301.203	.5723	1.911	.002	7
182.314	.3804	1.961	.001	8	245.235	.2451	2.166	.001	4	303.229	.7289	2.147	.004	9
182.436	.3899	1.945	.008	8	245.245	.2459	2.145	.003	6	304.225	.8060	2.117	.003	8
187.306	.7664	2.094	.001	8	246.256	.3241	2.120	.007	10	312.226	.4246	1.912	.004	10
187.471	.7791	2.084	.003	4	248.228	.4766	1.728	.005	10					

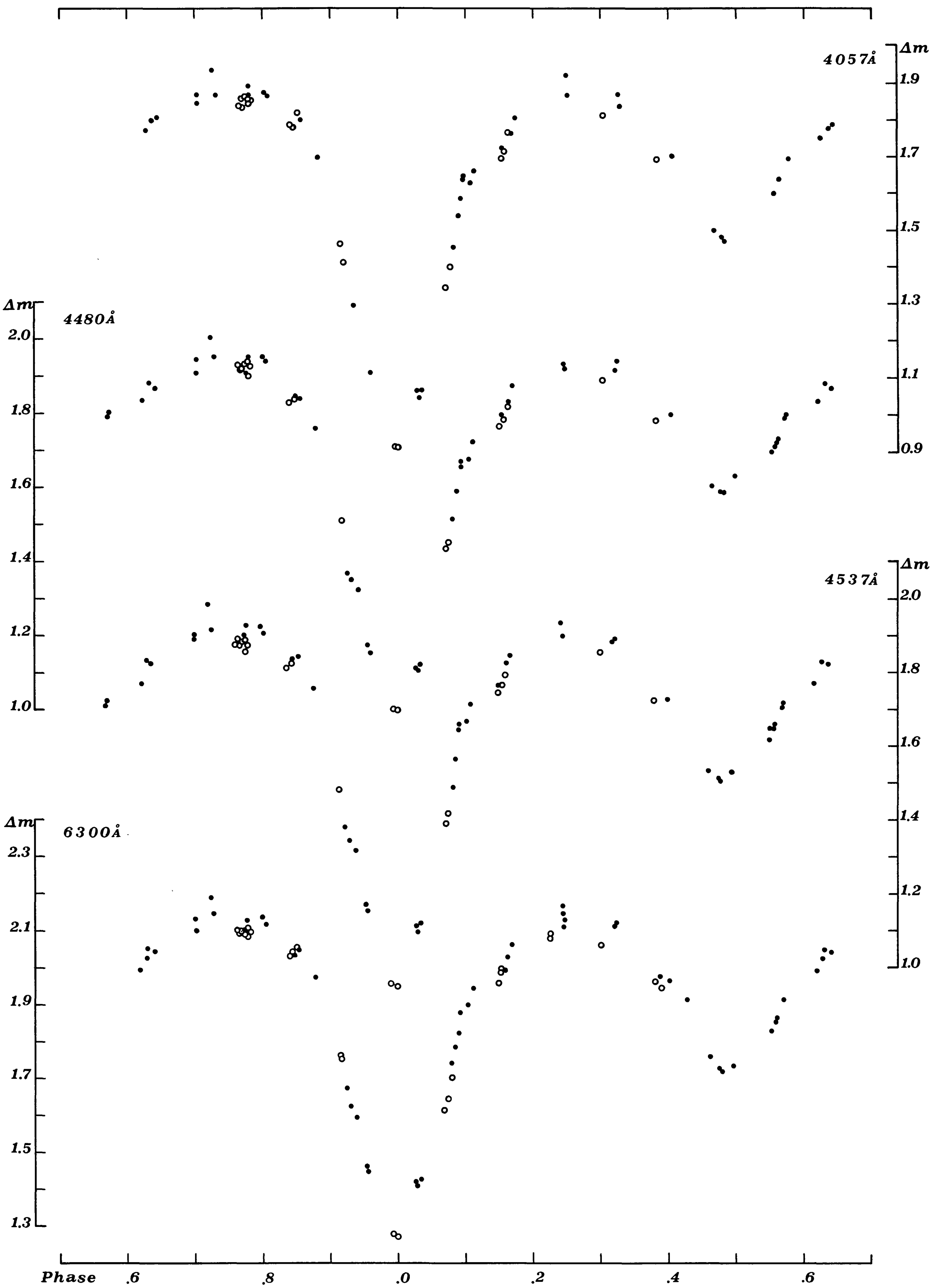

Figure 1 Lightcurves of β Lyr. The circles represent the observations obtained during the international campaign, the dots are the subsequent measurements until the fall of 1971.