

THE AUTOMATIZED PHOTOELECTRIC PHOTOMETER OF THE ASTRONOMICAL OBSERVATORY SKALNATÉ PLESO

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Abstract: An automatized photoelectric photometer has been built for the 60 cm Cassegrain telescope of the Skalnaté Pleso Observatory. The optical and mechanical unit of the photometer consists of a motorized filter wheel, a tiltable mirror, a field eyepiece with an off-set guiding possibility, a diaphragm wheel, an optical system for viewing the diaphragm and a photomultiplier box. The photometer electronics makes use of an integrating amplifier and an analog-digital converter. The photometer is provided with a digital clock, a unit for recording the collected data by a typewriter and by a paper tape punch, and with the necessary circuitry for programming and automatizing the operation of the photometer. The accuracy of the measurement as well as their transformation to the standard UBV system are given. The photometer is being used for measurements of variable stars, mostly of close binaries; magnetic stars are observed, too. As an example of UBV measurements with the photometer, the three colour data for the eclipsing binary RW Gem obtained during a six-year time interval are given.

Introduction

The wide application of the photoelectric method in astronomy has led to many advantages, the most important perhaps being a substantial increase of the accuracy of astronomical photometric observations. For some time, the photoelectric photometers were of standardized design, where the d.c. output of a photomultiplier was connected to an electronic recorder. Such a type of the photometer has been common at many observatories. However, the need to observe objects at the limit of detection has led to a different kind of photometers. In these more sophisticated photometers the photocurrent is being integrated during an exact time interval, either in analogous form in an integrating amplifier, or in digital form, in a counter which counts pulses generated by the photomultiplier. Stars many times fainter than the brightness of sky in the focal diaphragm were measured with these photometers at several occasions (Baum, 1954; Johnson, 1954). The pulse-counting method has some advantages (Baum, 1962); however, the d.c. integration can also be successfully used (Johnson, 1962; Dimov, 1963).

To make full use of the telescope observing time means to eliminate the dead times of observing process or to shorten them to a minimum.

Therefore, a faster operation of the photometer and a faster data recording than an observer can accomplish are necessary. Especially when pursuing further the exploitation of the light collected by a telescope by using several measuring channels, automatization of the photometer operation and of data collection is a necessity. When designing the photometer described below we had in mind the possibility of using more channels for simultaneous multicolour measurements, for two-channel star-sky measurements or for two-ray polarization measurements. (However, the necessary accessories to the basic photometer have not yet been provided.)

The automatized photoelectric photometer of the Astronomical Observatory Skalnaté Pleso makes use of the d.c. integrating method. The leading principle of the design was to automatize as many as possible operations connected with the photometric measurements, as well as to provide the possibility of processing the collected data by a computer. The astronomer does not need to make so many operations as before, and the precision of the measurements does not depend of his judgment. The time lost in data computation is also greatly reduced. The logic circuitry necessary for accomplishing the given desires has been based on the design of the data acquisition system UM 10 which is used for production process control in industry.

Optical Part

The photoelectric photometer is installed at the Cassegrain focus of the 600 mm reflector of the Astronomical Observatory Skalnaté Pleso. The primary focal length is 3300 mm, the focal length of the Cassegrain system is 9990 mm. The telescope had been predominantly used for astrometric programmes till 1966; since 1961 measurements were made from time to time with a standard photoelectric photometer (Tremko, 1975). The optical and mechanical unit of the automatized photometer includes an optical system, a focal diaphragm wheel, a colour filter wheel, a photomultiplier box and the necessary wiring for automatic operation of the photometer and for data displaying. The optical system utilizes the exit pupil arrangement, consequently, the performance of the photometer does not depend of the shape of the image and its position in the diaphragm. The optical system makes it possible to find the object, to point its image in the focal diaphragm, to focus the instrument and to transfer the light by means of a Fabry lens to the photocathode of the photomultiplier. The location of the optical elements in the photometer is shown in Figure 1. Figure 2 presents the te-

lescope with the photoelectric photometer and Figure 3 the optical and mechanical unit of the equipment. The operation of the optical system is controlled by the position of the mirror. If the mirror is in the position A, it is possible to look for the object required (in a field of 42 mm, i.e. 14,5 arc min in diameter), and to put the object on the optical axis. With the mirror in the position B the photometer measures; in the position C it is possible to check the location of the object in the diaphragm. With the motion of the mirror is synchronized the switching on and off of the illumination of the reticle and of the diaphragm, as well as the operation of the electronics. The data on focal diaphragms are summarized in Table 1.

The photometer optics enables an off-set guiding of faint objects. In order to avoid the necessity of moving the heavy eyepiece, a reticle with 3 mm squares (Fig. 4) is placed in the eyepiece focal plane. The reticle can be shifted by micrometric screws more than 1.5 mm in any direction from the optical axis. Therefore, at any point in the eyepiece field of view a reticle line-crossing can be located, and hence a star as far as 7 arc min from the optical axis may be used for setting a faint object on the optical axis.

The filter wheel contains presently standard filters for the *UBV* photometry, three filters for a medium-band photometry of eclipsing variable stars and three filter for a narrow-band photometry of the Balmer lines. The data on the filters available in the photometer are presented in Table 2. The setting of the appropriate filters is carried out automatically according to a pre-set programme. The transmittance of the colour filters as well as the spectral sensitivity of the photomultiplier is shown in Figure 5. An EMI 6256 B photomultiplier with the S 13 photocathode and a fused silica window is used as the detector. It is located in an uncooled box with a magnetic shielding.

Table 1

Number	Diameter mm	Diameter sec. of arc	Remarks
1	1.08	22.2	Used on nights with moonshine Used most often Used for measuring diffuse objects
2	1.78	36.8	
3	2.95	60.9	
4	5.00	103.1	
5	8.03	165.6	
6	0.80	16.5	
7	1.48 + 1.47	30.5 + 30.4	
8	1.07 + 1.08	22.1 + 22.2	

Table 2

Number	Type	Peak wavelength [Å]	Effective wavelength [Å]	Bandwidth [Å]
1	UG 2 2 mm	3550	3490	710
2	BG 12 1 mm + GG 13 2 mm	4200	4330	950
3	GG 11 2 mm	5080	5340	650
4	Medium-band 4035, interference	4040	4050	160
5	Medium-band 4670, interference	4700	4720	190
6	Medium-band 5260, interference	5275	5260	180
7	Narrow-band $H\delta$, interference	4100	4100	24
8	Narrow-band $H\gamma$, interference	4340	4341	28
9	Narrow-band $H\beta$, interference	4862	4860	40

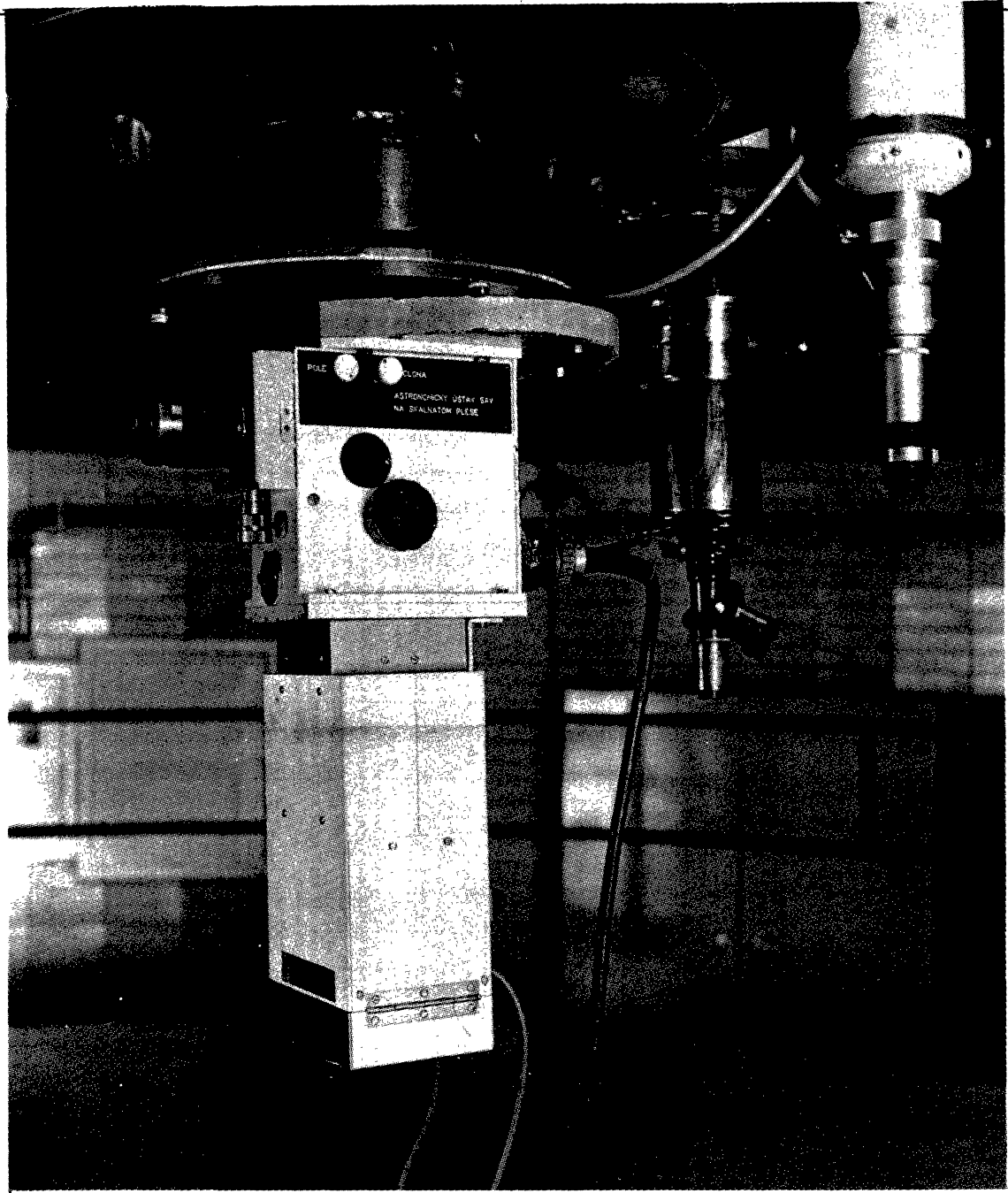


Fig. 1. The optical and mechanical unit of the photoelectric photometer. The photomultiplier tube located in the thermoelectrically refrigerated tube chamber used in summer months.

Electronics and the Operation of the Photoelectric Photometer

The block diagram of the automatized photoelectric photometer is in Figure 6. The signal is measured by a d.c. integrating amplifier with an electrometric tube at its input. The circuitry

of this amplifier is based on the paper by Weitbrecht (1957). The integrating amplifier has three different input sensitivities, with the ratios 1:10:100. The input sensitivities may be controlled either manually or automatically at considerable changes of the brightness of observed objects. Since the voltage range of the analog-digital con-

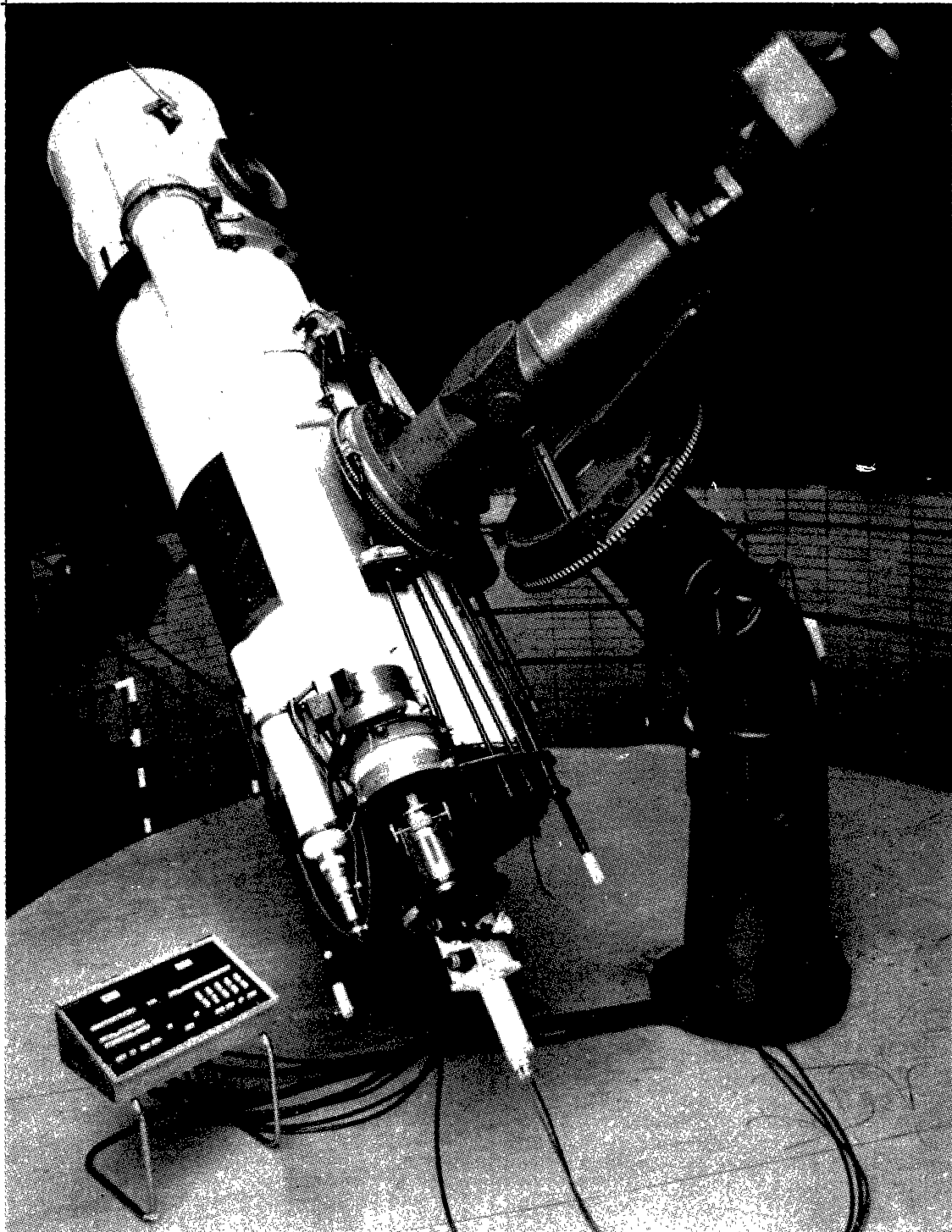


Fig. 2. The 60 cm telescope of the Skalnaté Pleso Observatory with the automatized photoelectric photometer.

verter is 11.99 volts, a lower sensitivity is switched on as soon as the integrated voltage reaches 11.0 V. This is done without disturbing the process of integration, by a parallel connection of

a larger capacitor. As the accuracy of the $A-D$ converter used is low, it was necessary also to provide for several output sensitivities. Like the input sensitivities, they may be controlled

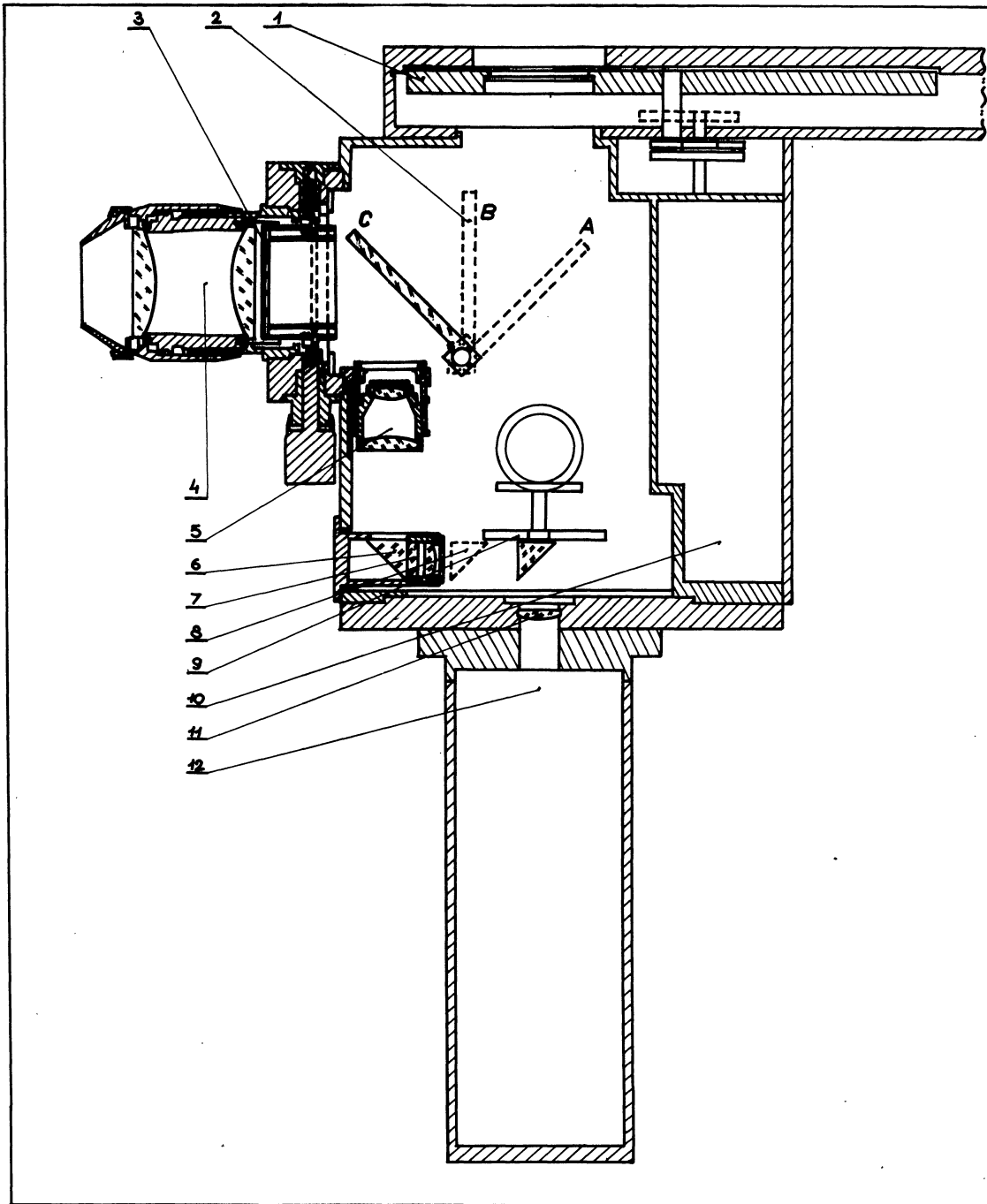


Fig. 3. Location of the optical elements in the optical and mechanical unit of the photometer: 1 - filter wheel, 2 - mirror, 3 - reticle, 4 - eyepiece, 5-8 - optical system for viewing the diaphragm, 9 - diaphragm wheel, 10 - motor compartment, 11 - Fabry lens, 12 - photomultiplier box.

either manually or automatically. There are four output ranges, with the ratio of neighbouring sensitivities 1:2.5144. The circuitry for the automatic setting of input as well as of output sensitivities makes use of the digital signal from the A-D converter. A cross-combination of input and

output sensitivities gives 12 different measurement ranges and, thus, the signal can be measured in the range of three orders.

