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A PHOTOMETRIC STUDY OF V508 CYGNI

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A PHOTOMETRIC STUDY OF V508 CYGNI

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ABSTRACT

The Behlen observatory 0.76 m telescope CCD photometer has been used to obtain nearly 700 observations of the short period eclipsing binary V508 Cyg. These observations were done using V and R bandpass filters on 9 nights in 1992. Previously published light elements and the present eight determinations of eclipse timings are used to determine a new epoch and a more accurate orbital period of 0.7796587 days. The photometric observations and solutions which have been obtained with the 1993 version of the Wilson–Devinney model show that V508 Cyg is a W UMa type contact binary system. Analyses give two possible contact solutions of different mass ratios ($q=m_2/m_1$, where star 1 is eclipsed at the primary minimum). One with $q=0.44$ gives an A-type W UMa system configuration, while the other with $q=1.19$ gives a W-type W UMa system configuration. V508 Cyg does not have a spectral classification, however, based on the color ($V-R=0.566$ Schmidt 1991b), we estimate it to be G5. Generally W UMa systems with spectral-type G5 have periods ranging from 0.25 to 0.5 days. The considerably longer period of V508 Cyg suggests that it may be an evolved contact system with case B mass transfer. Both solutions indicate that the two components have similar temperature and luminosities. It is suspected that this system may be a double lined spectroscopic binary. Therefore it is recommended that spectroscopic observations of V508 Cyg be obtained so that a unique mass ratio can be established. © *1995 American Astronomical Society.*

1. INTRODUCTION

The Behlen Observatory variable star survey contains various light curves and associated parameters for poorly studied variable stars from the General Catalog of Variable Stars (G.C.V.S.) (Schmidt 1991b). The selection criteria were (i) stars fainter than the tenth magnitude and (ii) north of the equator stars which were classified as pulsating variables. Schmidt suggested reclassification of 26 stars, 6 of which seem to be eclipsing variables which were previously classified as RR Lyrae stars.

V508 Cyg is one of the new eclipsing variables. The General Catalog mentions only a couple of references on this system, (Hoffmeister 1949; M.V.S. 1957) which relate to its discovery and early finding charts. There seems to be no other existing literature on V508 Cyg. The shape of the light-curve and its short orbital period indicates that it is likely to be a contact system. Further evidence in support of this comes from the criteria for potential contact systems (Leung 1990). According to its location in a Period–Spectral-type diagram (Leung & Schneider 1978), and from our Fig. 1, V508 Cyg could be an evolved contact system. Therefore a detailed photometric study of this system may be of interest to the theory of binary evolution. Thus, we decided to obtain a full phase coverage light curve of this system and derive photometric solutions.

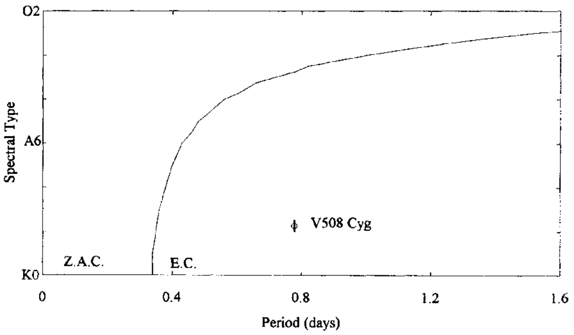

FIG. 1. Period vs spectral-type diagram. The theoretical zero-age contact periods are calculated for $q=1.0$ from the Z. A. M. S. mass–radius relation (Stotters 1972). The critical contact boundary divides the contact systems into zero-age contact systems (Z. A. C.) on the left and evolved contact systems (E. C.) on the right in the figure. The error in period is essentially zero, while the estimated error of ±1 subspectral type is shown as a vertical bar.

2. CCD PHOTOMETRY AND OBSERVATIONS

The observations on V508 Cyg were obtained with a liquid nitrogen cooled CCD photometer on the 0.76 m telescope at Behlen Observatory, University of Nebraska, on nine nights between 1992 July 28 and November 13. A total of 699 pairs of V- and R-band measurements were made to cover most of the light curve.

TABLE 1. Identification data for V508 Cyg.

Star	G.S.C No.	V	R	V-R	α(2000)	δ(2000)
V508 Cyg	3573:1794	11.99	11.43	0.566	20 34 05	+46 16 16
C1	3573:1541	12.39	11.56	0.794	20 33 57	+46 51 17
C2	3577:0181	11.81	11.52	0.300	20 34 15	+46 52 51

TABLE 2. Observational data for V508 Cyg.

