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PHOTOELECTRIC OBSERVATIONS OF THE PECULIAR VARIABLE V 389 CYGNI

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Nearly 300 new photoelectric observations in B and V of the peculiar variable V 389 Cyg are presented. The small amplitude light variation and its possible periodic behaviour are discussed. No correlation between the light variations and the marginal colour variations was found.

Key words: variable stars – photoelectric photometry – spectroscopic binaries

1. INTRODUCTION

The light variability of V 389 Cyg = HD 201433 ($\alpha_{1900}=21^h04^m.4$, $\delta_{1900}=29°48'$; $m_{pg}=5.5-5.7$; B9pV) was detected by Guthnick and Bottlinger (1922). This was the result of a direct search for variability just after the discovery of Young (1921), that HD 201433 is a spectroscopic binary with period $P_{SB}=3^d.313168$. His radial velocity measurements showed an unusual large scatter about the mean radial velocity curve. After some photoelectric observations in 1923 and 1924 by Stebbins (1928), V 389 Cyg was observed most extensively between 1936 and 1941 by Guthnick (1938, 1939, 1942). In these years Guthnick collected 588 photoelectric observations, resulting from generally 2 to 3 single measurements. Unfortunately all observations were made only in one colour. Due to unusual good weather conditions in autumn 1936 and 1937, the following very peculiar photometric behaviour of V 389 Cyg was revealed:

The light variations with variable amplitudes were sometimes irregular and sometimes periodic with two alternating periods $P_1=1^d.12912$ and $P_2=1^d.19328$, which are not commensurable with the orbital period. Both onset and duration of each of these three types of light variations were completely irregular. Each of the periodic oscillations turned on at unshifted phases (as if they had not been interrupted at all).

In combination with simultaneous radial velocity measurements, Guthnick interpreted the light variations as a double δ-Cephei effect. By analyzing new radial velocities, Gieseking and Seggewiss (1978) recently discovered that V 389 Cyg is triple: the spectroscopic pair is revolving in an approximately 154 days orbit about an unseen third companion. For a more detailed review on the properties of this most remarkable star, the reader is referred to that paper.

Though this variable is a very challenging object, surprisingly no further photometric observations have been published since 1941 (Guthnick 1942). So no independent confirmation of Guthnick's conclusions is available. In this paper new photoelectric observations in B and V are presented, which have been collected in 1975, 1976 and 1977.

2. OBSERVATIONS

The observations were performed with a photoelectric photometer, attached to the 36 cm (f/19) Cassegrain-reflector of Hoher List observatory. In combination with a 1P21 photomultiplier and standard B- and V-filters an instrumental colour system very close to the Johnson B- and V-bands was defined. The 50 arc-minutes distant star HD 201912 ($V=6^m.86$; B5III) was used as comparison star. All measurements have been corrected for differential extinction and (second order) colour extinction. The extraterrestrial differential

B- and *V*-data in the instrumental colour system are given in table 1, in the sense variable minus comparison. As a measure of the accuracy of the photometry, the mean standard deviation of the measurements from second order polynomial fits for the individual observing nights are given:

$$\sigma(V) = \pm 0^{m}.007 \qquad \sigma(B-V) = \pm 0^{m}.009$$

3. RESULTS AND DISCUSSION

The observations of ΔV and $\Delta(B-V)$ are shown in figure 1.

The total range of the light variation proves to be of the order of 0.16 mag in V, which is in agreement with the result of Guthnick. Only in 3 out of 14 observing nights significant light variations on a small time scale have been observed.

Furthermore, in figure 1 the first colour observations of V 389 Cyg are presented. We find that the $(B-V)$-variation is only marginal, as compared with the scatter of the measurements: besides some possible small systematic changes of the order of ± 0.012 mag, which do not show any correlation with the light variation, $B-V$ proves to be constant in the range of the error.

