Photo-Electric Observations of VZ Cnc and RZ Cep

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PHOTO-ELECTRIC OBSERVATIONS OF VZ Cnc AND RZ Cep

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Photo-electric observations are presented of the short-period variable VZ Cnc, which shows beat phenomena, and of the RR Lyrae c-type variable RZ Cep. The light-variation of VZ Cnc agrees with the formulae derived by Fitch. The period of RZ Cep has started lengthening again around 1955.

In 1956 and 1957 the first author made photo-electric observations in blue and yellow light of the short-period variable VZ Cancri and of the RR Lyrae c-type variable RZ Cephei. He used the Zunderman reflector of the Leiden Observatory with a 1P21 multiplier combined with the filters GG7 for the yellow and BG12+ GG13 for the blue. The second author prepared this article.

1. VZ Cancri

The star HD 73 938 was used as comparison star and the observations were corrected for differential extinction. The individual observations are given in table 1 and the resulting light-curve in yellow is shown in figure 1.

Extensive photometric studies of this variable have been published by FITCH (1955) and SPINRAD (1960). The light-curve is strongly variable and Fitch determined the beat period and derived formulae for both the range and the epoch of median brightness on the ascending branch as a function of time. The phases φ and ψ in table 1 were computed according to the formulae (4) and (1) of Fitch. The values of the range A and of the epoch $T(\overline{m})$ computed with Fitch's formulae (3) and (2) respectively and determined from our figure compare as follows

	computed	observed	difference
A	$0^m.657$	$0^m.678$	$0^m.021$
$T(\overline{m})$	$2435901^d.5254$	$2435901^d.5252$	$0^d.0002$

The difference in A may well be due to a slight difference between the colour systems. We conclude that our observations agree very closely with Fitch's analysis.

2. RZ Cephei

The star BD $+64°1701$ was used as comparison star. The variable has been observed in two nights. The individual observations are given in table 2. The phase φ was computed with the formula

$$\varphi = 3.23992\ (\text{J. D. Hel.} - 2430000).$$

From a plot of the observations it is seen that the blue light-curves of the two nights are identical in range and shape, but that the variable is about 0.04 magnitude brighter in the second night. We do not know whether this effect should be ascribed to the comparison star. In order to obtain the best light-curve we have applied a correction of this amount to the observations of the second night. The two light-curves can be brought to coincidence when we adopt a period of 0.308 65 days. The light-curve is shown in figure 2. Data on the normal points are given in table 3. The shape of the light-curve is very similar to that derived by GEYER (1958) and SPINRAD (1959). The light-curves show a broad maximum with some fine structure. The rising branch ends abruptly in a sharp maximum of short duration which is followed by a second broad maximum. The three light-curves differ slightly in the relative height of the two maxima.