The BCD output of the A-D converter is changed into a serial decadic code in a decoder, and in a recording unit it is changed further into an

internal code of the typewriter. The data are recorded simultaneously by a typewriter and a punching machine. The recording unit is connected not only to the A-D converter, but also to the electronic digital clock and to the digital data input unit. This unit permits to record codes of the diaphragm, colour filter, input and output sensitivities and integrating time used during

programme. This unit contains circuits which stop the operation of the photometer in the case when the optical path is not free for measurement. The automatic operation of the photometer is controlled mainly by the automation unit, the controlling unit and the input selector.

The sequence of the recordings of the individual data by the typewriter is determined by the

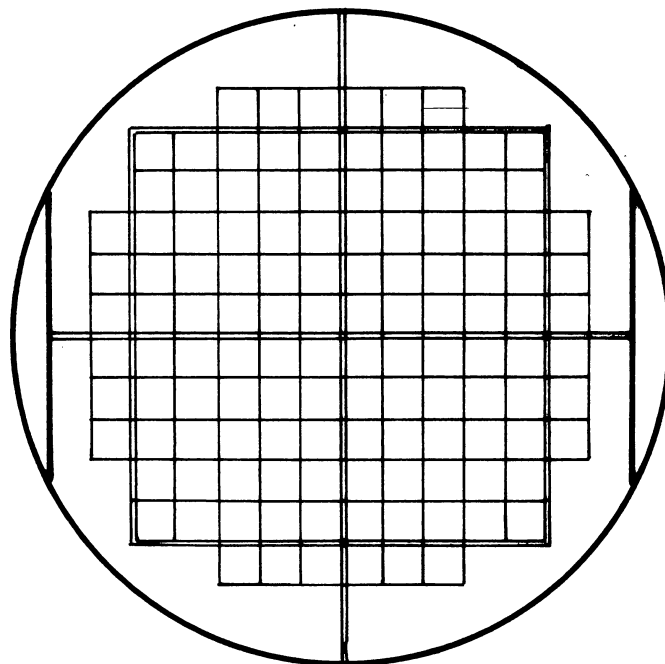


Fig. 4. The eyepiece reticle with a set of perpendicular lines for off-set guiding.

the measurement. The capacity of this unit is 20 decadic digits and 7 digits not larger than 5. A part of the capacity is used for recording data which are set manually by the observer; a code is always given for the measured object and, occasionally, hour angle, observing conditions etc. The observer may choose between two digital clocks: one indicates hours, minutes and seconds, the other gives time in decadic fractions of the day. The output signal of these clocks goes to the recording unit after being transformed into a serial decadic code in a time data decoder. The duration of the integration is set by the unit of integration time. The duration of the integration can be chosen manually within the range of 10 to 100 seconds in steps of 10 seconds. The unit of the filter wheel motion provides for a proper operation of the filter wheel motor in the optical and mechanical unit of the photometer. It facilitates a successive measuring with the built-in filters according to a previously chosen

programming unit. All parts of the photoelectric photometer, with the exception of the optical and mechanical unit, integrating amplifier and control desk, are situated in an air-conditioned room. The observer controls and checks the operation of the automatized photoelectric photometer by means of the control desk which is by the side of the telescope. Before the observation, the observer programmes colour filters, chooses the integration time and the focal diaphragm, designates the observed stars by numbers and, if required, chooses the sensitivities of the integrating amplifier. All mentioned data are indicated by digitrons on the control desk. The observer can view the clock data and at the same time the level of the signal. The operation of the photoelectric photometer, i.e. the readiness for observing, the integration, surpassing of the upper limit of the signal level and registration of the data by the typing machine, are indicated by colour signals on the control desk. For the in-

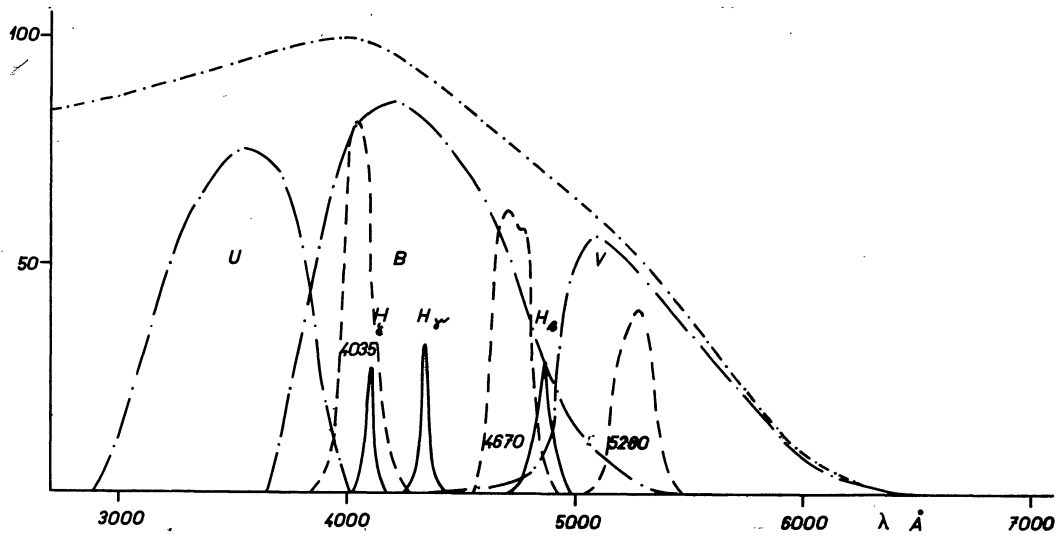


Fig. 5. The transmittance of the colour filters and the spectral response of the photomultiplier.

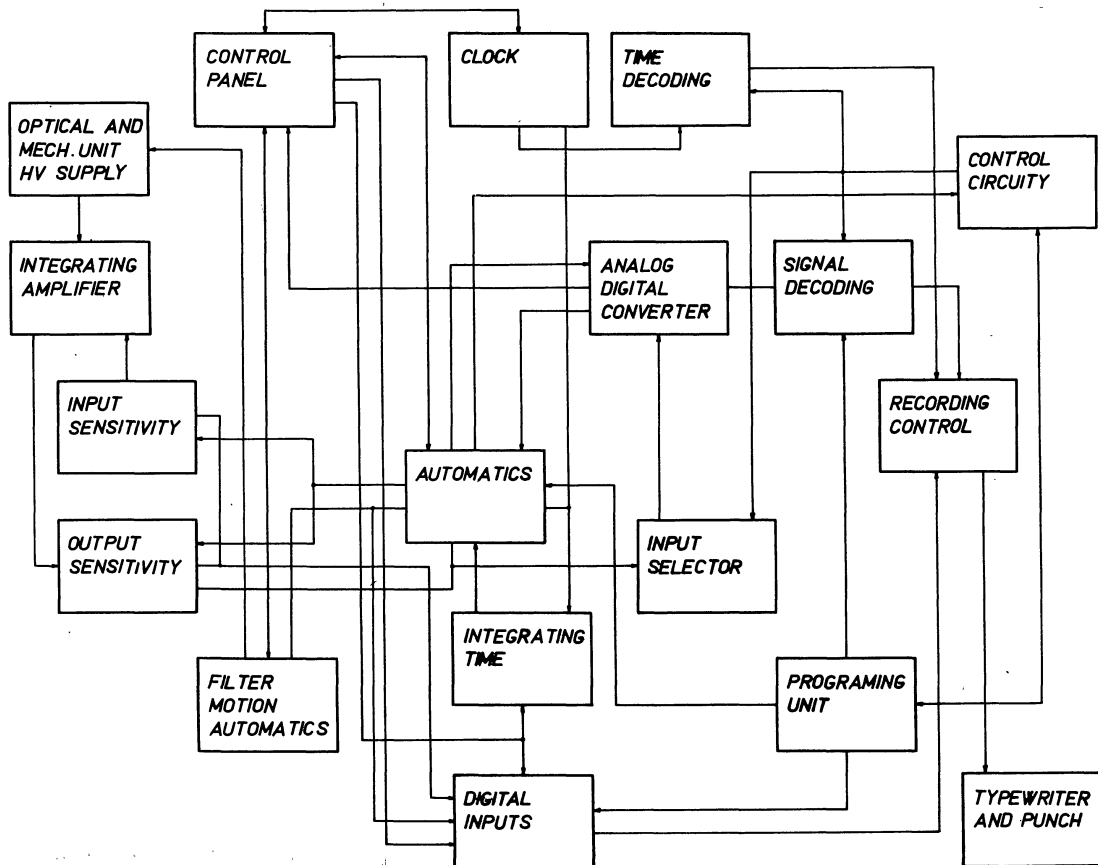


Fig. 6. The block diagram of the automatized photoelectric photometer.

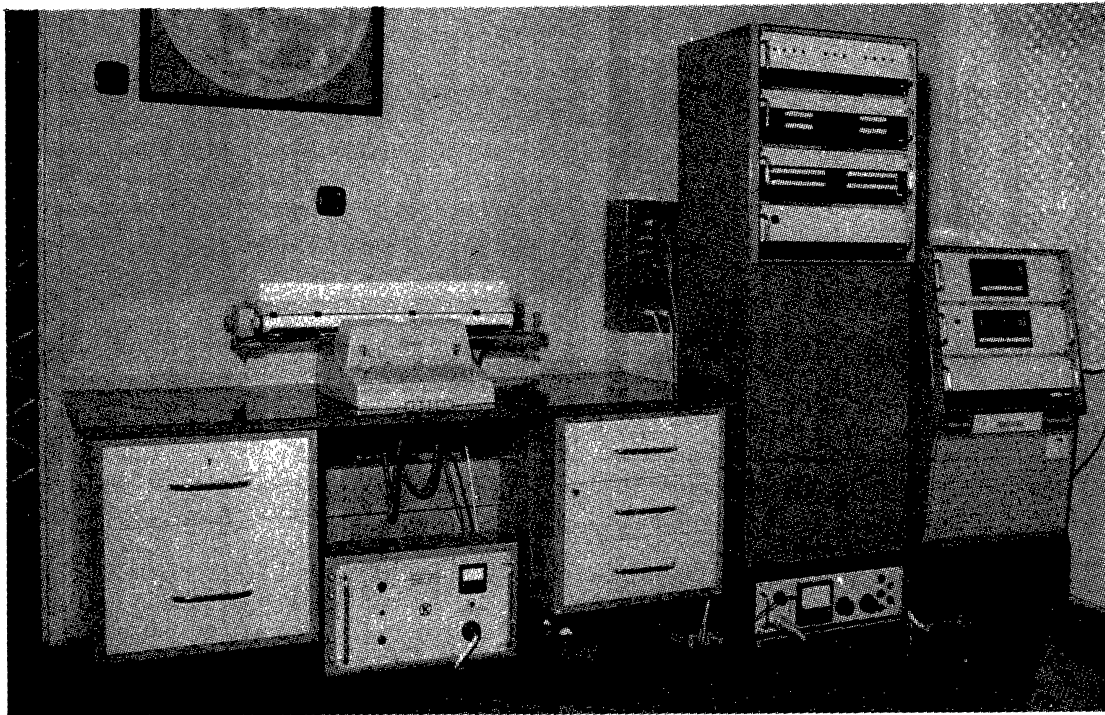


Fig. 7. The electronic part of the automatized photoelectric photometer.

tegrating amplifier a regulated power supply Tesla BS 275 is used. A regulated power supply Tesla NBZ 411 is used as the HV supply for the photomultiplier.

*The Precision of Observations
and the Photometric System*

The precision which may be achieved by the automatized photoelectric photometer depends on the accuracy of the $A-D$ converter, and is approximately $0.^m001$ with the signal level close to the upper limit, or $0.^m003$ when the signal level approaches the lower limit. The measurements of the radioactive standards of light have shown that the mean error of one observation reached the value of $0.^m0032$ and $0.^m0034$, respectively, in two different specimens (Tremko, 1969) with the integrating time 30 sec. The mean error includes not only the instrumental error but also the scintillation noise of radioactive light sources. The precision of observation is influenced by the seeing rather than by the precision of the measuring equipment. Under reasonable observation conditions, a precision of $0.^m0033$ was attained when observing stars with the integrating time 10 sec. The precision of observation of faint objects is affected by the sky brightness. The measurements of the sky bright-

ness on a moonless night in a region outside the Milky Way gave the following results: $V = 21.^m7$, $B = 21.^m9$, $U = 23.^m5$ per (arc sec)². A detailed analysis of the observational conditions at the Skalnaté Pleso Observatory as well as a study of the azimuthal effect is presented in the preceding paper (Tremko, 1975).

The photoelectric photometer is used mainly for observing variable stars. On the basis of photoelectric observations of stars of various spectral types in the open cluster NGC 7063 transformation equations were derived for the transition from the instrumental system ubv into the international photometric system UBV . The equations are as follows:

$$\begin{aligned}\Delta V &= v - 0.154(b - v), \\ \Delta(B - V) &= 1.145(b - v), \\ \Delta(U - B) &= 0.794(u - b),\end{aligned}$$

Observations of Close Binary RW Gem

Since being in operation, the photoelectric photometer has been used for observing variable stars. Greatest attention has been paid to close binaries which are observed predominantly in the UBV photometric system and in filters of medium-band photometry, with the purpose of determining the limb darkening. Magnetic stars are observed

by means of narrow-band interference filters. Extensive observational material has been obtained for the close binary RW Gem. The complete light curve was obtained for the V range; however, there are observations in other colours of the *UBV* system for some phases. The variable RW Gem was observed at Skalnaté Pleso from February 1, 1968 to March 24, 1973. The observations were difficult owing to the fact that there is a faint star in the close vicinity of the variable. The faint star was observed together with the variable so that the light of the third body is included in the brightness of the variable. HD 40740 was used as a comparison star, and on some nights also HD 250388. Table 3 shows the observed differences of brightness between the variable and HD 40740. The observations were carried out using the diaphragm 60"9 and the integrating time 10 sec. The reduction was done by the usual manner: the observed data were corrected by the brightness of the sky, the ratios of the intensities of the variable and the comparison stars were computed. The value

Δm was computed from the ratio of the intensities by means of tables. Owing to the fact that the distance between the variable and the comparison star is very small it was not necessary to make corrections for the differential extinction. In order to compute the fraction of the light of third body the observations at different phases were carried out with the smallest diaphragm 22"2 during best photometric nights. Then all observations were reduced for the third light. The observations reduced in such a manner are listed in the Table 3. The interpretation of the V observations were recently done by Tremko and Vetešník (1974).

Acknowledgements

The authors are greatly indebted to night assistants of the Skalnaté Pleso Observatory, mainly to P. Schalling, for obtaining the greatest part of the photoelectric observations and to K. Manik and P. Zimmermann for preparing the photos and the figures.

