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UBVRI Photometric Analysis of the Solar-Type Eclipsing Binary TYC 3034-299-1

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Research Article

UBVRI Photometric Analysis of the Solar-Type Eclipsing Binary TYC 3034-299-1

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TYC 3034-0299-1 (CV_n) is a magnetically active, contact binary, ROTSE variable. UBVR$_c$I$_c$ light curves are presented along with a period study and a simultaneous UBVRI light curve solution. Our light curves show eclipse amplitudes of 0.72 and 0.62 mags (V) in the primary and secondary eclipses. Modeled results include a dark spot region, found at longitude 51°, a 24% Roche lobe fill-out, and a mass ratio of 0.48. A total eclipse is found to occur in the secondary eclipse making TYC 3034-0299-1 a W-type (less massive star is hotter) W UMa variable.

1. History

TYC 3034-299-1 [$\alpha(2000) = 14\,\text{h}\,05\,\text{m}\,09.043\,\text{s}$, $\delta(2000) = +38°54'19.26''$] was discovered by ROTSE I [1]. It was reported in IBVS no. 5699 [2]. Observations were taken by Diethelm [3]. He gives the following ephemeris:

$$\text{HJD } T_{\min}\text{ I} = 2453382.6919 + 0.395010\ d * E. \quad (1)$$

TYC 3034-299-1 was listed in the catalog of 1022 bright contact binary stars by Geske et al. [4] lists a period of 0.395013 d, $V_{\max} = 11.462$ V mag, and amplitude = 0.585 V mag. In addition, two times of minimum light were determined by BBSAG observers given in IBVS no. 5781 [3]. Also, two eclipse timings were recently observed by Nelson [5, 6].

2. Finding Chart

Our comparison star (C) was GSC 3034 0404 [$\alpha(2000) = 14\,\text{h}\,05\,\text{m}\,21.4758\,\text{s}$, $\delta(2000) = +38°48'35.436''$]. The check star ($K$) was GSC 3034 0497 [$\alpha(2000) = 14\,\text{h}\,05\,\text{m}\,13.8544\,\text{s}$, $\delta(2000) = +38°57'24.156''$]. We include a finding chart of these stars including the variable (V) in Figure 1.

3. Observations

This system was observed as a part of our student/professional collaborative studies of interacting binaries from data taken from the national undergraduate research observatory (NURO). The observations were taken by RGS and NB. Reduction and analyses were jointly completed by RGS and AJ. The present 2010 UBVRI light curves were taken with the Lowell 0.81-m reflector in Flagstaff on May 10 and May 11 with CRYOTIGER cooled (−100°C) 2048X2048 NASACAM and standard UBVRI Besell filters. The individual observations included 216 in the U-filter, 230 in B, 232 in V, 243 in R, and 239 in I. The standard error of a single observation was 1% in U, V, and R and I an 1.2% in B (Table 1).

4. Period Determination

The following timings of minimum light were calculated using parabola fits from our present observations (PO). They were determined in each of UBVRI and averaged. They include (with standard errors) HJD I = 2455326.72754 ± 0.00024, 2455327.713303 ± 0.00025; HJD

Table 1

UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+
0.347	26.6640	0.402	26.7897	0.729	26.9510	0.996	27.7258	0.312	27.8302
0.370	26.6662	0.391	26.7920	0.626	26.9555	0.959	27.7281	0.319	27.8325
0.380	26.6685	0.381	26.7960	0.459	26.9705	0.907	27.7304	0.325	27.8353
0.439	26.6796	0.381	26.7983	0.427	26.9764	0.858	27.7329	0.339	27.8376
0.459	26.6819	0.377	26.8006	0.398	26.9810	0.801	27.7353	0.337	27.8399
0.484	26.6842	0.377	26.8043	0.392	27.6281	0.753	27.7375	0.349	27.8423
0.526	26.6873	0.361	26.8066	0.385	27.6327	0.707	27.7401	0.358	27.8446
0.547	26.6896	0.364	26.8089	0.391	27.6363	0.668	27.7424	0.379	27.8469
0.573	26.6919	0.363	26.8123	0.397	27.6386	0.639	27.7447	0.378	27.8507
0.607	26.6945	0.354	26.8146	0.413	27.6408	0.590	27.7474	0.388	27.8530
0.641	26.6968	0.356	26.8169	0.428	27.6439	0.560	27.7497	0.401	27.8553
0.669	26.6991	0.342	26.8200	0.433	27.6462	0.543	27.7520	0.422	27.8587
0.755	26.7031	0.352	26.8246	0.445	27.6485	0.515	27.7546	0.431	27.8610
0.803	26.7054	0.345	26.8276	0.457	27.6512	0.491	27.7569	0.441	27.8633
0.834	26.7077	0.366	26.8299	0.473	27.6534	0.472	27.7592	0.466	27.8665
0.913	26.7112	0.342	26.8322	0.478	27.6558	0.458	27.7615	0.478	27.8688
0.923	26.7135	0.348	26.8354	0.499	27.6600	0.410	27.7638	0.508	27.8711
0.960	26.7158	0.369	26.8377	0.506	27.6623	0.417	27.7661	0.537	27.8743
0.993	26.7190	0.375	26.8400	0.51	27.6646	0.404	27.7685	0.554	27.8766
0.997	26.7213	0.377	26.8435	0.536	27.6689	0.400	27.7708	0.595	27.8789
1.004	26.7236	0.406	26.8458	0.572	27.6712	0.392	27.7731	0.653	27.8820
0.981	26.7268	0.416	26.8481	0.579	27.6735	0.380	27.7757	0.677	27.8843
1.007	26.7291	0.412	26.8514	0.609	27.6763	0.365	27.7780	0.728	27.8866
1.014	26.7314	0.412	26.8537	0.641	27.6786	0.343	27.7803	0.775	27.8890
0.980	26.7351	0.423	26.8560	0.674	27.6809	0.333	27.7851	0.802	27.8913
0.994	26.7374	0.461	26.8599	0.694	27.6840	0.334	27.7874	0.848	27.8936
0.966	26.7397	0.472	26.8623	0.741	27.6863	0.315	27.7898	0.905	27.8970
0.900	26.7439	0.456	26.8646	0.788	27.6886	0.323	27.7921	0.946	27.8993
0.859	26.7461	0.510	26.8677	0.815	27.6909	0.312	27.7944	0.975	27.9016
0.818	26.7484	0.557	26.8782	0.869	27.6933	0.309	27.7972	1.005	27.9047
0.720	26.7540	0.582	26.8805	0.898	27.6956	0.306	27.7995	0.992	27.9070
0.696	26.7562	0.600	26.8828	0.95	27.6979	0.292	27.8018	0.999	27.9093
0.654	26.7585	0.637	26.8864	0.997	27.7002	0.287	27.8044	1.004	27.9117
0.571	26.7629	0.674	26.8887	1.051	27.7025	0.282	27.8067	0.992	27.9140
0.534	26.7652	0.686	26.8910	1.099	27.7049	0.283	27.8090	1.007	27.9163
0.520	26.7675	0.740	26.8948	1.126	27.7072	0.285	27.8117	0.997	27.9188
0.495	26.7713	0.791	26.8971	1.138	27.7095	0.291	27.8140	1.007	27.9211
0.487	26.7736	0.815	26.8994	1.143	27.7119	0.288	27.8163	0.978	27.9234
0.453	26.7759	0.908	26.9031	1.14	27.7142	0.295	27.8186	0.952	27.9262
0.443	26.7792	0.968	26.9054	1.13	27.7165	0.291	27.8210	0.899	27.9285
0.426	26.7814	1.026	26.9100	1.103	27.7189	0.303	27.8233	0.868	27.9308
0.422	26.7837	1.073	26.9123	1.08	27.7212	0.297	27.8256	0.806	27.9336
0.410	26.7873	1.122	26.9146	1.061	27.7235	0.314	27.8279	0.78	27.9359
								0.733	27.9383
BDM	BHJD 2455300+	BDM	BHJD 2455300+	BDM	BHJD 2455300+	BDM	BHJD 2455300+	BDM	BHJD 2455300+
0.257	26.6557	0.332	26.7844	1.027	26.9185	0.761	27.7311	0.231	27.8360
0.262	26.6580	0.330	26.7880	0.937	26.9362	0.735	27.7336	0.245	27.8383
0.281	26.6603	0.320	26.7903	0.894	26.9385	0.689	27.7359	0.248	27.8406