It has been known for a long time that the period

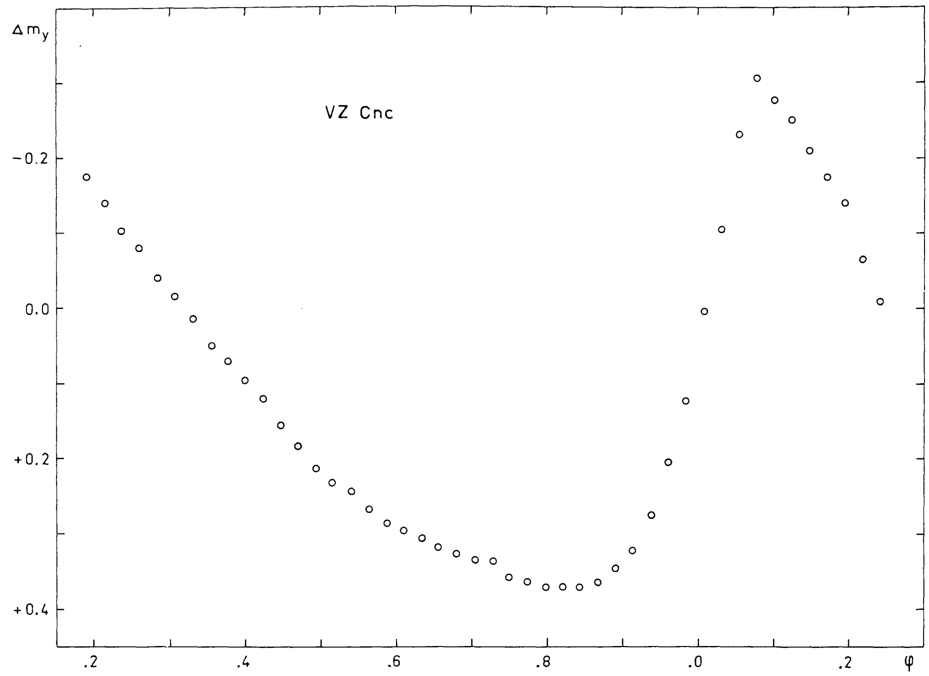

Figure 1. The light-variation of VZ Cnc in the night of 3–4 March 1957. Each point is the mean of two consecutive observations in yellow light.

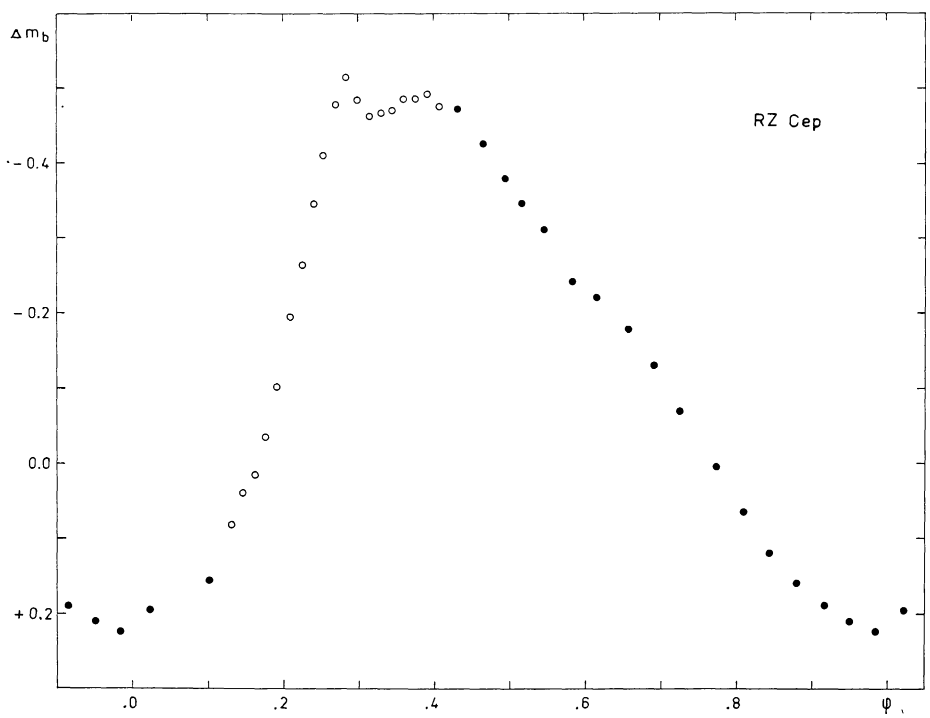

Figure 2. The mean light-curve of RZ Cep in blue light. Points represent the mean of 10 observations, open circles the mean of 5 observations.

