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Communication from the Observatory at Leiden

PHOTOMETRIC OBSERVATIONS OF THE SHORT-PERIOD VARIABLE STAR ρ PUPPIS

J. PONSEN†

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Photoelectric observations of the variable ρ Puppis, made with the Rockefeller telescope and with the light-collector of the Leiden southern station are discussed in this article. The blue Rockefeller observations yield a nearly sinusoidal light-curve with an amplitude of 0.127 magnitude. The individual light-curves seem to show small systematic deviations from the mean light-curve, but no periodicities could be found. The best value of the period is: $^{d}.140\,881\,41 \pm 6$. This period represents satisfactorily all the radial-velocity measurements from the years 1897 until 1956, as well as our photometric observations and unpublished observations made at the Cape. Only the observations by Eggen show a shift in phase relative to the remaining photometric observations. The same value of the period was derived by W. Buscombe in 1957 from the radial-velocity measurements. As has been noticed by many other observers, this variable is probably brighter absolutely than most of the other ultra-short-period variables.
After the death of the author the reduction of the observations and the discussion were completed at the Leiden observatory by P. Th. Oosterhoff.

It has been known for many years that the radial velocity of the star ρ Puppis is variable. The photometric variability of the star was discovered by O. J. Eggen (1956). He derived a period of .141 days and a visual range of slightly more than one tenth of a magnitude. At the Cape observatory (1953) photometric variability had been found with a photographic range of about .15 magnitude. Very accurate radial velocities were determined by Struve, Sahade and Zebergs (1956). Eggen's period is fully confirmed by these observations.

The variable has been observed photoelectrically with the Rockefeller astrograph of the Leiden southern station during 9 nights in 1961. Data on the comparison stars used are given in the following table:

Star	α (1900)		δ		m_{pg}	C.I.	Sp
ρ Pup	8h	3m.3	− 24°	1′	3.13	+ 0.22	F6 II
16 Pup	8	4.6	− 18	57	3.99	− 0.35	B3
ξ Pup	7	45.1	− 24	37	4.70	+ 1.01	G3 I

The magnitudes and colours were taken from Cape Mimeogram No. 1, the magnitude of the variable being a mean value. The spectrum of 16 Puppis is from the HD catalogue, while the others are from the MKK list.

As the second comparison star, ξ Pup, has been used only occasionally, all the measures of the variable have been reduced to the difference in magnitude with 16 Pup. The measures were made through a blue filter. However, the effective wavelength of these blue magnitudes is considerably longer than that of the Cape magnitudes. From the measures of the variable and the two comparison stars we find the relation:

$$\Delta m_{\text{blue}} + 4.103 = m_{\text{pg}} - .332\ \text{C.I.}\,,$$

in which the quantities at the right-hand side of the equation are taken from Cape Mimeogram No. 1. The corrections for differential extinction become important at large hour angles, due to the large distance between the variable and the comparison stars. For the extinction coefficient we have used throughout the value .35 magnitude. The resulting magnitude differences and the heliocentric Julian Days have been collected in table 1.