Table 3. Yellow observations

J.D. _{Hel.}	Δm	J.D. _{Hel.}	Δm	J.D. _{Hel.}	Δm	J.D. _{Hel.}	Δm
2439888.2964	1.222	.3344	1.533	.3681	2.029	.4120	3.059
.2971	1.235	.3354	1.542	.3689	2.050	.4299	2.920
.2987	1.249	.3360	1.543	.3699	2.050	.4306	2.909
.2985	1.254	.3367	1.557	.3704	2.062	.4318	2.942
.2992	1.245	.3347	1.566	.3712	2.082	.4323	2.948
.2999	1.243	.3381	1.581	.3719	2.103	.4333	2.948
.3006	1.264	.3388	1.582	.3727	2.134	.4348	2.967
.3012	1.258	.3396	1.594	.3735	2.123	.4363	2.942
.3022	1.258	.3403	1.635	.3741	2.134	.4372	2.934
.3028	1.282	.3410	1.629	.3794	2.251	.4379	2.961
.3087	1.317	.3418	1.663	.3802	2.274	.4458	2.931
.3095	1.337	.3427	1.686	.3809	2.296	.4472	2.896
.3103	1.333	.3435	1.667	.3816	2.319	.4479	2.904
.3113	1.340	.3442	1.674	.3823	2.339	.4486	2.931
.3119	1.335	.3449	1.689	.3831	2.405	.4493	2.956
.3124	1.337	.3457	1.724	.3837	2.349	.4500	2.931
.3133	1.357	.3464	1.713	.3845	2.376	.4526	2.964
.3140	1.360	.3521	1.776	.3852	2.398	.4535	2.981
.3147	1.361	.3528	1.798	.3862	2.438	.4597	2.950
.3154	1.353	.3536	1.811	.3918	2.491	.4603	2.981
.3208	1.433	.3547	1.826	.3935	2.595	.4610	2.978
.3215	1.450	.3554	1.847	.3951	2.658	.4617	2.998
.3229	1.460	.3567	1.864	.3976	2.672	.4626	2.953
.3236	1.454	.3573	1.864	.3983	2.705	.4632	2.990
.3242	1.454	.3577	1.877	.3992	2.705	.4641	2.948
.3250	1.466	.3587	1.885	.4000	2.720	.4650	2.945
.3257	1.454	.3595	1.850	.4008	2.757	.4665	2.917
.3264	1.466	.3606	1.915	.4017	2.754	.4681	2.956
.3271	1.477	.3614	1.903	.4024	2.754	.4691	2.953
.3279	1.483	.3665	1.992	.4032	2.807	.4753	2.923
.3287	1.483	.3674	2.039	.4114	3.033	.4760	2.965

Table 3 – continued

J.D. _{Hel.}	Δm	J.D. _{Hel}	Δm	J.D. _{Hel.}	Δm	J.D. _{Hel}	Δm
.4768	2.995	.5576	1.539	.5161	1.230	.5936	2.091
.4774	3.015	.5586	1.548	.5171	1.249	.5944	2.105
.4793	2.984	.5594	1.546	.5177	1.275	.5951	2.186
.4822	2.888	.5601	1.492	.5183	1.278	.5958	2.087
.4833	2.848	.5608	1.515	.5191	1.261	.5969	2.196
.4841	2.848	2439948.3437	0.922	.5196	1.282	.5977	2.211
.4849	2.797	.3455	0.923	.5205	1.298	.5986	2.205
.4858	2.744	.3465	0.932	.5211	1.269	.5992	2.213
.4868	2.744	.3472	0.944	.5256	1.256	.5998	2.272
.4914	2.653	.3479	0.932	.5269	1.256	.6006	2.247
.4938	2.609	.3487	0.930	.5277	1.292	.6013	2.313
.4945	2.553	.3503	0.917	.5283	1.296	.6019	2.319
.4967	2.580	.3510	0.939	.5298	1.290	.6055	2.347
.4977	2.537	.3556	0.957	.5304	1.308	.6061	2.419
.4984	2.535	.3564	0.954	.5312	1.281	.6068	2.449
.4991	2.553	.3572	0.949	.5338	1.311	.6081	2.444
.4997	2.535	.3578	0.962	.5346	1.347	.6088	2.444
.5005	2.502	.3586	0.955	.5352	1.390	.6096	2.372
.5013	2.513	.3592	0.958	.5360	1.385	.6103	2.368
.5061	2.286	.3600	0.944	.5366	1.394	.6108	2.466
.5068	2.292	.3607	0.945	.5374	1.391	.6116	2.517
.5079	2.292	.3615	0.944	.5381	1.394	.6124	2.506
.5086	2.253	.3622	0.931	.5387	1.404	.6158	2.498
.5093	2.276	.3629	0.963	.5417	1.415	.6163	2.607
.5099	2.211	2440160.4723	0.982	.5423	1.388	.6171	2.584
.5109	2.232	.4728	0.986	.5431	1.417	.6181	2.584
.5115	2.230	.4735	1.018	.5444	1.501	.6186	2.648
.5123	2.201	.4742	1.022	.5451	1.507	.6192	2.648
.5177	2.084	.4749	0.942	.5458	1.514	.6201	2.698
.5186	2.103	.4757	0.978	.5603	1.635	.6208	2.634
.5193	2.075	.4764	0.989	.5609	1.641	.6213	2.713
.5208	2.071	.4798	1.028	.5623	1.654	.6223	2.833
.5215	2.073	.4804	1.015	.5630	1.652	.6240	2.769
.5223	2.032	.4812	1.026	.5638	1.654	.6246	2.769
.5230	1.987	.4818	1.002	.5644	1.716	.6274	2.774
.5237	2.029	.4826	0.955	.5655	1.692	.6281	2.810
.5243	2.020	.4833	1.018	.5663	1.689	.6287	2.915
.5250	2.008	.4846	1.008	.5669	1.755	.6294	2.909
.5258	1.985	.4889	1.024	.5676	1.716	.6301	2.915
.5306	1.882	.4896	1.052	.5727	1.800	.6308	2.981
.5316	1.855	.4904	1.043	.5733	1.832	.6314	2.964
.5323	1.847	.4911	1.062	.5739	1.766	.6321	2.964
.5330	1.870	.4918	1.064	.5748	1.806	2440183.3950	1.002
.5338	1.836	.4925	1.104	.5754	1.827	.3957	0.991
.5344	1.819	.4933	1.104	.5762	1.785	.3964	0.996
.5352	1.862	.4939	1.077	.5768	1.797	.3972	1.002
.5367	1.797	.4983	1.102	.5774	1.787	.3979	1.016
.5376	1.777	.4988	1.068	.5782	1.893	.3986	0.994
.5420	1.749	.4997	1.037	.5789	1.862	.3993	0.998
.5429	1.725	.5002	1.093	.5796	1.864	.4001	1.018
.5436	1.738	.5008	1.083	.5804	1.964	.4007	1.028
.5444	1.728	.5018	1.098	.5831	1.963	.4014	1.026
.5452	1.709	.5024	1.085	.5836	1.958	.4019	1.020
.5458	1.711	.5031	1.059	.5843	1.944	.4049	1.047
.5465	1.709	.5072	1.113	.5851	1.987	.4054	1.044
.5473	1.688	.5079	1.120	.5858	1.997	.4062	1.039
.5480	1.677	.5086	1.121	.5865	1.954	.4068	1.058
.5487	1.702	.5093	1.147	.5873	1.980	.4075	1.033
.5532	1.617	.5099	1.134	.5879	2.036	.4082	1.044
.5542	1.582	.5107	1.150	.5887	1.982	.4089	1.043
.5555	1.566	.5113	1.185	.5894	1.983	.4096	1.051
.5562	1.546	.5121	1.204	.5901	2.062		
.5569	1.526			.5909	2.044		

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel}	Δ_m
.4105	1.051	.4706	1.480	.5359	2.522	.5994	3.074
.4109	1.059	.4712	1.511	.5369	2.491	.6003	3.080
.4118	1.055	.4719	1.495	.5376	2.535	.6009	3.027
.4138	1.059	.4726	1.489	.5384	2.539	.6016	3.059
.4146	1.044	.4733	1.483	.5410	2.609	.6023	3.050
.4151	1.055	.4739	1.493	.5419	2.648	.6031	2.998
.4158	1.072	.4761	1.521	.5428	2.630	.6038	3.065
.4168	1.065	.4768	1.493	.5434	2.672	.6046	3.059
.4173	1.058	.4776	1.526	.5441	2.722	.6051	2.998
.4179	1.051	.4783	1.535	.5449	2.693	.6076	3.024
.4188	1.077	.4790	1.535	.5456	2.722	.6082	3.033
.4196	1.056	.4798	1.530	.5462	2.735	.6089	3.027
.4201	1.069	.4806	1.552	.5477	2.727	.6099	3.050
.4207	1.088	.4816	1.551	.5493	2.779	.6108	3.080
.4236	1.088	.4821	1.569	.5517	2.848	.6115	3.033
.4244	1.100	.4828	1.588	.5524	2.859	.6121	3.041
.4249	1.104	.4835	1.602	.5533	2.917	.6129	3.110
.4258	1.101	.4843	1.609	.5541	2.861	.6138	3.056
.4264	1.118	.4865	1.638	.5549	2.931	.6144	3.036
.4270	1.128	.4872	1.661	.5556	2.978	.6151	3.027
.4278	1.120	.4880	1.658	.5563	2.861	.6165	3.050
.4284	1.129	.4887	1.677	.5569	3.001	.6191	3.047
.4291	1.131	.4896	1.678	.5577	3.030	.6199	2.995
.4296	1.152	.4903	1.697	.5583	2.990	.6206	3.010
.4305	1.154	.4911	1.692	.5591	3.033	.6218	3.033
.4312	1.182	.4918	1.695	.5600	2.987	.6230	3.015
.4333	1.190	.4924	1.722	.5631	3.024	.6238	2.970
.4341	1.181	.4931	1.768	.5641	2.975	.6246	2.953
.4347	1.182	.4937	1.758	.5649	3.033	.6254	2.987
.4356	1.197	.4949	1.774	.5657	3.004	.6259	2.959
.4362	1.189	.4993	1.824	.5666	2.981	.6267	2.917
.4371	1.188	.4999	1.816	.5674	2.998	.6277	2.885
.4377	1.212	.5006	1.836	.5684	3.036	.6284	2.948
.4384	1.190	.5014	1.831	.5693	3.004	.6293	2.833
.4391	1.223	.5021	1.870	.5698	2.975	.6324	2.833
.4399	1.228	.5029	1.873	.5706	2.961	.6334	2.792
.4406	1.192	.5035	1.903	.5714	3.033	.6339	2.744
.4444	1.223	.5043	1.900	.5750	2.956	.6348	2.730
.4454	1.254	.5049	1.915	.5774	3.030	.6354	2.739
.4463	1.223	.5056	1.976	.5783	2.967	.6361	2.735
.4471	1.239	.5083	2.016	.5789	3.021	.6367	2.667
.4478	1.249	.5107	2.037	.5798	3.074	.6375	2.696
.4494	1.242	.5112	2.098	.5807	2.967	.6382	2.689
.4504	1.253	.5121	2.080	.5818	2.939	.6389	2.639
.4530	1.274	.5127	2.084	.5827	2.950	.6397	2.639
.4570	1.368	.5135	2.043	.5831	2.987	.6418	2.625
.4576	1.381	.5142	2.069	.5838	3.068	.6424	2.605
.4583	1.371	.5149	2.067	.5863	2.990	.6433	2.571
.4589	1.377	.5164	2.082	.5869	3.030	.6442	2.575
.4596	1.387	.5187	2.122	.5876	3.030	.6454	2.522
.4604	1.388	.5201	2.194	.5883	3.027	.6462	2.493
.4610	1.404	.5207	2.226	.5890	3.001	.6473	2.485
.4618	1.405	.5215	2.266	.5897	3.033	.6479	2.481
.4625	1.408	.5221	2.175	.5904	3.041	.6486	2.449
.4630	1.411	.5235	2.216	.5911	3.024	.6496	2.438
.4637	1.420	.5243	2.298	.5917	3.036	.6501	2.401
.4644	1.420	.5253	2.215	.5924	3.056	.6515	2.396
.4665	1.440	.5260	2.276	.5931	3.047	.6543	2.372
.4673	1.438	.5268	2.259	.5939	3.018	.6549	2.329
.4680	1.444	.5301	2.374	.5946	3.056	.6556	2.308
.4686	1.472	.5309	2.370	.5973	3.065	.6565	2.302
.4693	1.486	.5331	2.409	.5981	3.027	.6589	2.270
.4699	1.482	.5338	2.440	.5989	3.056	.6598	2.257

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m
.6606	2.282	.3965	2.120	.4743	1.226	.5520	0.928
.6612	2.216	.3972	2.122	.4756	1.204	.5531	0.949
.6618	2.222	.3979	2.100	.4791	1.176	.5551	0.962
.6627	2.196	.3987	2.093	.4801	1.188	.5563	0.931
.6635	2.209	.3991	2.067	.4809	1.172	.5572	0.941
.6659	2.131	.3998	2.060	.4818	1.188	.5584	0.949
.6666	2.096	.4004	2.036	.4826	1.129	.5594	0.953
.6673	2.075	.4011	2.032	.4838	1.165	.5605	0.935
.6680	2.102	.4020	2.013	.4847	1.178	.5614	0.932
.6688	2.089	.4068	1.959	.4854	1.150		
.6694	2.085	.4077	1.932	.4861	1.153	2440193.5628	0.960
.6703	2.036	.4087	1.910	.4869	1.138	.5638	0.980
.6709	2.025	.4097	1.908	.4903	1.109	.5648	0.986
.6715	2.016	.4106	1.888	.4911	1.094	.5669	0.954
.6721	2.011	.4117	1.877	.4915	1.097	.5679	0.978
.6728	2.016	.4126	1.864	.4926	1.094	.5686	0.980
.6736	1.987	.4136	1.860	.4935	1.097	.5694	0.975
.6759	1.922	.4157	1.808	.4943	1.084	.5701	0.966
.6766	1.917	.4205	1.736	.4952	1.093	.5710	0.971
.6777	1.918	.4213	1.722	.4959	1.097	.5718	0.978
.6783	1.875	.4223	1.741	.4968	1.081	.5755	0.969
.6790	1.898	.4230	1.713	.4974	1.068	.5766	0.969
.6797	1.854	.4240	1.671	.4983	1.055	.5775	0.975
.6804	1.824	.4249	1.675	.5019	1.058	.5784	0.969
.6811	1.850	.4258	1.684	.5029	1.060	.5794	0.972
.6817	1.841	.4269	1.629	.5038	1.063	.5804	0.969
.6823	1.818	.4281	1.660	.5048	1.063	.5916	0.969
.6833	1.823	.4299	1.620	.5057	1.067	.5824	0.995
.6841	1.798	.4321	1.603	.5064	1.037	.5834	0.990
.6864	1.766	.4337	1.584	.5074	1.025	.5871	0.993
.6873	1.777	.4347	1.570	.5081	1.018	.5881	0.978
.6880	1.758	.4357	1.548	.5089	1.024	.5892	0.982
.6886	1.765	.4365	1.545	.5103	1.028	.5903	0.994
.6893	1.733	.4374	1.527	.5158	1.016	.5915	0.972
.6899	1.703	.4384	1.493	.5166	1.018	.5923	0.999
.6908	1.697	.4393	1.489	.5176	1.011	.5933	1.020
.6914	1.688	.4402	1.485	.5191	1.013	.5942	0.994
.6923	1.692	.4436	1.470	.5199	1.020	.5951	0.971
.6930	1.674	.4445	1.437	.5209	1.008	.5961	0.996
.6936	1.683	.4454	1.472	.5219	1.005	.5996	0.994
.6944	1.652	.4464	1.437	.5229	0.994	.6005	1.003
2440189.3756	2.575	.4471	1.418	.5239	0.990	.6016	1.000
.3763	2.571	.4482	1.418	.5272	0.958	.6026	1.011
.3770	2.524	.4496	1.390	.5281	0.977	.6036	0.986
.3771	2.500	.4501	1.384	.5291	0.967	.6048	1.016
.3783	2.463	.4514	1.383	.5298	0.963	.6056	1.002
.3790	2.478	.4560	1.333	.5307	0.968	.6058	0.996
.3799	2.493	.4568	1.349	.5316	0.968	.6074	1.009
.3805	2.466	.4576	1.335	.5325	0.980	.6083	1.011
.3811	2.428	.4585	1.317	.5338	0.968	.6118	0.985
.3849	2.405	.4598	1.336	.5345	0.957	.6121	0.994
.3857	2.345	.4605	1.317	.5355	0.945	.6138	1.013
.3863	2.286	.4614	1.304	.5393	0.951	.6154	1.020
.3877	2.234	.4621	1.286	.5403	0.945	.6165	1.037
.3886	2.333	.4631	1.292	.5412	0.942	.6174	1.005
.3893	2.310	.4639	1.300	.5421	0.953	.6183	1.007
.3898	2.224	.4671	1.261	.5429	0.928	.6195	0.984
.3904	2.261	.4685	1.269	.5438	0.931	.6204	0.989
.3911	2.263	.4703	1.263	.5449	0.939	.6241	0.966
.3918	2.222	.4711	1.248	.5456	0.951	.6249	1.002
.3948	2.177	.4719	1.238	.5465	0.927	.6258	0.982
.3956	2.175	.4726	1.233	.5472	0.928	.6268	1.021
		.4734	1.219	.5510	0.930	.6279	1.029