H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R
834.6348	-.088	-.107	834.7861	.548	.504	835.6895	.030	-.003	835.8291	-.033	-.056	884.6738	.479	.464
.6377	-.084	-.097	.7891	.557	.526	.6924	.020	.008	.8311	-.021	-.048	.6758	.502	.471
.6416	-.070	-.092	.7930	.558	.529	.6943	.005	-.010	.8340	-.024	-.056	.6777	.510	.485
.6465	-.057	-.070	.7949	.552	.534	.6963	.010	-.006	.8369	-.021	-.038	.6807	.519	.493
.6494	-.040	-.054	.7979	.559	.530	.6992	.007	-.022	.8398	-.017	-.032	.6826	.521	.509
.6523	-.076	-.063	.7998	.553	.530	.7031	-.016	-.039	.8418	-.004	-.020	.6846	.533	.528
.6543	-.054	-.044	.8027	.548	.532	.7061	-.031	-.056	.8447	.039	-.005	.6885	.554	.536
.6572	-.058	-.049	.8047	.539	.521	.7090	-.033	-.047	.8467	.012	-.011	.6914	.549	.530
.6621	-.074	-.061	.8086	.527	.515	.7119	-.038	-.072	.8496	.028	-.005	.6934	.558	.541
.6660	-.063	-.063	.8115	.519	.497	.7139	-.042	-.076	.8535	.047	.016	.6973	.573	.552
.6689	-.036	-.052	.8145	.510	.488	.7168	-.053	-.065	.8564	.052	.033	.7002	.561	.532
.6729	-.045	-.038	.8164	.483	.479	.7188	-.061	-.081	.8594	.060	.045	.7021	.559	.541
.6758	-.047	-.044	.8193	.482	.452	.7227	-.068	-.075	.8623	.073	.044	.7051	.545	.539
.6777	-.034	-.017	.8223	.461	.449	.7256	-.080	-.087	.8662	.079	.058	.7109	.526	.509
.6807	-.006	-.010	.8271	.409	.403	.7285	-.078	-.090	.8691	.093	.080	.7129	.515	.496
.6846	-.007	-.003	.8301	.403	.388	.7314	-.087	-.103	.8711	.097	.089	.7158	.505	.492
.6865	-.027	-.003	.8359	.387	.377	.7344	-.083	-.096	.8730	.103	.093	.7295	.426	.404
.6895	-.033	.015	.8389	.370	.366	.7373	-.083	-.101	.8779	.122	.097	.7324	.416	.397
.6924	.025	.013	.8418	.355	.342	.7393	-.094	-.103	.8799	.138	.117	.7373	.373	.360
.6943	.025	.045	.8467	.300	.288	.7432	-.101	-.116	.8828	.156	.123	.7402	.373	.332
.6973	.050	.043	.8496	.285	.276	.7461	-.104	-.117	.8848	.161	.129	.7461	.326	.298
.6992	.044	.083	.8545	.252	.246	.7490	-.098	-.127	.8877	.171	.149	.7539	.291	.269
.7041	.037	.076	.8574	.253	.229	.7520	-.100	-.115	.8896	.178	.165	.7578	.268	.262
.7061	.036	.069	.8604	.229	.217	.7539	-.104	-.108	.8936	.205	.181	.7607	.251	.237
.7080	.076	.093	.8682	.200	.172	.7568	-.106	-.118	.8984	-.774	-.257	.7637	.237	.223
.7109	.098	.087	.8701	.179	.161	.7588	-.110	-.106	.9326	-.994	-.469	.7656	.221	.207
.7139	.103	.096	.8740	.158	.158	.7617	-.111	-.115	884.6133	.178	.142	.7686	.211	.193
.7158	.119	.122	.8770	.144	.141	.7666	-.112	-.104	.6162	.190	.159	.7705	.198	.176
.7246	.158	.158	.8828	.124	.120	.7695	-.108	-.126	.6182	.200	.170	.7754	.165	.160
.7275	.182	.176	.8867	.105	.089	.7715	-.106	-.119	.6201	.205	.180	.7793	.153	.139
.7314	.213	.195	.8906	.093	.079	.7744	-.106	-.111	.6230	.219	.187	.8271	-.006	-.030
.7334	.222	.204	.8965	.063	.069	.7773	-.105	-.112	.6250	.231	.200	.8291	-.027	-.039