TABLE 1

Individual observations of VZ Cnc

J. D. Hel. −2435000	Δm_b	Δm_y	φ	ψ	J. D. Hel. −2435000	Δm_b	Δm_y	φ	ψ
901.3796	−0.122	−0.196	.185	.453	901.4774	+0.594	+0.339	.733	.589
901.3816	−0.086	−0.161	.196	.456	901.4795	+0.595	+0.353	.745	.592
901.3837	−0.060	−0.147	.208	.459	901.4816	+0.610	+0.362	.757	.595
901.3858	−0.050	−0.133	.219	.462	901.4837	+0.600	+0.364	.768	.598
901.3878	−0.032	−0.120	.231	.464	901.4858	+0.621	+0.362	.780	.601
901.3900	+0.010	−0.084	.243	.467	901.4878	+0.634	+0.377	.791	.604
901.3920	0.000	−0.094	.254	.470	901.4900	+0.625	+0.364	.804	.607
901.3941	+0.061	−0.061	.266	.473	901.4920	+0.612	+0.368	.815	.610
901.3962	+0.069	−0.043	.278	.476	901.4941	+0.611	+0.373	.827	.613
901.3982	+0.081	−0.034	.289	.479	901.4962	+0.602	+0.371	.838	.616
901.4004	+0.098	−0.026	.301	.482	901.4982	+0.604	+0.373	.850	.619
901.4024	+0.112	−0.007	.313	.485	901.5004	+0.606	+0.368	.862	.622
901.4045	+0.142	+0.004	.324	.488	901.5024	+0.594	+0.361	.873	.624
901.4066	+0.169	+0.024	.336	.491	901.5045	+0.586	+0.354	.885	.627
901.4087	+0.201	+0.042	.348	.494	901.5066	+0.559	+0.340	.897	.630
901.4108	+0.213	+0.059	.360	.497	901.5087	+0.564	+0.334	.908	.633
901.4128	+0.227	+0.065	.371	.499	901.5108	+0.529	+0.312	.920	.636
901.4150	+0.232	+0.081	.383	.502	901.5128	+0.510	+0.290	.931	.639
901.4170	+0.265	+0.084	.394	.505	901.5150	+0.464	+0.263	.944	.642
901.4191	+0.292	+0.107	.406	.508	901.5170	+0.420	+0.227	.955	.645
901.4212	+0.290	+0.111	.418	.511	901.5191	+0.372	+0.182	.967	.648
901.4232	+0.329	+0.131	.429	.514	901.5212	+0.313	+0.148	.979	.651
901.4254	+0.349	+0.145	.441	.517	901.5232	+0.252	+0.098	.990	.653
901.4274	+0.362	+0.166	.453	.520	901.5254	+0.197	+0.036	.002	.657
901.4296	+0.376	+0.177	.465	.523	901.5274	+0.107	−0.028	.013	.659
901.4316	+0.368	+0.190	.476	.526	901.5295	+0.023	−0.073	.025	.662
901.4337	+0.399	+0.204	.488	.528	901.5316	−0.065	−0.137	.037	.665
901.4358	+0.419	+0.223	.500	.531	901.5337	−0.170	−0.214	.049	.668
901.4378	+0.445	+0.230	.511	.534	901.5358	−0.197	−0.250	.060	.671
901.4400	+0.448	+0.235	.523	.537	901.5378	−0.230	−0.290	.072	.674
901.4420	+0.465	+0.234	.535	.540	901.5400	−0.277	−0.320	.084	.677
901.4441	+0.473	+0.252	.546	.543	901.5420	−0.223	−0.270	.095	.680
901.4462	+0.497	+0.264	.558	.546	901.5441	−0.236	−0.281	.107	.683
901.4482	+0.504	+0.273	.569	.549	901.5462	−0.231	−0.260	.119	.686
901.4504	+0.517	+0.282	.582	.552	901.5483	−0.205	−0.240	.130	.688
901.4524	+0.523	+0.291	.593	.555	901.5504	−0.194	−0.233	.142	.691
901.4545	+0.530	+0.294	.605	.558	901.5524	−0.128	−0.185	.153	.694
901.4566	+0.537	+0.293	.616	.560	901.5546	−0.069	−0.162	.166	.697
901.4587	+0.540	+0.306	.628	.563	901.5566	−0.100	−0.188	.177	.700
901.4608	+0.552	+0.305	.640	.566	901.5587	−0.062	−0.162	.189	.703
901.4628	+0.560	+0.316	.651	.569	901.5608	−0.035	−0.115	.201	.706
901.4650	+0.543	+0.319	.663	.572	901.5628	+0.017	−0.079	.212	.709
901.4670	+0.564	+0.325	.675	.575	901.5650	+0.049	−0.047	.224	.712
901.4691	+0.579	+0.328	.686	.578	901.5670	+0.064	−0.042	.235	.715
901.4712	+0.589	+0.336	.698	.581	901.5691	+0.160:	+0.026:	.247	.718
901.4732	+0.593	+0.331	.709	.584	901.5712	+0.227:	+0.104:	.259	.720
901.4754	+0.588	+0.335	.722	.587	901.5733	+0.151:	+0.026:	.271	.723