Table 1: Continued.

UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+
0.288	26.6646	0.320	26.7926	0.623	26.9539	0.660	27.7382	0.26	27.8430
0.318	26.6669	0.311	26.7966	0.333	26.9770	0.625	27.7408	0.262	27.8453
0.309	26.6691	0.297	26.7989	0.294	27.6334	0.593	27.7431	0.28	27.8476
0.386	26.6802	0.297	26.8012	0.296	27.6370	0.555	27.7454	0.295	27.8514
0.391	26.6825	0.285	26.8049	0.305	27.6393	0.525	27.7481	0.321	27.8537
0.428	26.6848	0.278	26.8072	0.33	27.6416	0.483	27.7504	0.338	27.8560
0.446	26.6879	0.262	26.8095	0.336	27.6446	0.470	27.7527	0.331	27.8594
0.474	26.6902	0.265	26.8130	0.34	27.6469	0.425	27.7553	0.355	27.8617
0.507	26.6925	0.269	26.8153	0.345	27.6492	0.383	27.7576	0.385	27.8640
0.547	26.6952	0.269	26.8176	0.369	27.6519	0.374	27.7599	0.4	27.8672
0.567	26.6975	0.269	26.8206	0.367	27.6542	0.365	27.7622	0.436	27.8695
0.593	26.6997	0.274	26.8230	0.378	27.6564	0.333	27.7645	0.451	27.8718
0.669	26.7037	0.278	26.8253	0.405	27.6607	0.323	27.7668	0.485	27.8750
0.713	26.7060	0.269	26.8282	0.425	27.6630	0.321	27.7692	0.512	27.8773
0.743	26.7083	0.253	26.8305	0.429	27.6653	0.305	27.7715	0.543	27.8796
0.808	26.7119	0.255	26.8328	0.456	27.6696	0.278	27.7738	0.6	27.8827
0.832	26.7142	0.285	26.8360	0.491	27.6719	0.277	27.7764	0.634	27.8850
0.880	26.7165	0.276	26.8383	0.504	27.6742	0.267	27.7787	0.677	27.8873
0.887	26.7196	0.284	26.8441	0.539	27.6770	0.264	27.7810	0.711	27.8897
0.886	26.7219	0.320	26.8464	0.556	27.6793	0.250	27.7835	0.738	27.8920
0.896	26.7242	0.302	26.8487	0.597	27.6816	0.226	27.7858	0.779	27.8943
0.891	26.7275	0.320	26.8520	0.635	27.6847	0.226	27.7881	0.842	27.8977
0.900	26.7298	0.320	26.8543	0.646	27.6870	0.212	27.7905	0.894	27.9000
0.893	26.7320	0.331	26.8566	0.699	27.6893	0.215	27.7928	0.906	27.9023
0.892	26.7358	0.356	26.8606	0.735	27.6916	0.212	27.7951	0.94	27.9054
0.871	26.7381	0.384	26.8652	0.774	27.6939	0.195	27.7979	0.922	27.9077
0.844	26.7404	0.382	26.8683	0.817	27.6962	0.202	27.8002	0.928	27.9124
0.777	26.7445	0.462	26.8788	0.851	27.6986	0.194	27.8025	0.91	27.9147
0.732	26.7468	0.476	26.8811	0.894	27.7009	0.181	27.8051	0.922	27.9170
0.696	26.7491	0.499	26.8835	0.941	27.7032	0.180	27.8074	0.916	27.9195
0.617	26.7546	0.526	26.8870	0.989	27.7056	0.182	27.8097	0.898	27.9218
0.580	26.7569	0.542	26.8893	0.988	27.7079	0.181	27.8124	0.887	27.9241
0.559	26.7592	0.607	26.8916	0.993	27.7102	0.202	27.8147	0.838	27.9269
0.497	26.7635	0.610	26.8954	0.974	27.7126	0.197	27.8170	0.805	27.9292
0.461	26.7658	0.684	26.8977	1.003	27.7149	0.196	27.8194	0.74	27.9315
0.444	26.7681	0.716	26.9000	0.98	27.7172	0.205	27.8217	0.716	27.9343
0.412	26.7719	0.755	26.9037	0.996	27.7196	0.214	27.8240	0.674	27.9366
0.414	26.7742	0.875	26.9060	0.954	27.7219	0.214	27.8263	0.641	27.9390
0.378	26.7765	0.872	26.9083	0.918	27.7242	0.199	27.8286		
0.363	26.7798	0.887	26.9106	0.857	27.7265	0.216	27.8309		
0.355	26.7821	0.956	26.9129	0.826	27.7288	0.230	27.8332		
VDM 2455300+	VHJD	VDM	VHJD 2455300+	VDM	VHJD 2455300+	VDM	VHJD 2455300+	VDM	VHJD 2455300+
0.192	26.6461	0.283	26.7907	0.781	26.9366	0.897	27.7152	0.18	27.8220
0.227	26.6561	0.271	26.7930	0.803	26.9389	0.896	27.7175	0.185	27.8243
0.234	26.6584	0.268	26.7970	0.679	26.9449	0.888	27.7199	0.182	27.8266
0.249	26.6606	0.263	26.7993	0.53	26.9520	0.851	27.7222	0.194	27.8289
0.256	26.6650	0.249	26.8016	0.515	26.9543	0.823	27.7245	0.2	27.8312
0.266	26.6672	0.253	26.8053	0.402	26.9610	0.785	27.7268	0.213	27.8335