.7363	.245	.245	.9004	.062	.050	.7803	-.104	-.113	.6270	.242	.216	.8320	-.030	-.052
.7393	.268	.255	.9033	.049	.041	.7832	-.095	-.104	.6299	.249	.219	.8340	-.039	-.064
.7412	.291	.278	.9053	.037	.035	.7852	-.100	-.108	.6318	.262	.228	.8379	-.045	-.069
.7451	.314	.286	.9082	.028	.022	.7881	-.097	-.114	.6338	.281	.253	.8408	-.057	-.063
.7480	.333	.305	.9131	.005	-.001	.7910	-.089	-.109	.6387	.291	.271	.8447	-.064	-.085
.7500	.341	.318	.9160	.002	-.012	.7930	-.097	-.108	.6406	.309	.278	.8477	-.069	-.092
.7529	.365	.341	.9189	-.009	-.014	.7949	-.097	-.106	.6426	.320	.293	.8535	-.071	-.095
.7559	.377	.351	.9219	-.009	-.021	.7979	-.083	-.094	.6455	.340	.305	.8555	-.082	-.112
.7588	.393	.369	.9258	-.019	-.034	.7998	-.082	-.096	.6475	.357	.311	.8584	-.087	-.112
.7617	.414	.399	.9287	-.027	-.031	.8027	-.078	-.085	.6504	.368	.343	.8613	-.082	-.103
.7646	.428	.391	.9316	-.033	-.040	.8057	-.076	-.075	.6523	.392	.348	887.6396	-.097	-.110
.7666	.446	.418	835.6680	.092	.071	.8086	-.068	-.063	.6553	.394	.368	.6416	-.098	-.100
.7686	.460	.427	.6729	.092	.067	.8105	-.066	-.075	.6572	.413	.375	.6445	-.089	-.088
.7715	.483	.448	.6748	.093	.059	.8125	-.060	-.068	.6602	.426	.398	.6465	-.096	-.097
.7734	.497	.464	.6777	.076	.061	.8193	-.059	-.084	.6641	.443	.420	.6484	-.092	-.090
.7773	.514	.479	.6807	.068	.040	.8213	-.049	-.070	.6660	.455	.420	.6514	-.097	-.098
.7803	.524	.497	.6826	.050	.048	.8242	-.047	-.059	.6689	.458	.433	.6533	-.092	-.078
.7832	.532	.495	.6855	.049	.033	.8262	-.038	-.054	.6709	.474	.451	.6553	-.076	-.078
887.6582	-.068	-.080	887.8037	.551	.507	888.6543	.258	.261	889.5996	-.092	-.097	889.7314	.443	.431
.6611	-.066	-.078	.8057	.539	.527	.6592	.229	.214	.6025	-.082	-.092	.7344	.456	.446
.6631	-.058	-.073	.8096	.548	.527	.6621	.228	.197	.6045	-.073	-.089	.7373	.487	.459
.6650	-.066	-.064	.8125	.576	.533	.6689	.200	.182	.6074	-.076	-.073	.7393	.494	.464
.6680	-.052	-.076	.8145	.550	.547	.6709	.177	.161	.6094	-.062	-.094	.7441	.503	.479
.6699	-.050	-.059	.8174	.557	.535	.6738	.154	.151	.6123	-.063	-.087	.7461	.516	.486
.6719	-.045	-.054	.8223	.537	.534	.6758	.161	.152	.6152	-.067	-.083	.7480	.523	.498
.6748	-.041	-.060	.8242	.563	.516	.6787	.138	.125	.6172	-.057	-.069	.7510	.536	.514
.6768	-.042	-.061	.8271	.536	.520	.7363	-.051	-.063	.6211	-.059	-.074	.7529	.538	.516
.6797	-.024	-.051	.8291	.523	.495	.7393	-.055	-.059	.6240	-.057	-.058	.7559	.557	.526
.6816	-.017	-.031	.8340	.507	.479	.7412	-.056	-.076	.6260	-.038	-.051	.7607	.565	.552
.6875	-.004	-.015	.8359	.497	.486	.7432	-.069	-.081	.6289	-.039	-.042	.7637	.568	.546
.6904	.006	-.004	.8389	.479	.440	.7471	-.074	-.082	.6309	-.029	-.039	.7666	.569	.539
.6924	.014	-.001	.8457	.426	.418	.7510	-.068	-.090	.6338	-.020	-.036	.7695	.557	.551