TABLE 2

Individual observations of RZ Cep

J. D. Hel. −2435000	Δm_b	Δm_y	φ	J. D. Hel. −2435000	Δm_b	Δm_y	φ	J. D. Hel. −2435000	Δm_b	φ
762.3330	−0.381	−0.368	.498	762.5389	+0.026	−0.083	.165	786.4223	−0.363	.545
762.3358	−0.368	−0.348	.507	762.5416	−0.026	−0.130	.174	786.4254	−0.375	.555
762.3389	−0.350	−0.338	.517	762.5444	−0.051	−0.146	.183	786.4282	−0.343	.564
762.3416	−0.361	−0.350	.526	762.5472	−0.101	−0.197	.192	786.4303	−0.313	.571
762.3455	−0.323	−0.337	.538	762.5528	−0.195	−0.280	.210	786.4324	−0.308	.578
762.3482	−0.335	−0.341	.547	762.5556	−0.258	−0.290	.219	786.4365	−0.299	.591
762.3514	−0.272	−0.322	.558	762.5583	−0.258	−0.329	.228	786.4379	−0.287	.596
762.3542	−0.274	−0.300	.567	762.5611	−0.311	−0.360	.237	786.4393	−0.290	.600
762.3570	−0.280	−0.310	.576	762.5638	−0.341	−0.409	.246	786.4407	−0.276	.605
762.3597	−0.274	−0.285	.584	762.5666	−0.412	−0.427	.255	786.4421	−0.270	.609
762.3622	−0.220	−0.254	.593	762.5694	−0.465	−0.460	.264	786.4435	−0.266	.614
762.4229	+0.006	−0.060	.789	762.5722	−0.504	−0.460	.273	786.4449	−0.246	.619
762.4257	+0.075	−0.034	.798	762.5750	−0.515	−0.452	.282	786.4463	−0.256	.623
762.4304	+0.080	−0.021	.814	762.5778	−0.459	−0.448	.291	786.4476	−0.245	.627
762.4340	+0.077	−0.017	.825	762.5806	−0.461	−0.477	.300	786.4490	−0.246	.632
762.4368	+0.101	+0.002	.834	762.5834	−0.455	−0.465	.309	786.4504	−0.248	.636
762.4396	+0.111	+0.040	.843	762.5861	−0.469	−0.471	.318	786.4518	−0.249	.641
762.4424	+0.134	+0.037	.852	762.5889	−0.463	−0.460	.327	786.4532	−0.250	.645
762.4465	+0.141	+0.047	.866	762.5916	−0.502	−0.463	.336	786.4546	−0.238	.650
762.4507	+0.153	+0.064	.879	762.5944	−0.483	−0.481	.345	786.4560	−0.209	.655
762.4534	+0.153	+0.087	.888	762.5972	−0.503	−0.500	.354	786.4574	−0.198	.659
762.4562	+0.168	+0.088	.897	762.6000	−0.488	−0.469	.363	786.4588	−0.183	.664
762.4590	+0.164	+0.069	.906	762.6056	−0.486	−0.480	.381	786.4601	−0.194	.668
762.4652	+0.236	+0.111	.926	762.6084	−0.518	−0.486	.390	786.4615	−0.204	.672
762.4680	+0.226	+0.070	.935	762.6111	−0.486	−0.457	.399	786.4629	−0.181	.677
762.4708	+0.211	+0.074	.944	762.6139	−0.461	−0.449	.408	786.4643	−0.160	.681
762.4743	+0.220	+0.081	.956	762.6166	−0.496	−0.484	.417	786.4657	−0.169	.686
762.4771	+0.199	+0.076	.965	762.6236	−0.497	−0.456	.439	786.4671	−0.150	.690
762.4798	+0.229	+0.100	.974	762.6264	−0.451	−0.416	.449	786.4685	−0.153	.695
762.4826	+0.271	+0.093	.983	762.6292	−0.393	−0.389	.458	786.4699	−0.156	.700
762.4854	+0.205	+0.053	.992	762.6320	−0.394	−0.410	.467	786.4713	−0.137	.704
762.4882	+0.278	+0.103	.001	762.6347	−0.401	−0.397	.475	786.4726	−0.112	.708
762.4910	+0.208	+0.086	.010	762.6375	−0.369	−0.384	.484	786.4740	−0.104	.713
762.4938	+0.174	+0.052	.019	762.6402	−0.358	−0.369	.493	786.4754	−0.121	.717
762.4966	+0.162	+0.067	.028	762.6430	−0.324	−0.346	.502	786.4768	−0.117	.722
762.4993	+0.196	+0.080	.037	762.6458	−0.292	−0.336	.511	786.4782	−0.111	.726
762.5021	+0.202	+0.063	.046	762.6486	−0.322	−0.350	.520	786.4796	−0.128	.731
762.5048	+0.171	+0.083	.055	762.6514	−0.307	−0.340	.530	786.4810	−0.096	.736
762.5076	+0.218	+0.081	.064	762.6542	−0.300	−0.351	.539	786.4824	−0.058	.740
762.5111	+0.196	+0.037	.075	762.6570	−0.278	−0.283	.548	786.4838	−0.064	.745
762.5139	+0.179	+0.047	.084	762.6652	−0.176	−0.236	.574	786.4851	−0.059	.749
762.5166	+0.194	+0.023	.093	762.6680	−0.212	−0.252	.583	786.4865	−0.078	.753
762.5194	+0.142	−0.008	.102	762.6708	−0.183	−0.209	.592	786.4879	−0.053	.758
762.5222	+0.179	+0.017	.111	762.6740	−0.188	−0.228	.603	786.4914	−0.034	.769
762.5250	+0.140	−0.001	.120	762.6952	−0.172	−0.172	.671	786.4928	−0.018	.774
762.5278	+0.116	−0.005	.129	762.6979	−0.181	−0.124	.680	786.4942	−0.021	.778
762.5306	+0.033	−0.053	.138	762.7007	−0.157	−0.106	.689	786.4956	−0.016	.783
762.5334	+0.036	−0.040	.147	762.7034	−0.142	−0.132	.698	786.4969	−0.024	.787
762.5361	+0.032	−0.060	.156	762.7062	−0.139	−0.114	.707			

