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Photometry and elements of GW Geminorum

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Summary. — Photoelectric observations of the eclipsing system GW Gem made during the years 1978 and 1979 enable us to derive nine epochs of minimum light. The period of the binary star appears to be constant. The light curves are analysed referring to the Roche model. The brighter component appears to be an A8 star and the secondary G3-G4 subgiant fills its Roche lobe.

Key words : Eclipsing binary — photometric solutions.

1. **Light curves and period.** — GW Gem = BD + 27°1494 was discovered to be an Algol-type variable by Hoffmeister (1949). On the basis of photographic material obtained at Sonneberg and Babelsberg Observatories which began in 1928, Löchel (1955) derived several epochs of minimum. Some other photographic epochs have been derived by Kippenhahn (1953) and by Romano and Perissinotto (1968). On the basis of all this material, 48 minima altogether, Romano and Perissinotto calculated the light elements :

$$\text{Min I} = \text{helioc. JD } 2425645.572 + 0.65944354\, n\ .$$

During the following years GW Gem has been monitored assiduously by the Observers of BBSAG (1973-1978) which on the basis of visual measurements calculated 27 epochs of minimum using the tracing paper method. However, as far as we know, no photoelectric light curve has been obtained so far for this relatively bright and short period system.

The observations studied in this article were made through B and V filters, a Lallemand photomultiplier and a Gardiner type integrator at the 102 cm reflector of the Merate Observatory, during the years 1978 and 1979. The integration time was set to 20 s. The variable was observed differentially relative to the star BD + 28°1494 ; the check star was BD + 27°1497. The extinction coefficients were determined on some nights ; when it was not possible, mean values were used. The extinction corrections exceptionally came out to $0^m.005$ for B and V measurements, but for the most part they were quite negligible.

At first sight the brightness of the comparison relative to the check star appeared to be constant. A total of 56 B and 54 V differential magnitudes $m_{\text{comp}} - m_{\text{check}}$ gave indeed :

$$\Delta B = -\ 0^m.285 \pm .001,$$
$$\Delta V = -\ 0^m.018 \pm .001 \text{ m.e.}$$

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The corresponding standard deviations for a single Δm, $0^m.010$ and $0^m.009$ respectively in B and V conformed to the usual observing conditions in Merate. However when computing the photometric solutions of GW Gem, the residuals of the observations obtained during some nights showed clearly a small and periodic trend. Since no second check star was used and since the number of observations on GW Gem widely exceeds the number of Δm between the comparison and check star, the observations of GW Gem itself better support the variability of BD + 28°1494. Effectively, after comparing both with GW Gem, cleared from the eclipse effects, and with BD + 27°1497, the comparison star turned out to be a δ Scuti star with an overall amplitude of about $0^m.035$ at the most (Broglia and Conconi, 1979), but which can also decrease below the noise level of measurements, as we have discussed in a separate paper (Broglia and Conconi, 1981). This fact produced some complications when solving the light curves, as will be said in the next section.

The reference star was tied to the standard UBV system on three nights. We obtained :

$$\text{BD} + 28°1494: \quad V = 9^m.32 \quad B\text{-}V = +\ 0^m.21\ .$$

The V value refers to the mean brightness of BD + 28°1494. Taking into account the δ Scuti variation, its incertitude is evaluated at $0^m.02$ at the most, whilst the colour is quite correct.

During fourteen nights we obtained altogether for GW Gem 1252 differential magnitudes in B and 1272 in V, listed in tables I and II. By fitting a second degree parabola to the lower part of each minimum we derived five epochs of primary and four of secondary eclipse, listed in table III. The quoted errors relate to the mean of B and V values. Taking into account only the primary minima we calculated the following ephemeris :

$$\text{Min I} = \text{helioc. JD } 2425645.5938 + 0.659443504\, n \quad (1)$$
$$\pm \quad 5 \qquad\qquad\qquad 17 \text{ m.e.}$$

To detect eventual changes in the period we have considered moreover the photographic and visual timings of light given in the literature from which we calculated the normal epochs given in table III with the corresponding mean errors, to have their precision valued. After weighting conveniently, all the instants of minimum lead to the following ephemeris :

$$\text{Min I} = \text{helioc. JD } 2425645.5798 + 0.659444013\, n$$
$$\pm 40 \qquad 146 \text{ m.e.}$$

The residuals O-C are given in table III. The period including all observations over 50 years would be slightly longer than the value determined from photoelectric data alone. Adding a quadratic term to the ephemeris, a reduction of the mean residual of only four percent is obtained, so on the basis of the meagre material available the period of GW Gem can be considered constant.

The observations were put in phase by means of the ephemeris (1). From the light curves given in figure 1 we deduce :

	Max	Min I	Min II
V	$10^{m}.485$	$11^{m}.450$	$10^{m}.685$
$B\text{-}V$	+0.27	0.33	0.24

2. **Photometric solutions and concluding remarks.** — A preliminary analysis of the light curves according to the Russell model was performed by means of the Irwin (1947) differential correction method in order :

1) to separate the eclipse changes from the δ Scuti variation ;

2) to evaluate the influence on the solutions of the variability of the comparison.

Harmonic analysis of the residual derived in the photometric solutions were performed, separately for each night and colour. The periods and amplitudes, non constant, of the δ Scuti variation are given elsewhere (Broglia and Conconi, 1981). Using these values the single measurements of GW Gem have been corrected afterwards for the Scuti variation of the comparison, limited to the nights when the variation was detected and the clearing out for the δ Scuti effect proved to be significant in comparison with natural dispersion of the observations. About two thirds of the measurements have been corrected and the corresponding reduction factor of the dispersion was 0.75.

The influence on the photometric solutions of the δ Scuti variation appeared to be negligible because its amplitude is small compared with the eclipse changes and in most parts of the mean light curves the fluctuations cancel out. In fact correcting the out of eclipse measurements the standard deviation for a single observation with respect to the Fourier representation decreased from $0^{m}.009$ to $0^{m}.007$ in B and from $0^{m}.008$ to $0^{m}.006$ in V. A similar improvement was attained for the measurements during the eclipse. We note moreover that when solving according to the Russell model the sin $n\theta$ terms resulted quite negligible.

Starting from these preliminary elements, solutions were then calculated by means of the Wilson and Devinney (1971) programmes, updated to 1978. In order to reduce the computing time when operating with the differential corrections programme we make the following change. According to the Wilson and Devinney notations the flux sorting in the observing direction from each areola in which both stars are subdivided is equal to :

$$\Delta F_{\lambda} = \cos \gamma \ \text{DIGRr}^2 \text{ sen } \theta \Delta\theta \Delta\phi / \cos \beta \ .$$

For a given orbital phase the factor cos γ, where γ is the angle between the local surface normal and the line of sight, depends only on the « geometrical » parameters (i, q, Ω_1, Ω_2) ; the limb darkening D depends on these parameters and on the coefficients x_1 and x_2 ; the product IGRr^2 sen θ/cos β depends not only on the geometrical parameters but also on the « photometric » ones (g_1, g_2, T_1, T_2, L_1, L_2, A_1, A_2, x_1, x_2), but not on the phase ; $\Delta\theta$ and $\Delta\phi$ depend on the grid's numbers. In the original programme the quantity IGRr^2 sen θ/cos β is computed for the initial set of parameters and the corresponding vector is memorized. Then the luminosity l is computed for each phase by means of the subroutine « Light ». If we want to compute the differential corrections for n parameters we must repeat n times this process after having incremented successively each of the n parameters. On the whole $n + 1$ light curves are computed and from these the derivatives $\delta l/\delta p$ belonging to each of the n parameters p are calculated.

The programme can be improved by storing in a matrix the factor IGRr^2 sen θ/cos β computed for the initial set of parameters and for the n sets obtained by increasing by Δp, one after another, each of the n photometric parameters to be corrected. In this way the quantity cos γ, corresponding to a given phase and to a given areola, can be computed in the subroutine « Light » only once for all the photometric parameters and we can derive simultaneously for each observation the ΔF_{λ} pertinent to all the sets of photometric parameters (the initial and the increased ones).

In the case of grids 25 × 25 and 15 × 15, when correcting three photometric and three geometric parameters the computing time is reduced by 30 percent. This improvement is appreciable especially when using a small computer.