TABLE 2. (continued)

H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R
.6963	.031	.005	.8477	.400	.399	.7529	-.086	-.099	.6367	-.018	-.023	.7734	.542	.531
.6992	.046	.025	.8506	.393	.398	.7568	-.072	-.083	.6387	-.003	-.015	.7754	.543	.523
.7021	.053	.027	.8535	.376	.378	.7598	-.079	-.090	.6416	.002	-.009	.7783	.535	.503
.7041	.059	.025	.8574	.368	.362	.7617	-.101	-.106	.6436	.016	-.003	.7803	.527	.508
.7070	.065	.049	.8613	.349	.343	.7646	-.081	-.106	.6465	.024	-.005	.7832	.512	.484
.7090	.075	.047	.8643	.326	.307	.7686	-.082	-.092	.6484	.026	.011	.7871	.472	.474
.7119	.082	.042	.8682	.282	.285	.7705	-.080	-.080	.6514	.029	.021	.7900	.470	.469
.7158	.078	.066	.8701	.283	.270	.7734	-.087	-.080	.6533	.036	.032	.7930	.460	.434
.7188	.090	.093	.8730	.288	.262	.7754	-.103	-.106	.6563	.045	.042	.7949	.422	.417
.7246	.117	.122	888.5742	.548	.494	.7783	-.103	-.098	.6582	.058	.043	.7969	.413	.400
.7266	.139	.130	.5771	.557	.493	.7803	-.102	-.104	.6611	.069	.067	.7998	.401	.389
.7295	.160	.142	.5791	.557	.530	.7871	-.092	-.099	.6631	.077	.061	.8037	.374	.366
.7324	.186	.144	.5820	.570	.528	.7910	-.098	-.102	.6660	.082	.083	.8066	.358	.356
.7373	.174	.153	.5869	.575	.500	.7930	-.096	-.104	.6689	.096	.090	.8096	.340	.337
.7393	.188	.165	.5898	.580	.525	.7959	-.106	-.097	.6709	.101	.095	.8115	.322	.323
.7422	.204	.179	.5918	.554	.536	.7998	-.100	-.100	.6738	.114	.100	.8145	.321	.303
.7441	.220	.193	.5947	.578	.538	.8018	-.102	-.101	.6758	.122	.120	.8164	.285	.292
.7480	.240	.226	.5967	.575	.538	.8057	-.102	-.106	.6787	.132	.127	.8203	.273	.265
.7510	.260	.216	.5986	.579	.528	.8096	-.100	-.119	.6807	.155	.144	.8232	.256	.252
.7539	.276	.237	.6016	.557	.543	.8125	-.090	-.107	.6836	.165	.151	.8262	.244	.230
.7568	.283	.266	.6055	.546	.508	.8154	-.104	-.104	.6855	.159	.155	.8291	.232	.226
.7588	.314	.278	.6084	.541	.498	.8174	-.095	-.116	.6885	.181	.176	.8330	.227	.198
.7617	.297	.286	.6104	.526	.499	.8203	-.106	-.112	.6904	.179	.179	.8350	.208	.209
.7666	.354	.324	.6133	.498	.489	.8242	-.078	-.089	.6934	.202	.186	.8369	.213	.179
.7695	.366	.354	.6162	.484	.467	.8271	-.081	-.089	.6953	.219	.204	898.5967	-.013	-.030
.7715	.371	.355	.6191	.481	.462	.8301	-.068	-.092	.7021	.263	.229	.5996	-.006	-.021
.7773	.408	.388	.6211	.476	.446	.8330	-.070	-.078	.7051	.277	.249	.6016	.020	-.008
.7813	.426	.416	.6240	.449	.430	889.5752	-.101	-.133	.7070	.295	.269	.6055	.021	.003
.7832	.454	.428	.6270	.442	.408	.5781	-.113	-.118	.7100	.305	.272	.6074	.024	.010
.7852	.455	.439	.6299	.429	.401	.5801	-.110	-.125	.7119	.312	.299	.6094	.040	.022
.7881	.480	.469	.6318	.402	.392	.5830	-.099	-.130	.7148	.339	.307	.6123	.054	.025
.7900	.490	.460	.6348	.383	.381	.5859	-.095	-.121	.7168	.349	.321	.6143	.056	.026
.7939	.493	.467	.6367	.378	.371	.5898	-.092	-.126	.7197	.371	.332	.6172	.057	.041
.7959	.518	.488	.6426	.335	.322	.5928	-.084	-.110	.7236	.401	.377	.6191	.064	.047
.7988	.517	.486	.6455	.308	.285	.5947	-.095	-.111	.7266	.420	.395	.6211	.071	.072
.8008	.533	.512	.6514	.268	.252	.5977	-.096	-.111	.7295	.446	.406	.6250	.079	.057
898.6279	.085	.069	898.7305	.582	.559	916.6143	.331	.292	916.7275	.235	.192	939.6357	.481	.436
.6299	.088	.078	.7324	.576	.566	.6182	.353	.332	.7305	.219	.174	.6387	.505	.465
.6318	.098	.090	.7354	.576	.559	.6201	.374	.349	.7324	.206	.164	.6406	.516	.474
.6338	.113	.102	.7393	.563	.547	.6230	.408	.365	.7363	.186	.146	.6436	.526	.479
.6367	.117	.100	.7441	.536	.526	.6260	.415	.398	.7393	.189	.166	.6455	.532	.505
.6387	.121	.109	.7471	.531	.532	.6289	.425	.413	.7412	.166	.141	.6484	.543	.506
.6406	.143	.116	.7490	.502	.514	.6309	.431	.408	.7432	.163	.123	.6504	.548	.505
.6426	.149	.125	.7520	.516	.491	.6348	.470	.427	.7461	.148	.119	.6533	.550	.521
.6455	.151	.130	.7539	.499	.472	.6367	.476	.444	.7480	.139	.087	.6553	.554	.514
.6494	.168	.142	.7568	.468	.461	.6396	.482	.457	.7529	.115	.076	.6582	.540	.513
.6523	.191	.163	.7588	.462	.445	.6416	.499	.486	.7559	.107	.061	.6611	.552	.538
.6543	.190	.177	.7637	.424	.411	.6445	.510	.473	.7578	.097	.050	.6641	.567	.528
.6572	.209	.206	.7656	.401	.410	.6484	.552	.513	.7607	.087	.061	.6660	.573	.519
.6592	.221	.209	.7695	.390	.365	.6514	.551	.524	939.5625	.090	.039	.6680	.569	.528
.6621	.245	.211	.7725	.368	.344	.6533	.544	.513	.5645	.090	.045	.6709	.555	.514
.6641	.262	.222	.7754	.353	.326	.6572	.550	.538	.5664	.096	.054	.6729	.523	.525
.6660	.259	.233	.7783	.325	.311	.6621	.554	.510	.5703	.117	.072	.6758	.526	.490
.6689	.270	.252	.7813	.328	.295	.6670	.556	.514	.5732	.139	.087	.6787	.513	.483
.6709	.279	.267	.7832	.297	.288	.6709	.543	.513	.5762	.146	.099	.6816	.502	.472
.6729	.301	.270	.7871	.275	.248	.6738	.538	.504	.5781	.150	.125	.6836	.476	.461
.6758	.306	.293	.7891	.258	.245	.6758	.527	.504	.5820	.180	.141	.6855	.466	.447
.6797	.326	.299	.7920	.252	.220	.6777	.507	.477	.5840	.177	.149	.6885	.439	.426
.6836	.351	.324	.7939	.232	.207	.6807	.513	.498	.5869	.201	.155	.6904	.462	.417
.6855	.365	.337	.7959	.205	.205	.6836	.493	.486	.5889	.208	.167	.6943	.405	.408
.6885	.382	.360	916.5762	.127	.085	.6855	.487	.472	.5908	.212	.179	.6973	.411	.377
.6904	.387	.356	.5781	.146	.096	.6875	.467	.439	.5947	.249	.202	.7002	.375	.359
.6924	.402	.367	.5811	.168	.104	.6904	.462	.443	.5977	.267	.242	.7031	.366	.326
.6963	.417	.407	.5830	.173	.124	.6924	.438	.412	.6016	.299	.238	.7061	.363	.308