In order to search for any periods which may be present in the new data, the period search method of Lafler and Kinman (1965) has been applied to the observations in ΔV. For a test of the applicability of the method and for a possible independent confirmation of the results of Guthnick, it has been applied to his observations too. The principle of the method is, under the assumption of a certain initial epoch to calculate for any trial period P a corresponding quality factor Q, which is defined by

$$Q = \frac{\sum_{i=1}^{N} (m_i - m_{i+1})^2}{\sum_{i=1}^{N} (m_i - <m>)^2}.$$

Here m_i and m_{i+1} are two observations, which have adjacent phases, $<m>$ is the mean of all observations and N is the number of observations. Q is therefore expected to be small in the region of a possible period. With stepwidths of $\Delta P = P^2/10\Delta T$, where ΔT is the epoch difference between the first and last observation, the period interval $0^{d}.5 < P < 2^{d}.0$ has been investigated systematically. The complete periodogram for the observations of Guthnick and for that of this paper consists of 13184 and 12235 Q-values, respectively. From the whole material a typical selection is plotted in two sections in figure 2a and figure 2b.

In the periodogram of Guthnick's observations a number of periods are indicated. Especially well marked are also Guthnick's periods in the region of $1^{d}.13$ and $1^{d}.19$. This shows the applicability of the method in spite of the very complex photometric behaviour described in the introduction. The periodogram of the observations of this paper looks completely different: it is characterized by countless spurious periods, which have surprisingly small Q-values especially in the large period domain. Plots of the observations over some of these "possible" periods show, that the special period search method itself and the distribution of the observations are responsible for probably all the spurious periods. Therefore we arrive at the conclusion, that in the new observations we are not able to find any significant period. In particular, all the periods, which are clearly indicated in Guthnick's observations, especially the probably real periods $1^{d}.13$ and $1^{d}.19$ discussed by Guthnick, cannot be confirmed. This negative result is at least partly due to the sporadic distribution of the observations. For further investigations thus a very extensive homogeneous observation material is essential.

Finally, a search for any correlation with the 154 days orbit was unsuccessful. A thorough inspection of Guthnick's measurements also did not reveal any correlation with the large period.

Thus, V 389 Cyg remains a very challenging object for future photometrists.