TABLE 2 *(continued)*

J. D. Hel. −2435000	Δm_b	φ	J. D. Hel. −2435000	Δm_b	φ	J. D. Hel. −2435000	Δm_b	φ
786.4983	−0.022	.792	786.5650	+0.151	.008	786.6608	−0.499	.318
786.4997	−0.028	.796	786.5664	+0.158	.012	786.6622	−0.507	.323
786.5011	+0.010	.801	786.5969	+0.081	.111	786.6636	−0.510	.327
786.5025	+0.022	.805	786.5983	+0.055	.116	786.6650	−0.505	.332
786.5039	+0.017	.810	786.5997	+0.061	.120	786.6664	−0.502	.336
786.5053	+0.026	.814	786.6011	+0.068	.125	786.6678	−0.486	.341
786.5067	+0.036	.819	786.6025	+0.033	.129	786.6692	−0.500	.345
786.5081	+0.044	.823	786.6039	+0.039	.134	786.6706	−0.496	.350
786.5094	+0.063	.828	786.6053	+0.028	.138	786.6719	−0.524	.354
786.5108	+0.070	.832	786.6067	−0.005	.143	786.6733	−0.496	.359
786.5122	+0.087	.837	786.6081	−0.005	.147	786.6747	−0.531	.363
786.5136	+0.081	.841	786.6094	−0.018	.152	786.6761	−0.529	.368
786.5150	+0.083	.846	786.6108	−0.014	.156	786.6775	−0.522	.372
786.5164	+0.092	.850	786.6122	−0.042	.161	786.6789	−0.525	.377
786.5178	+0.093	.855	786.6136	−0.049	.165	786.6803	−0.523	.381
786.5192	+0.095	.859	786.6150	−0.072	.170	786.6817	−0.544	.386
786.5206	+0.112	.864	786.6164	−0.062	.174	786.6831	−0.511	.390
786.5219	+0.109	.868	786.6178	−0.087	.179	786.6844	−0.518	.395
786.5233	+0.129	.873	786.6192	−0.103	.183	786.6858	−0.519	.399
786.5247	+0.132	.877	786.6206	−0.139	.188	786.6872	−0.515	.404
786.5261	+0.125	.882	786.6219	−0.154	.192	786.6886	−0.503	.408
786.5275	+0.138	.886	786.6233	−0.174	.197	786.6900	−0.534	.413
786.5289	+0.122	.891	786.6247	−0.202	.201	786.6914	−0.547	.417
786.5303	+0.137	.895	786.6261	−0.217	.206	786.6928	−0.512	.422
786.5317	+0.142	.900	786.6275	−0.253	.210	786.6942	−0.530	.426
786.5331	+0.153	.904	786.6289	−0.266	.215	786.6956	−0.497	.431
786.5344	+0.148	.909	786.6303	−0.283	.219	786.6969	−0.513	.435
786.5358	+0.140	.913	786.6317	−0.305	.224	786.6983	−0.470	.440
786.5372	+0.152	.918	786.6331	−0.336	.228	786.6997	−0.473	.444
786.5386	+0.160	.922	786.6344	−0.341	.233	786.7011	−0.500	.449
786.5400	+0.141	.927	786.6358	−0.405	.237	786.7025	−0.480	.453
786.5414	+0.150	.931	786.6372	−0.410	.242	786.7046	−0.467	.460
786.5428	+0.165	.936	786.6386	−0.424	.246	786.7060	−0.488	.465
786.5442	+0.139	.940	786.6400	−0.458	.251	786.7074	−0.451	.469
786.5456	+0.152	.945	786.6414	−0.472	.255	786.7088	−0.477	.474
786.5469	+0.173	.949	786.6428	−0.494	.260	786.7101	−0.488	.478
786.5483	+0.161	.954	786.6442	−0.508	.264	786.7115	−0.468	.482
786.5497	+0.192	.958	786.6456	−0.504	.269	786.7129	−0.435	.487
786.5511	+0.194	.963	786.6469	−0.530	.273	786.7143	−0.435	.491
786.5525	+0.217	.967	786.6483	−0.573	.278	786.7157	−0.408	.496
786.5539	+0.194	.972	786.6497	−0.542	.282	786.7171	−0.417	.500
786.5553	+0.203	.976	786.6511	−0.543	.287	786.7185	−0.428	.505
786.5567	+0.188	.981	786.6525	−0.555	.291	786.7199	−0.430	.510
786.5581	+0.184	.985	786.6539	−0.543	.296	786.7213	−0.430	.514
786.5594	+0.156	.990	786.6553	−0.530	.300	786.7226	−0.400	.518
786.5608	+0.149	.994	786.6567	−0.549	.305	786.7240	−0.360	.523
786.5622	+0.148	.999	786.6581	−0.500	.309	786.7254	−0.350	.527
786.5636	+0.137	.003	786.6594	−0.507	.314	786.7268	−0.368	.532