Table 3 – continued

J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m
.6288	1.034	.6718	1.578	.3203	2.123	.3772	1.361
.6296	0.990	.6726	1.602	.3209	2.109	.3779	1.371
.6306	0.986	.6751	1.585	.3218	2.085	.3788	1.346
.6315	0.993	.6759	1.585	.3226	2.080	.3798	1.356
.6327	0.977	.6766	1.602	.3239	2.060	.3807	1.333
.6335	0.996	.6773	1.629	.3244	2.032	.3851	1.292
		.6780	1.605	.3253	1.995	.3958	1.279
2440200.6136	1.110	.6786	1.638	.3257	2.015	.3868	1.296
.6143	1.090	.6793	1.672	.3286	1.951	.3876	1.265
.6149	1.081	.6802	1.655	.3293	1.912	.3884	1.267
.6155	1.096	.6807	1.678	.3301	1.961	.3891	1.265
.6163	1.094	.6840	1.700	.3308	1.920	.3896	1.261
.6169	1.096	.6847	1.728	.3314	1.915	.3906	1.263
.6177	1.104	.6860	1.694	.3323	1.893	.3918	1.250
.6187	1.106	.6868	1.705	.3329	1.897	.3925	1.253
.6229	1.146	.6874	1.724	.3336	1.870	.3932	1.239
.6234	1.150	.6880	1.731	.3344	1.870	.3968	1.226
.6242	1.145	.6887	1.736	.3350	1.855	.3974	1.227
.6249	1.172	.6902	1.803	.3356	1.841	.3981	1.211
.6256	1.147	.6908	1.793	.3384	1.800	.3986	1.200
.6263	1.161	.6935	1.834	.3390	1.771	.3996	1.207
.6271	1.172	.6941	1.867	.3397	1.787	.4002	1.203
.6277	1.146	.6948	1.860	.3404	1.810	.4009	1.193
.6287	1.174	.6956	1.898	.3411	1.766	.4015	1.193
.6289	1.150	.6971	1.865	.3418	1.768	.4022	1.186
.6296	1.153	.6977	1.915	.3426	1.774	.4031	1.178
.6304	1.180	.6991	1.920	.3433	1.750	.4041	1.178
.6337	1.234			.3439	1.724	.4080	1.134
.6346	1.222	2440212.2804	2.926	.3448	1.714	.4090	1.139
.6354	1.238	.2812	2.956	.3453	1.708	.4099	1.135
.6363	1.235	.2819	2.846	.3459	1.686	.4105	1.139
.6370	1.285	.2824	2.907	.3487	1.667	.4113	1.142
.6380	1.242	.2833	2.833	.3493	1.632	.4119	1.131
.6386	1.254	.2838	2.934	.3503	1.634	.4124	1.113
.6396	1.264	.2843	2.967	.3509	1.651	.4133	1.121
.6404	1.261	.2911	2.665	.3515	1.629	.4141	1.122
.6411	1.257	.2919	2.621	.3521	1.632	.4146	1.113
.6418	1.276	.2926	2.663	.3529	1.615	.4154	1.090
.6426	1.287	.2933	2.634	.3536	1.600	.4196	1.077
.6452	1.339	.2965	2.616	.3541	1.581	.4204	1.080
.6460	1.303	.2917	2.568	.3550	1.612	.4212	1.079
.6468	1.290	.2979	2.489	.3555	1.597	.4219	1.067
.6474	1.292	.2985	2.528	.3590	1.555	.4224	1.058
.6481	1.307	.2993	2.537	.3598	1.549	.4232	1.075
.6488	1.333	.3001	2.524	.3605	1.520	.4239	1.064
.6499	1.332	.3009	2.533	.3611	1.524	.4246	1.055
.6509	1.340	.3016	2.533	.3618	1.493	.4254	1.039
.6516	1.335	.3021	2.526	.3624	1.507	.4261	1.050
.6523	1.373	.3030	2.470	.3632	1.492	.4266	1.033
.6598	1.414	.3036	2.500	.3640	1.493	.4296	1.033
.6606	1.430	.3077	2.364	.3646	1.473	.4305	1.022
.6611	1.448	.3083	2.321	.3655	1.474	.4311	1.037
.6618	1.454	.3091	2.313	.3662	1.476	.4318	1.016
.6624	1.451	.3099	2.292	.3668	1.458	.4324	1.028
.6658	1.499	.3108	2.284	.3675	1.457	.4332	1.012
.6666	1.502	.3116	2.272	.3683	1.434	.4337	1.015
.6673	1.548	.3124	2.304	.3691	1.444	.4343	1.022
.6679	1.499	.3131	2.232	.3725	1.418	.4349	1.003
.6686	1.538	.3138	2.230	.3735	1.404	.4356	1.013
.6692	1.532	.3145	2.230	.3743	1.414	.4363	0.987
.6699	1.527	.3153	2.249	.3751	1.398	.4371	0.996
.6706	1.549	.3188	2.116	.3757	1.394	.4401	0.990
.6713	1.555	.3196	2.109	.3764	1.377	.4409	0.989

Table 3 – continued

J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m
.4418	0.981	.2999	0.900	.3807	0.967	.5889	0.906
.4427	0.985	.3008	0.916	.3831	1.012	.5899	0.894
.4436	0.972	.3015	0.936	.3839	1.044	.5909	0.888
.4446	0.969	.3025	0.909	.3856	1.063	.5916	0.926
.4456	0.964	.3034	0.930	.3910	0.975	.5924	0.903
.4465	0.962	.3042	0.890	.3914	0.995	.5931	0.907
.4476	0.963	.3080	0.878	.3924	1.013	.5939	0.911
.4486	0.962	.3091	0.917	.3929	0.949	.5947	0.884
.4534	0.918	.3149	0.946	.3937	1.039	.5954	0.885
.4544	0.930	.3158	0.906	.3944	1.005	.5961	0.894
.4554	0.939	.3166	0.930	.3951	0.968	.5981	0.932
.4562	0.935	.3176	0.908	.3958	0.994	.5989	0.892
.4571	0.934	.3184	0.927	.3973	0.963	.5994	0.897
.4582	0.925	.3249	0.937	.4003	0.993	.6001	0.888
.4591	0.926	.3256	0.934	.4009	0.927	.6008	0.904
.4599	0.921	.3268	0.969	.4016	0.941	.6014	0.895
.4607	0.916	.3279	0.944	.4031	0.951	.6021	0.878
.4616	0.925	.3286	0.957	.4039	0.976	.6027	0.878
.4624	0.934	.3294	0.949	.4046	0.954	.6034	0.904
.4633	0.913	.3302	0.950	.4053	1.035	.6041	0.918
.4640	0.917	.3310	0.972	.4061	1.007	.6050	0.918
.4648	0.922	.3318	0.916	.4066	1.029	.6070	0.900
.4681	0.900	.3328	0.923	.4103	1.024	.6079	0.930
.4690	0.899	.3362	0.962	.4111	1.012	.6087	0.926
.4699	0.899	.3369	0.926	.4116	1.008	.6094	0.955
.4713	0.895	.3378	0.931	.4123	0.995	.6103	0.932
.4721	0.909	.3386	0.909	.4133	0.994		
.4731	0.906	.3393	0.892	.4139	1.009	2440221.3485	0.855
.4739	0.902	.3401	0.878	.4144	0.976	.3493	0.858
.4748	0.895	.3409	0.916	.4162	0.995	.3499	0.853
.4758	0.907	.3416	0.911	.4189	1.033	.3507	0.866
.4766	0.897	.3426	0.898	.4194	0.957	.3514	0.841
.4776	0.909	.3432	0.940	.4200	0.957	.3524	0.860
.4800	0.904	.3461	0.954	.4210	0.959	.3534	0.855
.4807	0.914	.3469	0.940	.4215	0.971	.3540	0.847
.4815	0.885	.3477	0.930	.4223	0.969	.3548	0.842
.4824	0.898	.3485	0.977	.4230	0.928	.3557	0.849
.4833	0.898	.3494	0.969	.4274	0.967	.3601	0.858
.4841	0.897	.3501	1.012	.4283	0.953	.3618	0.840
.4850	0.899	.3508	1.011	.4291	1.034	.3626	0.871
.4860	0.899	.3523	0.944	.4299	1.002	.3631	0.869
.4868	0.908	.3531	1.005	.4309	1.004	.3641	0.846
.4876	0.904	.3539	0.993	.4314	1.003	.3656	0.839
.4884	0.907	.3571	0.951	.4322	1.012	.3668	0.850
.4894	0.912	.3582	0.945			.3677	0.860
.4925	0.911	.3589	1.016	2440220.5696	0.911	.3686	0.850
.4931	0.907	.3597	0.923	.5703	0.909	.3723	0.850
.4938	0.926	.3604	0.972	.5711	0.902	.3729	0.845
.4946	0.930	.3612	0.957	.5719	0.897	.3738	0.860
.4952	0.916	.3621	0.942	.5728	0.939	.3746	0.856
.4958	0.907	.3629	0.964	.5736	0.925	.3755	0.849
.4965	0.914	.3637	0.957	.5744	0.940	.3763	0.832
.4972	0.908	.3646	0.945	.5752	0.908	.3771	0.835
.4979	0.904	.3673	1.013	.5787	0.935	.3800	0.836
.4984	0.914	.3682	1.052	.5796	0.932	.3816	0.836
.4992	0.912	.3691	1.050	.5803	0.930	.3824	0.836
.4998	0.913	.3699	1.033	.5809	0.911	.3831	0.842
		.3714	0.995	.5818	0.912	.3839	0.845
2440219.2965	0.879	.3722	0.972	.5827	0.911	.3848	0.860
.2973	0.931	.3740	0.957	.5834	0.911	.3854	0.854
.2981	0.908	.3748	1.011	.5842	0.918	.3869	0.836
.2991	0.921	.3789	0.994	.5851	0.930	.3876	0.859
		.3799	0.976	.5857	0.940	.3902	0.875

Table 3 – continued

J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m
.3911	0.856	.2456	0.968	.3768	2.327	.4377	3.018
.3919	0.839	.2483	0.984	.3776	2.306	.4382	2.981
.3928	0.855	.2489	1.000	.3782	2.296	.4404	3.053
.3933	0.850	.2496	1.009	.3788	2.388	.4410	3.053
.3943	0.851	.2503	0.964	.3818	2.415	.4418	3.110
.3948	0.845	.2510	1.002	.3826	2.434	.4423	2.975
.3955	0.853	.2532	1.007	.3830	2.374	.4428	2.984
.3963	0.865	.2538	1.026	.3838	2.442	.4438	2.978
.3971	0.834	.2546	1.024	.3844	2.455	.4444	2.984
.3979	0.845	.2552	1.024	.3851	2.504	.4451	3.086
.4006	0.855	.2559	1.037	.3865	2.500	.4459	3.001
.4018	0.869	.2566	1.048	.3871	2.586	.4465	2.956
.4028	0.850	.2573	1.038	.3879	2.591	.4471	2.956
.4037	0.874	.2580	1.038	.3900	2.632	.4479	3.030
.4045	0.841	.2587	1.062	.3908	2.637	.4499	2.990
.4055	0.865	.2593	1.063	.3914	2.703	.4513	3.095
.4064	0.865	.2623	1.065	.3921	2.644	.4519	3.068
.4074	0.871	.2629	1.069	.3928	2.674	.4533	3.098
.4082	0.846	.2634	1.059	.3941	2.759	.4539	2.984
.4125	0.860	.2644	1.084	.3949	2.703	.4547	2.981
.4133	0.842	.2649	1.084	.3955	2.742	.4554	3.015
.4141	0.859	.2656	1.064	.3962	2.820	.4561	2.978
.4149	0.868	.2663	1.072	.3982	2.815	.4595	3.038
.4157	0.850	.2671	1.088	.3988	2.769	.4603	2.942
.4168	0.850	.2677	1.089	.3996	2.762	.4608	3.041
.4175	0.855	.2683	1.096	.4003	2.828	.4616	3.080
.4183	0.840	.2718	1.109	.4008	2.875	.4630	3.001
.4193	0.851	.2726	1.108	.4017	2.812	.4636	3.077
.4199	0.854	.2733	1.117	.4024	2.822	.4644	3.027
		.2738	1.121	.4031	2.848	.4650	2.953
2440229.2163	0.921	.2745	1.109	.4037	2.838	.4658	3.110
.2170	0.918	.2753	1.124	.4044	2.846	.4685	2.990
.2178	0.899	.2759	1.121	.4064	2.875	.4691	3.025
.2184	0.895	.2766	1.113	.4086	2.975	.4699	3.038
.2191	0.936	.2775	1.134	.4093	3.010	.4706	2.992
.2206	0.898	.2801	1.149	.4100	3.027	.4712	2.893
.2212	0.932	.2808	1.143	.4118	3.004	.4719	2.945
.2221	0.918	.2814	1.149	.4128	3.089	.4726	2.864
.2226	0.916	.2823	1.170	.4155	3.086	.4734	2.909
.2254	0.949	.2829	1.137	.4161	3.007	.4739	3.012
.2260	0.931	.2837	1.170	.4168	3.041	.4747	2.948
.2268	0.940	.2844	1.161	.4176	3.059	.4774	2.820
.2274	0.955	.3597	1.976	.4182	3.119	.4781	2.810
.2282	0.937	.3603	2.009	.4189	3.001	.4789	2.822
.2289	0.948	.3611	2.006	.4196	2.967	.4796	2.754
.2294	0.954	.3616	2.013	.4202	2.964	.4801	2.754
.2303	0.951	.3624	2.034	.4206	2.978	.4809	2.757
.2309	0.935	.3630	2.025	.4215	2.970	.4816	2.747
.2317	0.941	.3638	2.009	.4250	2.967	.4824	2.772
.2317	0.941	.3644	2.071	.4258	3.041	.4830	2.789
.2323	0.942	.3657	2.102	.4264	3.056	.4837	2.727
.2343	0.954	.3666	2.071	.4273	3.053	.4865	2.550
.2353	0.954	.3671	2.105	.4286	3.018	.4871	2.504
.2358	0.960	.3699	2.230	.4294	3.077	.4879	2.550
.2365	0.955	.3706	2.230	.4301	3.065	.4886	2.550
.2373	0.964	.3713	2.237	.4306	2.987	.4894	2.459
.2379	0.966	.3721	2.268	.4314	3.050	.4908	2.415
.2389	0.959	.3726	2.207	.4334	2.998	.4914	2.407
.2393	0.964	.3733	2.243	.4342	2.961	.4921	2.413
.2400	0.968	.3740	2.263	.4348	3.107	.4929	2.481
.2406	0.978	.3748	2.234	.4354	3.071	.4936	2.546
.2414	0.968	.3754	2.323	.4361	3.071	.4943	2.472
.2420	0.959	.3761	2.304	.4368	3.077	.4988	2.331

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m
.4995	2.310	.5539	1.492	.2821	2.904	.3783	2.118
.5001	2.415	.5546	1.480	.2828	2.934	.3813	2.011
.5009	2.364	.5558	1.488	.2834	2.973	.3832	1.985
.5016	2.290	.5564	1.530	.2841	2.896	.3839	1.990
.5024	2.286	.5570	1.474	.2848	2.912	.3846	1.947
.5028	2.241	.5576	1.473	.2856	2.953	.3852	1.985
.5036	2.218	.5581	1.488	.2884	3.012	.3860	1.954
.5043	2.261	.5594	1.410	.2890	3.062	.4621	1.177
.5050	2.160	.5601	1.435	.2906	2.896	.4629	1.158
.5057	2.237	.5629	1.422	.2911	2.961	.4635	1.139
.5064	2.188	.5636	1.402	.2919	2.978	.4643	1.134
.5091	2.168	.5643	1.417	.2928	2.899	.4649	1.146
.5098	2.164	.5651	1.394	.2935	3.015	.4656	1.161
.5106	2.098	.5658	1.346	.2941	2.928	.4663	1.138
.5111	2.164	.5665	1.378	.2949	3.033	.4670	1.133
.5121	2.129	.5671	1.349	.2978	3.010	.4678	1.120
.5126	2.096	.5679	1.329	.2986	2.937	.4683	1.109
.5132	2.067	.5687	1.340	.2992	3.086	.4711	1.116
.5140	2.091	.5714	1.374	.2999	2.973	.4718	1.114
.5147	2.123	.5723	1.340	.3006	2.992	.4726	1.121
.5153	2.043	.5729	1.342	.3012	2.915	.4733	1.088
.5159	1.990	.5743	1.274	.3021	2.998	.4738	1.102
.5166	1.980	.5751	1.308	.3027	3.012	.4746	1.083
.5195	1.918	.5758	1.307	.3034	2.990	.4753	1.100
.5201	1.918	.5764	1.310	.3041	2.926	.4760	1.075
.5207	1.903	.5771	1.298	.3069	2.942	.4768	1.090
.5214	1.978	.5779	1.257	.3076	3.027	.4774	1.075
.5223	1.898	.5806	1.241	.3083	2.931	.4803	1.063
.5229	1.905	.5815	1.274	.3089	2.956	.4810	1.072
.5236	1.915	.5820	1.272	.3096	2.939	.4816	1.060
.5241	1.832	.5826	1.253	.3103	3.033	.4822	1.059
.5249	1.844	.5834	1.235	.3110	2.950	.4830	1.056
.5258	1.842	.5843	1.209	.3118	2.953	.4836	1.041
.5286	1.834	.5846	1.252	.3124	3.038	.4843	1.028
.5293	1.805	.5856	1.205	.3131	3.033	.4849	1.051
.5299	1.808	.5862	1.201	.3157	2.978	.4857	1.038
.5305	1.805	.5869	1.252	.3165	2.970	.4864	1.055
.5312	1.811	.5874	1.219	.3173	2.885	.4893	1.025
.5327	1.765	.5904	1.204	.3179	2.965	.4899	1.029
.5333	1.741	.5912	1.172	.3186	2.891	.4907	1.028
.5341	1.727	.5918	1.197	.3193	2.923	.4913	1.016
.5346	1.738	.5926	1.184	.3199	2.899	.4919	1.016
.5353	1.722	.5934	1.182	.3207	2.923	.4926	1.018
.5375	1.681	.5940	1.192	.3213	3.065	.4934	1.026
.5381	1.663	.5955	1.157	.3221	2.899	.4941	1.025
.5388	1.652			.3227	2.970	.4949	1.034
.5396	1.671	2440232.2656	2.792	.3256	2.975	.4954	1.037
.5403	1.683	.2663	2.710	.3265	2.970	.4983	1.020
.5409	1.660	.2673	2.722	.3273	2.981	.4990	1.028
.5416	1.652	.2704	2.883	.3281	2.896	.4996	1.004
.5421	1.647	.2710	2.934	.3289	3.012	.5004	1.008
.5430	1.617	.2716	2.820	.3299	3.116	.5009	1.002
.5437	1.626	.2724	2.880	.3306	2.978	.5018	0.969
.5457	1.617	.2730	2.948	.3313	2.923	.5024	0.987
.5464	1.625	.2738	2.825	.3706	2.237	.5030	0.973
.5472	1.566	.2744	2.931	.3713	2.201	.5038	0.976
.5478	1.524	.2751	2.945	.3721	2.164	.5044	0.959
.5486	1.579	.2759	3.012	.3728	2.201	.5073	0.962
.5493	1.532	.2765	2.915	.3736	2.155	.5081	0.965
.5499	1.535	.2792	2.872	.3744	2.175	.5086	0.967
.5506	1.489	.2799	2.920	.3752	2.144	.5093	0.964
.5513	1.527	.2807	2.990	.3761	2.080	.5101	0.967
.5526	1.526	.2813	2.915	.3775	2.091	.5108	0.967