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Table 1 The observations

JD_{Hel} 2440000+	ΔV	ΔB	JD_{Hel} 2440000+	ΔV	ΔB	JD_{Hel} 2440000+	ΔV	ΔB	JD_{Hel} 2440000+	ΔV	ΔB
2687.3192	-1.215	-1.116	2957.5347	-1.213	-1.120	3331.5498	-1.179	-1.071	3433.2621	-1.160	-1.076
.3261	-1.202	-1.126	.5397	-1.198	-1.121	.5546	-1.184	-1.106	.2756	-1.151	-1.079
.3325	-1.203	-1.116	.5440	-1.231	-1.121	.5590	-1.187	-1.105	.2874	-1.157	-1.064
.3369	-1.203	-1.121	.5456	-1.223	-1.143	.5637	-1.193	-1.084	.2912	-1.174	-1.081
.3419	-1.205	-1.122	.5503	-1.217	-1.134	.5685	-1.205	-1.103	.2951	-1.169	-1.072
.3461	-1.204	-1.120	.5559	-1.203	-1.115	.5728	-1.195	-1.094	3435.2871	-1.238	-1.153
.3502	-1.203	-1.116	.5670	-1.210	-1.150	3335.4499	-1.264	-1.181	.3085	-1.230	-1.148
.3543	-1.206	-1.124	.5760	-1.213	-1.114	.4548	-1.277	-1.210	.3123	-1.233	-1.151
.3710	-1.213	-1.119	.5803	-1.216	-1.108	.4593	-1.261	-1.172	.3164	-1.229	-1.141
.3758	-1.197	-1.114	2960.4050	-1.241	-1.147	.4633	-1.279	-1.183	.3215	-1.219	-1.133
.3812	-1.197	-1.115	.4138	-1.242	-1.163	.4684	-1.269	-1.200	.3260	-1.225	-1.127
.3862	-1.198	-1.118	.4185	-1.247	-1.162	.4746	-1.288	-1.193	.3304	-1.225	-1.137
.3915	-1.195	-1.110	.4260	-1.263	-1.164	.4785	-1.296	-1.215	.3354	-1.217	-1.133
.3967	-1.191	-1.109	.4301	-1.263	-1.170	.4826	-1.297	-1.214	.3398	-1.219	-1.141
.4007	-1.196	-1.114	.4341	-1.257	-1.172	.4870	-1.278	-1.200	.3443	-1.221	-1.140
2709.4012	-1.272	-1.184	.4394	-1.251	-1.172	.4911	-1.283	-1.208	.3489	-1.223	-1.133
.4090	-1.261	-1.157	.4437	-1.262	-1.174	.4952	-1.280	-1.209	.3548	-1.216	-1.129
.4147	-1.241	-1.173	.4525	-1.260	-1.170	.4993	-1.288	-1.208	.3601	-1.206	-1.122
.4220	-1.257	-1.179	.4571	-1.248	-1.164	.5027	-1.284	-1.197	.3658	-1.209	-1.129
.4296	-1.256	-1.165	.4631	-1.260	-1.167	.5066	-1.274	-1.195	.4524	-1.180	-1.097
.4358	-1.250	-1.175	.4682	-1.267	-1.168	.5105	-1.281	-1.199	.4577	-1.172	-1.078
.4410	-1.247	-1.169	.4737	-1.261	-1.167	.5155	-1.262	-1.196	.4617	-1.160	-1.081
.4470	-1.248	-1.175	.4795	-1.254	-1.165	.5192	-1.267	-1.198	.4667	-1.173	-1.077
.4540	-1.257	-1.154	.4845	-1.260	-1.168	.5223	-1.263	-1.176	.4702	-1.168	-1.077
.4606	-1.243	-1.158	.4905	-1.261	-1.176	.5251	-1.268	-1.185	.4743	-1.162	-1.090
.4663	-1.246	-1.146	.4966	-1.261	-1.176	.5277	-1.269	-1.203	.4772	-1.164	-1.086
2955.4122	-1.238	-1.176	.5026	-1.262	-1.177	.5304	-1.267	-1.192	.4813	-1.173	-1.092
.4206	-1.210	-1.131	.5072	-1.258	-1.169	.5333	-1.271	-1.192	3436.2455	-1.303	-1.222
.4262	-1.220	-1.154	.5138	-1.264	-1.168	3420.2993	-1.218	-1.117	.2554	-1.311	-1.228
.4306	-1.209	-1.122	.5191	-1.264	-1.170	.3083	-1.206	-1.112	.2601	-1.298	-1.211
.4381	-1.220	-1.150	.5291	-1.260	-1.184	.3113	-1.207	-1.132	.2670	-1.303	-1.224
.4413	-1.210	-1.124	.5360	-1.258	-1.190	.3154	-1.200	-	.2714	-1.297	-1.210
.4450	-1.210	-1.137	.5412	-1.248	-1.177	.3167	-1.205	-1.118	.2761	-1.297	-1.217
.4497	-1.222	-1.152	.5463	-1.260	-1.170	.3214	-1.209	-1.133	.2810	-1.300	-1.214