TABLE 2. (continued)

H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R	H.J.D	Δ V	Δ R
.6992	.446	.415	.5850	.182	.125	.6953	.421	.396	.6045	.302	.267	.7080	.320	.294
.7012	.453	.439	.5869	.204	.126	.6973	.404	.383	.6064	.321	.269	.7109	.326	.295
.7031	.476	.434	.5908	.208	.175	.7002	.399	.366	.6094	.314	.277	.7139	.304	.272
.7061	.474	.446	.5938	.216	.176	.7031	.380	.366	.6123	.329	.285	.7158	.311	.234
.7080	.486	.471	.5967	.229	.197	.7051	.361	.350	.6152	.344	.316	.7188	.276	.253
.7109	.521	.477	.5986	.248	.191	.7080	.356	.323	.6172	.365	.328	.7207	.257	.225
.7139	.547	.537	.6006	.257	.226	.7100	.330	.312	.6201	.385	.344	.7227	.238	.200
.7168	.535	.524	.6025	.280	.244	.7119	.323	.306	.6221	.391	.357	.7256	.250	.219
.7188	.571	.519	.6055	.274	.247	.7148	.288	.282	.6270	.420	.371	.7275	.236	.177
.7207	.549	.547	.6074	.290	.261	.7178	.297	.253	.6289	.434	.388	.7305	.211	.189
.7236	.563	.552	.6094	.316	.276	.7207	.282	.268	.6309	.447	.408	.7324	.198	.191
.7266	.569	.544	.6123	.325	.301	.7236	.261	.246	.6338	.463	.413			

[a] Heliocentric Junlian date is 2,448,000+H.J.D

The CCD photometric system and observational techniques have been described previously (Schmidt 1988, 1991a; Schmidt *et al.* 1990). The extraction of differential magnitudes using the existing software on the Micro Vax II necessitated only minor changes in the observing scheme from that employed by Schmidt for his variable star survey.

For differential magnitudes we have used the same comparison stars as Schmidt (1991b). Since these comparison stars are within a few arcmin of the variable, accurate differential magnitudes can be derived even under inferior photometric conditions. Table 1 lists the Guide Star catalog identification numbers and coordinates for V508 Cyg and the comparison stars. The mean magnitude and color of the variable and the adopted magnitudes and colors of the comparison stars are also given (Schmidt 1993). A finder chart is published elsewhere (Schmidt & Reiswig 1993).

The extinction coefficients were obtained using one of the comparison stars as the extinction star. Average color terms from the past few years were adopted. The probable errors in V and R for the comparison stars are 15 and 29 millimagnitudes, respectively. Table 2 lists the heliocentric Julian Dates and differential V and R magnitudes for V508 Cyg (with respect to the mean of the comparison stars). Our observations show that V508 Cyg is a W UMa-type system with a continuously changing brightness and no indication of total eclipse in either the primary or the secondary minimum.

2.1 Period

Schmidt's (1993) light curve for V508 Cyg is based on 19 observations each in V and R. From it, he derived the following light elements:

$$\text{Minimum(I)}=\text{H.J.D. } 2447774.85+0^{\mathrm{d}}.77969(\pm 2)E. \tag{1}$$

Using the method of Kwee & Van Woerden (1956), we have determined eight times of minimum from our data in each filter band. The times of minimum, their probable errors, and weights are collected in Table 3. We utilized Schmidt's epoch [Eq. (1)] in our calculation of the new light elements. The method of generalized least squares was applied to the times of these minimum (Table 3), to obtain the following light elements for V508 Cyg:

$$\text{Minimum(I)}=\text{H.J.D. } 2448888.5923(\pm 3) + 0^{\mathrm{d}}.7796587(\pm 7)E. \tag{2}$$

Equation (2) shows that the new period differs from that in Eq. (1) by 0.00003 (≃2.6 s) days. The differences between the observed and the computed times of minima (O–C) are listed in Table 3. Figure 2 shows the plot of (O–C) vs E (cycles) for V508 Cyg. The results do not give any evidence of a change in period, keeping in mind that the one point

TABLE 3. Times of minima for V508 Cyg.