Because no spectroscopic study of GW Gem is as yet available in the literature, taking into account the fact that the eclipses are deep, in conformity with the colour at the Min II a spectral type A8 was attributed to the primary component, supposed to be a main sequence star and a temperature T_h = 7 700 K was assumed according to the Flower (1977) temperature scale. The following parameters were allowed to vary : i, L_1, L_2, A_2, Ω_1, Ω_2. Of the remaining parameters which were not adjusted during the calculations, the limb darkening coefficients were taken from Grygar *et al.* (1972), and the gravity darkening exponents were set equal to one for both stars. Since the spectroscopic mass-ratio q is unknown and the solutions show a correlation between q and i, we searched for solutions, by means of the differential corrections programme, with different assumed values for q ranging from $q = 0.32$ to $q = 0.60$ at convenient steps. In the range from $q = 0.32$ to 0.45 the filling factor $F_2 = \Omega_{\text{int}}/\Omega_2$ for the secondary component is 1.0 and in the interval 0.45 to 0.60 it decreases to 0.985 only ; therefore the secondary component fills its Roche lobe.

The best solution (with the smallest sum of the squares of the residuals) is at $q = 0.43$, as appears from figure 2 where the solutions calculated with F_2 as free parameter (dots) and those derived with $F_2 = 1$ (circles) are represented. The adopted solution calculated assuming q also as free parameter and using the programme in mode 0, according to Wilson' code, is listed in table IV together with the related standard errors pertinent to the adjusted parameters. The luminosity of the bright star is normalized to make the sum of the two components unity. The temperature $T_c = 5\,270$ K, calculated according to the Planck's law for the secondary component, favours a spectral type G3-4 for the secondary subgiant. The solutions were calculated using all the B and V individual observations together.

A more realistic evaluation of the uncertainty of the solutions and in particular of the mass-ratio q can be derived by looking at figure 2. Assuming a 5 percent worsening of the factor R (see legend to figure 2) is significant, an incertitude of $\pm$ 0.05 can be assigned to q. The corresponding errors for the elements i, Ω_1, A_2, L_{1B}, L_{1V} are given between brackets in table IV.

In conclusion GW Gem appears to be a semidetached system ; the small value for the r.m.s. residual σ for single B or V observations computed in the solution (table IV) and the small dispersion of the measurements displayed in figure 1 confirms that the light curves have been stable and devoid of sensible perturbations over the two observing seasons and that the computed elements are reliable.

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TABLE I. — *B observations of GW Gem.*

HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B
514.4803	10.939	514.5921	10.918	543.3744	10.747	543.4578	10.811	543.5316	11.514
.4829	10.976	.5944	10.905	.3766	10.762	.4589	10.804	.5342	11.573
.4851	11.001	.5975	10.878	.3774	10.750	.4612	10.805	.5353	11.585
.4875	11.020	.5998	10.875	.3799	10.766	.4646	10.802	.5357	11.602
.4907	11.060	.6025	10.861	.3810	10.757	.4656	10.802	.5378	11.640
.4940	11.121	.6048	10.856	.3831	10.762	.4680	10.825	.5388	11.670
.4962	11.119	.6071	10.849	.3841	10.752	.4718	10.823	.5396	11.692
.4989	11.191	.6104	10.849	.3888	10.773	.4745	10.809	.5413	11.715
.5015	11.209	.6157	10.808	.3910	10.753	.4768	10.827	.5420	11.721
.5038	11.271	.6166	10.809	.3917	10.755	.4782	10.821	.5427	11.731
.5063	11.340	.6195	10.808	.3936	10.754	.4813	10.849	.5448	11.761
.5088	11.358	.6220	10.816	.3943	10.757	.4821	10.850	.5456	11.763
.5111	11.384	.6244	10.817	.3965	10.754	.4841	10.847	.5463	11.774
.5119	11.419	.6266	10.827	.3973	10.755	.4864	10.871	.5493	11.775
.5141	11.458	.6291	10.801	.3992	10.752	.4872	10.890	.5501	11.791
.5163	11.507	543.3217	10.774	.4011	10.751	.4892	10.890	.5519	11.771
.5184	11.564	.3235	10.778	.4032	10.752	.4900	10.912	.5527	11.778
.5207	11.618	.3260	10.779	.4056	10.761	.4922	10.909	.5534	11.763
.5252	11.702	.3271	10.770	.4077	10.746	.4935	10.923	.5555	11.752
.5275	11.714	.3296	10.779	.4085	10.751	.4945	10.928	.5562	11.727
.5298	11.744	.3312	10.773	.4124	10.756	.4970	10.953	.5571	11.724
.5335	11.774	.3342	10.771	.4132	10.751	.4987	10.964	.5598	11.684
.5360	11.785	.3349	10.776	.4151	10.754	.4997	10.980	.5607	11.674
.5385	11.765	.3371	10.774	.4158	10.748	.5018	11.003	.5626	11.627
.5432	11.695	.3388	10.789	.4180	10.747	.5025	11.015	.5643	11.597
.5475	11.613	.3409	10.768	.4195	10.753	.5046	11.043	.5661	11.556
.5509	11.536	.3433	10.774	.4241	10.759	.5052	11.045	.5668	11.544
.5550	11.455	.3456	10.767	.4248	10.761	.5073	11.081	.5678	11.516
.5581	11.356	.3467	10.759	.4269	10.758	.5081	11.079	.5700	11.485
.5599	11.330	.3489	10.777	.4326	10.760	.5103	11.120	.5709	11.462
.5622	11.301	.3517	10.767	.4333	10.765	.5111	11.129	.5717	11.454
.5651	11.245	.3538	10.764	.4362	10.769	.5146	11.194	.5738	11.420
.5675	11.214	.3545	10.765	.4369	10.767	.5154	11.206	.5747	11.377
.5683	11.197	.3564	10.766	.4388	10.781	.5178	11.237	.5757	11.355
.5714	11.146	.3576	10.758	.4398	10.789	.5186	11.254	.5776	11.328
.5738	11.099	.3598	10.769	.4429	10.784	.5205	11.299	.5785	11.299
.5743	11.101	.3623	10.766	.4436	10.772	.5227	11.325	.5805	11.267
.5789	11.052	.3632	10.753	.4460	10.788	.5235	11.345	.5812	11.265
.5822	11.020	.3655	10.760	.4467	10.792	.5254	11.385	.5833	11.222
.5828	11.005	.3663	10.756	.4492	10.798	.5262	11.397	.5842	11.203
.5851	10.995	.3686	10.755	.4512	10.799	.5270	11.416	.5851	11.191
.5875	10.960	.3711	10.771	.4532	10.805	.5297	11.454	.5872	11.162
.5899	10.941	.3736	10.774	.4555	10.806	.5306	11.486	.5881	11.150

HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B
595.3757	10.835	596.3972	10.814	849.5347	11.774	876.4224	10.757	876.5172	10.961
.3763	10.837	.4010	10.808	.5390	11.744	.4231	10.766	.5179	10.966
.3783	10.838	.4058	10.808	.5433	11.647	.4255	10.775	.5200	10.993
.3790	10.823	.4079	10.792	876.3391	10.789	.4271	10.756	.5210	11.005
.3807	10.822	.4130	10.781	.3409	10.795	.4294	10.769	.5250	11.055
.3823	10.827	849.4506	10.810	.3434	10.784	.4302	10.754	.5257	11.075
.3851	10.825	.4518	10.808	.3480	10.800	.4327	10.760	.5285	11.103
.3879	10.814	.4538	10.818	.3495	10.793	.4334	10.755	.5293	11.112
.3892	10.809	.4554	10.826	.3522	10.796	.4341	10.754	.5346	11.212
.3910	10.818	.4575	10.831	.3529	10.789	.4365	10.746	.5354	11.209
.3923	10.808	.4583	10.823	.3553	10.794	.4372	10.756	.5377	11.265
.3939	10.802	.4602	10.836	.3561	10.780	.4398	10.753	.5391	11.307
.3953	10.815	.4622	10.842	.3593	10.766	.4414	10.758	.5415	11.340
.3971	10.807	.4642	10.849	.3602	10.774	.4437	10.755	.5423	11.341
.3985	10.805	.4660	10.866	.3628	10.791	.4447	10.750	.5445	11.371
.4009	10.793	.4681	10.878	.3636	10.777	.4454	10.757	.5453	11.414
.4022	10.796	.4689	10.873	.3667	10.773	.4476	10.750	.5476	11.436
.4045	10.799	.4709	10.886	.3675	10.759	.4487	10.745	.5484	11.471
.4070	10.796	.4717	10.898	.3683	10.758	.4511	10.752	.5509	11.519
.4096	10.777	.4738	10.917	.3711	10.762	.4518	10.759	.5515	11.525
.4115	10.788	.4754	10.925	.3717	10.752	.4529	10.758	.5537	11.567
.4140	10.787	.4773	10.944	.3724	10.752	.4553	10.764	.5544	11.590
.4157	10.791	.4780	10.933	.3756	10.748	.4573	10.777	.5567	11.642
.4187	10.786	.4801	10.967	.3763	10.741	.4581	10.779	.5586	11.661
.4209	10.785	.4808	10.995	.3789	10.732	.4606	10.781	.5611	11.726
596.3599	10.943	.4815	10.986	.3917	10.749	.4620	10.789	.5645	11.756
.3615	10.940	.4832	11.003	.3924	10.748	.4654	10.771	.5679	11.795
.3634	10.910	.4848	10.997	.3950	10.751	.4661	10.766	.5709	11.773
.3658	10.901	.4869	11.036	.3957	10.741	.4776	10.812	.5733	11.766
.3693	10.878	.4877	11.071	.3982	10.765	.4783	10.789	.5740	11.763
.3715	10.855	.4884	11.067	.3991	10.760	.4828	10.814	.5761	11.721
.3722	10.876	.4907	11.090	.4017	10.762	.4835	10.811	.5775	11.724
.3741	10.846	.4923	11.132	.4025	10.757	.4910	10.816	.5802	11.657
.3760	10.846	.4931	11.138	.4049	10.768	.4917	10.817	.5809	11.634
.3767	10.850	.5049	11.323	.4056	10.748	.4941	10.825	.5813	11.644
.3786	10.830	.5068	11.340	.4081	10.754	.4948	10.831	.5817	11.637
.3805	10.831	.5090	11.379	.4088	10.758	.4972	10.828	.5840	11.579
.3828	10.818	.5097	11.403	.4116	10.762	.4988	10.853	.5848	11.564
.3836	10.818	.5143	11.521	.4132	10.762	.5043	10.854	.5871	11.518
.3855	10.810	.5183	11.604	.4162	10.754	.5087	10.884	.5883	11.475
.3862	10.817	.5223	11.694	.4169	10.762	.5095	10.883	.5910	11.434
.3896	10.820	.5265	11.755	.4194	10.761	.5142	10.934	.5917	11.418
.3940	10.808	.5305	11.776	.4201	10.757	.5149	10.936	.5933	11.384

HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B
543.5892	11.133	544.3198	10.776	544.3933	10.753	544.4657	10.822	577.2993	10.795
.5900	11.125	.3220	10.776	.3952	10.751	.4664	10.821	.3013	10.794
.5909	11.103	.3228	10.772	.3976	10.761	.4689	10.831	.3030	10.794
.5932	11.073	.3248	10.770	.4005	10.756	.4696	10.822	.3060	10.782
.5941	11.060	.3283	10.769	.4013	10.755	.4719	10.840	.3068	10.778
.5961	11.043	.3315	10.766	.4034	10.759	.4730	10.840	.3098	10.793
.5972	11.018	.3335	10.768	.4042	10.770	.4749	10.825	.3116	10.784
.5992	10.998	.3357	10.769	.4065	10.766	.4771	10.828	.3136	10.784
.6020	10.968	.3366	10.772	.4072	10.771	.4795	10.839	.3145	10.783
.6027	10.950	.3385	10.758	.4092	10.774	.4802	10.832	.3166	10.773
.6049	10.934	.3392	10.762	.4100	10.767	.4831	10.828	.3540	10.760
.6058	10.926	.3413	10.748	.4120	10.773	.4835	10.832	.3561	10.757
.6078	10.915	.3420	10.751	.4127	10.772	.4858	10.843	.3586	10.762
.6099	10.896	.3442	10.756	.4146	10.776	.4867	10.837	.3593	10.752
.6119	10.892	.3450	10.773	.4153	10.771	.4887	10.854	.3613	10.769
.6127	10.876	.3471	10.770	.4176	10.778	.4895	10.861	.3634	10.771
544.2738	10.868	.3478	10.758	.4186	10.772	.4917	10.845	.3657	10.769
.2756	10.848	.3502	10.776	.4207	10.769	.4926	10.840	.3664	10.768
.2774	10.840	.3509	10.772	.4230	10.770	.4946	10.863	.3684	10.761
.2790	10.823	.3529	10.767	.4253	10.768	.4971	10.857	.3690	10.753
.2799	10.829	.3544	10.760	.4278	10.768	.5010	10.868	.3713	10.771
.2817	10.827	.3567	10.762	.4299	10.772	.5013	10.875	.3720	10.774
.2825	10.837	.3574	10.757	.4307	10.776	.5040	10.870	.3746	10.763
.2843	10.826	.3595	10.755	.4329	10.773	.5048	10.878	.3763	10.760
.2862	10.824	.3617	10.758	.4336	10.776	.5075	10.886	.3782	10.752
.2881	10.838	.3636	10.751	.4355	10.780	.5086	10.885	.3789	10.762
.2901	10.819	.3647	10.750	.4363	10.765	.5307	10.926	.3808	10.759
.2919	10.818	.3669	10.757	.4384	10.778	.5326	10.936	.3818	10.762
.2926	10.811	.3678	10.749	.4391	10.781	.5346	10.931	.3839	10.762
.2946	10.827	.3704	10.762	.4413	10.778	.5363	10.934	.3847	10.784
.2965	10.826	.3711	10.754	.4420	10.779	.5385	10.922	.3868	10.771
.2972	10.810	.3731	10.752	.4439	10.786	.5404	10.929	.3874	10.761
.2992	10.808	.3762	10.746	.4460	10.791	.5435	10.921	.3901	10.760
.3012	10.810	.3786	10.741	.4480	10.801	.5458	10.928	.3922	10.772
.3031	10.807	.3795	10.738	.4503	10.805	.5492	10.917	.3946	10.784
.3060	10.819	.3816	10.743	.4523	10.800	.5520	10.920	.3963	10.781
.3077	10.795	.3825	10.734	.4530	10.799	.5550	10.926	.3986	10.778
.3100	10.791	.3844	10.741	.4552	10.810	.5584	10.920	.3995	10.765
.3118	10.797	.3851	10.743	.4576	10.813	.5620	10.889	.4017	10.783
.3126	10.791	.3873	10.746	.4597	10.818	.5648	10.900	.4026	10.780
.3146	10.794	.3880	10.743	.4605	10.821	.5675	10.906	.4047	10.776
.3154	10.785	.3902	10.741	.4627	10.821	.5709	10.895	.4055	10.775
.3177	10.781	.3925	10.749	.4635	10.822	577.2977	10.782	.4084	10.782

HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B
876.5957	11.348	903.5109	10.786	905.3121	10.859	905.3799	10.784	905.4493	10.762
.5964	11.330	.5116	10.788	.3142	10.853	.3814	10.775	.4513	10.761
.5989	11.289	.5138	10.794	.3148	10.854	.3834	10.775	.4519	10.755
.5996	11.278	.5159	10.803	.3169	10.848	.3868	10.764	.4548	10.764
.6130	11.068	.5166	10.790	.3184	10.838	.3875	10.761	.4555	10.757
.6145	11.059	.5187	10.800	.3205	10.837	.3895	10.753	.4575	10.763
903.4365	10.760	.5203	10.808	.3213	10.829	.3905	10.748	.4583	10.752
.4381	10.766	.5222	10.803	.3234	10.824	.3926	10.749	.4603	10.761
.4404	10.757	.5230	10.809	.3241	10.826	.3941	10.746	.4610	10.750
.4424	10.756	.5264	10.814	.3260	10.816	.3960	10.746	.4648	10.758
.4439	10.763	.5271	10.811	.3277	10.817	.3987	10.740	.4656	10.760
.4462	10.757	.5292	10.815	.3298	10.810	.3994	10.740	.4677	10.765
.4469	10.753	.5299	10.811	.3305	10.801	.4013	10.737	.4686	10.763
.4490	10.759	.5319	10.813	.3325	10.805	.4020	10.737	.4707	10.776
.4498	10.753	.5327	10.810	.3334	10.801	.4039	10.739	.4714	10.770
.4523	10.754	.5348	10.831	.3356	10.801	.4046	10.736	.4735	10.781
.4539	10.748	.5367	10.841	.3363	10.799	.4066	10.744	.4751	10.780
.4560	10.749	.5400	10.857	.3383	10.802	.4082	10.749	.4772	10.784
.4568	10.743	.5407	10.865	.3400	10.797	.4101	10.736	.4778	10.787
.4595	10.741	.5426	10.863	.3420	10.787	.4108	10.740	.4799	10.794
.4618	10.735	.5433	10.891	.3428	10.776	.4128	10.752	.4805	10.801
.4654	10.745	.5454	10.900	.3448	10.785	.4146	10.756	.4827	10.797
.4661	10.737	.5461	10.893	.3455	10.782	.4165	10.761	.4834	10.797
.4681	10.747	.5482	10.919	.3473	10.780	.4172	10.760	.4863	10.803
.4701	10.758	.5491	10.932	.3481	10.777	.4193	10.756	.4871	10.806
.4749	10.763	.5513	10.944	.3510	10.787	.4200	10.765	.4892	10.801
.4780	10.770	.5533	10.952	.3527	10.793	.4219	10.766	.4900	10.797
.4811	10.761	.5577	10.993	.3547	10.785	.4227	10.768	.4962	10.809
.4818	10.771	.5600	11.012	.3555	10.791	.4246	10.775	.4970	10.810
.4845	10.770	.5622	11.037	.3593	10.792	.4254	10.762	.4988	10.803
.4870	10.779	.5643	11.068	.3601	10.789	.4274	10.768	.4996	10.812
.4878	10.773	.5665	11.094	.3621	10.785	.4281	10.762	.5016	10.812
.4904	10.766	905.2949	10.876	.3628	10.782	.4301	10.766	.5024	10.803
.4920	10.781	.2965	10.870	.3649	10.784	.4310	10.763	.5043	10.814
.4944	10.796	.2984	10.876	.3658	10.799	.4330	10.769	.5059	10.811
.4977	10.801	.2992	10.878	.3678	10.788	.4348	10.757	.5078	10.812
.4993	10.788	.3015	10.867	.3694	10.787	.4368	10.757	.5085	10.813
.5014	10.779	.3034	10.871	.3715	10.789	.4375	10.755	.5104	10.819
.5021	10.789	.3055	10.859	.3722	10.787	.4409	10.763	.5111	10.809
.5044	10.793	.3062	10.861	.3742	10.792	.4416	10.753	.5131	10.836
.5051	10.794	.3081	10.870	.3749	10.780	.4436	10.747	.5138	10.825
.5081	10.788	.3096	10.866	.3767	10.782	.4447	10.751	.5157	10.835
.5089	10.783	.3114	10.867	.3774	10.780	.4466	10.764	.5164	10.841

HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B
577.4091	10.787	577.5106	10.929	578.3298	10.769	589.3025	10.790	589.3813	10.920
.4132	10.793	.5133	10.928	.3304	10.760	.3045	10.801	.3845	10.908
.4153	10.790	.5171	10.922	.3322	10.765	.3053	10.816	.3878	10.913
.4169	10.802	.5197	10.926	.3330	10.756	.3074	10.825	.3907	10.923
.4189	10.804	.5224	10.925	.3348	10.757	.3090	10.824	.3933	10.908
.4196	10.796	.5287	10.919	.3355	10.752	.3110	10.814	.3964	10.918
.4216	10.805	.5335	10.912	.3393	10.748	.3117	10.811	.3992	10.913
.4223	10.805	.5395	10.913	.3447	10.762	.3137	10.818	.4013	10.898
.4243	10.804	.5429	10.897	.3525	10.737	.3144	10.822	.4047	10.881
.4250	10.797	.5477	10.884	.3569	10.740	.3164	10.817	.4018	10.901
.4277	10.806	.5504	10.877	.3635	10.740	.3171	10.817	.4027	10.888
.4284	10.815	.5535	10.879	.3673	10.751	.3191	10.823	.4194	10.864
.4304	10.805	.5561	10.874	.3713	10.748	.3205	10.839	.4237	10.855
.4319	10.811	.5594	10.867	.3763	10.750	.3226	10.854	.4257	10.855
.4340	10.818	.5647	10.843	.3809	10.764	.3235	10.851	595.3274	10.925
.4358	10.813	.5673	10.845	.3850	10.771	.3265	10.846	.3289	10.926
.4379	10.803	.5700	10.851	.3889	10.776	.3271	10.846	.3306	10.923
.4386	10.819	578.2850	10.781	.3929	10.769	.3297	10.859	.3313	10.917
.4405	10.825	.2866	10.779	.3968	10.770	.3305	10.873	.3332	10.925
.4412	10.810	.2883	10.775	583.3581	10.799	.3323	10.868	.3348	10.923
.4431	10.819	.2890	10.777	.3600	10.794	.3338	10.873	.3367	10.906
.4438	10.818	.2947	10.764	.3608	10.801	.3357	10.877	.3374	10.901
.4459	10.811	.2961	10.778	.3633	10.807	.3365	10.858	.3392	10.902
.4474	10.813	.2978	10.774	.3653	10.814	.3385	10.863	.3399	10.897
.4494	10.821	.2993	10.756	.3671	10.807	.3392	10.867	.3418	10.902
.4501	10.826	.3011	10.763	.3678	10.813	.3411	10.869	.3433	10.893
.4532	10.831	.3025	10.767	.3695	10.818	.3433	10.877	.3453	10.893
.4560	10.833	.3042	10.760	.3704	10.826	.3458	10.873	.3460	10.885
.4567	10.829	.3057	10.765	.3725	10.825	.3467	10.884	.3479	10.892
.4591	10.834	.3075	10.753	.3732	10.809	.3523	10.899	.3502	10.887
.4597	10.836	.3091	10.766	.3757	10.841	.3542	10.906	.3525	10.875
.4635	10.855	.3108	10.756	.3788	10.840	.3562	10.905	.3543	10.883
.4657	10.866	.3126	10.752	.3815	10.838	.3570	10.903	.3550	10.866
.4684	10.869	.3150	10.740	.3821	10.831	.3590	10.901	.3567	10.876
.4715	10.882	.3157	10.746	.3849	10.836	.3607	10.905	.3574	10.871
.4756	10.888	.3176	10.761	.3873	10.845	.3628	10.913	.3590	10.866
.4822	10.889	.3194	10.760	.3900	10.840	.3637	10.916	.3613	10.873
.4887	10.911	.3212	10.760	.3927	10.839	.3661	10.919	.3629	10.870
.4923	10.916	.3227	10.760	589.2943	10.802	.3667	10.914	.3659	10.857
.4953	10.921	.3245	10.763	.2962	10.801	.3689	10.927	.3669	10.861
.4990	10.922	.3252	10.756	.2970	10.800	.3710	10.929	.3688	10.860
.5041	10.924	.3270	10.762	.2991	10.796	.3741	10.922	.3703	10.851
.5079	10.934	.3277	10.764	.3005	10.793	.3782	10.924	.3723	10.847

HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B	HEL. J.D. 2443..	B
905.5183	10.861	905.5688	11.559	926.3063	10.835	926.3572	10.926	926.4133	10.841
.5201	10.857	.5709	11.604	.3082	10.858	.3594	10.933	.4141	10.843
.5220	10.879	.5724	11.646	.3087	10.858	.3601	10.933	.4148	10.845
.5227	10.880	.5731	11.667	.3094	10.866	.3616	10.928	.4156	10.839
.5248	10.895	.5755	11.710	.3117	10.864	.3637	10.919	.4176	10.850
.5269	10.913	.5762	11.718	.3126	10.859	.3643	10.917	.4186	10.836
.5288	10.948	.5780	11.733	.3133	10.861	.3675	10.927	.4193	10.834
.5295	10.954	.5818	11.786	.3154	10.869	.3697	10.921	.4211	10.821
.5317	10.988	.5863	11.805	.3172	10.877	.3717	10.908	.4231	10.843
.5324	10.985	.5898	11.776	.3192	10.886	.3739	10.915	.4253	10.830
.5343	10.984	.5931	11.723	.3205	10.884	.3745	10.919	.4262	10.818
.5351	11.002	.5959	11.654	.3227	10.895	.3749	10.911	.4269	10.806
.5370	11.025	.5974	11.615	.3235	10.895	.3757	10.909	.4309	10.794
.5378	11.021	.6011	11.549	.3256	10.892	.3778	10.905	.4316	10.803
.5399	11.052	.6030	11.489	.3264	10.888	.3785	10.908	.4323	10.813
.5421	11.070	.6037	11.471	.3271	10.887	.3805	10.909	.4348	10.788
.5442	11.110	.6066	11.436	.3290	10.889	.3812	10.901	.4355	10.785
.5449	11.107	.6093	11.369	.3297	10.904	.3816	10.914	.4429	10.806
.5470	11.142	.6101	11.357	.3317	10.906	.3845	10.889	.4437	10.816
.5477	11.153	.6120	11.305	.3334	10.901	.3865	10.879	.4444	10.808
.5497	11.181	.6127	11.307	.3360	10.919	.3874	10.881	.4477	10.807
.5504	11.194	.6147	11.260	.3368	10.923	.3896	10.894	.4511	10.796
.5511	11.199	.6163	11.250	.3387	10.924	.3904	10.881	.4528	10.786
.5532	11.245	.6184	11.197	.3394	10.911	.3926	10.895	.4551	10.787
.5539	11.255	.6190	11.176	.3414	10.916	.3933	10.893	.4558	10.779
.5547	11.273	.6219	11.142	.3421	10.912	.3969	10.882	.4565	10.791
.5565	11.305	.6246	11.110	.3444	10.923	.3976	10.871	.4585	10.795
.5572	11.311	.6253	11.100	.3452	10.928	.3983	10.861	.4591	10.772
.5580	11.331	.6272	11.059	.3468	10.932	.4004	10.850	.4599	10.784
.5600	11.363	.6279	11.057	.3489	10.919	.4012	10.853	.4627	10.785
.5618	11.404	.6300	11.036	.3496	10.927	.4030	10.851	.4634	10.795
.5639	11.448	.6307	11.036	.3516	10.930	.4064	10.854	.4653	10.783
.5646	11.462	.6331	11.021	.3524	10.942	.4088	10.851	.4667	10.795
.5653	11.483	926.2990	10.834	.3538	10.942	.4105	10.851	.4687	10.796
.5673	11.527	.3018	10.833	.3555	10.932	.4111	10.841	.4694	10.791
.5681	11.543	.3025	10.830						