TABLE 1

J. D. hel. — 2 430 000	Δm	Phase	J. D. hel. — 2 430 000	Δm	Phase	J. D. hel. — 2 430 000	Δm	Phase	J. D. hel. — 2 430 000	Δm	Phase
7330.3208	— 1.015	0.889	7331.2930	— 1.074	0.789	7331.5159	— 1.022	0.372	7332.4770	— 0.980	0.194
7330.3272	— 1.009	0.934	7331.2951	— 1.066	0.804	7331.5180	— 1.041	0.386	7332.4791	— 0.984	0.209
7330.3291	— 1.014	0.947	7331.2972	— 1.050	0.819	7331.5208	— 1.048	0.406	7332.4812	— 0.984	0.223
7330.3312	— 1.004	0.962	7331.2992	— 1.041	0.833	7331.5229	— 1.054	0.421	7332.4833	— 0.979	0.238
7330.3329	— 0.995	0.974	7331.3013	— 1.042	0.848	7331.5249	— 1.062	0.435	7332.4853	— 0.982	0.253
7330.3353	— 0.994	0.991	7331.3034	— 1.034	0.863	7331.5270	— 1.065	0.450	7332.4874	— 0.991	0.267
7330.3374	— 0.991	0.006	7331.3055	— 1.030	0.878	7331.5353	— 1.089	0.509	7332.4895	— 0.996	0.282
7330.3395	— 0.986	0.021	7331.3076	— 1.040	0.893	7331.5374	— 1.085	0.524	7332.4916	— 1.004	0.297
7330.3416	— 0.981	0.036	7331.3097	— 1.022	0.908	7331.5395	— 1.094	0.539	7332.4937	— 1.011	0.312
7330.3437	— 0.979	0.051	7331.3117	— 1.015	0.922	7331.5416	— 1.089	0.554	7332.4958	— 1.014	0.327
7330.3458	— 0.978	0.066	7331.3138	— 1.009	0.937	7331.5437	— 1.102	0.569	7332.4979	— 1.015	0.342
7330.3479	— 0.971	0.081	7331.3159	— 1.016	0.952	7331.5458	— 1.111	0.584	7332.4999	— 1.016	0.356
7330.3499	— 0.976	0.095	7331.3180	— 1.009	0.967	7331.5479	— 1.110	0.599	7332.5020	— 1.025	0.371
7330.3520	— 0.974	0.110	7331.3201	— 1.008	0.982	7331.5499	— 1.114	0.613	7332.5041	— 1.036	0.386
7330.3541	— 0.970	0.125	7331.3222	— 1.009	0.997	7331.5520	— 1.124	0.628	7332.5062	— 1.046	0.401
7330.3562	— 0.975	0.140	7331.3242	— 0.989	0.011	7331.5541	— 1.108	0.643	7332.5083	— 1.045	0.416
7330.3583	— 0.971	0.155	7331.3263	— 0.986	0.026	7331.5562	— 1.109	0.658	7332.5103	— 1.055	0.430
7330.3603	— 0.976	0.169	7331.3284	— 0.981	0.041	7331.5583	— 1.110	0.673	7332.5124	— 1.056	0.445
7330.3624	— 0.978	0.184	7331.3305	— 0.980	0.056	7331.5603	— 1.095	0.687	7332.5145	— 1.068	0.460
7330.3645	— 0.975	0.199	7331.3326	— 0.982	0.070	7331.5624	— 1.104	0.702	7332.5166	— 1.070	0.475
7330.3666	— 0.970	0.214	7331.3347	— 0.980	0.085	7331.5645	— 1.104	0.717	7332.5187	— 1.080	0.490
7330.3687	— 0.975	0.229	7331.3367	— 0.974	0.100	7331.5666	— 1.084	0.731	7332.5208	— 1.086	0.505
7330.3708	— 0.980	0.243	7331.3388	— 0.976	0.114	7331.5687	— 1.085	0.746	7332.5229	— 1.084	0.519
7330.3729	— 0.980	0.258	7331.3409	— 0.974	0.129	7331.5708	— 1.086	0.761	7332.5249	— 1.098	0.534
7330.3749	— 0.986	0.273	7331.3430	— 0.970	0.144	7331.5729	— 1.079	0.776	7332.5270	— 1.102	0.549
7330.3770	— 0.992	0.287	7331.3451	— 0.972	0.159	7331.5749	— 1.075	0.790	7332.5291	— 1.105	0.563
7330.3791	— 0.990	0.302	7331.3472	— 0.975	0.174	7331.5770	— 1.069	0.805	7332.5312	— 1.112	0.578
7330.3812	— 0.999	0.317	7331.3492	— 0.968	0.188	7331.5798	— 1.061	0.825	7332.5333	— 1.106	0.593
7330.3833	— 1.015	0.332	7331.3503	— 0.974	0.196	7331.5826	— 1.056	0.845	7332.5353	— 1.101	0.607
7330.3853	— 1.010	0.346	7331.3534	— 0.976	0.218	7331.5853	— 1.054	0.864	7332.5374	— 1.109	0.622
7330.3874	— 1.008	0.361	7331.3555	— 0.978	0.233	7331.5881	— 1.045	0.884	7332.5395	— 1.114	0.637
7330.3895	— 1.018	0.376	7331.3576	— 0.992	0.248	7331.5909	— 1.039	0.904	7332.5416	— 1.101	0.652
7330.3916	— 1.029	0.391	7331.3597	— 0.986	0.263	7331.5937	— 1.035	0.924	7332.5437	— 1.104	0.667
7330.3937	— 1.032	0.406	7331.3617	— 0.991	0.277	7331.5972	— 1.038	0.949	7332.5458	— 1.089	0.682
7330.3958	— 1.042	0.421	7331.3638	— 1.000	0.292	7331.5992	— 1.002	0.963	7332.5479	— 1.091	0.697
7330.3979	— 1.048	0.436	7331.3659	— 0.991	0.307				7332.5499	— 1.094	0.711
7330.3999	— 1.050	0.450	7331.3680	— 1.005	0.322	7332.3270	— 0.978	0.129	7332.5520	— 1.090	0.726
7330.4020	— 1.055	0.465	7331.3701	— 1.011	0.337	7332.3291	— 0.979	0.144	7332.5541	— 1.089	0.741
7330.4041	— 1.064	0.480	7331.3729	— 1.018	0.357	7332.3312	— 0.981	0.159	7332.5562	— 1.079	0.756
7330.4062	— 1.075	0.495	7331.3749	— 1.025	0.371	7332.3333	— 0.988	0.174	7332.5583	— 1.075	0.771
7330.4083	— 1.076	0.510	7331.3770	— 1.035	0.386	7332.3353	— 0.989	0.188	7332.5603	— 1.074	0.785
7330.4103	— 1.084	0.524	7331.3791	— 1.031	0.401	7332.3374	— 0.984	0.203	7332.5624	— 1.079	0.800
7330.4124	— 1.085	0.539	7331.3812	— 1.042	0.415	7332.3395	— 0.988	0.218	7332.5645	— 1.078	0.815
7330.4145	— 1.085	0.554	7331.3833	— 1.060	0.430	7332.3416	— 0.995	0.233	7332.5680	— 1.060	0.840
7330.4166	— 1.089	0.569	7331.3853	— 1.060	0.445	7332.3437	— 0.995	0.247			
7330.4187	— 1.095	0.583	7331.3874	— 1.065	0.459	7332.3458	— 0.995	0.262	7405.2233	— 1.092	0.559
7330.4208	— 1.096	0.598	7331.3895	— 1.076	0.474	7332.3479	— 0.999	0.277	7405.2268	— 1.098	0.584
7330.4229	— 1.094	0.613	7331.3916	— 1.070	0.489	7332.3499	— 0.998	0.291	7405.2285	— 1.095	0.596
7330.4249	— 1.098	0.627	7331.3937	— 1.075	0.504	7332.3520	— 1.006	0.306	7405.2303	— 1.092	0.609
7330.4270	— 1.100	0.642	7331.3958	— 1.075	0.519	7332.3541	— 1.010	0.321	7405.2320	— 1.094	0.621
7330.4291	— 1.094	0.657	7331.3979	— 1.082	0.534	7332.3562	— 1.009	0.336	7405.2337	— 1.096	0.633
7330.4312	— 1.091	0.672	7331.3999	— 1.090	0.548	7332.3583	— 1.020	0.351	7405.2354	— 1.091	0.645
7330.4333	— 1.086	0.687	7331.4020	— 1.088	0.563	7332.3603	— 1.034	0.365	7405.2372	— 1.094	0.658
7330.4353	— 1.082	0.701	7331.4041	— 1.098	0.578	7332.3624	— 1.030	0.380	7405.2389	— 1.094	0.670
7330.4374	— 1.079	0.716	7331.4062	— 1.095	0.593	7332.3645	— 1.030	0.395	7405.2407	— 1.091	0.683
7330.4395	— 1.079	0.731	7331.4083	— 1.100	0.608	7332.3666	— 1.046	0.410	7405.2424	— 1.098	0.695
7330.4416	— 1.070	0.746	7331.4103	— 1.100	0.622	7332.3687	— 1.055	0.425	7405.2445	— 1.092	0.710
7330.4437	— 1.069	0.761	7331.4124	— 1.095	0.637	7332.3708	— 1.055	0.440	7405.2465	— 1.085	0.724
7330.4458	— 1.062	0.776	7331.4145	— 1.096	0.652	7332.3729	— 1.060	0.455	7405.2504	— 1.065	0.751
7330.4479	— 1.059	0.791	7331.4166	— 1.099	0.667	7332.3749	— 1.059	0.469	7405.2521	— 1.065	0.763
7330.4499	— 1.058	0.805	7331.4187	— 1.091	0.682	7332.3770	— 1.075	0.484	7405.2539	— 1.072	0.776
7330.4520	— 1.056	0.820	7331.4208	— 1.085	0.697	7332.3791	— 1.080	0.499	7405.2553	— 1.071	0.786
7330.4541	— 1.042	0.835	7331.4229	— 1.085	0.711	7332.3812	— 1.080	0.514	7405.2570	— 1.062	0.798
7330.4562	— 1.036	0.850	7331.4249	— 1.079	0.726	7332.3833	— 1.084	0.529	7405.2587	— 1.060	0.810
7330.4583	— 1.031	0.865	7331.4270	— 1.090	0.741	7332.3853	— 1.090	0.543	7405.2604	— 1.052	0.822
7330.4603	— 1.030	0.879	7331.4291	— 1.085	0.755	7332.3874	— 1.098	0.558	7405.2622	— 1.056	0.835
7330.4624	— 1.026	0.894	7331.4312	— 1.069	0.770	7332.3895	— 1.098	0.573	7405.2639	— 1.046	0.847
7330.4645	— 1.018	0.909	7331.4333	— 1.055	0.785	7332.3916	— 1.095	0.587	7405.2657	— 1.038	0.860
7330.4687	— 1.008	0.938	7331.4353	— 1.062	0.799	7332.3937	— 1.092	0.602	7405.2674	— 1.044	0.872
7330.4784	— 0.994	0.007	7331.4374	— 1.061	0.814	7332.3958	— 1.109	0.617	7405.2692	— 1.031	0.885
7330.4847	— 0.980	0.052	7331.4395	— 1.052	0.829	7332.3979	— 1.104	0.632	7405.2708	— 1.021	0.896
7330.4881	— 0.982	0.076	7331.4416	— 1.041	0.844	7332.3999	— 1.108	0.646	7405.2728	— 1.028	0.910
7330.4909	— 0.971	0.096	7331.4437	— 1.035	0.859	7332.4020	— 1.101	0.661	7405.2747	— 1.026	0.924
7330.4930	— 0.974	0.111	7331.4458	— 1.038	0.874	7332.4041	— 1.104	0.676	7405.2764	— 1.011	0.936
7330.4958	— 0.970	0.131	7331.4513	— 1.025	0.913	7332.4062	— 1.099	0.691	7405.2782	— 1.009	0.949
7330.5090	— 0.982	0.224	7331.4534	— 1.019	0.928	7332.4083	— 1.086	0.706	7405.2799	— 1.010	0.961
7330.5117	— 0.984	0.244	7331.4555	— 1.004	0.943	7332.4103	— 1.082	0.720	7405.2817	— 1.004	0.974
7330.5149	— 0.981	0.266	7331.4576	— 1.010	0.958	7332.4124	— 1.088	0.735	7405.2833	— 0.994	0.985
7330.5176	— 1.001	0.285	7331.4597	— 1.004	0.973	7332.4145	— 1.081	0.750	7405.2851	— 1.002	0.998
			7331.4617	— 0.994	0.987	7332.4166	— 1.088	0.765	7405.2868	— 0.996	0.010
7331.2784	— 1.095	0.686	7331.5013	— 0.982	0.268	7332.4187	— 1.075	0.780	7405.2886	— 0.986	0.023
7331.2805	— 1.098	0.701	7331.5034	— 0.989	0.283	7332.4208	— 1.060	0.795	7405.2907	— 0.989	0.037
7331.2826	— 1.091	0.716	7331.5055	— 0.969	0.298	7332.4229	— 1.056	0.810	7405.2928	— 0.991	0.052
7331.2847	— 1.074	0.730	7331.5076	— 0.998	0.313	7332.4256	— 1.050	0.829	7405.2949	— 0.991	0.067
7331.2867	— 1.082	0.745	7331.5097	— 1.012	0.328	7332.4708	— 0.970	0.150	7405.2965	— 0.991	0.079
7331.2888	— 1.080	0.760	7331.5117	— 1.015	0.342	7332.4729	— 0.978	0.164	7405.2983	— 0.980	0.091
7331.2909	— 1.071	0.774	7331.5138	— 1.014	0.357	7332.4749	— 0.975	0.179	7405.3000	— 0.981	0.103