.4537	-1.225	-1.144	.5515	-1.263	-1.176	.3256	-1.206	-1.137	.2862	-1.294	-1.212
.4580	-1.206	-1.119	.5602	-1.268	-1.175	.3296	-1.215	-1.149	.2913	-1.290	-1.204
.4617	-1.220	-1.139	.5640	-1.264	-1.171	.3335	-1.213	-1.135	.2959	-1.288	-1.205
.4653	-1.228	-1.147	.5689	-1.260	-1.174	.3375	-1.209	-1.137	-3005	-1.286	-1.205
.4698	-1.225	-1.142	.5769	-1.266	-1.172	.3413	-1.188	-1.104	.3050	-1.287	-1.203
.4805	-1.234	-1.124	.5811	-1.259	-1.175	.3527	-1.217	-1.116	.3177	-1.284	-1.208
.4845	-1.228	-1.138	3330.4406	-1.200	-1.112	.3637	-1.216	-1.115	.3221	-1.285	-1.200
.4886	-1.199	-1.119	.4459	-1.197	-1.106	.3684	-1.183	-1.099	.3262	-1.279	-1.206
.4927	-1.234	-1.146	.4506	-1.200	-1.115	.3735	-1.213	-1.118	.3323	-1.286	-1.206
.4972	-1.214	-1.136	.4565	-1.203	-1.119	.4003	-1.210	-1.139	.3373	-1.277	-1.188
.5060	-1.227	-1.139	.4616	-1.197	-1.123	.4041	-1.221	-1.153	.3428	-1.276	-1.192
.5104	-1.210	-1.131	.4726	-1.218	-1.125	.4095	-1.214	-1.145	.3485	-1.272	-1.195
.5195	-1.218	-1.129	.4771	-1.224	-1.121	.4150	-1.235	-1.157	.3539	-1.272	-1.200
.5246	-1.223	-1.130	.4955	-1.223	-1.123	.4259	-1.211	-1.145	.3613	-1.278	-1.192
.5281	-1.221	-1.138	.5003	-1.238	-1.128	.4510	-1.223	-1.138	.3673	-1.271	-1.194
.5315	-1.212	-1.137	.5047	-1.239	-1.137	.4555	-1.241	-1.159	.3728	-1.264	-1.189
.5352	-1.215	-1.141	.5093	-1.231	-1.128	3425.3402	-1.233	-1.126	.3776	-1.273	-1.185
.5388	-1.209	-1.129	.5137	-1.229	-1.136	.3429	-1.217	-1.120	.3825	-1.269	-1.190
.5428	-1.211	-1.126	.5184	-1.227	-1.134	.3573	-1.215	-1.133	.4007	-1.267	-1.174
.5472	-1.215	-1.132	.5233	-1.234	-1.139	.4193	-1.202	-1.099	.4060	-1.260	-1.167
.5507	-1.208	-1.121	.5275	-1.250	-1.152	.4243	-1.201	-1.113	.4112	-1.256	-1.177
.5541	-1.209	-1.130	.5313	-1.254	-1.149	.4281	-1.198	-1.101	.4165	-1.253	-1.162
.5570	-1.211	-1.130	.5351	-1.257	-1.153	.4323	-1.206	-1.106			
.5605	-1.212	-1.127	.5394	-1.242	-	.4368	-1.209	-1.100			
.5637	-1.213	-1.120	.5425	-1.242	-1.135	.4404	-1.203	-1.106			
.5696	-1.210	-1.126	.5483	-1.246	-1.145	.4955	-1.212	-1.117			
.5725	-1.212	-1.131	.5517	-1.248	-1.150	.4994	-1.206	-1.105			
.5783	-1.216	-1.130	.5558	-1.249	-1.142	.5036	-1.222	-1.130			
.5813	-1.214	-1.132	.5597	-1.238	-1.134	.5073	-1.222	-1.099			
.5872	-1.215	-1.128	.5636	-1.243	-1.138	.5106	-1.224	-1.133			
2957.4850	-1.226	-1.154	.5672	-1.241	-1.143	.5127	-1.222	-1.130			
.4888	-1.225	-1.165	.5708	-1.239	-1.155	.5154	-1.218	-1.126			
.4929	-1.217	-1.144	.5743	-1.239	-1.146	3429.2704	-1.227	-1.125			
.4967	-1.218	-1.159	3331.5204	-1.211	-1.082	.2797	-1.213	-1.112			
.5030	-1.208	-1.152	.5244	-1.183	-1.096	.2836	-1.211	-1.110			
.5085	-1.224	-1.158	.5310	-1.184	-1.103	.3048	-1.195	-1.099			
.5168	-1.213	-1.138	.5359	-1.184	-1.093	.3162	-1.213	-1.101			
.5209	-1.216	-1.152	.5407	-1.189	-1.097	.3593	-1.193	-1.092			
.5240	-1.219	-1.139	.5453	-1.182	-1.105	.3617	-1.196	-1.100			
.5285	-1.221	-1.134									