TABLE II. — *V observations of GW Gem.*

HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V
514.4799	10.668	514.6184	10.539	543.3968	10.480	543.4785	10.551	543.5431	11.398
.4833	10.697	.6236	10.529	.3976	10.481	.4817	10.569	.5452	11.419
.4855	10.741	543.3214	10.508	.3995	10.480	.4825	10.567	.5460	11.441
.4879	10.755	.3231	10.515	.4014	10.472	.4849	10.579	.5467	11.433
.4904	10.775	.3257	10.501	.4035	10.478	.4867	10.583	.5488	11.441
.4936	10.821	.3267	10.498	.4060	10.489	.4877	10.601	.5497	11.440
.4958	10.837	.3292	10.507	.4080	10.496	.4896	10.607	.5505	11.437
.4985	10.886	.3309	10.511	.4089	10.491	.4904	10.621	.5523	11.427
.5018	10.944	.3334	10.492	.4128	10.487	.4926	10.638	.5531	11.418
.5042	10.988	.3345	10.498	.4135	10.483	.4939	10.668	.5538	11.425
.5066	11.041	.3367	10.500	.4154	10.491	.4948	10.659	.5559	11.403
.5091	11.062	.3385	10.502	.4161	10.487	.4974	10.676	.5566	11.403
.5115	11.105	.3406	10.507	.4183	10.486	.4983	10.689	.5579	11.378
.5122	11.117	.3430	10.502	.4198	10.492	.4993	10.708	.5603	11.361
.5145	11.162	.3452	10.512	.4226	10.500	.5014	10.734	.5611	11.318
.5167	11.204	.3459	10.508	.4245	10.502	.5021	10.730	.5630	11.282
.5188	11.254	.3492	10.494	.4265	10.496	.5042	10.751	.5646	11.265
.5210	11.283	.3520	10.493	.4272	10.492	.5055	10.772	.5665	11.230
.5256	11.373	.3542	10.489	.4301	10.504	.5078	10.800	.5671	11.226
.5278	11.399	.3549	10.487	.4323	10.513	.5085	10.809	.5682	11.202
.5302	11.412	.3567	10.485	.4330	10.496	.5107	10.844	.5705	11.161
.5331	11.451	.3580	10.488	.4365	10.501	.5114	10.854	.5713	11.143
.5356	11.456	.3602	10.482	.4372	10.507	.5135	10.888	.5724	11.108
.5382	11.443	.3626	10.489	.4393	10.511	.5149	10.911	.5742	11.085
.5425	11.391	.3636	10.483	.4402	10.503	.5159	10.915	.5752	11.071
.5447	11.337	.3659	10.489	.4432	10.515	.5181	10.948	.5760	11.050
.5492	11.261	.3667	10.485	.4439	10.515	.5189	10.959	.5779	11.032
.5536	11.198	.3690	10.482	.4464	10.512	.5231	11.040	.5788	10.996
.5557	11.113	.3715	10.480	.4471	10.524	.5239	11.043	.5808	10.968
.5578	11.081	.3740	10.491	.4495	10.528	.5258	11.078	.5815	10.958
.5607	11.027	.3747	10.479	.4516	10.538	.5266	11.089	.5838	10.923
.5625	11.004	.3769	10.479	.4535	10.538	.5274	11.105	.5847	10.906
.5648	10.967	.3780	10.481	.4582	10.532	.5301	11.160	.5854	10.898
.5672	10.927	.3806	10.476	.4592	10.536	.5310	11.178	.5876	10.869
.5680	10.930	.3814	10.482	.4616	10.543	.5319	11.206	.5884	10.864
.5821	10.737	.3837	10.472	.4643	10.545	.5338	11.246	.5895	10.845
.5858	10.714	.3847	10.469	.4652	10.544	.5346	11.265	.5904	10.836
.5906	10.659	.3871	10.477	.4673	10.548	.5354	11.271	.5913	10.823
.5952	10.641	.3893	10.482	.4688	10.540	.5382	11.319	.5936	10.789
.5983	10.611	.3914	10.474	.4713	10.540	.5391	11.335	.5945	10.784
.6033	10.598	.3921	10.475	.4740	10.549	.5399	11.342	.5964	10.739
.6078	10.580	.3939	10.475	.4749	10.543	.5417	11.375	.5969	10.737
.6137	10.546	.3946	10.478	.4778	10.550	.5424	11.381	.5988	10.722

HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V
595.3515	10.612	596.3738	10.578	849.4935	10.849	876.3986	10.495	876.4779	10.538
.3522	10.610	.3756	10.577	.4956	10.867	.3994	10.492	.4823	10.540
.3540	10.612	.3763	10.582	.4964	10.885	.4021	10.491	.4831	10.544
.3547	10.608	.3782	10.557	.4968	10.896	.4028	10.489	.4907	10.549
.3564	10.609	.3802	10.562	.5046	11.018	.4053	10.489	.4914	10.554
.3570	10.616	.3832	10.553	.5064	11.052	.4060	10.477	.4938	10.559
.3587	10.599	.3839	10.542	.5086	11.085	.4085	10.487	.4945	10.558
.3601	10.596	.3858	10.540	.5093	11.100	.4092	10.488	.4968	10.567
.3619	10.604	.3866	10.540	.5140	11.192	.4119	10.481	.4985	10.578
.3626	10.593	.3900	10.541	.5179	11.290	.4135	10.490	.5007	10.587
.3662	10.590	.3940	10.536	.5234	11.373	.4159	10.481	.5050	10.586
.3672	10.592	.3969	10.544	.5281	11.448	.4166	10.481	.5088	10.602
.3691	10.576	.4006	10.522	.5321	11.475	.4190	10.493	.5146	10.653
.3706	10.578	.4062	10.517	.5365	11.460	.4197	10.497	.5153	10.667
.3726	10.572	.4088	10.521	.5407	11.389	.4221	10.508	.5175	10.695
.3754	10.574	.4156	10.523	.5439	11.323	.4228	10.494	.5182	10.703
.3760	10.564	849.4510	10.539	876.3396	10.520	.4252	10.508	.5206	10.725
.3779	10.563	.4521	10.539	.3413	10.517	.4268	10.500	.5213	10.723
.3786	10.561	.4541	10.544	.3438	10.515	.4298	10.515	.5254	10.779
.3804	10.561	.4557	10.551	.3483	10.513	.4305	10.502	.5263	10.799
.3820	10.548	.4579	10.549	.3499	10.519	.4330	10.501	.5288	10.817
.3848	10.557	.4586	10.557	.3526	10.520	.4337	10.498	.5298	10.833
.3876	10.552	.4606	10.557	.3533	10.509	.4345	10.495	.5343	10.929
.3889	10.538	.4625	10.562	.3558	10.506	.4368	10.492	.5351	10.924
.3905	10.537	.4646	10.586	.3565	10.495	.4376	10.491	.5381	10.998
.3920	10.538	.4664	10.586	.3589	10.508	.4401	10.482	.5415	11.053
.3936	10.529	.4685	10.600	.3598	10.504	.4418	10.493	.5442	11.091
.3950	10.536	.4692	10.610	.3624	10.509	.4441	10.484	.5449	11.086
.3985	10.536	.4713	10.611	.3633	10.514	.4450	10.490	.5472	11.141
.4088	10.514	.4720	10.621	.3662	10.499	.4457	10.486	.5480	11.144
.4143	10.503	.4741	10.634	.3671	10.488	.4480	10.493	.5505	11.211
.4160	10.506	.4757	10.640	.3679	10.478	.4491	10.489	.5512	11.217
.4184	10.512	.4776	10.664	.3706	10.479	.4515	10.486	.5533	11.252
.4205	10.500	.4784	10.677	.3714	10.490	.4522	10.486	.5541	11.287
.4236	10.503	.4805	10.707	.3721	10.481	.4533	10.496	.5563	11.326
.4252	10.510	.4812	10.710	.3753	10.492	.4557	10.499	.5570	11.324
596.3603	10.639	.4835	10.727	.3760	10.496	.4576	10.504	.5603	11.381
.3619	10.647	.4852	10.746	.3785	10.479	.4585	10.497	.5611	11.402
.3638	10.624	.4872	10.770	.3793	10.479	.4609	10.516	.5641	11.442
.3666	10.621	.4881	10.780	.3921	10.477	.4632	10.508	.5672	11.440
.3690	10.610	.4888	10.788	.3928	10.485	.4658	10.513	.5679	11.452
.3710	10.602	.4910	10.820	.3953	10.479	.4665	10.508	.5686	11.462
.3718	10.603	.4927	10.846	.3960	10.475	.4772	10.537	.5708	11.445

HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V
543.6017	10.693	544.3331	10.503	544.4030	10.491	544.4725	10.549	577.2960	10.514
.6025	10.674	.3338	10.503	.4037	10.496	.4756	10.553	.2989	10.521
.6045	10.658	.3360	10.492	.4061	10.496	.4791	10.559	.3034	10.507
.6055	10.660	.3369	10.495	.4069	10.491	.4799	10.561	.3056	10.507
.6075	10.634	.3389	10.498	.4089	10.508	.4819	10.565	.3064	10.507
.6096	10.620	.3396	10.495	.4096	10.497	.4827	10.566	.3120	10.500
.6115	10.611	.3417	10.488	.4117	10.506	.4859	10.572	.3140	10.490
.6124	10.598	.3424	10.487	.4124	10.501	.4882	10.591	.3148	10.490
544.2742	10.585	.3446	10.491	.4143	10.503	.4892	10.589	.3170	10.511
.2760	10.570	.3453	10.497	.4150	10.502	.4913	10.581	.3544	10.484
.2777	10.573	.3474	10.501	.4170	10.507	.4933	10.599	.3564	10.481
.2794	10.567	.3481	10.495	.4181	10.506	.4966	10.612	.3589	10.496
.2802	10.566	.3505	10.504	.4204	10.505	.4989	10.604	.3596	10.482
.2821	10.556	.3512	10.497	.4227	10.490	.4966	10.606	.3617	10.493
.2828	10.556	.3532	10.497	.4249	10.487	.5036	10.630	.3638	10.491
.2848	10.543	.3549	10.503	.4274	10.496	.5044	10.623	.3661	10.498
.2866	10.543	.3571	10.491	.4295	10.496	.5071	10.636	.3668	10.495
.2885	10.546	.3578	10.493	.4303	10.506	.5081	10.630	.3687	10.489
.2904	10.547	.3599	10.491	.4325	10.512	.5311	10.670	.3694	10.490
.2923	10.531	.3620	10.485	.4332	10.506	.5330	10.682	.3717	10.480
.2929	10.537	.3642	10.485	.4352	10.502	.5353	10.681	.3730	10.489
.2950	10.555	.3651	10.485	.4359	10.500	.5367	10.679	.3749	10.498
.2968	10.544	.3673	10.488	.4380	10.508	.5403	10.690	.3767	10.498
.2976	10.543	.3682	10.479	.4388	10.504	.5439	10.676	.3786	10.491
.2995	10.527	.3708	10.487	.4410	10.512	.5462	10.675	.3792	10.490
.3016	10.537	.3715	10.479	.4416	10.504	.5485	10.669	.3811	10.486
.3034	10.537	.3736	10.483	.4435	10.501	.5506	10.675	.3821	10.491
.3053	10.523	.3759	10.494	.4457	10.507	.5513	10.674	.3842	10.478
.3074	10.521	.3782	10.470	.4476	10.511	.5534	10.676	.3850	10.482
.3081	10.524	.3791	10.468	.4499	10.512	.5553	10.671	.3871	10.475
.3103	10.527	.3812	10.469	.4520	10.523	.5588	10.666	.3879	10.483
.3122	10.513	.3821	10.472	.4527	10.522	.5617	10.658	.3905	10.477
.3129	10.515	.3840	10.474	.4548	10.535	.5645	10.664	.3925	10.493
.3194	10.534	.3847	10.470	.4573	10.532	.5672	10.660	.3949	10.499
.3157	10.519	.3870	10.479	.4593	10.539	.5706	10.642	.3966	10.497
.3180	10.509	.3877	10.480	.4601	10.534	577.2844	10.519	.3990	10.495
.3201	10.512	.3898	10.479	.4623	10.542	.2853	10.512	.3998	10.498
.3224	10.501	.3920	10.481	.4631	10.535	.2888	10.497	.4021	10.490
.3232	10.505	.3929	10.488	.4653	10.534	.2902	10.513	.4030	10.493
.3252	10.515	.3949	10.476	.4661	10.540	.2910	10.507	.4051	10.501
.3274	10.499	.3973	10.496	.4685	10.549	.2924	10.501	.4059	10.505
.3299	10.493	.4002	10.491	.4693	10.552	.2935	10.523	.4080	10.515
.3308	10.499	.4010	10.496	.4715	10.554	.2949	10.512	.4087	10.509

HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V
876.5716	11.449	903.4940	10.519	903.5719	10.908	905.3514	10.512	905.4203	10.491
.5736	11.435	.4974	10.520	.5735	10.919	.3530	10.511	.4223	10.499
.5743	11.423	.4989	10.515	.5738	10.921	.3550	10.512	.4230	10.491
.5764	11.398	.5010	10.517	.5760	10.961	.3559	10.511	.4250	10.491
.5779	11.386	.5018	10.514	.5774	10.984	.3585	10.513	.4257	10.492
.5805	11.338	.5040	10.517	.5777	10.997	.3597	10.515	.4277	10.494
.5837	11.264	.5048	10.514	.5791	11.027	.3617	10.516	.4285	10.485
.5845	11.252	.5085	10.517	905.2953	10.609	.3625	10.506	.4305	10.481
.5868	11.205	.5092	10.510	.2968	10.605	.3645	10.508	.4314	10.492
.5880	11.196	.5113	10.517	.2988	10.605	.3653	10.514	.4334	10.491
.5889	11.164	.5119	10.525	.2996	10.608	.3674	10.521	.4351	10.488
.5914	11.111	.5142	10.520	.3018	10.592	.3691	10.512	.4371	10.504
.5921	11.095	.5162	10.522	.3030	10.596	.3711	10.519	.4379	10.492
.5937	11.071	.5170	10.523	.3052	10.584	.3718	10.502	.4405	10.490
.5965	11.035	.5190	10.529	.3059	10.582	.3738	10.508	.4412	10.488
.5992	10.997	.5206	10.524	.3077	10.589	.3745	10.512	.4432	10.500
.5999	10.974	.5225	10.539	.3093	10.592	.3767	10.512	.4444	10.499
.6141	10.785	.5233	10.531	.3111	10.586	.3778	10.502	.4482	10.489
903.4369	10.478	.5261	10.540	.3118	10.580	.3803	10.495	.4490	10.505
.4385	10.489	.5268	10.545	.3138	10.569	.3818	10.500	.4509	10.492
.4407	10.488	.5288	10.544	.3145	10.568	.3838	10.492	.4516	10.491
.4428	10.480	.5295	10.549	.3166	10.565	.3865	10.501	.4552	10.487
.4443	10.483	.5315	10.553	.3180	10.559	.3872	10.488	.4559	10.496
.4465	10.497	.5323	10.546	.3201	10.561	.3892	10.488	.4579	10.496
.4472	10.482	.5330	10.543	.3209	10.559	.3899	10.484	.4586	10.486
.4494	10.487	.5351	10.557	.3231	10.552	.3922	10.489	.4606	10.494
.4502	10.481	.5371	10.566	.3238	10.543	.3938	10.489	.4614	10.496
.4526	10.480	.5396	10.577	.3257	10.548	.3957	10.478	.4645	10.497
.4543	10.487	.5404	10.581	.3274	10.543	.3990	10.484	.4652	10.505
.4564	10.482	.5430	10.611	.3295	10.533	.3997	10.489	.4673	10.505
.4571	10.476	.5450	10.627	.3302	10.526	.4017	10.474	.4682	10.500
.4609	10.474	.5458	10.628	.3322	10.535	.4024	10.468	.4704	10.500
.4655	10.479	.5478	10.644	.3331	10.548	.4043	10.464	.4710	10.503
.4687	10.485	.5487	10.662	.3351	10.541	.4050	10.468	.4731	10.513
.4755	10.503	.5520	10.657	.3360	10.526	.4069	10.475	.4748	10.518
.4788	10.500	.5574	10.725	.3380	10.518	.4085	10.476	.4768	10.526
.4807	10.505	.5596	10.753	.3396	10.522	.4105	10.470	.4775	10.522
.4815	10.505	.5619	10.766	.3417	10.519	.4112	10.468	.4795	10.529
.4842	10.510	.5640	10.793	.3424	10.508	.4132	10.485	.4802	10.524
.4866	10.517	.5661	10.830	.3445	10.513	.4150	10.493	.4823	10.520
.4874	10.510	.5684	10.856	.3451	10.513	.4168	10.488	.4830	10.525
.4900	10.509	.5701	10.859	.3469	10.515	.4175	10.491	.4867	10.526
.4917	10.512	.5716	10.910	.3478	10.505	.4196	10.492	.4875	10.531

HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V
577.4129	10.523	577.5284	10.673	578.3359	10.479	583.3788	10.558	589.3538	10.644
.4136	10.523	.5323	10.654	.3383	10.473	.3796	10.555	.3559	10.650
.4156	10.521	.5360	10.657	.3412	10.477	.3818	10.571	.3566	10.662
.4172	10.521	.5398	10.636	.3440	10.485	.3824	10.568	.3586	10.652
.4192	10.514	.5433	10.631	.3465	10.470	.3857	10.574	.3604	10.658
.4199	10.522	.5474	10.606	.3508	10.478	.3897	10.570	.3633	10.665
.4219	10.527	.5500	10.615	.3535	10.479	.3914	10.569	.3643	10.668
.4226	10.533	.5531	10.609	.3564	10.495	.3941	10.580	.3664	10.664
.4246	10.520	.5558	10.596	.3603	10.483	589.2939	10.528	.3671	10.679
.4253	10.517	.5597	10.573	.3635	10.477	.2958	10.515	.3689	10.676
.4272	10.522	.5643	10.562	.3651	10.479	.2967	10.521	.3701	10.683
.4281	10.526	.5670	10.565	.3664	10.494	.2988	10.535	.3727	10.683
.4300	10.534	.5696	10.548	.3678	10.485	.3002	10.540	.3745	10.674
.4316	10.534	578.2853	10.498	.3690	10.478	.3021	10.532	.3786	10.702
.4336	10.537	.2869	10.495	.3704	10.482	.3049	10.532	.3816	10.703
.4355	10.529	.2886	10.486	.3718	10.480	.3058	10.529	.3850	10.687
.4375	10.537	.2893	10.486	.3732	10.481	.3078	10.533	.3884	10.683
.4382	10.533	.2950	10.494	.3746	10.477	.3093	10.531	.3913	10.678
.4402	10.544	.2964	10.498	.3752	10.478	.3113	10.533	.3937	10.684
.4409	10.548	.2982	10.489	.3765	10.485	.3120	10.541	.3969	10.682
.4428	10.553	.2996	10.492	.3779	10.499	.3140	10.535	.3935	10.666
.4435	10.547	.3015	10.490	.3795	10.494	.3148	10.530	.4016	10.659
.4463	10.548	.3029	10.494	.3815	10.501	.3167	10.547	.4047	10.669
.4494	10.550	.3046	10.479	.3836	10.498	.3174	10.551	.4074	10.651
.4533	10.565	.3078	10.477	.3858	10.501	.3195	10.555	.4131	10.621
.4560	10.558	.3094	10.482	.3876	10.512	.3210	10.556	.4190	10.611
.4590	10.559	.3111	10.475	.3896	10.501	.3230	10.580	.4222	10.602
.4641	10.589	.3130	10.483	.3916	10.513	.3238	10.579	595.3270	10.692
.4668	10.582	.3153	10.482	.3935	10.523	.3261	10.578	.3286	10.677
.4694	10.606	.3160	10.489	.3952	10.504	.3268	10.572	.3303	10.675
.4740	10.620	.3179	10.503	583.3578	10.525	.3300	10.571	.3310	10.670
.4850	10.633	.3197	10.491	.3597	10.528	.3308	10.580	.3329	10.666
.4883	10.647	.3216	10.495	.3605	10.528	.3326	10.596	.3343	10.679
.4918	10.655	.3230	10.484	.3636	10.531	.3341	10.591	.3363	10.654
.4954	10.673	.3248	10.489	.3656	10.542	.3360	10.590	.3370	10.652
.4999	10.682	.3256	10.486	.3674	10.540	.3368	10.587	.3388	10.646
.5044	10.683	.3274	10.497	.3681	10.544	.3388	10.605	.3395	10.647
.5083	10.693	.3280	10.491	.3698	10.548	.3395	10.605	.3415	10.649
.5109	10.682	.3301	10.494	.3708	10.545	.3414	10.608	.3430	10.642
.5136	10.679	.3307	10.504	.3728	10.539	.3430	10.619	.3456	10.635
.5174	10.682	.3326	10.485	.3735	10.543	.3462	10.618	.3463	10.631
.5200	10.689	.3333	10.489	.3751	10.554	.3471	10.626	.3482	10.626
.5228	10.685	.3351	10.476	.3770	10.556	.3512	10.647	.3489	10.632

HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V	HEL. J.D. 2443..	V
905.4896	10.533	905.5508	10.903	905.6194	10.898	926.3464	10.680	926.4045	10.581
.4904	10.533	.5528	10.949	.6222	10.854	.3471	10.679	.4083	10.576
.4966	10.533	.5535	10.950	.6249	10.826	.3493	10.680	.4092	10.568
.4973	10.533	.5543	10.966	.6256	10.812	.3500	10.672	.4108	10.566
.4992	10.542	.5562	10.999	.6276	10.785	.3520	10.696	.4115	10.568
.5000	10.540	.5569	11.018	.6284	10.771	.3527	10.691	.4137	10.566
.5020	10.533	.5576	11.036	.6303	10.746	.3541	10.694	.4144	10.566
.5028	10.537	.5597	11.073	.6310	10.739	.3561	10.677	.4151	10.569
.5047	10.536	.5615	11.117	.6330	10.728	.3569	10.679	.4159	10.565
.5062	10.533	.5635	11.138	926.2986	10.558	.3591	10.678	.4183	10.562
.5082	10.537	.5642	11.154	.3001	10.571	.3598	10.689	.4190	10.554
.5089	10.542	.5649	11.161	.3022	10.559	.3605	10.681	.4196	10.552
.5107	10.540	.5669	11.226	.3029	10.560	.3633	10.678	.4203	10.538
.5115	10.540	.5676	11.236	.3049	10.567	.3640	10.669	.4227	10.556
.5134	10.556	.5685	11.254	.3067	10.564	.3679	10.675	.4235	10.551
.5141	10.549	.5705	11.285	.3091	10.580	.3686	10.677	.4257	10.544
.5161	10.561	.5721	11.318	.3098	10.583	.3705	10.668	.4265	10.533
.5167	10.565	.5728	11.327	.3121	10.584	.3714	10.672	.4272	10.541
.5186	10.583	.5751	11.380	.3129	10.595	.3735	10.660	.4305	10.531
.5204	10.586	.5758	11.394	.3137	10.606	.3742	10.675	.4313	10.527
.5224	10.608	.5765	11.408	.3157	10.612	.3754	10.671	.4319	10.537
.5231	10.614	.5815	11.427	.3185	10.612	.3775	10.659	.4344	10.522
.5252	10.625	.5849	11.445	.3201	10.620	.3782	10.643	.4392	10.526
.5265	10.641	.5869	11.441	.3223	10.619	.3802	10.658	.4440	10.529
.5284	10.667	.5890	11.447	.3230	10.629	.3809	10.656	.4448	10.528
.5292	10.674	.5898	11.432	.3252	10.632	.3850	10.629	.4481	10.522
.5313	10.685	.5919	11.420	.3260	10.624	.3869	10.621	.4523	10.512
.5320	10.701	.5935	11.370	.3267	10.640	.3878	10.637	.4531	10.521
.5340	10.698	.5956	11.347	.3287	10.640	.3900	10.622	.4554	10.504
.5347	10.712	.5970	11.308	.3294	10.638	.3907	10.630	.4561	10.512
.5367	10.731	.6014	11.208	.3314	10.649	.3930	10.625	.4568	10.510
.5374	10.743	.6033	11.198	.3331	10.653	.3937	10.613	.4588	10.508
.5396	10.766	.6040	11.171	.3364	10.660	.3966	10.609	.4596	10.500
.5417	10.786	.6069	11.130	.3371	10.657	.3973	10.608	.4630	10.503
.5438	10.810	.6101	11.055	.3391	10.651	.3980	10.610	.4637	10.515
.5445	10.821	.6123	11.023	.3397	10.652	.4001	10.592	.4657	10.505
.5466	10.851	.6130	11.002	.3417	10.658	.4009	10.590	.4671	10.513
.5473	10.859	.6150	10.970	.3427	10.662	.4017	10.592	.4690	10.499
.5494	10.890	.6166	10.954	.3448	10.665	.4037	10.580	.4697	10.499
.5500	10.900	.6187	10.899						