TABLE 1 *(Continued)*

J. D. hel. — 2 430 000	Δm	Phase
7405.3018	— 0.978	0.116
7405.3035	— 0.988	0.128
7405.3053	— 0.986	0.141
7405.3070	— 0.982	0.153
7405.3087	— 0.982	0.165
7405.3108	— 0.979	0.180
7405.3122	— 0.989	0.190
7405.3136	— 0.984	0.200
7405.3153	— 0.981	0.212
7405.3167	— 0.986	0.222
7405.3185	— 0.991	0.235
7405.3202	— 0.998	0.247
7405.3219	— 0.990	0.259
7405.3240	— 1.002	0.274
7405.3257	— 1.002	0.286
7405.3275	— 1.008	0.299
7405.3292	— 1.016	0.311
7405.3310	— 1.026	0.324
7405.3326	— 1.024	0.335
7405.3344	— 1.025	0.348
7405.3358	— 1.026	0.358
7405.3375	— 1.036	0.370
7405.3393	— 1.045	0.382
7405.3407	— 1.045	0.392
7405.3421	— 1.052	0.402
7405.3442	— 1.060	0.417
7405.3457	— 1.068	0.428
7405.3476	— 1.072	0.441
7405.3490	— 1.076	0.451
7405.3504	— 1.080	0.461
7405.3518	— 1.084	0.471
7405.3532	— 1.081	0.481
7405.3546	— 1.088	0.491
7405.3563	— 1.084	0.503
7405.3580	— 1.092	0.515
7405.3597	— 1.098	0.527
7405.3611	— 1.098	0.537
7405.3629	— 1.094	0.550
7405.3646	— 1.106	0.562
7405.3664	— 1.099	0.575
7405.3685	— 1.098	0.590
7405.3705	— 1.110	0.604
7405.3729	— 1.102	0.621
7405.3754	— 1.098	0.639
7405.3771	— 1.098	0.651
7405.3792	— 1.108	0.666
7405.3813	— 1.100	0.681
7405.3837	— 1.106	0.698
7405.3861	— 1.100	0.715
7405.3879	— 1.089	0.727
7405.3907	— 1.098	0.747
7405.3928	— 1.088	0.762
7405.3949	— 1.078	0.777
7405.3976	— 1.082	0.796
7407.1961	— 1.106	0.562
7407.1975	— 1.102	0.572
7407.2007	— 1.102	0.595
7407.2628	— 0.994	0.036
7407.2642	— 0.991	0.046
7407.2656	— 0.982	0.056
7407.2670	— 0.984	0.066
7407.2684	— 0.981	0.076
7407.2698	— 0.975	0.085
7407.2711	— 0.979	0.095
7407.2725	— 0.979	0.105
7407.2739	— 0.982	0.115
7407.2753	— 0.980	0.125
7407.2795	— 0.972	0.154
7407.3156	— 1.046	0.411
7407.3170	— 1.056	0.420
7407.3184	— 1.060	0.430
7407.3204	— 1.068	0.445
7407.3392	— 1.095	0.578
7407.3409	— 1.099	0.590
7407.3427	— 1.109	0.603
7407.3444	— 1.108	0.615
7407.3461	— 1.111	0.627
7407.3479	— 1.110	0.640
7407.3496	— 1.111	0.652
7407.3513	— 1.102	0.664
7407.3531	— 1.104	0.677
7407.3548	— 1.109	0.689
7407.3569	— 1.105	0.704
7407.3586	— 1.096	0.716
7407.3600	— 1.101	0.726
7407.3618	— 1.098	0.738