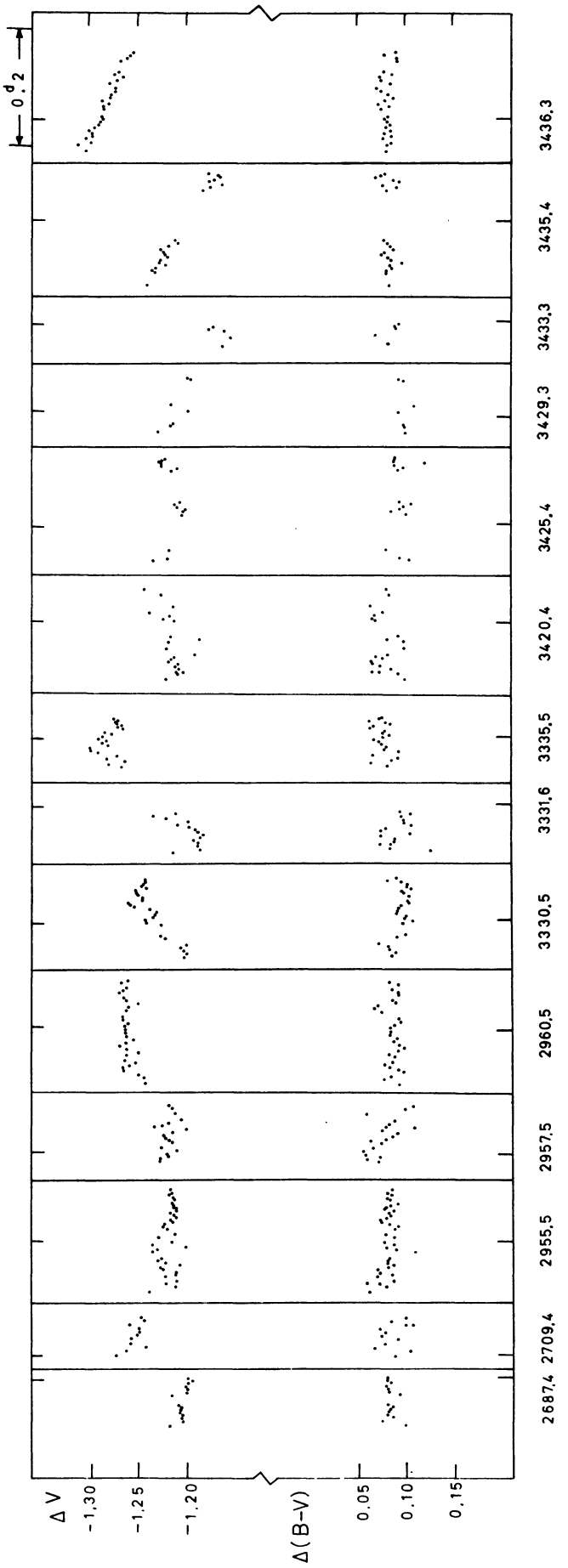

Figure 1 The differential photoelectric *V*- and *(B − V)*-observations of V 389 Cyg plotted over heliocentric Julian date. The uniform scale for all observation sections is given at upper right.