	V(5500Å)					R(7000Å)			
H.J.D.	P.E.	Wt.	E	O-C	H.J.D.	P.E.	Wt.	E	O-C
7774.8500*	···	06	-1428.5	0.0002					
8834.7945	0.00053	07	-0069.0	-0.0013	8834.7946	0.00033	08	-0069.0	-0.0012
8884.6923	0.00040	08	-0005.0	-0.0017	8884.6924	0.00037	08	-0005.0	-0.0016
8887.8134	0.00055	07	-0001.0	0.0008	8887.8140	0.00097	04	-0001.0	0.0014
8888.5912	0.00068	06	0000.0	-0.0011	8888.5999	0.00158	01	0000.0	0.0076
8889.7624	0.00011	10	0001.5	0.0007	8889.7633	0.00127	02	0001.5	0.0016
8898.7279	0.00065	06	0013.0	0.0001	8898.7281	0.00055	07	0013.0	0.0003
8916.6618	0.00036	08	0036.0	0.0018	8916.6622	0.00048	07	0036.0	0.0022
8939.6589	0.00074	06	0065.5	-0.0010	8939.6591	0.00049	07	0065.5	-0.0008

*Adopted from the epoch of the Schmidts (1993) light elements.

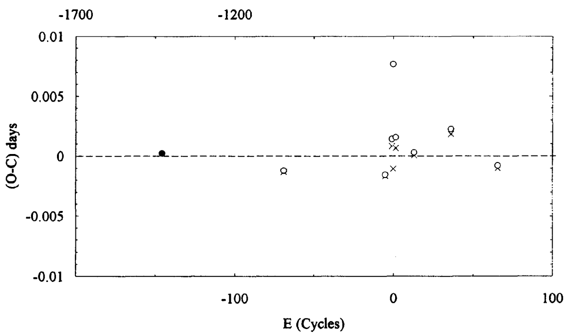

FIG. 2. (O–C) vs elapsed cycles. The filled circle (cycles on the top axis) represents Schmidt's observation. The open circles represent our *V* observations, while the crosses represent the *R* observations (cycles are on the bottom axis).

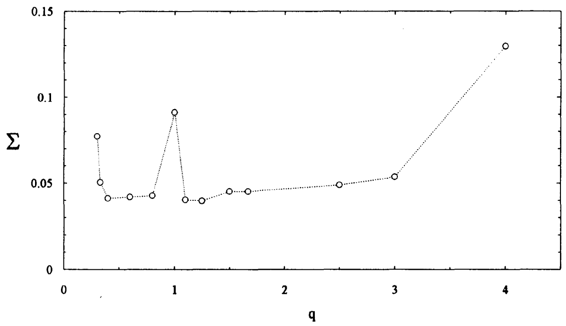

FIG. 3. Sum of the residuals vs mass ratio for V508 Cyg. Each open circle represents a solution.

which has the high (O–C) is the one with a large probable error (see Table 3).

2.2 *Photometric Analysis*

The latest 1993 version of the Wilson–Devinney program (W–D) (first described by Wilson & Devinney 1971) was used for our photometric analysis. About 80 normal points were formed for each light curve with weights proportional to the number of points used to form each normal point. After making rough estimates of the photometric parameters with the lightcurve program, the analysis was started with the W–D differential correction program. Both *V* and *R* light curves were employed simultaneously in deriving the solutions. In the W–D notation, star 1 is eclipsed at the primary minimum. The analysis started with a detached binary configuration (mode 2 in the W–D code). The temperature (T_1) of the hotter star was obtained from the color of the system assuming no reddening (see Table 1), and the program was allowed to adjust the following parameters: inclination (i) of the orbit, temperature (T_2) of the cooler star, nondimensional gravity potentials (Ω_1 and Ω_2) of two stars, mass ratio ($q=m_2/m_1$) of the system, and luminosity ($L_{V,1}$ and $L_{R,1}$) of the hotter star (that of the cooler star is computed by assuming blackbody atmosphere). The values for the limb darkening coefficients (x_1 and x_2) were interpolated from the tables of Al-Naimy (1978). Albedos (A_1 and A_2) and gravity darkening coefficients (g_1 and g_2) for convective atmospheres were assumed.

TABLE 4. Photometric solutions for V508 Cyg.