J. D. hel. — 2 430 000	Δm	Phase
7408.2547	— 0.979	0.076
7408.2561	— 0.979	0.086
7408.2578	— 0.976	0.098
7408.2592	— 0.980	0.108
7408.2606	— 0.978	0.118
7408.2620	— 0.986	0.128
7408.2637	— 0.986	0.140
7408.2655	— 0.982	0.153
7408.2669	— 0.982	0.163
7408.2683	— 0.980	0.173
7408.2700	— 0.980	0.185
7408.2717	— 0.981	0.197
7408.2731	— 0.981	0.207
7408.2745	— 0.978	0.217
7408.2759	— 0.984	0.227
7408.2773	— 0.984	0.237
7408.2787	— 0.993	0.247
7408.2804	— 0.996	0.259
7408.2825	— 0.995	0.274
7408.2846	— 0.996	0.289
7408.2860	— 1.000	0.299
7408.2874	— 1.002	0.309
7408.2891	— 1.008	0.321
7408.2912	— 1.011	0.336
7408.2940	— 1.030	0.355
7408.2957	— 1.026	0.367
7408.2971	— 1.033	0.377
7408.2985	— 1.037	0.387
7408.3002	— 1.040	0.399
7408.3016	— 1.044	0.409
7408.3037	— 1.049	0.424
7408.3047	— 1.054	0.431
7408.3061	— 1.062	0.441
7408.3078	— 1.065	0.453
7408.3092	— 1.061	0.463
7408.3110	— 1.074	0.476
7408.3124	— 1.082	0.486
7408.3137	— 1.084	0.495
7408.3155	— 1.082	0.508
7408.3172	— 1.091	0.520
7408.3190	— 1.084	0.533
7408.3203	— 1.090	0.542
7408.3217	— 1.091	0.552
7408.3238	— 1.094	0.567
7408.3252	— 1.090	0.577
7408.3269	— 1.101	0.589
7408.3283	— 1.094	0.599
7408.3308	— 1.102	0.617
7408.3321	— 1.110	0.626
7408.3339	— 1.104	0.639
7408.3360	— 1.099	0.654
7408.3377	— 1.102	0.666
7408.3394	— 1.096	0.678
7408.3412	— 1.082	0.690
7408.3429	— 1.091	0.703
7408.3447	— 1.091	0.715
7408.3464	— 1.086	0.727
7408.3481	— 1.088	0.739
7408.3499	— 1.088	0.752
7408.3533	— 1.085	0.776
7408.3554	— 1.079	0.791
7408.3578	— 1.074	0.808
7408.3592	— 1.068	0.818
7408.3610	— 1.071	0.831
7408.3624	— 1.065	0.841
7409.2362	— 0.988	0.043
7409.2380	— 0.994	0.056
7409.2393	— 0.986	0.065
7409.2414	— 0.985	0.080
7409.2428	— 0.986	0.090
7409.2446	— 0.979	0.103
7409.2463	— 0.985	0.115
7409.2480	— 0.980	0.127
7409.2494	— 0.978	0.137
7409.2508	— 0.982	0.147
7409.2525	— 0.974	0.159
7409.2539	— 0.981	0.169
7409.2553	— 0.985	0.179
7409.2570	— 0.985	0.191
7409.2588	— 0.992	0.204
7409.2609	— 0.984	0.219
7409.2630	— 0.990	0.234
7409.2647	— 1.005	0.246
7409.2664	— 0.996	0.258
7409.2685	— 1.000	0.273
7409.2699	— 1.006	0.283

J. D. hel. — 2 430 000	Δm	Phase
7409.2716	— 1.012	0.295
7409.2734	— 1.005	0.307
7409.2734	— 1.005	0.307
7411.1924	— 1.015	0.929
7411.1938	— 1.012	0.939
7411.1979	— 1.004	0.968
7411.1993	— 1.004	0.978
7411.2007	— 1.001	0.988
7411.2021	— 1.001	0.998
7411.2035	— 0.998	0.008
7411.2049	— 0.996	0.017
7411.2063	— 0.998	0.027
7411.2076	— 0.990	0.037
7411.2090	— 0.990	0.047
7411.2104	— 0.988	0.057
7411.2118	— 0.992	0.066
7411.2132	— 0.989	0.076
7411.2146	— 0.991	0.086
7411.2160	— 0.982	0.096
7411.2174	— 0.981	0.106
7411.2188	— 0.984	0.116
7411.2201	— 0.981	0.125
7411.2215	— 0.981	0.135
7411.2229	— 0.979	0.145
7411.2243	— 0.970	0.155
7411.2257	— 0.979	0.165
7411.2271	— 0.971	0.175
7411.2285	— 0.978	0.185
7411.2299	— 0.982	0.195
7411.2313	— 0.986	0.205
7411.2326	— 0.984	0.214
7411.2340	— 0.990	0.224
7411.2354	— 0.986	0.234
7411.2368	— 0.994	0.244
7411.2382	— 0.986	0.254
7411.2396	— 0.992	0.264
7411.2410	— 0.995	0.274
7411.2424	— 0.994	0.284
7411.2438	— 1.002	0.294
7411.2451	— 1.011	0.303
7411.2465	— 1.011	0.313
7411.2479	— 1.018	0.323
7411.2493	— 1.016	0.333
7411.2507	— 1.021	0.343
7411.2521	— 1.022	0.352
7411.2535	— 1.029	0.362
7411.2549	— 1.035	0.372
7411.2563	— 1.035	0.382
7411.2576	— 1.046	0.392
7411.2590	— 1.052	0.401
7411.2604	— 1.058	0.411
7411.2618	— 1.061	0.421
7411.2632	— 1.061	0.431
7411.2646	— 1.066	0.441
7411.2660	— 1.070	0.451
7411.2674	— 1.076	0.461
7411.2688	— 1.081	0.471
7411.2701	— 1.085	0.480
7411.2715	— 1.092	0.490
7411.2729	— 1.102	0.500
7411.2743	— 1.089	0.510
7411.2757	— 1.096	0.520
7411.2771	— 1.098	0.530
7411.2792	— 1.105	0.545
7411.2806	— 1.098	0.555
7411.2819	— 1.104	0.564
7411.2833	— 1.104	0.574
7411.2847	— 1.100	0.584
7411.2868	— 1.111	0.599
7411.2882	— 1.112	0.609
7411.2896	— 1.110	0.619
7411.2910	— 1.116	0.629
7411.2924	— 1.104	0.639
7411.2938	— 1.120	0.648
7411.2951	— 1.114	0.658
7411.2965	— 1.112	0.668
7411.2979	— 1.106	0.678
7411.3000	— 1.106	0.692
7411.3014	— 1.101	0.702
7411.3028	— 1.095	0.712
7411.3042	— 1.095	0.722
7411.3056	— 1.091	0.732
7411.3069	— 1.096	0.741
7411.3083	— 1.089	0.751
7411.3097	— 1.084	0.761
7411.3111	— 1.086	0.771