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m
.5170	0.944	.3008	0.856	.3746	0.849	2440320.3088	0.831
.5176	0.942	.3015	0.858	.3752	0.856	.3096	0.835
.5203	0.954	.3022	0.869			.3102	0.835
.5209	0.927	.3029	0.865	2440302.2836	0.863	.3109	0.840
.5218	0.937	.3038	0.873	.2841	0.827	.3117	0.827
.5225	0.944	.3078	0.849	.2850	0.841	.3146	0.869
.5233	0.955	.3085	0.855	.2856	0.835	.3212	0.859
.5239	0.926	.3093	0.870	.2863	0.830	.3219	0.837
.5246	0.941	.3098	0.847	.2869	0.830	.3226	0.832
.5253	0.916	.3106	0.856	.2878	0.822	.3239	0.822
.5260	0.917	.3115	0.850	.2884	0.836	.3322	0.842
.5267	0.931	.3123	0.860	.2891	0.855	.3328	0.836
.5301	0.937	.3131	0.853	.2893	0.855	.3337	0.825
.5310	0.940	.3138	0.855	.2918	0.841	.3360	0.839
.5322	0.948	.3146	0.856	.2924	0.858	.3366	0.831
.5329	0.940	.3288	0.889	.2932	0.840	.3376	0.842
.5337	0.928	.3296	0.864	.2939	0.856	.3382	0.815
.5344	0.930	.3303	0.856	.2944	0.856	.3389	0.821
.5350	0.942	.3308	0.874	.2951	0.846	.3469	0.826
.5358	0.932	.3324	0.863	.2959	0.837	.3474	0.841
.5364	0.962	.3331	0.840	.2965	0.845	.3498	0.841
.5409	0.962	.3343	0.850	.2973	0.856	.3506	0.817
.5416	0.927	.3351	0.842	.2979	0.845	.3514	0.830
.5424	0.914	.3357	0.839	.2988	0.854	.3521	0.827
.5431	0.918	.3364	0.846	.3009	0.863	.3528	0.816
.5436	0.923	.3401	0.846	.3015	0.870	.3537	0.807
.5444	0.920	.3407	0.830	.3024	0.863		
.5450	0.934	.3415	0.851	.3031	0.869	2440321.3176	1.025
		.3435	0.825	.3038	0.855	.3185	1.025
2440249.2525	0.923	.3441	0.849	.3046	0.866	.3191	1.039
.2546	0.936	.3450	0.830	.3051	0.871	.3198	1.026
.2553	0.921	.3456	0.850	.3059	0.870	.3205	1.012
.2561	0.881	.3463	0.837	.3066	0.873	.3213	1.005
.2658	0.904	.3484	0.861	.3073	0.855	.3220	1.022
.2676	0.951	.3491	0.853	.3093	0.866	.3228	1.029
.2681	0.931	.3499	0.847	.3107	0.866	.3244	0.994
.2689	0.939	.3506	0.841	.3108	0.866	.3253	1.020
.2613	0.923	.3512	0.837	.3114	0.851		
.2621	0.927	.3520	0.846	.3121	0.853	2440322.3403	0.869
.2627	0.912	.3525	0.846	.3130	0.858	.3409	0.871
.2635	0.871	.3532	0.858	.3137	0.854	.3416	0.849
.2641	0.868	.3539	0.839	.3143	0.858	.3423	0.854
.2648	0.878	.3546	0.841	.3150	0.868	.3430	0.864
.2663	0.870	.3553	0.840	.3157	0.897	.3437	0.863
.2678	0.898	.3574	0.839	.3177	0.875	.3444	0.844
		.3582	0.822	.3593	0.927	.3449	0.846
2440264.2846	0.863	.3588	0.842	.3600	0.911	.3459	0.870
.2854	0.874	.3596	0.858	.3607	0.914	.3463	0.870
.2861	0.853	.3609	0.853	.3616	0.903	.3473	0.865
.2869	0.871	.3616	0.832	.3623	0.914	.3549	0.865
.2881	0.871	.3623	0.849	.3629	0.908	.3555	0.876
.2888	0.888	.3631	0.837			.3561	0.868
.2896	0.888	.3638	0.829	2440317.3306	0.810	.3575	0.874
.2904	0.889	.3645	0.850	.3312	0.810	.3583	0.854
.2910	0.870	.3665	0.841	.3319	0.811	.3603	0.840
.2916	0.887	.3673	0.864	.3326	0.810	.3609	0.840
.2924	0.889	.3679	0.854	.3333	0.810	.3617	0.888
.2958	0.876	.3687	0.854	.3341	0.803	.3624	0.898
.2966	0.866	.3699	0.871	.3349	0.810	.3666	0.863
.2974	0.875	.3705	0.850	.3359	0.822	.3681	0.870
.2981	0.880	.3713	0.850	.3367	0.784	.3688	0.870
.2992	0.866	.3727	0.846	.3374	0.798	.3694	0.890
.2999	0.868	.3738	0.836				

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m
.3702	0.883	.5163	0.816	.5348	0.863	.5949	0.878
.3708	0.878	.5185	0.861	.5354	0.858	.5959	0.870
		.5199	0.809	.5366	0.865	.5966	0.876
2440327.3152	0.909	.5212	0.875	.5373	0.864	.5989	0.863
.3160	0.894	.5223	0.824	.5381	0.866	.5996	0.860
.3168	0.903	.5254	0.846	.5389	0.861	.6006	0.864
.3174	0.922	.5264	0.811	.5399	0.861	.6012	0.858
.3181	0.871	.5274	0.791	.5429	0.861	.6019	0.868
.3188	0.902	.5353	0.858	.5436	0.860	.6058	0.846
.3196	0.884	.5364	0.855	.5444	0.859	.6067	0.856
.3203	0.881	.5375	0.865	.5449	0.859	.6076	0.874
.3210	0.894	.5400	0.851	.5456	0.858	.6082	0.868
.3218	0.895	.5412	0.854	.5463	0.860	.6092	0.873
.3268	0.909	.5422	0.854	.5471	0.859	.6099	0.879
.3275	0.914	.5433	0.842	.5478	0.865	.6108	0.874
.3283	0.900	.5444	0.840	.5486	0.855	.6115	0.879
.3290	0.902	.5458	0.863	.5492	0.864	.6121	0.885
.3298	0.902	.5535	0.834	.5498	0.861	.6128	0.878
.3304	0.884	.5546	0.839	.5505	0.865	.6134	0.858
.3311	0.914	.5557	0.827	.5533	0.846	.6165	0.884
.3318	0.907	.5568	0.812	.5541	0.856	.6171	0.878
.3326	0.902			.5548	0.861	.6180	0.868
.3332	0.908			.5555	0.864	.6207	0.884
		2440512.4658	0.870	.5561	0.856	.6216	0.863
2440500.4159	0.851	.4666	0.858	.5567	0.853	.6223	0.863
.4171	0.816	.4675	0.853	.5575	0.869	.6230	0.873
.4181	0.839	.4688	0.866	.5583	0.865	.6234	0.870
.4191	0.810	.4694	0.853	.5589	0.861	.6263	0.874
.4196	0.821	.4703	0.841	.5603	0.883	.6271	0.875
.4216	0.822	.4708	0.869	.5631	0.871	.6278	0.885
.4226	0.795	.4716	0.864	.5638	0.858	.6284	0.884
.4239	0.780	.4758	0.842	.5646	0.868	.6291	0.889
.4253	0.830	.4766	0.846	.5652	0.878	.6299	0.885
.4556	0.839	.4774	0.851	.5658	0.851	.6305	0.870
.4567	0.841	.4782	0.842	.5665	0.868	.6313	0.866
.4579	0.821	.4791	0.856	.5673	0.871	.6319	0.871
.4589	0.824	.4804	0.826	.5679	0.850	.6326	0.879
.4604	0.829	.4814	0.849	.5686	0.869	.6333	0.868
.4615	0.835	.4824	0.856	.5693	0.859	.6363	0.875
.4626	0.831	.4834	0.858	.5701	0.863	.6371	0.881
.4637	0.858	.4841	0.835	.5721	0.871	.6378	0.881
.4648	0.851	.4871	0.861	.5729	0.861	.6384	0.866
.4659	0.854	.4883	0.855	.5735	0.869	.6391	0.892
.4718	0.827	.4893	0.841	.5743	0.859	.6406	0.894
.4729	0.830	.4904	0.840	.5749	0.881	.6412	0.883
.4741	0.853	.4911	0.859	.5757	0.858	.6418	0.887
.4756	0.842	.4919	0.846	.5763	0.840	.6426	0.876
.4766	0.850	.4929	0.856	.5771	0.865	.6433	0.887
.4778	0.837	.4937	0.859	.5779	0.853	.6458	0.892
.4789	0.814	.4944	0.847	.5785	0.860	.6466	0.866
.4798	0.834	.4979	0.832	.5812	0.876	.6473	0.865
.4809	0.841	.4986	0.858	.5839	0.853	.6480	0.863
.4820	0.836	.4996	0.858	.5847	0.839	.6487	0.861
.4885	0.864	.5005	0.866	.5854	0.856	.6493	0.880
.4896	0.887	.5011	0.879	.5861	0.861	.6501	0.873
.4906	0.887	.5026	0.855	.5869	0.870	.6509	0.866
.4918	0.824	.5033	0.846	.5878	0.849	.6516	0.859
.4928	0.805	.5041	0.859	.5881	0.868	.6523	0.865
.4940	0.824	.5048	0.858	.5888	0.875		
.4952	0.798	.5326	0.854	.5896	0.869	2440514.4899	0.962
.4964	0.799	.5333	0.842	.5904	0.853	.4909	0.939
.4975	0.825	.5340	0.861	.5933	0.874	.4921	0.969
.4985	0.803			.5940	0.870	.4936	0.939

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m
.4946	0.963	.6154	0.972	.5784	0.881	.3153	0.841
.4983	0.951	.6174	0.969	.5813	0.894	.3173	0.844
.4998	0.955	.6186	0.960	.5819	0.897	.3181	0.841
.5009	0.958	.6196	0.948	.5826	0.871	.3188	0.845
.5021	0.969	.6207	1.025	.5833	0.883	.3195	0.834
.5030	0.930	.6286	0.963	.5840	0.880	.3203	0.837
.5041	0.955	.6296	0.969	.5848	0.881	.3209	0.839
.5051	0.984	.6308	0.953	.5855	0.880	.3216	0.830
.5063	0.972	.6353	0.967	.5860	0.894	.3226	0.835
.5131	0.954	.6363	0.976	.5868	0.887	.3238	0.834
.5143	0.954	.6374	0.969	.5874	0.890	.3259	0.855
.5154	0.972	.6386	0.959	.5895	0.904	.3264	0.865
.5165	0.976	.6396	0.969	.5902	0.904	.3271	0.859
.5176	0.978	.6407	0.955	.5909	0.899	.3279	0.856
.5185	0.971	.6418	0.969	.5916	0.907	.3286	0.873
.5198	0.960			.5922	0.899	.3292	0.858
.5208	0.978	2440534.3741	0.837	.5931	0.900	.3301	0.870
.5220	0.989	.3749	0.829	.5937	0.894	.3307	0.863
.5229	0.963	.3754	0.815	.5949	0.898	.3313	0.844
.5301	0.975	.3763	0.806	.5959	0.898	.3321	0.856
.5311	0.971	.3769	0.789	.5963	0.900	.3335	0.863
.5322	0.985	.3777	0.790	.5986	0.912	.3343	0.855
.5334	0.991	.3784	0.778	.5993	0.902	.3349	0.858
.5345	0.981	.3791	0.811	.5999	0.925	.3356	0.840
.5359	1.002			.6006	0.912	.3364	0.866
.5365	1.029	2440868.5870	1.279	.6014	0.920	.3369	0.858
.5376	0.986	.5888	1.260	.6021	0.941	.3378	0.859
.5388	0.996	.5899	1.246	.6029	0.935	.3384	0.854
.5476	0.986	.5912	1.231	.6033	0.920	.3390	0.854
.5568	0.990	.5941	1.226	.6040	0.907	.3398	0.866
.5581	0.978	.5951	1.224	.6047	0.913	.3405	0.859
.5593	0.967	.5959	1.218	.6054	0.914	.3411	0.870
.5602	0.969	.5968	1.215	.6061	0.916	.3578	0.849
.5613	0.975	.6098	1.141			.3587	0.853
.5623	0.975	.6123	1.137	2440916.2894	0.835	.3593	0.854
.5634	0.969	.6163	1.125	.2902	0.842	.3599	0.854
.5647	0.978	.6174	1.120	.2908	0.826	.3606	0.858
.5657	0.969	.6385	1.018	.2916	0.856	.3614	0.845
.5668	0.986	.6394	1.017	.2921	0.851	.3619	0.853
.5738	0.982	.6404	1.020	.2928	0.835	.3628	0.839
.5748	0.978	.6413	1.017	.2937	0.836	.3634	0.856
.5760	0.989	.6423	1.028	.2944	0.826	.3641	0.846
.5769	1.000	.6434	0.986	.2952	0.836	.3662	0.860
.5787	1.003	.6443	0.977	.2958	0.830	.3668	0.855
.5791	1.007	.6454	0.984	.2978	0.829	.3674	0.854
.5803	1.004	.6463	0.977	.2993	0.844	.3682	0.855
.5814	1.017			.3000	0.841	.3688	0.839
.5834	1.038	2440915.5631	0.898	.3006	0.842	.3701	0.845
.5906	0.973	.5639	0.897	.3013	0.835	.3710	0.849
.5918	0.981	.5645	0.894	.3021	0.854	.3718	0.844
.5928	0.962	.5652	0.894	.3027	0.859	.3724	0.841
.5939	0.963	.5660	0.892	.3049	0.849	.3732	0.854
.5949	0.955	.5665	0.884	.3056	0.853	.3753	0.835
.5961	0.955	.5687	0.895	.3063	0.850	.3760	0.844
.5973	0.959	.5694	0.889	.3069	0.854	.3768	0.836
.5983	0.969	.5721	0.904	.3078	0.855	.3774	0.842
.5993	0.969	.5727	0.899	.3084	0.854	.3781	0.837
.6004	0.971	.5734	0.902	.3091	0.849	.3789	0.827
.6016	0.971	.5749	0.881	.3103	0.855	.3796	0.855
.6109	0.976	.5755	0.880	.3121	0.866	.3801	0.849
.6120	0.958	.5764	0.871	.3140	0.863	.3808	0.853
.6131	0.977	.5771	0.870	.3148	0.839	.3815	0.853
.6143	0.964	.5777	0.889			.3836	0.864