Parameter	First Solution	Second Solution
$q(m_2/m_1)$	0.4431 ± 0.0043	1.1915 ± 0.0037
$L_1/(L_1+L_2)(5500Å)$	0.6436 ± 0.0039	0.4704 ± 0.0040
$L_1/(L_1+L_2)(7000Å)$	0.6470 ± 0.0037	0.4689 ± 0.0037
i	78°.30 ± 0.14	76°.29 ± 0.09
$\Omega_1 = \Omega_2$	2.5771 ± 0.0079	3.7445 ± 0.0041
$\Omega(in)$**	2.7646	4.0528
$\Omega(out)$**	2.4968	3.4940
f(% of overflow)	70.01%	55.17%
$A_1 = A_2$*	0.50	0.50
$x_1 = x_2$*	0.60	0.60
$g_1 = g_2$*	0.30	0.30
r_1(pole)	0.4599 ± 0.0008	0.3801 ± 0.0006
r_1(side)	0.4999 ± 0.0011	0.4066 ± 0.0008
r_1(back)	0.5452 ± 0.0012	0.4685 ± 0.0018
r_2(pole)	0.3286 ± 0.0039	0.4088 ± 0.0008
r_2(side)	0.3499 ± 0.0051	0.4391 ± 0.0011
r_2(back)	0.4257 ± 0.0148	0.4947 ± 0.0020
$T_1K°$	5600*	5600*
$T_2K°$	5688 ± 7	5565 ± 6

* Assumed ** Theorectical values

After many runs the system converged toward a contact configuration (mode 3). This was tested by starting the solution as a semidetached configuration (mode 4 in the W–D code) and again the solution converged toward a contact configuration. Having established a contact configuration for the system, we proceeded with the mode 3 configuration for all further solutions. The next step was to find a global value of the mass ratio from a "q" search procedure. In this search,13 localized solutions were obtained for discrete fixed values of the mass ratio. The results are displayed in Fig. 3.

As one can see from the Fig. 3 there are unfortunately two sets of photometric parameters which give essentially the same good fit to the observations: One with a mass ratio of 0.40 and the other with a value of 1.15. The former solution gives us an A-type contact system (primary eclipse occurs at transit), while the latter solution gives us a W-type contact system (primary eclipse occurs at occultation). The next step in the analysis was to investigate solutions around the mass ratios of 0.40 and 1.15, which have the smallest sum of the residuals shown in Fig. 3. However, this time we allowed the mass ratio to be a free parameter. Thus two sets of photometric parameters were found for mass ratios of 0.443 and 1.192 (see Table 4). As a final step in the analysis, the values of limb darkening, albedo, and gravity darkening were treated as free parameters to see if adjusting them would improve the two solutions. All trials did not show any convergence or an improvement in the sum of residuals over what we had obtained earlier by keeping the values fixed. Thus, the two sets of solutions with mass ratio of 0.443 and 1.192 were adopted as the photometric solutions for V508 Cyg.

The computed light curves are shown as continuous curves in Figs. 4 and 5 for the final two solutions while Table

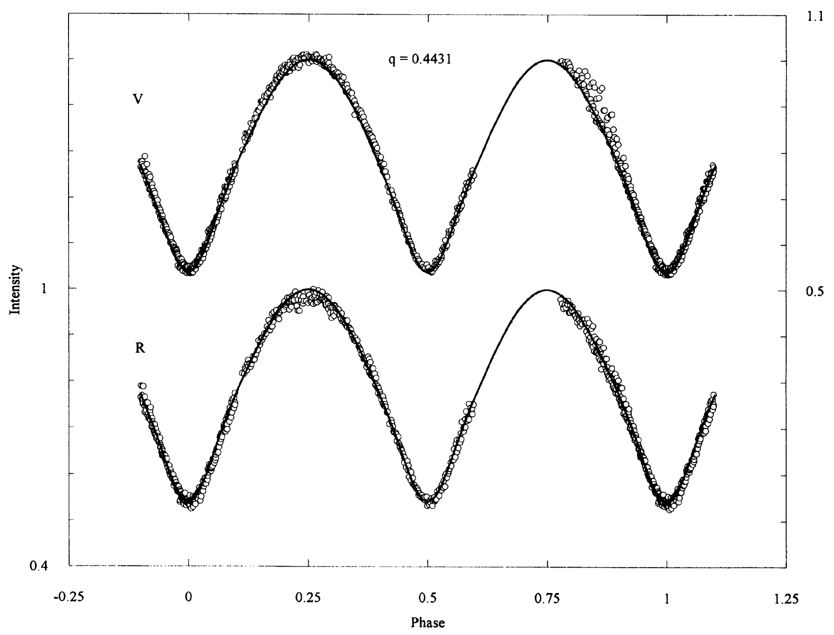

FIG. 4. Observed and computed light curves for V508 Cyg, q=0.4431. The circles show individual observations while the continuous curve is the computed curve.

4 describes them. For both solutions the agreement between the theoretical and observed light curve is good. In both of the solutions the temperature difference between the components is less than 100 K. This determination of differences in temperature in eclipsing systems is very reliable since these are directly related to eclipse depths. The primary minimum is only slightly deeper than the secondary by about $0.^{\rm m}009$ for V bandpass and $0.^{\rm m}014$ for R bandpass. Such small differences demonstrate that the components are of similar color (see Table 1). Assuming no reddening, both compo-