J. D. hel. — 2 430 000	Δm	Phase
7411.3125	— 1.078	0.781
7411.3139	— 1.076	0.791
7411.3153	— 1.074	0.801
7411.3195	— 1.060	0.831
7411.3208	— 1.052	0.840
7411.3222	— 1.060	0.850
7411.3236	— 1.055	0.860
7411.3250	— 1.046	0.870
7411.3271	— 1.046	0.885
7411.3285	— 1.040	0.895
7411.3299	— 1.038	0.905
7411.3313	— 1.039	0.915
7413.1930	— 0.966	0.129
7413.1950	— 0.972	0.144
7413.1985	— 0.972	0.168
7413.2006	— 0.971	0.183
7413.2020	— 0.976	0.193
7413.2034	— 0.978	0.203
7413.2048	— 0.976	0.213
7413.2062	— 0.984	0.223
7413.2075	— 0.985	0.232
7413.2089	— 0.988	0.242
7413.2103	— 0.985	0.252
7413.2117	— 0.994	0.262
7413.2131	— 0.990	0.272
7413.2145	— 0.998	0.282
7413.2159	— 0.996	0.292
7413.2173	— 1.004	0.302
7413.2187	— 1.006	0.312
7413.2200	— 1.009:	0.321
7413.2214	— 1.039:	0.331
7413.2228	— 1.048:	0.341
7413.2242	— 1.026:	0.351
7413.2256	— 1.036:	0.361
7413.2272	— 1.034:	0.372
7413.2286	— 1.039:	0.382
7413.2301	— 1.039:	0.393
7413.2318	— 1.048:	0.405
7413.2332	— 1.055:	0.415
7413.2353	— 1.051	0.430
7413.2374	— 1.060	0.444
7413.2395	— 1.076	0.459
7413.2409	— 1.079:	0.469
7413.2423	— 1.082:	0.479
7413.2437	— 1.090:	0.489
7413.2452	— 1.091:	0.500
7413.2468	— 1.094:	0.511
7413.2485	— 1.108:	0.523
7413.2499	— 1.099:	0.533
7413.2513	— 1.102	0.543
7413.2527	— 1.099	0.553
7413.2541	— 1.098	0.563
7413.2555	— 1.108	0.573
7413.2568	— 1.116	0.582
7413.2584	— 1.108	0.594
7413.2603	— 1.102	0.607
7413.2617	— 1.110	0.617
7413.2631	— 1.105	0.627
7413.2647	— 1.112	0.638
7413.2662	— 1.110:	0.649
7413.2676	— 1.101:	0.659
7413.2697	— 1.100:	0.674
7413.2714	— 1.106:	0.686
7413.2739	— 1.095	0.704
7413.2756	— 1.092	0.716
7413.2770	— 1.092	0.726
7413.2787	— 1.095	0.738
7413.2801	— 1.084	0.748
7413.2818	— 1.090	0.760
7413.2834	— 1.081	0.771
7413.2848	— 1.076	0.781
7413.2867	— 1.069	0.794
7413.2884	— 1.064	0.806
7413.2902	— 1.061	0.819
7413.2916	— 1.058	0.829
7413.2933	— 1.058	0.841
7413.2950	— 1.054	0.853
7413.2964	— 1.048	0.863
7413.2978	— 1.045	0.873
7413.2999	— 1.042	0.888
7413.3013	— 1.036	0.898
7413.3027	— 1.031	0.908

The observations fully confirm Eggen's results. The period is very close to .141 days, the amplitude is slightly larger than one tenth of a magnitude and our observations indicate a light-curve which is nearly sinusoidal. Our observations cover an interval of about three months. We have derived a more accurate value of the period from the observations with $\Delta m = -1.040$ on the rising and descending branches of the light-curve. The resulting elements are:

$$\text{Epoch}\ (\Delta m = -1.040) =$$
$$= 2\,437\,330.3926 + .140\,880\,6\,E + .0668\,X.$$
$$\pm \quad 11 \qquad\qquad 2\,6 \qquad\qquad 15$$

The quantity X equals zero on the rising and $+1$ on the descending branch. The epochs used in this solution and the residuals are given in table 2.

TABLE 2

Epoch — 2 430 000	E	X	$(O - C)$
7330.396	0	0	+ 0.003
.456	0	1	— 0.003
31.302	6	1	— 0.003
.380	7	0	+ 0.001
.443	7	1	— 0.003
.519	8	0	— 0.001
.591	8	1	+ 0.005
32.365	14	0	0.000
.506	15	0	0.000
7405.267	531	1	0.000
.339	532	0	— 0.002
8.300	553	0	0.000
11.256	574	0	— 0.002
13.230	588	0	0.000
.301	588	1	+ 0.004

The phases given in table 1 have been computed with the formula

$$\text{phase} = 7.098\,168\ (\text{J. D. hel.} - 2\,400\,000).$$

This value of the reciprocal period, which deviates very slightly from the reciprocal value of the period given in the formula above, will be derived below. From the data in table 1 we have computed a mean light-curve, which is shown in figure 1. Each normal point is a mean of twenty observations. Phase and magnitude of the normal points are given in table 3.

The range of the light-variation is .127 magnitude. The maximum is slightly sharper than the minimum and the rising and descending branches are practically equally steep. Some of the observed light-curves deviate at certain phases systematically from the mean

TABLE 3

Number of observations	Mean phase	Mean magnitude
20	0.0291	— 0.990
20	0.0696	— 0.984
20	0.1012	— 0.979
20	0.1304	— 0.978
20	0.1584	— 0.977
20	0.1864	— 0.979
20	0.2136	— 0.983
20	0.2396	— 0.988
20	0.2655	— 0.991
20	0.2898	— 0.997
20	0.3170	— 1.009
20	0.3503	— 1.019
20	0.3834	— 1.034
20	0.4148	— 1.050
20	0.4410	— 1.061
20	0.4710	— 1.072
20	0.5058	— 1.085
20	0.5388	— 1.093
20	0.5653	— 1.098
20	0.5887	— 1.101
20	0.6122	— 1.104
20	0.6361	— 1.106
20	0.6621	— 1.102
20	0.6886	— 1.095
20	0.7121	— 1.093
20	0.7346	— 1.087
20	0.7593	— 1.082
20	0.7845	— 1.072
20	0.8114	— 1.063
20	0.8420	— 1.052
20	0.8785	— 1.037
21	0.9224	— 1.022
21	0.9740	— 1.005

curve. The largest differences are about .01 magnitude. Some of these systematic deviations may be due to uncertainties in the correction for differential extinction when the observations were made at large hour angles. But they also occur at small hour angles and we have the impression that they are intrinsic. However we have not succeeded in finding a period for the deviations of the observations from the mean light-curve.