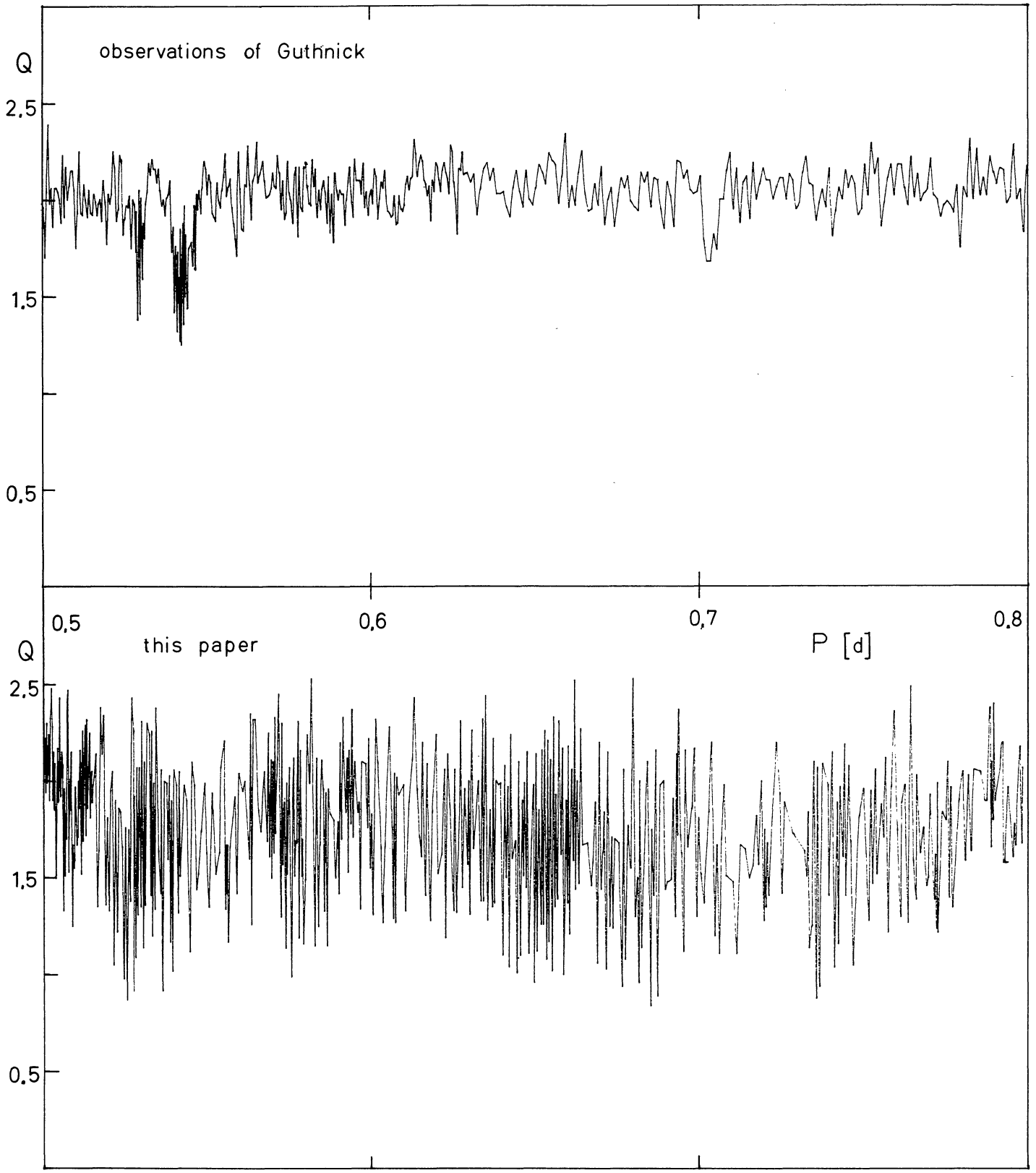

Figure 2a The Lafler-Kinman-periodogram for the observations of Guthnick and for those of this paper in the period interval $0^d5 < P < 0^d8$. For the definition of the quality parameter Q, see text.