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m
.4508	0.827	.2493	0.849	.3063	0.875	.4106	0.889
.4519	0.846	.2499	0.850	.3071	0.884	.4113	0.878
.4528	0.840	.2508	0.855	.3077	0.916	.4120	0.868
.4535	0.842	.2513	0.887	.3105	0.881	.4128	0.859
.4543	0.845	.2542	0.861	.3112	0.898	.4134	0.851
.4549	0.851	.2549	0.885	.3119	0.912	.4141	0.863
.4556	0.863	.2557	0.884	.3127	0.899	.4148	0.860
.4561	0.849	.2563	0.873	.3134	0.893	.4177	0.861
.4568	0.845	.2570	0.887	.3140	0.858	.4181	0.846
.4576	0.837	.2577	0.871	.3147	0.861	.4189	0.850
.4583	0.846	.2584	0.871	.3154	0.861	.4196	0.878
.4589	0.841	.2591	0.871	.3161	0.854	.4203	0.884
.4611	0.844	.2599	0.884	.3168	0.870	.4210	0.892
.4616	0.853	.2606	0.892	.3175	0.883	.4216	0.881
.4624	0.850	.2618	0.876	.3175	0.869	.4224	0.875
.4632	0.864	.2652	0.918	.3203	0.868	.4232	0.859
.4638	0.847	.2659	0.916	.3208	0.868	.4238	0.831
.4645	0.853	.2666	0.913	.3214	0.853	.4238	0.831
.4653	0.864	.2673	0.907	.3223	0.853	.4246	0.902
.4657	0.863	.2681	0.900	.3229	0.884	.4272	0.870
.4666	0.869	.2687	0.880	.3236	0.885	.4279	0.869
.4673	0.881	.2694	0.865	.3241	0.869	.4287	0.873
.4681	0.869	.2702	0.871	.3249	0.879	.4293	0.875
.4687	0.851	.2708	0.880	.3257	0.900		
.4708	0.858	.2715	0.913	.3264	0.876	2440970.2858	0.950
.4715	0.870	.2722	0.914	.3271	0.863	.2865	0.925
.4723	0.855	.2729	0.898	.3278	0.861	.2872	0.935
.4729	0.864	.2737	0.900	.3306	0.860	.2879	0.917
.4734	0.855	.2743	0.914	.3314	0.889	.2889	0.921
.4739	0.858	.2751	0.916	.3320	0.879	.2896	0.913
.4744	0.856	.2758	0.903	.3328	0.873	.2905	0.900
.4749	0.860	.2764	0.903	.3334	0.860	.2913	0.902
.4757	0.865	.2771	0.913	.3340	0.865	.2919	0.885
.4764	0.858	.2770	0.874	.3348	0.874	.2928	0.873
.4771	0.858	.2806	0.875	.3354	0.866	.2935	0.864
.4791	0.859	.2812	0.881	.3360	0.890	.2943	0.874
.4798	0.856	.2819	0.890	.3366	0.892	.2963	0.897
.4806	0.858	.2826	0.899	.3876	0.837	.2970	0.894
.4812	0.859	.2833	0.906	.3884	0.836	.2977	0.894
.4827	0.855	.2841	0.914	.3890	0.846	.2984	0.894
.4839	0.856	.2848	0.903	.3898	0.859	.2993	0.893
.4850	0.858	.2854	0.898	.3906	0.841	.2999	0.881
.4854	0.861	.2861	0.899	.3911	0.847	.3006	0.884
		.2868	0.923	.3916	0.841	.3013	0.881
2440966.2333	0.936	.2874	0.897	.3926	0.855	.3021	0.885
.2340	0.941	.2902	0.883	.3931	0.850	.3027	0.906
.2346	0.936	.2909	0.884	.3939	0.853	.3034	0.898
.2355	0.937	.2916	0.888	.3946	0.842	.3042	0.909
.2362	0.913	.2937	0.899	.3953	0.855	.3061	0.908
.2368	0.946	.2944	0.903	.3961	0.855	.3069	0.902
.2375	0.912	.2952	0.898	.3968	0.865	.3078	0.895
.2383	0.914	.2958	0.890	.3994	0.863	.3084	0.894
.2388	0.921	.2966	0.902	.4003	0.860	.3093	0.878
.2396	0.917	.2971	0.893	.4009	0.858	.3099	0.899
.2404	0.925	.2979	0.888	.4016	0.841	.3106	0.889
.2410	0.911	.3008	0.912	.4023	0.854	.3114	0.909
.2437	0.893	.3014	0.893	.4031	0.853	.3120	0.876
.2445	0.879	.3021	0.892	.4036	0.876	.3127	0.889
.2452	0.880	.3028	0.893	.4044	0.856	.3134	0.876
.2459	0.871	.3035	0.874	.4051	0.849	.3141	0.866
.2466	0.864	.3042	0.890	.4058	0.866	.3149	0.893
.2473	0.860	.3049	0.898	.4085	0.894	.3155	0.874
.2481	0.844	.3056	0.885	.4091	0.893	.3176	0.903
.2487	0.853			.4099	0.869	.3182	0.917
						.3188	0.889

Table 3 – continued

J.D.·Hel.	Δm	J.D.·Hel.	Δm	J.D.·Hel.	Δm	J.D.·Hel.	Δm
.3194	0.889	.3802	0.832	.3607	0.897	.5471	0.888
.3201	0.871	.3809	0.827	.3628	0.890	.5478	0.890
.3208	0.888	.3817	0.829	.3636	0.884	.5486	0.885
.3215	0.884	.3823	0.835	.3643	0.890	.5493	0.886
.3222	0.876	.3830	0.834	.3649	0.884	.5499	0.887
.3230	0.868	.3838	0.825	.3656	0.899	.5506	0.883
.3237	0.876	.3843	0.812	.3663	0.894	.5513	0.878
.3246	0.860			.3671	0.888	.5521	0.888
.3251	0.866	2441666.3079	0.830	.3677	0.895	.5527	0.893
.3277	0.822	.3085	0.836	.3684	0.881	.5543	0.884
.3283	0.822	.3093	0.825	.3691	0.893	.5541	0.883
.3290	0.820	.3099	0.840	.3699	0.897	.5548	0.879
.3298	0.806	.3106	0.841	.3732	0.914	.5554	0.884
.3304	0.837	.3113	0.841	.3741	0.906	.5562	0.881
.3311	0.846	.3127	0.836	.3746	0.908	.5569	0.890
.3318	0.829	.3133	0.831	.3755	0.899	.5593	0.894
.3324	0.846	.3141	0.827	.3761	0.906	.5601	0.887
.3333	0.840	.3149	0.831	.3768	0.897	.5608	0.877
.3339	0.839	.3197	0.814	.3775	0.920	.5614	0.892
.3346	0.812	.3164	0.806	.3782	0.907	.5622	0.877
.3353	0.811	.3193	0.830	.3789	0.913	.5629	0.893
.3374	0.859	.3199	0.820	.3796	0.917	.5636	0.897
.3381	0.845	.3208	0.832			.5643	0.890
.3388	0.861	.3213	0.856	2441667.5094	0.878	.5649	0.887
.3394	0.865	.3221	0.835	.5100	0.874	.5656	0.885
.3402	0.873	.3228	0.831	.5107	0.874	.5685	0.883
.3408	0.861	.3234	0.807	.5115	0.867	.5691	0.883
.3413	0.853	.3240	0.826	.5143	0.872	.5699	0.883
.3421	0.850	.3248	0.831	.5151	0.871	.5705	0.881
.3428	0.841	.3254	0.822	.5158	0.865	.5713	0.886
.3436	0.841	.3261	0.821	.5164	0.870	.5719	0.889
.3442	0.835	.3268	0.827	.5171	0.871	.5726	0.893
.3449	0.842	.3301	0.809	.5179	0.874	.5733	0.897
.3470	0.837	.3308	0.817	.5185	0.876	.5741	0.890
.3478	0.840	.3314	0.819	.5193	0.878	.5748	0.887
.3484	0.839	.3321	0.830	.5199	0.872	.5773	0.888
.3491	0.837	.3329	0.821	.5207	0.877	.5781	0.888
.3498	0.841	.3336	0.821	.5212	0.876	.5787	0.890
.3512	0.837	.3343	0.815	.5218	0.875	.5794	0.888
.3519	0.847	.3349	0.821	.5226	0.877	.5801	0.895
.3528	0.839	.3357	0.826	.5233	0.884	.5808	0.887
.3534	0.834	.3363	0.819	.5240	0.884	.5814	0.891
.3543	0.855	.3369	0.809	.5268	0.878	.5821	0.890
.3548	0.853	.3377	0.858	.5274	0.877	.5829	0.890
.3552	0.831	.3409	0.816	.5280	0.878	.5865	0.887
.3621	0.875	.3416	0.806	.5289	0.881	.5871	0.890
.3628	0.869	.3424	0.845	.5295	0.882	.5879	0.886
.3635	0.875	.3431	0.839	.5301	0.890	.5886	0.887
.3669	0.878	.3437	0.868	.5309	0.875	.5893	0.887
.3691	0.851	.3445	0.850	.5315	0.886	.5900	0.887
.3698	0.837	.3451	0.837	.5322	0.893	.5908	0.888
.3704	0.847	.3478	0.895	.5329	0.893	.5914	0.886
.3711	0.840	.3484	0.880	.5337	0.892	.5921	0.884
.3718	0.832	.3523	0.860	.5380	0.890	.5928	0.880
.3725	0.890	.3530	0.869	.5387	0.896	.5936	0.880
.3733	0.849	.3540	0.855	.5394	0.888	.5944	0.881
.3739	0.885	.3550	0.878	.5402	0.898	.5969	0.885
.3746	0.849	.3558	0.880	.5408	0.902	.5976	0.889
.3753	0.837	.3571	0.864	.5415	0.892	.5984	0.895
.3759	0.834	.3578	0.880	.5421	0.905	.5990	0.890
.3768	0.870	.3585	0.863	.5429	0.881	.5996	0.890
.3773	0.871	.3591	0.879	.5435	0.886	.6010	0.890
.3795	0.831	.3600	0.873	.5442	0.894	.6017	0.905

Table 3 – continued

J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m
.6024	0.902	.6561	0.893	.3241	0.886	.3749	0.866
.6031	0.904	.6568	0.901	.3249	0.895	.3756	0.871
.6039	0.902			.3255	0.889	.3763	0.864
.6046	0.893	2441668.2718	0.896	.3562	0.888	.3771	0.865
.6068	0.886	.2727	0.896	.3269	0.889	.3791	0.871
.6074	0.889	.2734	0.905	.3276	0.897	.3799	0.867
.6079	0.890	.2741	0.903	.3284	0.882	.3805	0.869
.6086	0.907	.2748	0.914	.3291	0.890	.3813	0.860
.6091	0.895	.2756	0.895	.3297	0.888	.3819	0.860
.6099	0.894	.2763	0.907	.3304	0.886	.3827	0.867
.6105	0.905	.2769	0.912	.3312	0.887	.3833	0.867
.6113	0.890	.2778	0.902	.3318	0.882	.3839	0.852
.6118	0.900	.2784	0.912	.3339	0.905	.3847	0.862
.6127	0.906	.2791	0.890	.3348	0.883	.3855	0.861
.6151	0.896	.2798	0.890	.3354	0.878	.3861	0.867
.6158	0.895	.2805	0.876	.3361	0.881	.3883	0.863
.6165	0.883	.2812	0.889	.3368	0.877	.3893	0.864
.6171	0.896	.2833	0.887	.3376	0.873	.3901	0.871
.6179	0.901	.2838	0.881	.3382	0.883	.3907	0.863
.6186	0.890	.2846	0.891	.3389	0.878	.3914	0.867
.6194	0.886	.2860	0.922	.3396	0.880	.3921	0.864
.6201	0.888	.2868	0.913	.3404	0.879	.3928	0.868
.6207	0.878	.2875	0.910	.3410	0.880	.3935	0.870
.6214	0.893	.2882	0.904	.3418	0.895	.3943	0.861
.6255	0.894	.2888	0.893	.3425	0.905	.3949	0.854
.6262	0.874	.2897	0.893	.3431	0.882	.3971	0.857
.6269	0.883	.2903	0.905	.3439	0.893	.3976	0.866
.6276	0.875	.2909	0.885	.3445	0.895	.3984	0.873
.6284	0.879	.2918	0.889	.3452	0.869	.3991	0.862
.6291	0.877	.2937	0.883	.3459	0.867	.3999	0.854
.6298	0.877	.2944	0.884	.3465	0.868	.4007	0.866
.6304	0.879	.2952	0.883	.3473	0.882	.4011	0.863
.6311	0.881	.2957	0.886	.3491	0.874	.5300	0.833
.6318	0.881	.2965	0.891	.3499	0.873	.5308	0.833
.6326	0.879	.2971	0.890	.3506	0.879	.5313	0.821
.6332	0.883	.2978	0.887	.3512	0.873	.5321	0.822
.6338	0.881	.2985	0.890	.3519	0.873	.5335	0.831
.6344	0.888	.2993	0.886	.3527	0.881	.5341	0.834
.6352	0.881	.3000	0.885	.3533	0.873	.5349	0.831
.6359	0.879	.3031	0.891	.3541	0.876	.5356	0.829
.6366	0.886	.3041	0.884	.3546	0.885	.5363	0.831
.6374	0.883	.3048	0.883	.3554	0.880	.5371	0.827
.6380	0.889	.3056	0.889	.3561	0.885	.5392	0.823
.6386	0.883	.3062	0.881	.3568	0.877	.5399	0.836
.6394	0.878	.3069	0.882	.3596	0.874	.5404	0.819
.6399	0.882	.3076	0.887	.3606	0.862	.5412	0.825
.6407	0.877	.3083	0.888	.3611	0.873	.5419	0.817
.6415	0.881	.3088	0.898	.3616	0.872	.5426	0.817
.6421	0.885	.3096	0.886	.3622	0.874	.5433	0.821
.6429	0.884	.3122	0.873	.3629	0.873	.5440	0.816
.6435	0.871	.3132	0.885	.3636	0.879	.5446	0.821
.6443	0.880	.3139	0.869	.3643	0.874	.5454	0.817
.6449	0.879	.3146	0.875	.3650	0.885	.5461	0.816
.6456	0.890	.3153	0.866	.3658	0.885	.5482	0.821
.6463	0.885	.3159	0.880	.3663	0.871	.5488	0.819
.6505	0.889	.3166	0.871	.3674	0.877	.5495	0.818
.6512	0.892	.3171	0.881	.3699	0.878	.5503	0.817
.6519	0.888	.3179	0.881	.3708	0.873	.5509	0.824
.6526	0.883	.3187	0.886	.3714	0.859	.5516	0.830
.6534	0.897	.3213	0.887	.3721	0.871	.5523	0.824
.6539	0.889	.3220	0.889	.3728	0.876	.5530	0.821
.6546	0.892	.3227	0.894	.3735	0.859	.5537	0.820
.6554	0.893	.3235	0.895	.3742	0.864	.5541	0.824

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m
.5552	0.831	.6221	0.795	.6834	0.810	.3815	0.966
.5558	0.828	.6229	0.802	.6843	0.816	.3823	0.977
.5579	0.830	.6235	0.790	.6849	0.813	.3829	0.975
.5586	0.823	.6243	0.805	.6856	0.808	.3835	0.974
.5594	0.828	.6249	0.800	.6863	0.816	.3843	0.984
.5601	0.823	.6256	0.798	.6871	0.814	.3849	0.981
.5607	0.819	.6262	0.803	.6877	0.791	.3856	0.982
.5614	0.826	.6271	0.804	.6884	0.802	.3885	1.001
.5621	0.834	.6291	0.825	.6891	0.814	.3898	0.980
.5628	0.817	.6298	0.822	.6899	0.816	.3906	0.979
.5635	0.822	.6305	0.807	.6906	0.811	.3912	0.976
.5643	0.824	.6312	0.811			.3919	0.974
.5649	0.823	.6318	0.804	2441669.3348	1.003	.3926	0.961
.5657	0.829	.6324	0.806	.3355	0.975	.3934	0.961
.5663	0.821	.6332	0.809	.3364	0.987	.3940	0.972
.5671	0.818	.6339	0.807	.3371	0.997	.3946	0.986
.5704	0.837	.6353	0.815	.3381	0.964	.3954	1.011
.5710	0.819	.6361	0.812	.3388	0.987	.3984	0.985
.5717	0.823	.6388	0.808	.3395	0.983	.3991	0.996
.5724	0.827	.6396	0.819	.3400	0.994	.3999	0.989
.5732	0.828	.6409	0.822	.3409	1.000	.4004	0.982
.5738	0.823	.6415	0.808	.3413	0.997	.4011	0.984
.5746	0.827	.6421	0.804	.3421	0.984	.4017	0.978
.5752	0.821	.6429	0.818	.3449	0.984	.4024	0.971
.5758	0.822	.6451	0.811	.3454	0.977	.4031	0.967
.5774	0.829	.6474	0.806	.3463	0.992	.4038	0.967
.5801	0.818	.6484	0.797	.3470	0.987	.4044	0.973
.5808	0.824	.6492	0.801	.3477	0.986	.4053	0.990
.5815	0.828	.6518	0.791	.3486	0.994	.4094	0.978
.5823	0.827	.6529	0.802	.3491	0.974	.4101	0.981
.5829	0.828	.6546	0.806	.3498	0.976	.4109	0.974
.5835	0.835	.6553	0.810	.3505	0.975	.4115	0.967
.5852	0.814	.6559	0.801	.3513	0.984	.4121	0.991
.5866	0.845	.6566	0.801	.3519	1.011	.4129	0.977
.5881	0.842	.6573	0.800	.3541	0.992	.4136	0.981
.5887	0.824	.6580	0.804	.3549	0.987	.4568	0.904
.5893	0.822	.6587	0.801	.3556	0.975	.4573	0.896
.5899	0.807	.6595	0.806	.3563	0.986	.4580	0.898
.5921	0.835	.6601	0.809	.3570	0.979	.4587	0.897
.5943	0.808	.6624	0.819	.3578	0.968	.4594	0.916
.5969	0.802	.6629	0.812	.3585	0.971	.4601	0.888
.5977	0.809	.6636	0.808	.3593	0.988	.4609	0.899
.5984	0.799	.6641	0.800	.3599	0.984	.4616	0.888
.5991	0.816	.6648	0.807	.3606	0.999	.4624	0.886
.5998	0.820	.6656	0.800	.3613	0.997	.4631	0.898
.6006	0.806	.6664	0.805	.3619	0.998	.4656	0.874
.6012	0.801	.6669	0.799	.3644	0.991	.4664	0.896
.6019	0.816	.6677	0.798	.3652	1.004	.4671	0.881
.6026	0.806	.6684	0.807	.3659	0.987	.4677	0.876
.6033	0.797	.6692	0.793	.3666	0.983	.4684	0.867
.6039	0.793	.6724	0.803	.3674	0.970	.4692	0.872
.6064	0.837	.6733	0.800	.3680	0.977	.4699	0.879
.6071	0.800	.6739	0.805	.3688	0.963	.4707	0.867
.6078	0.798	.6748	0.806	.3693	0.986	.4715	0.864
.6084	0.811	.6755	0.800	.3701	0.983	.4721	0.869
.6098	0.798	.6763	0.810	.3708	0.982	.4729	0.870
.6105	0.780	.6769	0.809	.3714	0.982	.4756	0.855
.6111	0.808	.6777	0.804	.3721	0.991	.4763	0.863
.6116	0.815	.6782	0.807	.3728	0.982	.4770	0.920
.6124	0.794	.6789	0.807	.3764	0.980	.4776	0.890
.6131	0.825	.6796	0.804	.3770	0.979	.4783	0.924
.6208	0.794	.6803	0.804	.3801	0.982	.4804	0.872
.6214	0.787	.6828	0.801	.3808	0.981	.4810	0.879