In table 4 we have collected epochs of maximum brightness from the observations by Eggen and by

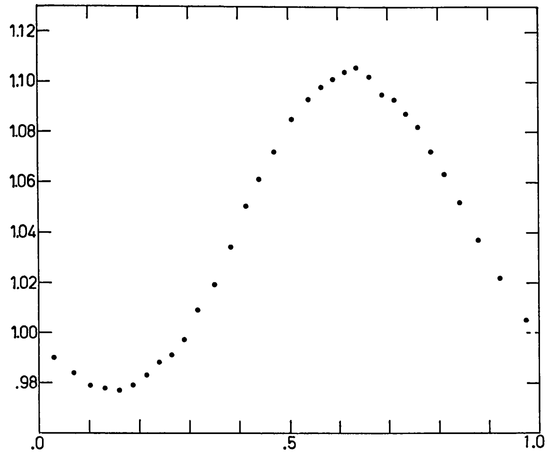

Figure 1

Ponsen. A least-squares solution yields the following elements:

$$\text{Max. } 2\,435\,552.807 + .140\,879\,55\,E\,.$$
$$\pm \quad 3 \qquad\qquad 33 \quad \text{(m.e.)}$$

This period agrees within the mean error with the period given above, which was derived from the own observations. Details of this solution are given in the first three columns of table 4. To check the correctness of the counting of periods in the five-year interval between the two sets of observations, we have computed the residuals for the Leiden epochs when the counting of periods in this interval is changed by − 1 and + 1 respectively. These residuals are given in the last two columns of table 4. The corresponding periods are: .140 890 19 and .140 868 85 . The residuals $(O - C)_2$ show a small systematic run, the residuals $(O - C)_3$ a very strong one. But even the period corresponding with $(O - C)_2$ does not seem acceptable, as it differs by 3.5 times the mean error from the period derived from the Leiden observations alone. Consequently the counting of periods given in table 4 may be considered as correct.

As this counting covers five years, it should be possible to improve the period still further by using the radial-velocity measures made at the Lick Observatory (1928) in the years from 1897 to 1907, at the Cape Observatory (1928) in the years from 1908 to 1923 and by STRUVE, SAHADE and ZEBERGS (1956) in 1956. As the maximum of the light-curve does not necessarily coincide exactly with the minimum of the radial-velocity curve, we have derived the period from the radial velocities alone, starting with the value of the period which was found from the own observations. In table 5 we have collected epochs of minimum radial velocity. In the other two columns the number of periods and the residuals from a least-squares solution are shown. The resulting elements are:

$$\text{Minimum radial velocity} =$$
$$= 2\,435\,561.672 + .140\,881\,41\,E\,.$$
$$\pm \quad 6 \qquad\qquad 6 \quad \text{(m.e.)}$$

This value of the period, corresponding with the reciprocal period 7.098 168, is identical with that derived by W. BUSCOMBE (1957) and falls within the mean error

TABLE 4

Epochs of maximum 2 435 000	E	$(O - C)$	$(O - C)_2$	$(O - C)_3$
5 552.825	0	+ 0.018		
.929	1	− 0.019		
53.931	8	− 0.004		
55.906	22	− 0.001		
59.858	50	+ 0.007		
7 330.425	12618	− 0.001	+ 0.002	− 0.004
31.409	12625	− 0.003	0.000	− 0.006
.552	12626	− 0.001	+ 0.002	− 0.004
32.398	12632	0.000	+ 0.003	− 0.003
.536	12633	− 0.003	0.000	− 0.006
405.375	13150	+ 0.001	− 0.001	+ 0.004
7.350	13164	+ 0.004	+ 0.001	+ 0.007
8.333	13171	+ 0.001	− 0.002	+ 0.004
11.292	13192	+ 0.001	− 0.001	+ 0.004
13.262	13206	− 0.001	− 0.004	+ 0.002

TABLE 5

Epoch minimum radial velocity	E	$(O - C)$
2 413 979.75	0	− 0.017
5 484.67	10 682	+ 0.008
6 512.81	17 980	− 0.005
2 423 160.32	65 165	+ 0.016
3 431.37	67 089	+ 0.010
2 435 561.67	153 192	− 0.002
62.65	153 199	− 0.008
93.65	153 419	− 0.002
94.64	153 426	+ 0.002

of the value derived from our own photometric observations, but well outside the mean error of the value derived from the combination of Eggen's and Ponsen's observations. With the period derived above the old radial velocities yield very reasonable velocity curves. With the period derived from the combined photometric material no such representation of the radial velocities seems possible. Therefore phases have been computed for the photometric and the radial-velocity measures with the formula:

$$\text{phase} = 7.098\,168\,(\text{J.D.} - 2\,400\,000)\,.$$

Our own mean light-curve is shown in figure 1, the observations by Eggen have been plotted in figure 2, while the three sets of radial-velocity measures are shown in figure 3. From figure 3 we find for minimum radial velocity a phase near .7, the maximum of our light-curve has phase .63, while Eggen's curve has its maximum near phase .8. It is not clear how this discordance should be explained. As the photometric variability had been discovered at the Cape, I asked Dr A. W. J. Cousins for the observations on which this conclusion was based. We are grateful that these observations can now be discussed here together with the remaining material. The observations of the Cape Observatory are given in table 6. The fourth observation has not been used, as it is evidently in error. The observations have been plotted in figure 4. Phases were computed with the same formula as used for the other observations. The maximum of the light-curve has a phase close to .65, which is practically the same as for our own observations. It is interesting that Dr