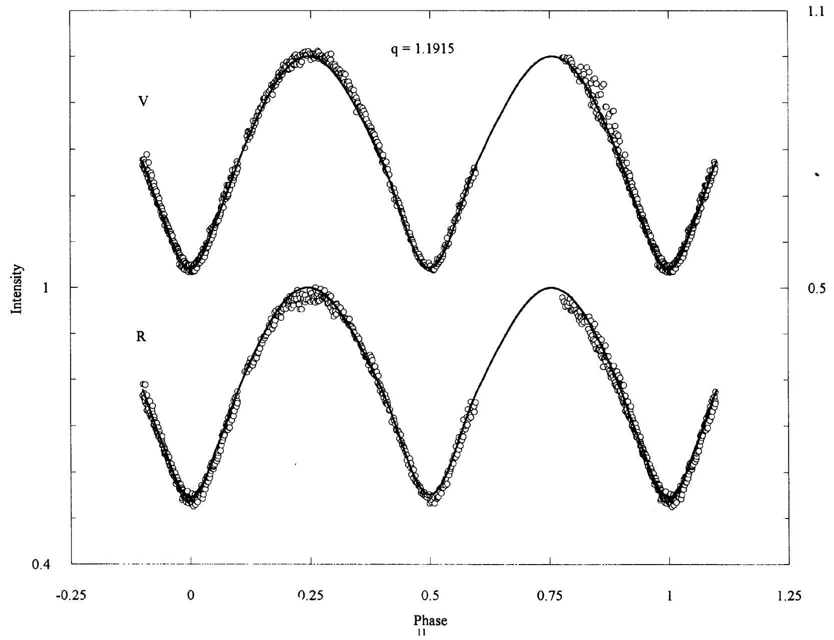

FIG. 5. Observed and computed light curves for V508 Cyg, q=1.1915. The circles show individual observations while the continuous curve is the computed curve.

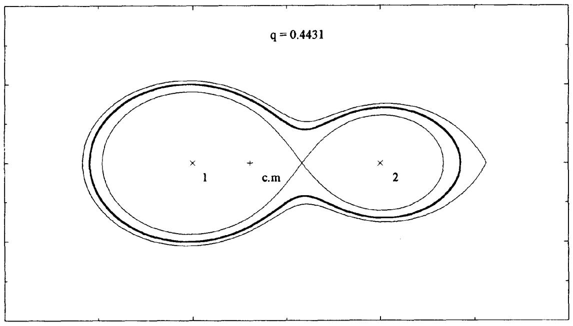

FIG. 6. Binary configuration for V508 Cyg as an A-type W UMa system with $q=0.4431$.

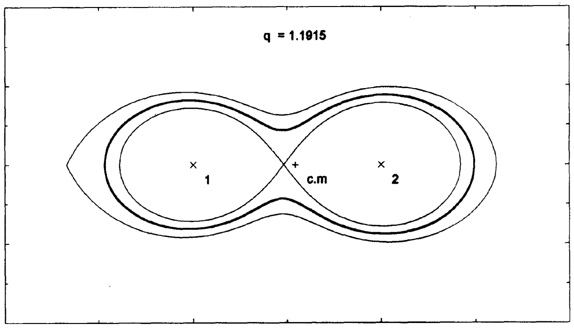

FIG. 7. Binary configuration for V508 Cyg as a B-type W UMa system with $q=1.1915$.

nents have a spectral type of about G5. The orbital inclinations found for both the solutions are small ($i \simeq 76^\circ$) which makes it more difficult to determine the values of limb darkening, albedo, and gravity darkening. However, as can be seen, the solution at $q \simeq 1.19$ has a shallower contact ($f=55\%$) than at $q=0.44$, where the contact is $f=70\%$. Table 4 also shows that for both the solutions the two stars have similar luminosities, suggesting that V508 Cyg should be a doubled lined spectroscopic binary. Solution 1 in Table 4 suggests that the temperature of the secondary may be slightly higher, however, the difference in eclipse minimum from the computed curve is within the observational scatter of the observed data. The configurations are shown in Figs. 6 and 7. It is believed that spectroscopic study of this system will settle the uniqueness of mass ratio and yield more information on the system.

3. DISCUSSION

We believe that evolved contact systems start out from a detached configuration and evolve into a semidetached system and in some cases eventually become contact due to evolution of the massive component (see for example, de Loore & Doom 1992; Guinan & Giménez 1993). For relatively close systems, the mass transfer phase takes place during the core H-burning phase; such systems are referred to as case A-type mass transfer (Kippenhahn & Weigert 1967; Plavec 1968; Paczyński 1971). Most of the evolved contact systems discovered so far are case A-type systems. It is believed that this is the result of observational selection effect (short period systems are often selected for observation). These systems should lie relatively close to the main sequence in an H–R diagram. With respect to the period–spectral-type diagram, they will be found in the evolved contact domain and relatively close to the zero-age critical contact boundary (e.g., Fig. 1). On the other hand, for wider binaries the mass transfer phase takes place during the shell H-burning phase of stellar evolution. Such pairs are called case B mass transfer systems. Since these systems are derived from wider pairs, their periods would be longer. Thus, these systems will be located relatively farther away from the zero-age critical contact boundary in the period-spectral-type diagram as shown in Fig. 1 for the case of V508 Cyg. For this reason we believe that this system may be a evolved contact under case B mass transfer.

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