Table 3 – continued

J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m	J.D. Hel.	Δ_m
.4818	0.881	.3804	0.784	.4346	0.801	.4914	0.808
.4826	0.872	.3812	0.781	.4352	0.806	.4921	0.805
.5249	0.849	.3818	0.785	.4359	0.810	.4928	0.804
.5257	0.831	.3826	0.798	.4366	0.803	.4935	0.801
.5263	0.851	.3832	0.803	.4373	0.792	.4942	0.809
.5269	0.846	.3839	0.800	.4379	0.816	.4963	0.821
.5276	0.831	.3846	0.793	.4388	0.808	.4969	0.829
.5284	0.829	.3854	0.791	.4406	0.797	.4976	0.807
.5289	0.841	.3860	0.795	.4415	0.790	.4986	0.820
.5298	0.834	.3867	0.788	.4421	0.797	.4990	0.825
.5304	0.838	.3874	0.792	.4428	0.786	.4996	0.808
.5311	0.834	.3894	0.811	.4435	0.799	.5003	0.820
.5333	0.838	.3899	0.803	.4443	0.824	.5011	0.820
.5338	0.851	.3908	0.792	.4449	0.823	.5016	0.816
.5347	0.842	.3914	0.795	.4456	0.798	.5024	0.811
.5354	0.836	.3921	0.803	.4471	0.791	.5031	0.806
.5361	0.834	.3929	0.803	.4476	0.800	.5038	0.817
.5367	0.843	.3935	0.818	.4483	0.796	.5060	0.785
.5374	0.842	.3943	0.803	.4503	0.788	.5066	0.793
.5382	0.839	.3949	0.801	.4510	0.788	.5076	0.791
.5388	0.840	.3957	0.805	.4518	0.784	.5082	0.796
.5396	0.847	.3963	0.813	.4524	0.793	.5089	0.786
.5422	0.830	.3971	0.806	.4532	0.803	.5096	0.775
.5429	0.826	.3977	0.803	.4538	0.793	.5103	0.796
.5436	0.829	.4006	0.820	.4543	0.816	.5109	0.782
.5444	0.818	.4013	0.830	.4548	0.811	.5118	0.788
.5451	0.822	.4020	0.814	.4556	0.803	.5124	0.790
.5458	0.811	.4028	0.810	.4562	0.802	.5130	0.795
.5465	0.808	.4034	0.815	.4569	0.800	.5136	0.796
.5470	0.812	.4041	0.806	.4576	0.794	.5158	0.802
		.4048	0.803	.4600	0.802	.5193	0.777
2441677.2867	0.809	.4055	0.807	.4608	0.803	.5199	0.778
.2874	0.824	.4062	0.807	.4614	0.808	.5206	0.779
.2881	0.827	.4069	0.804	.4623	0.801	.5213	0.794
.2889	0.816	.4076	0.801	.4629	0.807	.5220	0.814
.2895	0.822	.4084	0.799	.4635	0.803	.5228	0.792
.2900	0.816	.4105	0.799	.4641	0.787	.5234	0.784
.2915	0.808	.4111	0.800	.4649	0.804	.5241	0.791
.2921	0.804	.4118	0.819	.4656	0.794	.5249	0.800
.2928	0.806	.4126	0.805	.4663	0.810	.5255	0.786
.2936	0.817	.4132	0.798	.4670	0.805	.5262	0.793
.2958	0.807	.4146	0.800	.4677	0.784	.5268	0.779
.2963	0.812	.4153	0.797	.4684	0.794	.5290	0.800
.2971	0.809	.4160	0.788	.4713	0.795	.5298	0.830
.2978	0.826	.4168	0.801	.4721	0.808	.5304	0.807
.2985	0.819	.4174	0.801	.4728	0.813	.5312	0.810
.2993	0.790	.4181	0.793	.4782	0.776	.5317	0.803
.2999	0.794	.4203	0.803	.4789	0.784	.5324	0.815
.3005	0.793	.4210	0.814	.4796	0.768	.5331	0.830
.3012	0.821	.4218	0.800	.4804	0.772	.5336	0.813
.3018	0.818	.4224	0.808	.4810	0.794	.5344	0.807
.3046	0.801	.4231	0.802	.4818	0.798	.5353	0.808
.3055	0.801	.4239	0.801	.4825	0.803	.5371	0.788
.3061	0.797	.4246	0.804	.4831	0.803	.5380	0.785
.3067	0.802	.4251	0.799	.4838	0.803	.5386	0.794
.3071	0.802	.4260	0.810	.4845	0.796	.5393	0.806
.3082	0.821	.4268	0.799	.4866	0.806	.5399	0.807
.3089	0.807	.4274	0.799	.4873	0.806	.5408	0.796
.3096	0.799	.4281	0.812	.4879	0.798	.5414	0.809
.3101	0.798	.4287	0.802	.4886	0.800	.5421	0.810
.3109	0.806	.4324	0.795	.4893	0.796	.5428	0.808
.3115	0.803	.4331	0.791	.4901	0.805	.5435	0.815
.3798	0.787	.4338	0.797	.4907	0.799	.5442	0.792

Table 3 – continued

J.D. Hel.	Δm	J.D. Hel.	Δm	J.D. Hel.	Δm	J.D. Hel.	Δm
.5463	0.817	.5984	0.789	.2673	0.875	.2578	0.890
.5469	0.804	.5991	0.811	.2679	0.889	.2584	0.907
.5474	0.809	.5996	0.808	.2686	0.911	.2591	0.928
.5484	0.801	.6004	0.811	.2693	0.906	.2599	0.940
.5491	0.806	.6011	0.806	.2700	0.870	.2606	0.909
.5499	0.788	.6018	0.818	.2707	0.878	.2613	0.948
.5505	0.793	.6024	0.813	.2714	0.869	.2619	0.922
.5511	0.785	.6033	0.810	.2734	0.854	.2626	0.906
.5519	0.786	.6039	0.805	.2743	0.846	.2633	0.935
.5527	0.787	.6046	0.814	.2749	0.851	.2640	0.911
.5533	0.809	.6053	0.816	.2756	0.865		
.5540	0.807	.6074	0.812	.2763	0.866	2441708.3260	0.883
.5560	0.793	.6081	0.811	.2769	0.868	.3265	0.946
.5568	0.787	.6088	0.802	.2777	0.868	.3273	0.944
.5574	0.797	.6096	0.818	.2784	0.858	.3280	0.908
.5581	0.798	.6103	0.805	.2791	0.860	.3288	0.932
.5588	0.802	.6108	0.824	.2798	0.871	.3294	0.911
.5595	0.806	.6115	0.815	.2831	0.821	.3301	0.922
.5602	0.805	.6123	0.814	.2838	0.850	.3308	0.884
.5610	0.818	.6129	0.832	.2845	0.834	.3315	0.916
.5616	0.819	.6136	0.803	.2853	0.842	.3321	0.921
.5624	0.829	.6143	0.805	.2859	0.836	.3329	0.876
.5631	0.829	.6149	0.791	.2866	0.829	.3335	0.918
.5637	0.827	.6173	0.809	.2874	0.845		
.5644	0.804	.6179	0.800	.2880	0.821	2441709.4269	0.964
.5664	0.838	.6186	0.798	.2888	0.814	.4277	0.981
.5673	0.838	.6194	0.825	.2895	0.811	.4283	0.951
.5679	0.837	.6201	0.810			.4296	0.963
.5687	0.831	.6207	0.799	2441696.2237	0.903	.4304	0.989
.5694	0.836	.6214	0.801	.2244	0.894	.4310	0.989
.5701	0.814	.6221	0.807	.2251	0.923	.4318	0.949
.5706	0.823	.6229	0.822	.2259	0.914	.4324	0.949
.5714	0.815	.6234	0.812	.2264	0.922	.4332	0.955
.5721	0.817	.6242	0.821	.2272	0.921	.4337	0.986
.5728	0.816	.6249	0.818	.2279	0.894	.4346	0.984
.5735	0.820	.6256	0.823	.2286	0.939	.4352	0.966
.5743	0.812			.2294	0.917	.4359	0.990
.5765	0.803	2441695.2424	0.920	.2301	0.925	.4410	0.975
.5769	0.813	.2431	0.906	.2307	0.922	.4418	0.991
.5777	0.816	.2437	0.912	.2328	0.909	.4424	0.981
.5783	0.814	.2444	0.899	.2335	0.911	.4432	0.982
.5788	0.810	.2452	0.888	.2343	0.874	.4438	0.986
.5796	0.816	.2459	0.903	.2349	0.850	.4445	0.975
.5803	0.820	.2466	0.903	.2383	0.940	.4451	0.977
.5810	0.818	.2474	0.885	.2389	0.916	.4459	1.000
.5818	0.827	.2480	0.887	.2411	0.912	.4464	0.996
.5826	0.845	.2488	0.893	.2416	0.920	.4473	0.987
.5832	0.837	.2513	0.881	.2424	0.904	.4479	1.004
.5839	0.824	.2521	0.912	.2431	0.887	.4518	0.967
.5846	0.837	.2543	0.908	.2438	0.892	.4527	0.982
.5853	0.825	.2569	0.892	.2446	0.902	.4534	0.987
.5881	0.802	.2574	0.889	.2453	0.926	.4541	0.987
.5887	0.801	.2582	0.903	.2458	0.914	.4548	0.982
.5894	0.801	.2590	0.899	.2493	0.881	.4555	1.004
.5901	0.802	.2596	0.897	.2499	0.912	.4562	0.985
.5918	0.818	.2603	0.909	.2506	0.899	.4569	0.993
.5914	0.802	.2610	0.904	.2514	0.898	.4575	0.999
.5923	0.832	.2616	0.908	.2521	0.892	.4582	0.986
.5929	0.807	.2624	0.913	.2529	0.902	.4588	0.999
.5936	0.807	.2625	0.893	.2535	0.893	.4588	0.999
.5943	0.801	.2652	0.902	.2543	0.900	.4596	0.964
.5950	0.829	.2659	0.892	.2549	0.889	.4637	0.972
.5957	0.825	.2666	0.878	.2557	0.864	.4644	0.996

Table 3 – continued

J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m	J.D. _{Hel.}	Δ_m
.4652	0.973	.2583	0.954	.3876	0.845	.3370	2.907
.4659	1.007	.2591	0.937	.3883	0.850	.3377	2.926
.4667	1.007	.2598	0.932	.3890	0.825	.3388	2.920
.4674	0.989	.2604	0.930	.3896	0.856	.3395	2.891
.4680	0.985	.2610	0.932	.3907	0.837	.3402	2.939
.4687	1.011	.2617	0.914	.3911	0.827	.3409	2.883
.4694	0.957	.2623	0.913	.3918	0.881	.3416	2.961
.4728	0.994	.2635	0.889	.3926	0.837	.3423	2.953
.4741	1.000	.2698	0.941	.3935	0.859	.3431	2.926
.4748	1.002	.2704	0.907	.3943	0.842	.3459	2.920
.4756	1.011	.2712	0.927	.3968	0.856	.3645	2.917
.4762	0.971	.2718	0.948	.3976	0.854	.3477	2.885
.4769	0.953	.2725	0.899	.3982	0.853	.3479	2.877
.4776	1.011	.2735	0.892	.3989	0.841	.3486	2.970
.4784	0.996	.2743	0.897	.4002	0.827	.3493	2.948
.4791	0.993	.2749	0.913	.4009	0.845	.3499	2.970
.4799	0.971	.2754	0.935	.4016	0.844	.3507	2.992
.4805	0.975	.2761	0.955	.4023	0.856	.3514	2.934
.4830	0.973	.2768	0.959	.4030	0.866	.3521	2.975
.4837	0.948	.2774	0.936			.3562	2.909
.4844	0.960	.2835	0.860	2441765.2958	2.580	.3569	2.942
.4851	0.953	.2841	0.873	.2965	2.595	.3576	2.931
.4858	0.976	.2848	0.883	.2980	2.568	.3583	3.001
.4866	0.955	.2856	0.916	.2986	2.593	.3591	2.945
.4874	0.982	.2862	0.922	.2993	2.618	.3596	2.926
.4882	0.976	.2869	0.920	.2999	2.639	.3604	2.981
.4889	1.003	.2874	0.902	.3008	2.674	.3611	3.021
.4896	0.982	.2883	0.899	.3014	2.648	.3618	2.981
.4903	0.944	.2889	0.903	.3021	2.696	.3624	2.948
.4929	0.969	.2903	0.899	.3028	2.715	.3694	3.044
.4938	0.976			.3035	2.679	.3701	2.984
.4944	0.962	2441747.2568	0.809	.3043	2.744	.3708	3.033
.4951	0.994	.2577	0.811	.3077	2.802	.3715	2.975
.4958	0.985	.2584	0.831	.3082	2.822	.3721	2.950
.4965	1.003	.2591	0.811	.3089	2.822	.3729	2.945
.4973	0.986	.2598	0.807	.3098	2.797	.3736	3.007
.4980	0.978	.2605	0.796	.3104	2.815	.3743	3.004
.4986	0.975	.2611	0.810	.3111	2.851	.3749	2.970
.4994	0.977	.2619	0.803	.3118	2.817	.3756	3.030
.4999	0.966	.2627	0.811	.3125	2.804	.3785	2.953
.5021	0.949	.2633	0.845	.3133	2.877	.3792	2.909
.5028	0.994	.2674	0.800	.3138	2.959	.3798	2.896
.5035	0.987	.2681	0.814	.3174	2.928	.3805	2.888
.5043	1.024	.2688	0.805	.3181	2.880	.3812	2.896
.5049	0.972	.2695	0.817	.3188	2.896	.3820	2.864
.5056	1.022	.2703	0.827	.3193	2.956	.3827	2.896
.5064	0.986	.2709	0.810	.3202	2.893	.3834	2.854
.5069	0.994	.2716	0.809	.3208	2.937	.3841	2.810
.5077	0.996	.2723	0.841	.3215	2.915	.3848	2.828
.5084	0.918	.2731	0.834	.3226	2.953	.3853	2.869
.5091	0.993	.2737	0.820	.3231	2.901	.3881	2.742
.5118	0.958	.2758	0.815	.3239	2.923	.3888	2.730
.5125	0.993	.2764	0.827	.3264	2.937	.3896	2.710
.5131	1.028	.2786	0.806	.3271	2.888	.3902	2.698
.5138	0.966	.2791	0.846	.3277	2.928	.3909	2.667
.5145	0.962	.2799	0.819	.3285	2.942	.3917	2.637
.5153	0.975	.2806	0.816	.3291	2.937	.3923	2.632
.5159	0.987	.3629	0.845	.3297	2.981	.3930	2.658
.5164	0.973	.3636	0.803	.3205	2.987	.3937	2.653
.5174	0.966	.3643	0.832	.3312	2.956	.3944	2.625
.5179	1.028	.3649	0.836	.3319	2.926	.3971	2.533
		.3657	0.827	.3326	2.953	.3978	2.564
2441711.2574	0.876	.3871	0.816	.3364	2.945	.3986	2.524

Table 3 - continued

J.D. Hel.	Δm	J.D. Hel.	Δm	J.D. Hel.	Δm	J.D. Hel.	Δm
.3991	2.522	.3156	0.817	.3743	0.795	.3364	0.803
.3999	2.537	.3163	0.809	.3752	0.789	.3371	0.807
.4006	2.478	.3171	0.814	.3758	0.795		
.4012	2.411	.3177	0.811	.3763	0.800	2440327.3266	0.875
.4018	2.401	.3185	0.809	.3793	0.801	.3273	0.871
.4024	2.461	.3213	0.809	.3799	0.807	.3280	0.867
.4036	2.378	.3218	0.819	.3806	0.798	.3287	0.869
.4048	2.349	.3226	0.815	.3813	0.807	.3295	0.868
.4076	2.306	.3233	0.819	.3821	0.807	.3307	0.866
.4084	2.286	.3239	0.816	.3827	0.790	.3309	0.869
.4090	2.268	.3248	0.821	.3835	0.815	.3316	0.858
.4098	2.272	.3254	0.807	.3848	0.801	.3323	0.859
.4104	2.296	.3261	0.809	.3855	0.785		
.4116	2.251	.3268	0.810	.3863	0.796	2440500.4155	0.820
.4123	2.239	.3274	0.807	.3890	0.809	.4166	0.827
.4131	2.228	.3308	0.819	.3898	0.804	.4177	0.822
.4136	2.192	.3316	0.815	.3904	0.811	.4188	0.825
		.3323	0.819	.3912	0.817	.4199	0.826
2441766.2753	0.798	.3330	0.817	.3918	0.811	.4212	0.815
.2760	0.801	.3338	0.807	.3924	0.799	.4224	0.828
.2768	0.810	.3343	0.820	.3930	0.788	.4229	0.814
.2774	0.806	.3350	0.812	.3936	0.784	.4248	0.810
.2781	0.804	.3357	0.822	.3951	0.781	.4314	0.821
.2789	0.806	.3364	0.812	.3981	0.807	.4328	0.826
.2795	0.806	.3371	0.804	.3987	0.790	.4338	0.814
.2804	0.804	.3398	0.799	.3993	0.805	.4349	0.821
.2807	0.809	.3406	0.796	.3999	0.809	.4360	0.817
.2814	0.809	.3413	0.816	.4007	0.809	.4371	0.814
.2849	0.807	.3421	0.819	.4014	0.812	.4383	0.813
.2858	0.800	.3426	0.826	.4021	0.805	.4399	0.821
.2863	0.810	.3433	0.824	.4027	0.798	.4410	0.812
.2871	0.812	.3439	0.831	.4035	0.811	.4552	0.831
.2878	0.814	.3448	0.811			.4563	0.826
.2885	0.800	.3454	0.811			.4574	0.829
.2893	0.811	.3461	0.816			.4585	0.824
.2898	0.805	.3488	0.825			.4600	0.821
.2906	0.807	.3496	0.832	2439948.3434	0.894	.4611	0.818
.2912	0.815	.3503	0.821	.3452	0.888	.4622	0.811
.2940	0.798	.3509	0.815	.3462	0.890	.4633	0.825
.2947	0.801	.3516	0.811	.3464	0.895	.4644	0.815
.2954	0.807	.3523	0.816	.3477	0.883	.4655	0.825
.2963	0.805	.3530	0.789	.3484	0.876	.4714	0.819
.2968	0.800	.3537	0.801	.3500	0.894	.4725	0.820
.2977	0.810	.3543	0.781	.3508	0.879	.4738	0.821
.2982	0.811	.3549	0.785	.3553	0.886	.4751	0.818
.2989	0.809	.3558	0.779	.3561	0.888	.4762	0.816
.2996	0.796	.3591	0.794	.3568	0.896	.4773	0.808
.3004	0.794	.3599	0.803	.3576	0.888	.4784	0.808
.3033	0.776	.3606	0.793	.3583	0.888	.4794	0.816
.3040	0.800	.3614	0.786	.3590	0.898	.4805	0.814
.3046	0.812	.3621	0.794	.3597	0.905	.4816	0.840
.3051	0.811	.3627	0.803	.3605	0.900	.4881	0.831
.3059	0.810	.3634	0.814	.3612	0.891	.4891	0.865
.3066	0.801	.3641	0.795	.3620	0.895	.4902	0.860
.3073	0.799	.3648	0.791	.3627	0.897	.4913	0.842
.3080	0.811	.3656	0.789			.4924	0.812
.3087	0.812	.3683	0.796	2440319.3302	0.816	.4936	0.825
.3094	0.811	.3702	0.816	.3309	0.791	.4948	0.805
.3120	0.803	.3709	0.821	.3316	0.815	.4960	0.811
.3128	0.807	.3716	0.804	.3323	0.798	.4971	0.817
.3135	0.824	.3724	0.783	.3331	0.798	.4981	0.812
.3143	0.821	.3730	0.783	.3338	0.784	.5349	0.816
.3149	0.812	.3738	0.841	.3346	0.803	.5359	0.810
				.3356	0.797		