Table 1: Continued.

UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+
0.290	26.6695	0.252	26.8076	0.397	26.9633	0.735	27.7291	0.199	27.8363
0.347	26.6806	0.221	26.8099	0.328	26.9715	0.705	27.7314	0.223	27.8386
0.357	26.6829	0.239	26.8133	0.276	26.9820	0.655	27.7339	0.233	27.8409
0.372	26.6852	0.218	26.8156	0.252	26.9867	0.619	27.7362	0.24	27.8433
0.402	26.6883	0.211	26.8179	0.245	26.9890	0.585	27.7385	0.24	27.8456
0.434	26.6906	0.212	26.8210	0.231	27.6250	0.506	27.7414	0.247	27.8479
0.453	26.6929	0.226	26.8233	0.227	27.6291	0.516	27.7434	0.273	27.8517
0.490	26.6955	0.217	26.8256	0.247	27.6314	0.492	27.7457	0.293	27.8540
0.517	26.6978	0.212	26.8286	0.248	27.6337	0.452	27.7484	0.32	27.8563
0.554	26.7001	0.220	26.8309	0.258	27.6373	0.427	27.7507	0.327	27.8597
0.612	26.7041	0.229	26.8332	0.256	27.6396	0.399	27.7530	0.344	27.8620
0.662	26.7064	0.234	26.8364	0.276	27.6418	0.377	27.7556	0.354	27.8643
0.700	26.7087	0.234	26.8387	0.283	27.6449	0.349	27.7579	0.384	27.8675
0.754	26.7122	0.254	26.8445	0.289	27.6472	0.336	27.7602	0.411	27.8698
0.794	26.7146	0.244	26.8468	0.295	27.6495	0.317	27.7625	0.438	27.8721
0.816	26.7169	0.259	26.8491	0.316	27.6522	0.315	27.7648	0.465	27.8753
0.826	26.7200	0.276	26.8524	0.328	27.6545	0.284	27.7671	0.49	27.8776
0.830	26.7223	0.292	26.8547	0.333	27.6567	0.275	27.7695	0.531	27.8799
0.829	26.7246	0.284	26.8570	0.364	27.6610	0.265	27.7718	0.559	27.8830
0.834	26.7278	0.314	26.8609	0.36	27.6633	0.254	27.7741	0.622	27.8853
0.817	26.7301	0.317	26.8633	0.367	27.6656	0.233	27.7767	0.643	27.8876
0.835	26.7324	0.303	26.8656	0.407	27.6699	0.235	27.7790	0.685	27.8900
0.826	26.7361	0.319	26.8687	0.43	27.6722	0.228	27.7813	0.723	27.8923
0.823	26.7384	0.413	26.8792	0.409	27.6748	0.214	27.7838	0.788	27.8946
0.775	26.7407	0.395	26.8815	0.475	27.6773	0.208	27.7861	0.794	27.8980
0.711	26.7449	0.453	26.8838	0.488	27.6796	0.191	27.7884	0.823	27.9003
0.674	26.7472	0.452	26.8874	0.509	27.6819	0.198	27.7908	0.826	27.9027
0.646	26.7495	0.487	26.8897	0.565	27.6850	0.196	27.7931	0.853	27.9057
0.561	26.7550	0.535	26.8920	0.597	27.6873	0.187	27.7954	0.842	27.9080
0.528	26.7572	0.546	26.8958	0.616	27.6896	0.178	27.7982	0.844	27.9103
0.500	26.7596	0.667	26.9004	0.65	27.6919	0.179	27.7982	0.846	27.9127
0.437	26.7639	0.705	26.9041	0.696	27.6942	0.179	27.8005	0.868	27.9150
0.414	26.7662	0.746	26.9064	0.739	27.6965	0.180	27.8028	0.847	27.9173
0.403	26.7685	0.772	26.9086	0.78	27.6989	0.171	27.8054	0.844	27.9198
0.357	26.7723	0.829	26.9110	0.823	27.7012	0.169	27.8077	0.802	27.9221
0.335	26.7746	0.871	26.9133	0.855	27.7035	0.164	27.8100	0.721	27.9244
0.342	26.7769	0.871	26.9189	0.888	27.7059	0.176	27.8127	0.684	27.9295
0.313	26.7802	0.908	26.9212	0.882	27.7082	0.170	27.8150	0.643	27.9318
0.317	26.7824	0.875	26.9235	0.898	27.7105	0.186	27.8173	0.605	27.9346
0.289	26.7847	0.919	26.9260	0.914	27.7129	0.192	27.8197	0.58	27.9369
0.285	26.7883	0.870	26.9306						
RDM	RHJD 2455300+	RDM	RHJD 2455300+	RDM	RHJD 2455300+	RDM	RHJD 2455300+	RDM	RHJD 2455300+
0.195	26.6564	0.229	26.7973	0.454	26.9523	0.835	27.7108	0.155	27.8269
0.209	26.6587	0.219	26.7996	0.44	26.9568	0.839	27.7132	0.167	27.8292
0.216	26.6609	0.230	26.8019	0.365	26.9636	0.832	27.7155	0.177	27.8315
0.239	26.6652	0.197	26.8056	0.278	26.9717	0.828	27.7178	0.176	27.8338
0.240	26.6675	0.217	26.8079	0.267	26.9740	0.811	27.7202	0.183	27.8366
0.241	26.6698	0.209	26.8102	0.235	26.9823	0.807	27.7225	0.195	27.8389

Table 1: Continued.

UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+
0.317	26.6809	0.200	26.8136	0.232	26.9870	0.774	27.7248	0.194	27.8412
0.333	26.6832	0.186	26.8159	0.212	26.9893	0.736	27.7271	0.21	27.8436
0.347	26.6855	0.185	26.8182	0.252	26.9740	0.696	27.7294	0.208	27.8459
0.380	26.6886	0.188	26.8213	0.241	26.9823	0.652	27.7317	0.224	27.8482
0.392	26.6909	0.188	26.8236	0.233	26.9870	0.606	27.7342	0.258	27.8520
0.417	26.6932	0.183	26.8259	0.22	26.9893	0.575	27.7365	0.254	27.8543
0.461	26.6958	0.181	26.8289	0.838	26.9270	0.527	27.7388	0.255	27.8566
0.492	26.6981	0.194	26.8312	0.805	26.9293	0.465	27.7437	0.271	27.8600
0.524	26.7004	0.180	26.8335	0.716	26.9344	0.435	27.7460	0.294	27.8623
0.583	26.7044	0.204	26.8367	0.674	26.9367	0.402	27.7487	0.295	27.8646
0.613	26.7066	0.189	26.8390	0.641	26.9390	0.384	27.7510	0.328	27.8678
0.656	26.7090	0.210	26.8448	0.19	27.6294	0.357	27.7533	0.343	27.8701
0.714	26.7125	0.214	26.8471	0.19	27.6316	0.337	27.7559	0.36	27.8724
0.735	26.7148	0.236	26.8494	0.215	27.6339	0.316	27.7582	0.403	27.8756
0.773	26.7171	0.225	26.8526	0.218	27.6376	0.303	27.7605	0.416	27.8779
0.790	26.7202	0.231	26.8550	0.215	27.6398	0.280	27.7628	0.437	27.8802
0.784	26.7225	0.247	26.8573	0.224	27.6421	0.268	27.7651	0.499	27.8833
0.778	26.7249	0.281	26.8659	0.246	27.6452	0.253	27.7674	0.531	27.8856
0.784	26.7281	0.297	26.8690	0.248	27.6475	0.246	27.7698	0.557	27.8879
0.792	26.7304	0.349	26.8795	0.254	27.6497	0.239	27.7721	0.59	27.8903
0.770	26.7327	0.373	26.8818	0.258	27.6525	0.228	27.7744	0.633	27.8926
0.780	26.7364	0.400	26.8841	0.271	27.6547	0.222	27.7770	0.678	27.8949
0.773	26.7387	0.402	26.8877	0.273	27.6570	0.201	27.7793	0.718	27.8983
0.725	26.7410	0.440	26.8900	0.298	27.6613	0.195	27.7816	0.76	27.9006
0.662	26.7452	0.463	26.8923	0.309	27.6636	0.190	27.7841	0.793	27.9029
0.627	26.7474	0.518	26.8961	0.317	27.6659	0.182	27.7864	0.783	27.9060
0.592	26.7497	0.549	26.8984	0.346	27.6702	0.169	27.7887	0.788	27.9083
0.509	26.7552	0.586	26.9007	0.37	27.6725	0.171	27.7911	0.79	27.9106
0.486	26.7575	0.629	26.9044	0.417	27.6776	0.160	27.7934	0.796	27.9130
0.461	26.7598	0.716	26.9067	0.443	27.6799	0.160	27.7957	0.785	27.9153
0.407	26.7642	0.727	26.9089	0.457	27.6822	0.151	27.7985	0.795	27.9176
0.376	26.7665	0.752	26.9113	0.516	27.6853	0.143	27.8008	0.768	27.9201
0.348	26.7688	0.799	26.9136	0.532	27.6876	0.150	27.8031	0.783	27.9224
0.329	26.7726	0.848	26.9191	0.571	27.6899	0.137	27.8057	0.747	27.9247
0.318	26.7749	0.822	26.9214	0.606	27.6922	0.141	27.8080	0.712	27.9275
0.311	26.7772	0.848	26.9237	0.637	27.6945	0.144	27.8103	0.673	27.9298
0.279	26.7805	0.832	26.9262	0.682	27.6968	0.147	27.8130	0.632	27.9321
0.266	26.7827	0.838	26.9285	0.718	27.6992	0.151	27.8153	0.597	27.9349
0.255	26.7850	0.808	26.9308	0.755	27.7015	0.152	27.8176	0.545	27.9372
0.245	26.7887	0.777	26.9346	0.785	27.7038	0.156	27.8199	0.536	27.9395
0.240	26.7909	0.750	26.9369	0.818	27.7061	0.140	27.8222		
0.242	26.7933	0.732	26.9392	0.83	27.7084	0.155	27.8246		
IDM	IHJD 2455300+	IDM	IHJD 2455300+	IDM	IHJD 2455300+	IDM	IHJD 2455300+	IDM	IHJD 2455300+
0.181	26.6566	0.222	26.7912	0.649	26.9395	0.769	27.7205	0.141	27.8272
0.182	26.6589	0.207	26.7935	0.629	26.9432	0.748	27.7228	0.142	27.8295
0.186	26.6612	0.189	26.7975	0.446	26.9526	0.718	27.7251	0.148	27.8318
0.206	26.6655	0.187	26.7998	0.362	26.9571	0.686	27.7274	0.15	27.8341
0.221	26.6678	0.186	26.8022	0.258	26.9697	0.644	27.7297	0.175	27.8369
0.271	26.6812	0.183	26.8059	0.241	26.9743	0.616	27.7320	0.16	27.8392

Table 1: Continued.

UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+	UDM	UHJD 2455300+
0.308	26.6835	0.171	26.8082	0.232	26.9826	0.565	27.7345	0.17	27.8415
0.318	26.6858	0.167	26.8105	0.74	26.9316	0.541	27.7368	0.198	27.8439
0.345	26.6889	0.160	26.8139	0.716	26.9344	0.502	27.7391	0.19	27.8462
0.353	26.6911	0.139	26.8162	0.674	26.9367	0.461	27.7417	0.194	27.8485
0.402	26.6935	0.148	26.8185	0.641	26.9390	0.434	27.7440	0.233	27.8522
0.430	26.6961	0.147	26.8216	0.156	27.6296	0.401	27.7463	0.235	27.8545
0.462	26.6984	0.156	26.8239	0.165	27.6319	0.378	27.7490	0.225	27.8569
0.473	26.7007	0.157	26.8262	0.167	27.6342	0.346	27.7513	0.25	27.8603
0.538	26.7047	0.153	26.8291	0.176	27.6379	0.328	27.7536	0.262	27.8626
0.589	26.7069	0.160	26.8314	0.174	27.6401	0.302	27.7562	0.272	27.8649
0.618	26.7092	0.148	26.8337	0.181	27.6424	0.278	27.7585	0.287	27.8681
0.662	26.7128	0.189	26.8370	0.194	27.6455	0.264	27.7608	0.312	27.8704
0.699	26.7151	0.168	26.8393	0.221	27.6477	0.237	27.7631	0.333	27.8727
0.724	26.7174	0.145	26.8416	0.221	27.6500	0.234	27.7654	0.355	27.8759
0.737	26.7205	0.197	26.8450	0.248	27.6527	0.223	27.7677	0.382	27.8782
0.731	26.7228	0.180	26.8496	0.245	27.6550	0.213	27.7701	0.456	27.8805
0.751	26.7251	0.207	26.8529	0.245	27.6573	0.218	27.7724	0.472	27.8835
0.727	26.7284	0.209	26.8552	0.262	27.6616	0.198	27.7747	0.481	27.8858
0.725	26.7307	0.217	26.8575	0.28	27.6639	0.188	27.7773	0.517	27.8881
0.721	26.7330	0.229	26.8615	0.291	27.6661	0.177	27.7796	0.557	27.8906
0.722	26.7367	0.223	26.8638	0.326	27.6705	0.174	27.7819	0.6	27.8929
0.706	26.7390	0.224	26.8661	0.341	27.6728	0.162	27.7844	0.631	27.8952
0.670	26.7413	0.315	26.8798	0.348	27.6751	0.158	27.7867	0.698	27.8986
0.625	26.7454	0.340	26.8821	0.383	27.6778	0.156	27.7890	0.711	27.9009
0.588	26.7477	0.351	26.8844	0.434	27.6825	0.161	27.7913	0.743	27.9032
0.554	26.7500	0.375	26.8880	0.468	27.6856	0.140	27.7937	0.747	27.9063
0.483	26.7555	0.412	26.8903	0.502	27.6879	0.130	27.7960	0.715	27.9086
0.441	26.7578	0.446	26.8926	0.53	27.6902	0.129	27.7988	0.756	27.9109
0.402	26.7601	0.511	26.8963	0.562	27.6925	0.125	27.8011	0.76	27.9133
0.371	26.7644	0.514	26.8987	0.593	27.6948	0.125	27.8034	0.775	27.9156
0.344	26.7667	0.559	26.9009	0.633	27.6971	0.123	27.8060	0.773	27.9179
0.327	26.7691	0.574	26.9046	0.687	27.6995	0.110	27.8083	0.746	27.9204
0.293	26.7729	0.654	26.9069	0.699	27.7018	0.115	27.8106	0.727	27.9227
0.280	26.7752	0.736	26.9116	0.755	27.7041	0.120	27.8133	0.698	27.9250
0.269	26.7775	0.732	26.9139	0.778	27.7064	0.122	27.8156	0.642	27.9278
0.259	26.7807	0.788	26.9194	0.783	27.7087	0.113	27.8179	0.636	27.9301
0.231	26.7830	0.781	26.9265	0.781	27.7135	0.134	27.8202	0.589	27.9324
0.233	26.7853	0.712	26.9349	0.774	27.7158	0.133	27.8225	0.578	27.9352
0.223	26.7889	0.694	26.9372	0.763	27.7181	0.132	27.8248		

II = 2455326.92427 ± 0.00068, 2455327.91256 ± 0.00060. We also obtained the following timings of minimum light from parabola fits to the data of Blattler, 2006: HJD I = 2453382.6915, 2453445.4980, 2453502.3800, 2453515.4154, 2453517.3907; HJD II = 2453463.4719, 2453515.607. From these and Bob Nelson's timings, an improved ephemeris below was calculated from all the available eclipse timings:

$$\text{J.D. Hel Min I} = 2455326.9244 \pm 0.0005 + 0.39500870 \pm 0.00000016\, d * E. \quad (2)$$

The O-C residuals are shown, graphically, in Figure 2 and tabled residualsare tabulated in Table 2.

Observations taken over some 5000 orbits (5.3 years) seem to show a constant period. A quadratic ephemeris was calculated, but the negative quadratic term was not significant. Further observations are needed to determine any trends that indicate changes in period.

5. Standard Magnitudes

Observations of over a dozen Landolt standard stars along with the variable, comparison, and check stars throughout

Table 2: Times of minimum light, TYC 3034-299-1.

NO.	JD Hel. EPOCHS	CYCLES	WEIGHT	O-C	REF
1	53382.6915	−4922.0	1.0	−0.0001	[2]
2	53445.4980	−4763.0	1.0	0.0000	[2]
3	53463.4719	−4717.5	1.0	0.0010	[2]
4	53502.3800	−4619.0	1.0	0.0007	[2]
5	53515.4154	−4586.0	1.0	0.0008	[2]
6	53515.6070	−4585.5	1.0	−0.0051	[2]
7	53517.3907	−4581.0	1.0	0.0011	[2]
8	53936.4936	−3520.0	0.5	−0.0002	[3]
9	54174.4898	−2917.5	1.0	0.0032	[3]
10	54547.7692	−1972.5	1.0	−0.0006	[5]
11	54879.9715	−1131.5	1.0	−0.0006	[5]
12	55326.7275	−0.5	1.0	0.0006	PO
13	55326.9242	0.0	1.0	−0.0002	PO
14	55327.7133	2.0	1.0	−0.0012	PO
15	55327.9125	2.5	1.0	0.0005	PO

Table 3: Standard magnitudes of the variable, comparison and check stars.