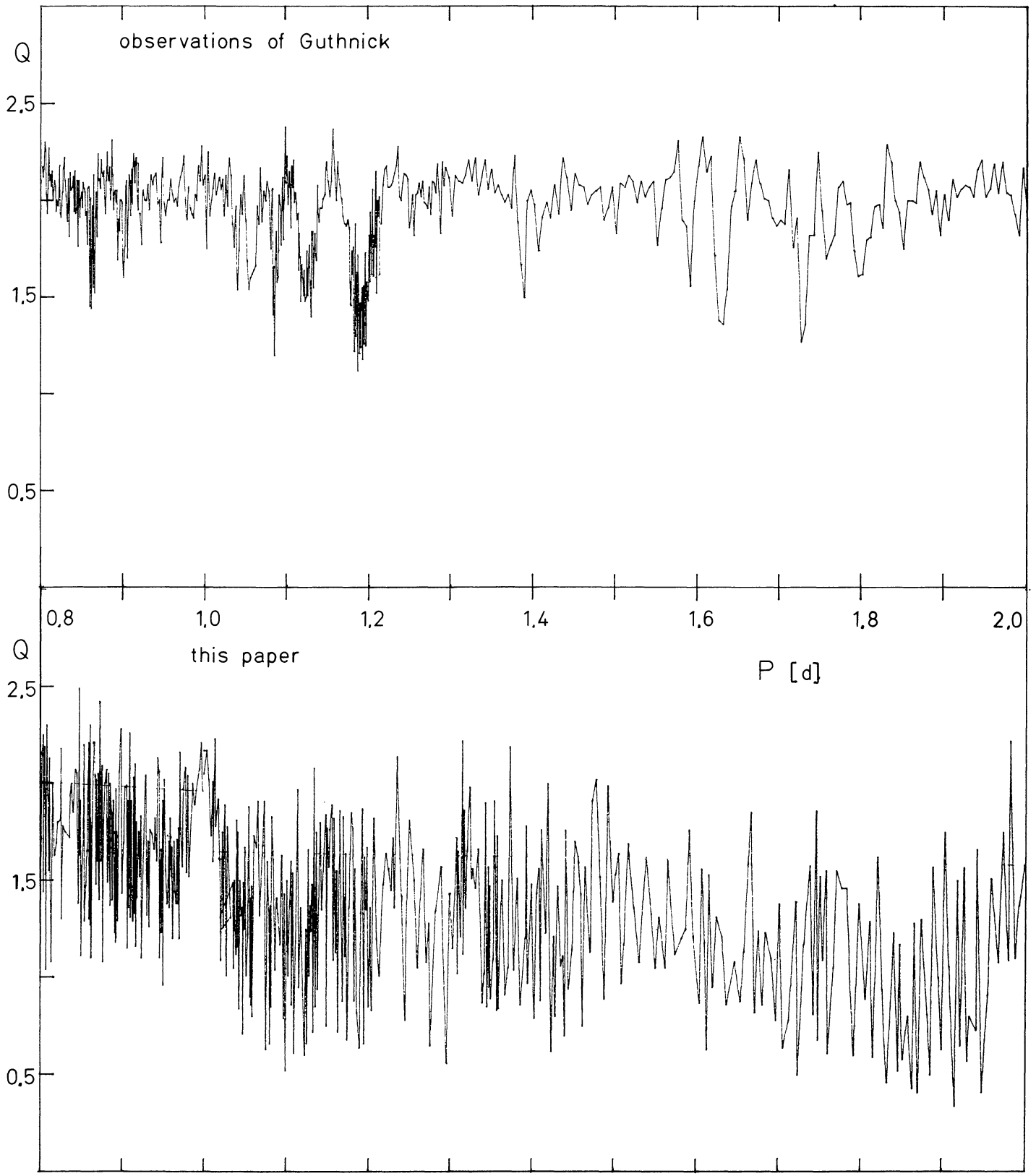

Figure 2b Same as figure 2a for the period interval $0^d8 < P < 2^d0$.