TABLE III. — *Times of minima of GW Gem.*

n	helioc. JD	m.e.	O-C	Observer	
0	2425645.569	$\pm 0^{d}.007$	$-0^{d}.011$	ph (6)	L
1131	26391.416	.007	+ .005	ph (13)	K
4325	28497.671	.006	- .004	ph (8)	L
4514	28622.324	.006	+ .014	ph (7)	K
7741	30750.346	.007	+ .010	ph (5)	L
16045	36226.348	.011	- .011	ph (5)	R,P
20555	39200.426	.003	- .026	ph (4)	R,P
24440	41762.390	.002	- .002	v (6)	BBSAG
25412	42403.367	.001	- .004	v (8)	"
26008	42796.401	.002	+ .001	v (8)	"
26474	43103.701	.004	.000	v (5)	"
27097	43514.53438	.00003	+ .00011	pe	B,C
27141	43543.55006	.00004	+ .00026	pe	"
27142.5	43544.5411	.0005	+ .0021	pe	"
27192.5	43577.5120	.0004	+ .0008	pe	"
27210.5	43589.3798	.001C	- .0014	pe	"
27605	43849.53175	.00006	- .00007	pe	"
27646	43876.56881	.00006	- .00022	pe	"
27690	43905.58451	.00001	- .00006	pe	"
27721.5	43926.3566	.0003	- .0004	pe	"

L = Löchel (1955) ; R, P = Romano and Perissinotto (1968).
K = Kippenhahn (1953) ; BBSAG = BBSAG Observers (1973-1978).
B, C = Broglia and Conconi, present work.

TABLE IV. — *Photometric elements of GW Gem.*

$i = 81°.41 \pm 0.08$ p.e. (1.4)	$r_{1,pt} = 0.380$	$r_{2,pt} = 0.415$	$g_1 = 1.00$
$q = 0.436 \pm 0.004$ (.05)	$r_{1,s} = 0.361$	$r_{2,s} = 0.302$	$g_2 = 1.00$
$\Omega_1 = 3.271 \pm 0.003$ (.017)	$r_{1,b} = 0.372$	$r_{2,b} = 0.334$	$A_1 = 1.00$
$\Omega_2 = 2.751$ (contact)	$r_{1,pl} = 0.350$	$r_{2,pl} = 0.289$	$A_2 = 0.50 \pm 0.01$ (.03)

λ	x_1	x_2	L_1
0.430μ	0.78	0.83	0.9283 ± 0.0006 (.007)
0.550	0.60	0.70	0.8936 ± 0.0008 (.008)

$\sigma = 0^{m}.008$

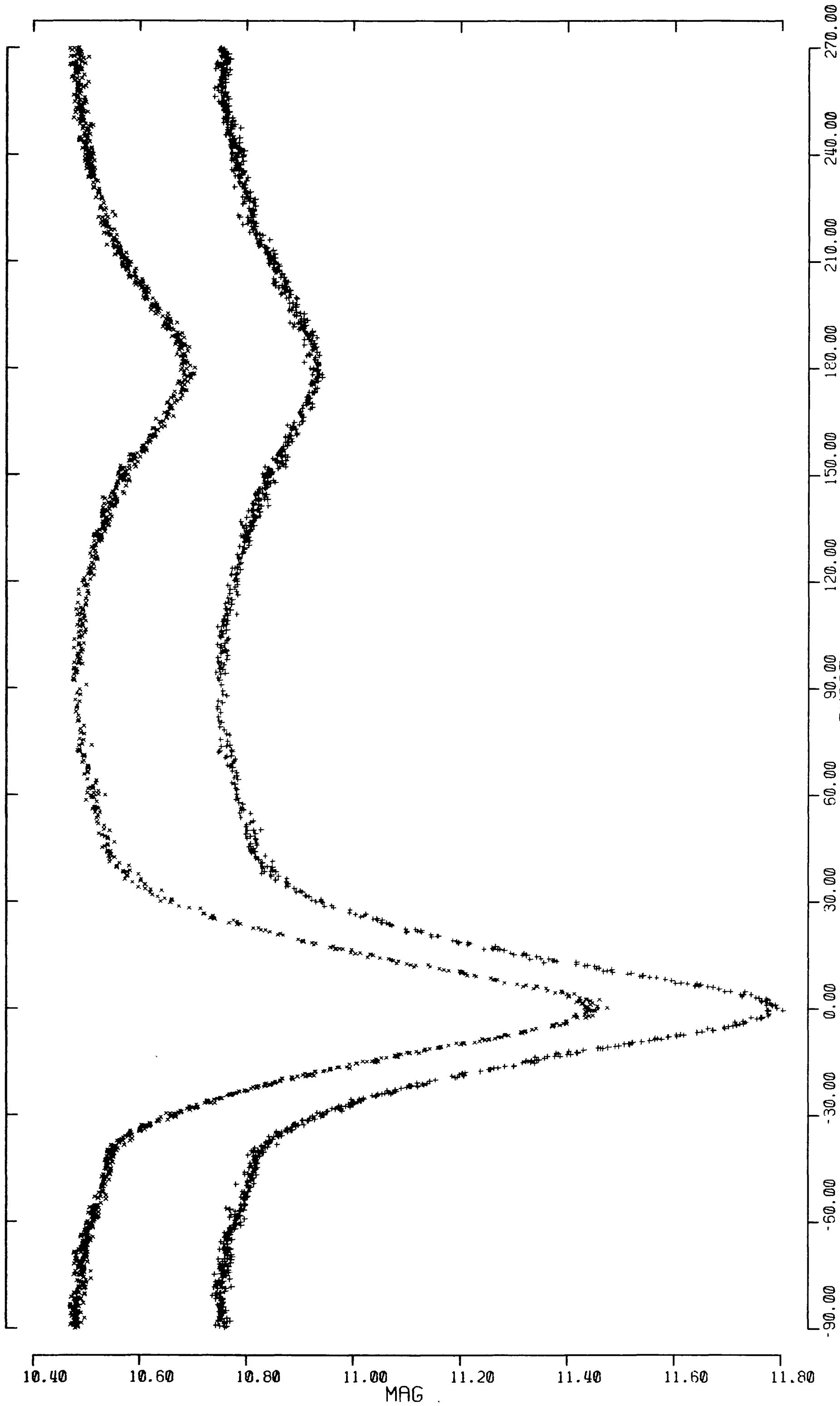

FIGURE 1. — *B* (below) and *V* (above) observations of GW Geminorum corrected for the δ Scuti variability of the comparison star (see text).

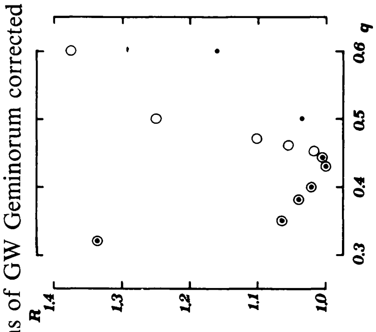

FIGURE 2. — Representation of the solutions calculated with assumed values for the mass ratio *q*. *R* is the ratio between the sum of the squares of residuals of a given solution and the corresponding value for the best solution.