	V	B-V	V-R	R-I	V-I	mean
VAR (phase 0.00)	11.54 (20)	0.35 (2)	0.31 (0)	0.28 (4)	0.47 (5)	
Sp type		F2	F9	F8	F4	F6 (3)
VAR (phase 0.25)	10.83 (2)	0.28 (1)	0.11 (1)	0.30 (1)	0.44 (1)	
Sp type		F0	A7	G0	F3	F2.5 (5.5)
VAR (phase 0.50)	11.51 (5)	0.34 (5)	0.16 (4)	0.30 (8)	0.44 (10)	
Sp type		F2	F0	F9	F3	F3.5 (4.0)
VAR (phase 0.75)	10.71 (2)	0.32 (1)	0.12 (1)	0.31 (0)	0.45 (1)	
Sp type		F1	A7	G1	F3	F3 (6)
COMP	10.66 (6)	0.26 (3)	0.08 (2)	0.28 (3)	0.37 (5)	
Sp type		F0	A5	F8	F1	F1 (5)
CHK	10.58 (4)	0.31 (2)	0.14 (2)	0.34 (3)	0.50 (5)	
Sp type		F1	F8.5	G4	F5	F7.0 (5.5)

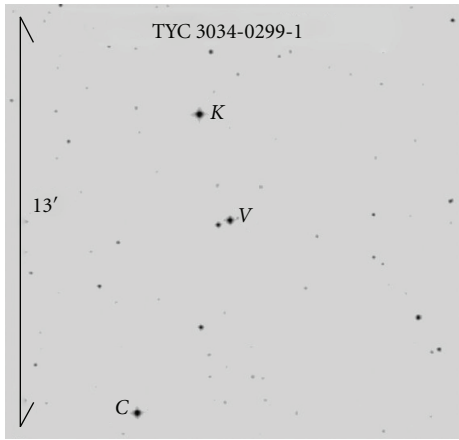


Figure 1: Finding chart, TYC 3034-299-1 variable (V), comparison (C) and check (K).

the evening of May 11 allowed us to calculate principal and transformation coefficients in BVR and I. Comparing these to Kron-Cousins calibrations, we found the results given in Table 3 [7] with the standard errors given in parentheses. From these calculations, we found a temperature of 6600 K (type F6V) for our primary star used for our synthetic light curve modeling.

6. Light Curves

The light curves were folded ΔU, ΔB, ΔV, ΔR, ΔI, Δ(U-B), Δ(B-V), and Δ(R-I) color curves using (2). They are given in Figures 3(a), 3(b), and 3(c). All bands give high precision, high amplitude W UMa light curves with an obvious O'Connell effect due to spot activity. The curves reveal a time of constant light in the secondary minima

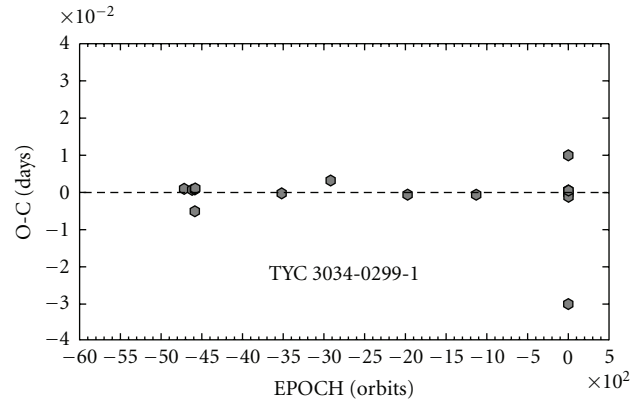


Figure 2: O-C residuals from (2).