of this variable is subject to considerable changes. We have used our own observations and those obtained by Spinrad to derive the period for the interval 1956–1958. Epochs were determined for a point on the rising branch of median magnitude, this magnitude being defined as the mean of the magnitude at minimum and of the magnitude of the second broad maximum.

The five epochs obtained yield the elements

$$\text{epoch } (\overline{m}) = 2435762^{d}.5489 \pm 4 + 0^{d}.30865234 \pm 32 \; E \quad \text{(m.e.)}.$$

The epochs, the number of periods elapsed and the residuals from a least-squares solution are

Epoch		E	$(O-C)$
2435762.5483	yellow	0	$-0^{d}.0006$
2435762.5497	blue	0	+0.0008
2435786.6237	blue	78	−0.0001
2436403.9280	yellow	2078	−0.0005
2436403.9290	blue	2078	+0.0005

Comparing this result with figure 2 of the paper by GEYER (1958) we conclude that the period has started lengthening again around 1955.

TABLE 3

Normal points of the mean light-curve of RZ Cep

Mean phase	Mean Δm_b	n	Mean phase	Mean Δm_b	n
.022	+0.196	10	.392	−0.491	5
.100	+0.156	10	.406	−0.474	5
.131	+0.082	5	.432	−0.472	10
.145	+0.039	5	.465	−0.425	10
.161	+0.015	5	.494	−0.378	10
.176	−0.036	5	.517	−0.346	10
.190	−0.102	5	.546	−0.310	10
.208	−0.195	5	.581	−0.242	10
.224	−0.264	5	.613	−0.221	10
.239	−0.346	5	.656	−0.178	10
.253	−0.411	5	.690	−0.131	10
.269	−0.478	5	.724	−0.069	10
.284	−0.514	5	.773	+0.004	10
.298	−0.484	5	.810	+0.065	10
.314	−0.462	5	.843	+0.121	11
.329	−0.465	5	.879	+0.161	11
.343	−0.469	5	.914	+0.189	11
.359	−0.484	5	.950	+0.210	11
.376	−0.485	5	.983	+0.224	11

References

W. S. FITCH, 1955, *Ap. J.* **121** 690
E. GEYER, 1958, *Z. Ap.* **44** 100
H. SPINRAD, 1959, *Ap. J.* **130** 550
H. SPINRAD, 1960, *Ap. J.* **131** 134