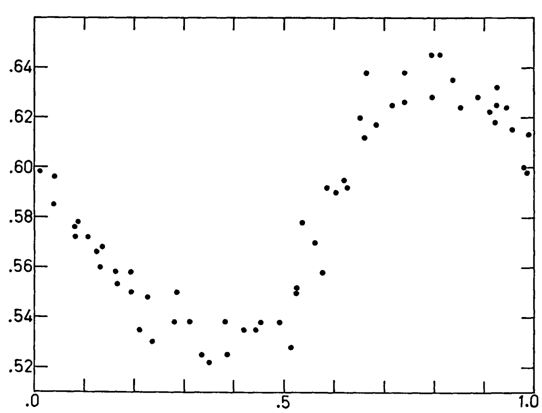

Figure 2

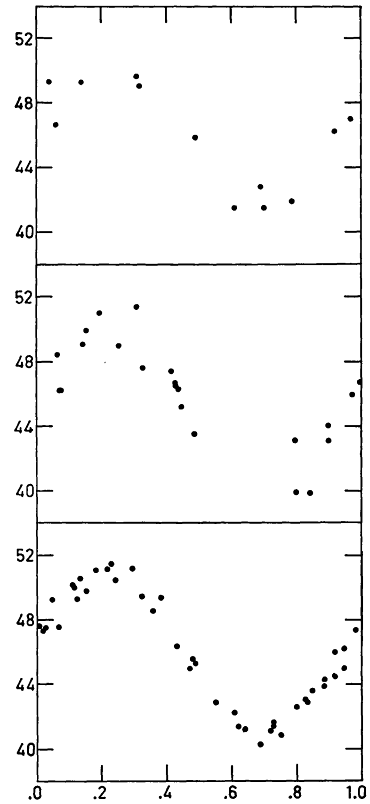

Figure 3

TABLE 6

Year	J. D. Hel. — 2430000	P_g	Phase
1946	1855.325	3.19:	0.449
1947	2294.304	3.15::	0.395
1948	2590.324	3.03	0.595
	2633.333	2.66:	0.880
	2634.367	3.19	0.220
	2635.346	3.19::	0.169
1949	2932.432	3.16:	0.935
	2933.416	3.16	0.920
	3015.289	3.16	0.068
	.332	3.13	0.373
	3018.250	3.19	0.086
	3022.265	3.05	0.585
	.307	3.14	0.883
1950	3331.350	3.06	0.522
	3338.319	3.18	0.989
	3339.319	3.18:	0.087
	3356.350	3.16:	0.976
	3358.345	3.18	0.137
	3361.337	3.18::	0.375
	3372.390	3.10	0.831
	3374.347	3.03:	0.722
	3385.271	3.19:	0.262

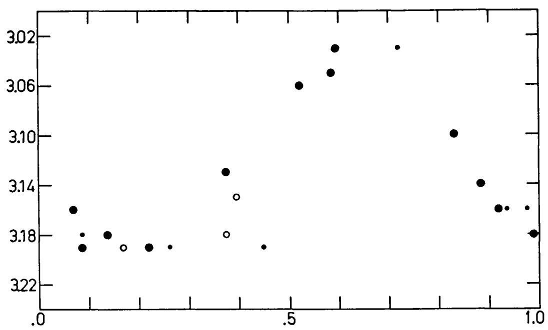

Figure 4

Cousins has given phases in his letter which were computed with the reciprocal period 7.098 167 6, which is practically identical with the value derived in our paper. Dr Cousins writes: "I do not remember where this value came from. I appear to have rejected 0.141 050 days as unsatisfactory, so the other may have been a trial period of my own".

We have computed sine curves through all the different sets of observations. The resulting formulae, the range and the phase of minimum radial velocity or maximum brightness have been collected in table 7. From this table it is seen that the only discordance is found in the phase of maximum of Eggen's observations.

The shift in phase between Eggen's observations and our own is about .19 period or 40 minutes.

During one night the author and Dr Th. Walraven made a long run of nearly four hours with the light-collector in which they observed a full period of ρ Pup and of AI Vel together with five bright B-type stars. The photometer, designed for five-colour photometry, has been described by TH. and J. WALRAVEN (1960). As AI Vel is more than three magnitudes fainter than ρ Pup, the photometer response was reduced for the measures of ρ Pup and of the bright comparison stars. For this attenuation constant we have adopted the value 2.92 magnitude. For the five colours we have used the following extinction coefficients:

		m
V	+	.234
B	+	.381
L	+	.550
U	+	.668
W	+	1.080

With the aid of these coefficients all measures were reduced to "no atmosphere". The atmospheric conditions must have been very stable during this night, because from the repeated measures of the comparison stars the mean error of one measurement was found to be:

		m
V	±	.0068
B		.0053
L		.0067
U		.0067
W		.0096

TABLE 7

Observ.	Formula	Range	Phase
radial velocities			
Lick	$V_r = +46.0 + 3.9 \sin 2\pi\varphi + 1.2 \cos 2\pi\varphi$	8.2	0.70
	$\pm\ 3 \quad 4 \quad 4$	8	2
Cape	$= +45.1 + 4.7 \sin 2\pi\varphi + .8 \cos 2\pi\varphi$	9.5	0.72
	$\pm\ 3 \quad 4 \quad .4$	8	14
Struve	$= +46.04 + 4.67 \sin 2\pi\varphi + 1.29 \cos 2\pi\varphi$	9.7	0.707
c.s.	$\pm\ 10 \quad 13 \quad 13$	3	4
magnitudes			
COUSINS	$m = +3.130 + 0.063 \sin 2\pi\varphi + 0.037 \cos 2\pi\varphi$	0.146	0.665
	$\pm\ 6 \quad 10 \quad 8$	18	22
EGGEN	$\Delta m = +0.5805 - 0.0469 \sin 2\pi\varphi + 0.0258 \cos 2\pi\varphi$	0.107	0.830
	$\pm\ 17 \quad 23 \quad 25$	5	8
PONSEN	$\Delta m = -1.0375 + 0.0475 \sin 2\pi\varphi + 0.0422 \cos 2\pi\varphi$	0.127	0.634
	$\pm\ 5 \quad 7 \quad 8$	2	3