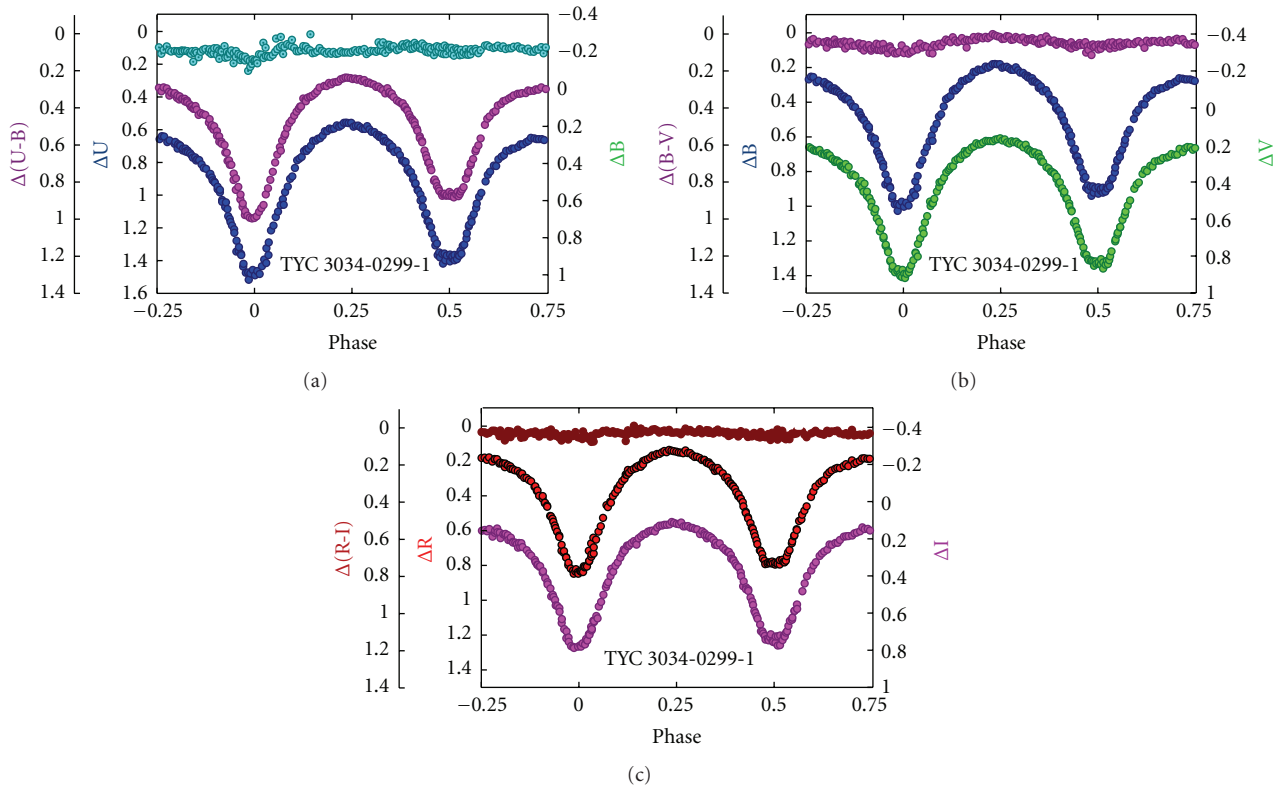


Figure 3: (a) U, B delta magnitude and color magnitudes versus phase plots in the sense of V-C. (b) B, V delta magnitude and color magnitudes versus phase plots in the sense of V-C. (c) R, I delta magnitude and color magnitudes versus phase plots in the sense of V-C.

indicating total eclipses. This usually indicates that the system is a W-type W UMa binary system. The amplitudes are rather deep for a contact binary, ranging from 0.85 mag in U to 0.66 in I. The O'Connell effect ranges from 67 mmag to 36 mmag from U to I, respectively, revealing substantial magnetic activity.

7. Synthetic Light Curve Solutions

The U, B, V, R, and I curves were premodeled with Binary Maker 2.0 [8] fits in all filter bands. The parameters were then averaged and input into a 5-color simultaneous light curve calculation using the Wilson Code [9–12]. Adjusted parameters were those with parentheses in Table 4.

The solution was computed in Mode 3, the contact mode. Convective parameters, $g = 0.32$, $A = 0.5$, were used. Our first solution, $q = 0.52$, gave a sum of square residuals equal to 8.33 (goodness of fit parameter). This fit the out of eclipse shoulders well but did not match the eclipse at phase 0.50. Due to the brevity of the total eclipse, the modeling procedure does not produce unambiguous results (many solutions may be possible). Consequently, we performed a

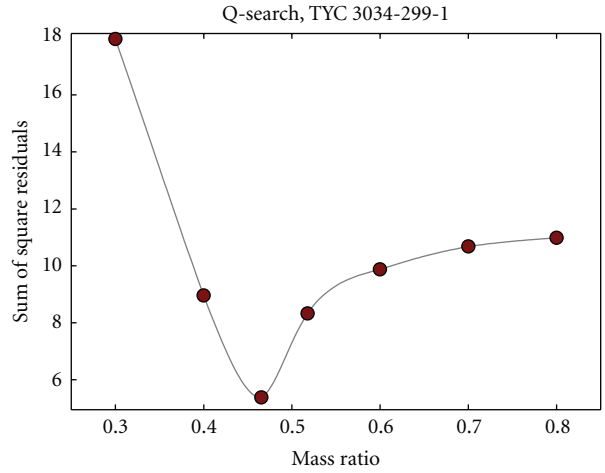


Figure 4: Determination of best fitting mass ratio.

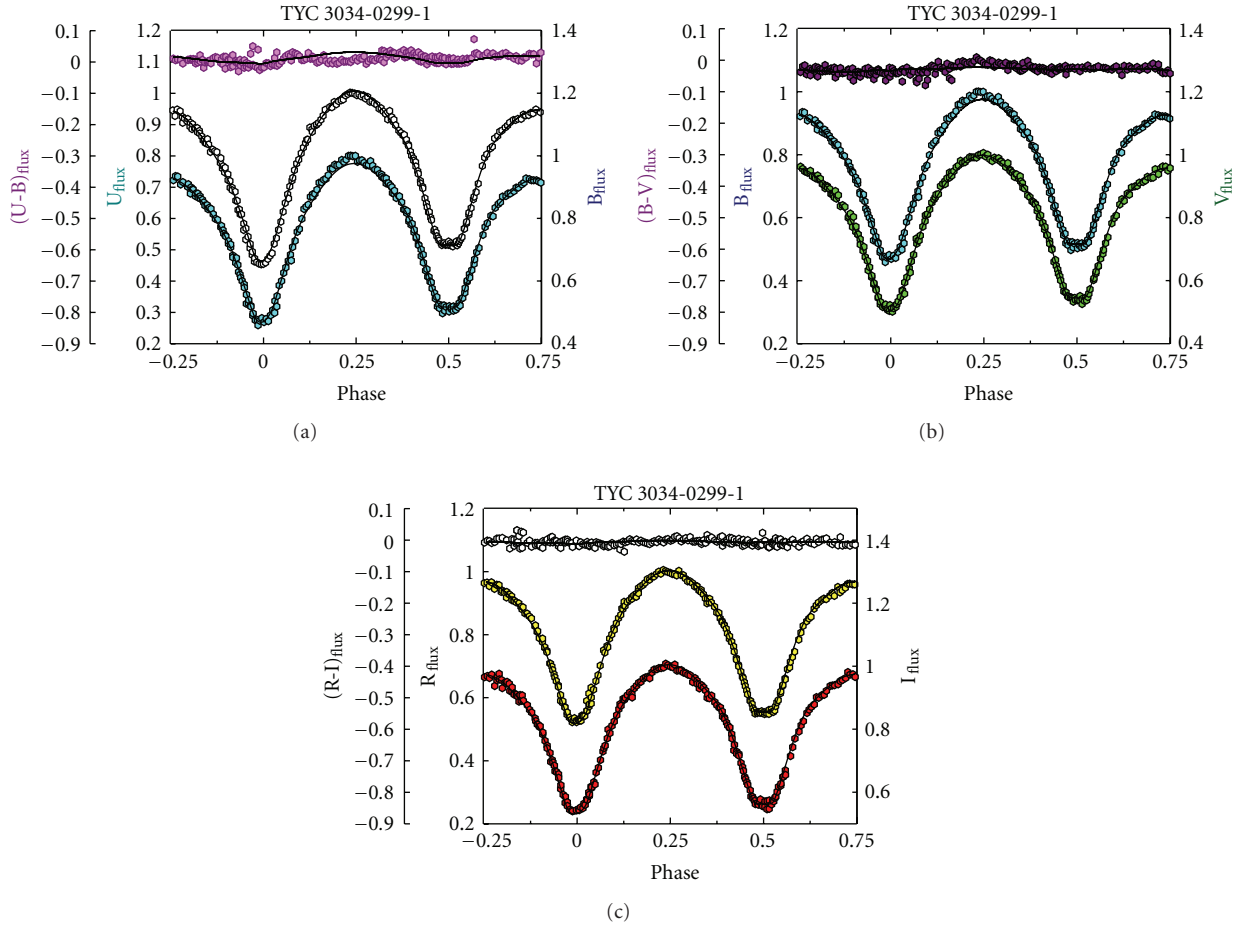
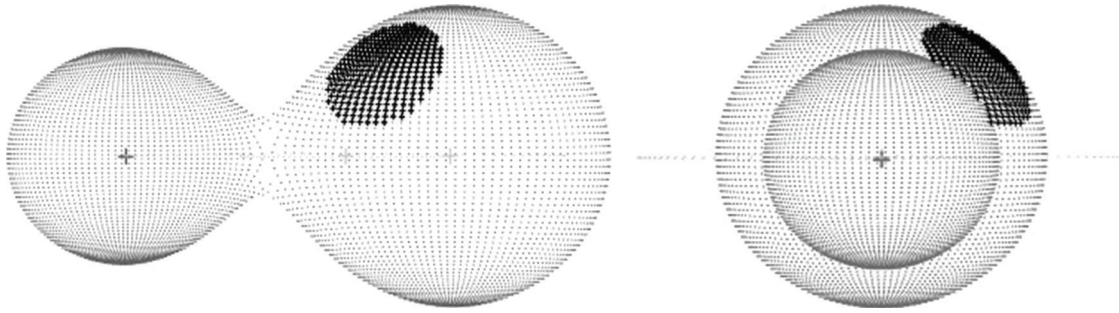