TABLE 8

Star	Sp	J. D. Hel. −2430000	Phase	*V*	*B—V*	*U—B*	*W—U*	*L—B*
HD 67 797	B3			4.388	−0.896	+0.393	+0.601	+0.175
HD 70 930	B2			4.800	−0.884	+0.075	+0.522	+0.058
HD 74 575	B2			3.665	−0.904	+0.050	+0.517	+0.044
HD 104 337	B3			5.249	−0.937	+0.076	+0.522	+0.058
HD 122 980	B3			4.370	−0.943	+0.172	+0.521	+0.109
ρ Pup	F6	7415.2039	0.403	2.823	−0.330	+1.142	+1.064	+0.696
		.2171	0.497	2.795	−0.343	+1.142	+1.064	+0.690
		.2171	0.497	2.794	−0.343	+1.146	+1.060	+0.691
		.2296	0.585	2.780	−0.354	+1.149	+1.067	+0.687
		.2442	0.689	2.784	−0.349	+1.150	+1.067	+0.687
		.2573	0.782	2.803	−0.347	+1.147	+1.071	+0.690
		.2688	0.864	2.823	−0.337	+1.146	+1.072	+0.691
		.2900	0.014	2.862	−0.326	+1.144	+1.093	+0.701
		.3080	0.142	2.872	−0.320	+1.136	+1.089	+0.696
		.3108	0.162	2.875	−0.321	+1.139	+1.084	+0.696
		.3108	0.162	2.877	−0.323	+1.139	+1.086	+0.696
		.3261	0.270	2.866	−0.330	+1.139	+1.083	+0.686
		.3289	0.290	2.864	−0.336	+1.135	+1.077	+0.691
		.3462	0.413	2.820	−0.353	+1.130	+1.063	+0.671
		.3497	0.438	2.818	−0.356	+1.134	+1.066	+0.670
AI Vel	A2—F2	.2100	0.806	6.382	−0.527	+1.163	+0.959	+0.582
		.2236	0.928	6.528	−0.485	+1.117	+0.964	+0.583
		.2371	0.049	6.643	−0.453	+1.079	+0.989	+0.579
		.2510	0.174	6.743	−0.426	+1.055	+0.996	+0.576
		.2635	0.286	6.748	−0.438	+1.040	+0.998	+0.570
		.2757	0.395	6.559	−0.491	+1.059	+0.955	+0.574
		.2757	0.395	6.561	−0.490	+1.056	+0.954	+0.574
		.2840	0.469	6.399	−.0547	+1.132	+0.943	+0.581
		.2941	0.560	6.331	−0.570	+1.181	+0.947	+0.579
		.3020	0.631	6.373	−0.554	+1.175	+0.955	+0.578
		.3170	0.765	6.508	−0.516	+1.131	+0.955	+0.577
		.3198	0.790	6.537	−0.505	+1.121	+0.969	+0.577
		.3364	0.939	6.646	−0.472	+1.083	+0.991	+0.567
		.3399	0.970	6.632	−0.469	+1.080	+0.984	+0.568
HD 160461	A0			−2.172	−0.759	+1.183	+0.895	+0.464
V 703 Sco	F0	7069.4932	0.994	−1.754	−0.366	+0.990	+1.029	+0.545
		.4977	0.033	−1.757	−0.373	+0.987	+1.037	+0.567
		.5016	0.067	−1.774	−0.381	+0.984	+1.016	+0.537
		.5064	0.108	−1.815	−0.403	+0.989	+1.000	+0.536
		.5102	0.141	−1.859	−0.437	+0.989	+0.992	+0.527
		.5127	0.163	−1.912	−0.434	+0.989	+0.987	+0.533
		.5158	0.190	−1.935	−0.471	+1.002	+0.967	+0.538
		.5193	0.220	−1.976	−0.488	+1.015	+0.960	+0.530
		.5220	0.244	−2.010	−0.508	+1.029	+0.977	+0.534
		.5255	0.274	−2.066	−0.532	+1.049	+0.964	+0.528
		.5293	0.307	−2.139	−0.574	+1.081	+0.937	+0.531
		.5325	0.335	−2.181	−0.594	+1.102	+0.962	+0.535
		.5366	0.370	−2.186	−0.604	+1.119	+0.940	+0.530
		.5405	0.404	−2.169	−0.592	+1.126	+0.947	+0.531
		.5436	0.431	−2.143	−0.584	+1.118	+0.950	+0.529
		.5467	0.458	−2.109	−0.574	+1.110	+0.964	+0.525
		.5501	0.488	−2.075	−0.567	+1.121	+0.941	+0.533
		.5529	0.512	−2.068	−0.542	+1.101	+0.971	+0.535
		.5564	0.542	−2.036	−0.526	+1.091	+0.980	+0.534
		.5599	0.573	−2.010	−0.520	+1.079	+0.980	+0.531

TABLE 8 *(Continued)*

Star	Sp	J. D. Hel. −2430000	Phase	V	$B-V$	$U-B$	$W-U$	$L-B$
		7069.5630	0.600	−1.996	−0.508	+1.072	+0.968	+0.536
		.5658	0.624	−1.986	−0.496	+1.061	+0.987	+0.539
		.5689	0.651	−1.967	−0.491	+1.063	+0.980	+0.544
		.5724	0.681	−1.963	−0.474	+1.051	+0.978	+0.540
		.5752	0.705	−1.953	−0.465	+1.046	+0.988	+0.538
		.5779	0.729	−1.934	−0.466	+1.042	+0.988	+0.534
		.5814	0.759	−1.928	−0.454	+1.038	+0.971	+0.536
		.5845	0.786	−1.909	−0.441	+1.029	+0.975	+0.538
		.5870	0.808	−1.896	−0.432	+1.022	+0.994	+0.530
		.5904	0.837	−1.873	−0.421	+1.023	+1.007	+0.539
		.5939	0.868	−1.846	−0.421	+1.014	+1.011	+0.547
		.5967	0.892	−1.837	−0.406	+1.013	+1.017	+0.546
		.6002	0.922	−1.809	−0.397	+1.004	+1.026	+0.547
		.6036	0.952	−1.798	−0.383	+1.999	+1.004	+0.539
		.6074	0.985	−1.779	−0.376	+0.994	+1.024	+0.546

Therefore we have used the measurements of the two variables without any further reference to the comparison stars. The magnitude V and the four colour-indices $(B - V)$, $(U - B)$, $(W - U)$ and $(L - B)$ all expressed in magnitudes are given in table 8. The zero-point was adjusted in such a way that the V magnitude of HD 122980 has the same value as in the article by TH. and J. WALRAVEN (1960). These observations of ρ Pup and AI Vel will be discussed in a forthcoming article by Ponsen and Walraven in which a number of ultra-short-period variables will be intercompared. For the same purpose we have given in table 8 colours of V 703 Sco and its comparison star HD 160461, for observations during one cycle, which have been discussed in the preceding article on that variable, but now reduced to "no atmosphere" in exactly the same way as was applied for ρ Pup. The comparison star was only used to check the quality of the sky, which proved to be excellent. In this case however the zero-point of the magnitude V is arbitrary. The phases in table 8 were computed with the formula:

phase $= P^{-1}$ (J.D.hel. − 2 400 000), the reciprocal period being:

7.098 168 for ρ Pup
8.962 66 for AI Vel
8.679 32 for V 703 Sco

As the range of the light-curve of ρ Pup and of its radial-velocity curve are small, the ratio between them is rather uncertain. Using our value for the photometric range and Struve's value for the range in radial velocity, we find a ratio of 76 km/sec/magnitude, which fits in well with the values found for other RR Lyrae short-period variables studied by L. WOLTJER (1956).

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