Figure 5: (a) U, B synthetic light curve solutions overlaying the normalized flux curves. (b) B, V synthetic light curve solutions overlaying the normalized flux curves. (c) R, I synthetic light curve solutions overlaying the normalized flux curves.



Phase 0.76 TYC 3034-299-1 (a)

Phase 0 TYC 3034-299-1 (b)

Figure 6: (a) Roche lobe surfaces from our UBVRI solution, phase 0.76. (b) Roche lobe surfaces from our UBVRI solution, phase 0.00.

Table 4: Synthetic curve parameters, TYC 3034-299-1.

Parameters	Values
$\lambda_B, \lambda_V, \lambda_R, \lambda_I$ (nm)	360, 440, 550, 640, 790
$x_{bol1,2}$, $y_{bol1,2}$	0.641, 0.641 0.246, 0.246
$x_{1I,2I}$, $y_{1I,2I}$	0.541, 0.541 0.276, 0.276
$x_{1R,2R}$, $y_{1R,2R}$	0.625, 0625, 0.289, 0.289
$x_{1V,2V}$, $y_{1V,2V}$	0.794, 0.794 0.263, 0.263
$x_{1B,2B}$, $y_{1B,2B}$	0.821, 0.821, 0.299, 0.299
g_1, g_2	0.32
A_1, A_2	0.5
Inclination (°)	89.6 ± 0.6
T_1, T_2 (K)	6600 ± 500, 6695 ± 3*
$\Omega_1 = \Omega_2$	2.7645 ± 0.0023
q (m_2/m_1)	0.4777 ± 0.0008
Fill-outs: $F_1 = F_2$	24%
$L_1/(L_1 + L_2)_I$	0.6494 ± 0.0005
$L_1/(L_1 + L_2)_R$	0.6473 ± 0.0009
$L_1/(L_1 + L_2)_V$	0.6449 ± 0.0009
$L_1/(L_1 + L_2)_B$	0.6407 ± 0.0007
$L_1/(L_1 + L_2)_U$	0.6404 ± 0.0007
JD_o (days)	2455326.92478 ± 0.00005
Period (days)	0.395014 ± 0.000032
r_1, r_2 (pole)	0.4300 ± 0.0012, 0.3087 ± 0.0017
r_1, r_2 (side)	0.4600 ± 0.0016, 0.3240 ± 0.0022
r_1, r_2 (back)	0.4927 ± 0.0023, 0.3657 ± 0.0041
SPOT parameters	*Dark Spot*
STAR 1	
Latitude (°)	55 ± 1
Longitude (°)	51.3 ± 0.8
Spot radius (°)	24.86 ± 0.21
Spot temperature	5468 ± 30

* All Errors are formal; here the error in T_2 is in relation to T_1. We expect errors to T_1 to be on the order of ~500 K from the errors of our standard star determinations.

q-search over the interval from $q = 0.3$ to 0.8. The residuals minimized at $q \sim 0.45$ (see Figure 4). Additional iterations were run from the minimized q with the mass ratio allowed to adjust to our final solution. Our final solution is a W-type W UMa binary, as noted from the light curve appearance. The solution is seen overlaying the normalized flux curves shown in Figures 5(a), 5(b), and 5(c). The complete solutions are given as Table 4. Two phases of the Roche-lobe model of the binary for the dark spot solution are shown in Figures 6(a) and 6(b). Phase 0.0 shows the total eclipse.

8. Discussion

TYC 3034-299-1 is a mid-F type magnetically active contact binary. The solution gives a eclipse duration of ~7 minutes. The firm 24% fillout and the nearly identical temperatures of the two stars show that the system has nearly reached thermal contact. After this point is reached, we would suspect that over long periods the mass ratio would become more extreme. This is caused by torques provided by stellar winds leaving the star along stiff magnetic field lines [13] rotating synchronously with the gravitationally coupled binary.

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