Blue observations

Table 3 - continued

J.D. Hel.	Δm	J.D. Hel.	Δm	J.D. Hel.	Δm	J.D. Hel.	Δm
.5371	0.822	.6192	0.894	.4619	0.128	.5806	0.197
.5381	0.823			.4630	0.128	.5817	0.197
.5396	0.821	Ultraviolet observations		.4641	0.144	.5828	0.192
.5408	0.811			.4652	0.132	.5899	0.187
.5418	0.816	2439948.3432	0.225	.4711	0.166	.5910	0.177
.5429	0.810	.3450	0.218	.4722	0.152	.5921	0.174
.5440	0.803	.3460	0.255	.4735	0.137	.5932	0.174
.5454	0.809	.3468	0.223	.4748	0.159	.5943	0.179
		.3474	0.212	.4759	0.166	.5954	0.171
2440514.4979	0.898	.3482	0.224	.4781	0.131	.5965	0.169
.4994	0.887	.3498	0.232	.4791	0.142	.5975	0.186
.5005	0.883	.3506	0.210	.4802	0.131	.5986	0.171
.5016	0.879	.3551	0.212	.4813	0.138	.5997	0.179
.5026	0.896	.3559	0.239			.6008	0.181
.5037	0.878	.3566	0.232	2440514:4902	0.233	.6102	0.181
.5047	0.887	.3573	0.240	.4913	0.217	.6113	0.191
.5059	0.891	.3581	0.237	.4928	0.220	.6124	0.176
.5128	0.889	.3588	0.229	.4939	0.216	.6135	0.181
.5139	0.892	.3595	0.234	.4991	0.177	.6146	0.186
.5150	0.894	.3602	0.238	.5002	0.176	.6157	0.187
.5161	0.895	.3610	0.247	.5013	0.179	.6167	0.188
.5172	0.897	.3617	0.219	.5023	0.196	.6178	0.191
.5181	0.902	.3625	0.220	.5034	0.173	.6189	0.183
.5193	0.884			.5045	0.205	.6200	0.186
.5204	0.892	2440327.3147	0.233	.5056	0.185	.6279	0.198
.5215	0.900	.3155	0.225	.5125	0.181	.6290	0.206
.5225	0.894	.3167	0.230	.5136	0.178	.6301	0.206
.5472	0.912	.3169	0.211	.5147	0.184	.6346	0.214
.5563	0.916	.3177	0.217	.5158	0.184	.6356	0.209
.5577	0.916	.3191	0.233	.5169	0.192	.6378	0.210
.5589	0.908	.3198	0.188	.5178	0.204	.6389	0.210
.5598	0.906	.3205	0.214	.5190	0.170	.6400	0.200
.5619	0.916	.3213	0.209	.5201	0.170	.6411	0.197
.5631	0.900	.3271	0.211	.5212	0.195		
.5642	0.914	.3278	0.221	.5222	0.195		
.5653	0.912	.3285	0.211	.5264	0.186		
.5664	0.908	.3306	0.255	.5304	0.191		
.5733	0.897	.3313	0.217	.5315	0.189		
.5744	0.881	.3321	0.245	.5326	0.191		
.5755	0.889	.3328	0.228	.5337	0.194		
.5765	0.891			.5347	0.178		
.5776	0.892	2440500.4139	0.159	.5358	0.188		
.5787	0.899	.4152	0.181	.5369	0.180		
.5798	0.912	.4163	0.196	.5330	0.202		
.5902	0.903	.4174	0.185	.5391	0.199		
.5913	0.902	.4185	0.169	.5469	0.196		
.5924	0.910	.4189	0.169	.5560	0.198		
.5935	0.898	.4209	0.179	.5574	0.185		
.5946	0.901	.4221	0.169	.5586	0.187		
.5957	0.882	.4232	0.188	.5595	0.190		
.5968	0.879	.4243	0.159	.5606	0.182		
.5978	0.878	.4311	0.176	.5616	0.172		
.5989	0.892	.4325	0.146	.5628	0.182		
.6000	0.906	.4335	0.151	.5639	0.182		
.6011	0.911	.4346	0.151	.5650	0.190		
.6105	0.894	.4357	0.139	.5661	0.185		
.6116	0.891	.4368	0.155	.5730	0.213		
.6127	0.868	.4380	0.167	.5741	0.179		
.6138	0.867	.4407	0.129	.5752	0.190		
.6149	0.887	.4418	0.132	.5762	0.197		
.6160	0.860	.4559	0.159	.5773	0.195		
.6170	0.909	.4560	0.147	.5784	0.187		
.6181	0.892	.4582	0.151	.5795	0.189		

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AUTOMATIZOVANÝ FOTOELEKTRICKÝ FOTOMETER ASTRONOMICKÉHO OBSERVATÓRIA NA SKALNATOM PLESE

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Súhrn

Vývoj fotoelektrických fotometrov sa postupne ustálil na štandardnom type, kde sa pre záznam údajov používa líniový elektronický kompenzačný zosilňovač. Potreba pozorovaní veľmi slabých objektov na hranici detekcie si vynútila vývoj fotometrov, ktorých koncepcia sa zakladá na princípe integračnej alebo impulznej metódy. Tým sa umožnilo aj meranie objektov slabších ako jas jednotkovej plochy oblohy. Vzrast množstva údajov pri pozorovaní, výhodnosť úpravy záznamu na číselnú formu, prípadne záznam na diernu pásku či dierny štítok pre strojové spracovanie dát, ako aj potreba znížiť podiel práce pozorovateľa na pozorovaní, vyžadujú si automatizáciu fotoelektrických fotometrov.

Automatizovaný fotoelektrický fotometer Astronomického observatória na Skalnatom Plese je postavený na princípe integračnej metódy. Koncepcia jeho výstavby vyplynula z požiadaviek automatizovania, podľa možností všetkých operácií spojených s vlastným fotometrom a s možnosťou ďalšieho spracovania nameraných údajov samočinným počítačim strojom. Činnosť automatizovaných častí fotoelektrického fotometra, určených pre záznam dát, odvodila sa z činnosti meracej ústredne ÚM 10, ktorá sa používa na automatizáciu výrobných procesov v priemysle. Opticko-mechanická časť fotometra a časť automatizačných prvkov sa vyrobili podľa špeciálnych astronomických požiadaviek.

Automatizovaný fotoelektrický fotometer je inštalovaný na reflektore 600/3300 Astronomického observatória na Skalnatom Plese v Cassegrainovom ohnisku s ekvivalentnou ohniskovou vzdialenosťou 9990 mm. Opticko-mechanická časť automatizovaného fotoelektrického fotometra obsahuje optickú sústavu, ohniskové clony, farebné filtre, násobič elektrónov a elektronické obvody na automatickú činnosť a indikáciu. Optická sústava používa systém výstupnej pupily a tak výkon fotoelektrického fotometra nezávisí od tvaru objektu a od jeho polohy v ohniskovej clone. Ako detektor sa používa násobič elektrónov EMI 6256 B. V opticko-mechanickej časti je inštalovaných 9 filtrov: tri pre štandardnú *UBV*-fotometriu, tri pre strednopásmovú fotometriu zákrytových premenných hviezd a tri pre úzkopásmovú fotometriu v oblasti čiar Balmerovej série vodíka. Optická časť automatizovaného fotoelektrického fotometra má mikrometrický posuv v dvoch na seba kolmých smeroch, ktorý umožňuje ofsetové pozorovanie slabých objektov.

Signál sa meria integračným zosilňovačom s elektrometrickou elektrónkou na vstupe. Integračný zosilňovač má tri vstupné rozsahy s pomerom citlivostí 1:10:100. Na výstupe sú štyri rozsahy s pomerom citlivostí 1:2,5144. Vstupné a výstupné citlivosti sa môžu ovládať automaticky alebo ručne. Kombinácia vstupných a výstupných citlivostí dáva 12 stupňov s meracím rozsahom tri rády. Záznam údajov sa súčasne robí na písacom stroji a dierovači. Záznamová jednotka registruje údaje namerané analógovo-číslícovým prevodníkom, čas pozorovania z elektronických číslicových hodín a ostatné údaje, ako sú: clona, farebný filter, vstupná a výstupná citlivosť, číslo hviezdy a pozorovací interval. Pri pozorovaní sa môžu použiť elektronické číslicové hodiny, ktoré zaznamenávajú hodiny, minúty a sekundy alebo hodiny udávajúce zlomok dňa. Dĺžku pozorovacieho intervalu možno voliť v medziach od 10 do 100 sek.

s krokom 10 sekúnd. Automatika pohybu filtrov umožňuje automatickú zmenu filtrov podľa vopred zvoleného programu. Pozorovateľ riadi a kontroluje činnosť automatizovaného fotoelektrického fotometra od riadiaceho pultu, ktorý je umiestnený v kopuli pri ďalekohľade. Činnosť fotoelektrického fotometra, ako aj číselné údaje, ktoré sa zaznamenávajú, indikujú sa digitrónmi na riadiacom pulte. Násobič elektrónov sa napája vysokonapäťovým zdrojom Tesla NBZ 411.

Presnosť pozorovaní astronomických objektov fotoelektrickým fotometrom ohraničujú najmä atmosférické podmienky. Teoretická presnosť analógovo-číslicového prevodníka je 0,001, ak je úroveň signálu blízko hornej medze a 0,003, ak je signál na úrovni dolnej medze. Meranie rádioaktívnych svetelných normálov ukázalo, že stredná chyba bola 0,0032 a 0,0034 pri dvoch rozličných exemplároch. Stredná chyba zahŕňa nielen chybu meriaceho zariadenia, ale aj scintilačný šum rádioaktívnych normálov svetla. Za veľmi dobrých pozorovacích atmosférických podmienok s integračnou dobou 10 sek. sa dosiahla presnosť 0,0033 pri pozorovaní hviezd.

Fotoelektrický fotometer sa používa na pozorovanie premenných hviezd. Najviac pozornosti sa venuje zákrytovým premenným hviezdám, ktoré sa pozorujú v *UBV* a v strednopásmovom fotometrickom systéme. Úzkopásmová fotometria a *UBV*-fotometria sa používa pri pozorovaní pekulárnych hviezd. Pre zákrytovú premennú RW Gem sa získala kompletná *V* svetelná krivka a *B*, *U*-pozorovania v niektorých fázach v rokoch 1968–1973. Tieto pozorovania sú v tabuľke 3. Tabuľka 3 obsahuje heliocentrické časové údaje pozorovaní a Δm medzi RW Gem s porovnávacou hviezdou HD 40740. Pozorovania sa robili predvažne s ohniskovou clonou 60",9, pri ktorej sa súčasne s RW Gem merala ďalšia slabá hviezda poľa, ktorá sa nachádza blízko premennej. Vo veľmi dobrých fotometrických nociach sa robili merania s najmenšou clonou a zistil sa podiel jasnosti tretieho telesa. Pozorovania sa redukovali obvyklým spôsobom, pričom sa eliminoval aj efekt tretieho telesa. Keďže uhlová vzdialenosť medzi premennou hviezdou a porovnávacou je veľmi malá, nebolo potrebné aplikovať korekcie na diferenciálnu extinkciu.

АВТОМАТИЗИРОВАННЫЙ ФОТОЭЛЕКТРИЧЕСКИЙ ФОТОМЕТР АСТРОНОМИЧЕСКОЙ ОБСЕРВАТОРИИ СКАЛНАТЕ ПЛЕСО

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Резюме

Изготовление фотоэлектрических фотометров постепенно установилось на стандартном типе, у которого для записи измеряемых данных используется электронный самописец. Необходимость наблюдений очень слабых объектов на пределах детекции сделала необходимым изготовление фотоэлектрических фотометров на принципах методов накопления и счета фотонов. Современные фотоэлектрические фотометры сделали возможным наблюдения очень слабых объектов, которые слабее яркости единицы площади фона неба. Нарастание количества наблюдаемых данных, выгоды их записи на перфоленгу или перфокарты для обработки на быстродействующих счетных машинах требуют автоматизирования фотоэлектрических фотометров.

Автоматизированный фотоэлектрический фотометр Астрономической обсерватории Скалнате плесо был построен на принципе метода накопления. Концепция его изготовления вытекла из потребностей автоматизирования, по возможности, всех операций связанных с фотоэлектрическими наблюдениями и из возможности их прямой обработки быстродействующей счетной машиной. Автоматизированные части фотоэлектрического фотометра, предназначенные для измерения и записи данных, использовались, с некоторыми изменениями, из измерительной централи UM 10, которая применяется для автоматизации процессов в промышленности. Оптико-механическая часть фотометра и некоторые части автоматики фотометра изготовились по специальному заказу.

Автоматизированный фотоэлектрический фотометр установлен на рефлекторе 600/3300 Астрономической обсерватории Скалнате плесо в фокусе Кассегрена. Эквивалентное фокусное рас-

стояние рефлектора 9990 мм. Оптико-механическая часть содержит оптическую систему, фокальные диафрагмы, цветные фильтры, умножитель электронов и электронные схемы для автоматизированной деятельности и показания. Оптическая система работает на принципе выходного зрачка, так что мощность фотоэлектрического фотометра не зависит от формы объекта и от его положения в фокальной диафрагме. В роли детектора используется умножитель электронов типа EMI 6256 В. В оптико-механической части помещено 9 фильтров: три для стандартной UVV фотометрии, три для средне-полосной затменных переменных звезд три для узко-полосной фотометрии в области линий Бальмерової серии водорода. Оптико-механическая часть фотоэлектрического фотометра снабжена микрометрическим устройством для офсетного наблюдения слабых объектов.

Сигнал измеряется при помощи интеграционного усилителя с электрометрической лампой на входе. Интеграционный усилитель имеет три измерительных диапазона с отношением чувствительностей 1: 10: 100. На выходе интеграционного усилителя имеется 4 измерительных диапазона с отношением чувствительностей 1:2,5144. Входные и выходные чувствительности можно регулировать автоматически или вручную. Комбинация входных и выходных чувствительностей дает 12 диапазонов измерения и возможность измерять световые потоки, которые отличаются на три порядка. Запись данных осуществляется одновременно пишущей машинкой и перфоратором. Записывающее устройство записывает данные, измеренные аналого-цифровым преобразователем, время наблюдения по электроническим цифровым часам и остальные данные: фокальную диафрагму, цветовой фильтр, входную и выходную чувствительности, номер звезды и интервал наблюдения. Для наблюдения можно использовать электронные часы, которые показывают часы, минуты и секунды, или электронные часы, которые показывают доли суток. Длину интервала наблюдений можно выбрать от 10 до 100 секунд с шагом 10 секунд. Автоматика движения фильтров позволяет переход фильтров по заранее заданной программе. Наблюдатель управляет и контролирует ход автоматизированного фотометра от пульта управления, который помещен в башне близ телескопа. Ход фотоэлектрического фотометра и все данные, которые записываются пишущей машинкой, одновременно можно контролировать на пульте управления. Электронный умножитель питается через стабилизатор высокого напряжения.

Точность наблюдений астрономических объектов фотоэлектрическим фотометром ограничена именно атмосферными условиями во время наблюдений. Теоретическая точность аналого-цифрового преобразователя 0.001, если уровень сигнала находится близ верхнего предела диапазона и 0.003, если уровень сигнала находится близ нижнего предела. Измерения радиоактивных световых стандартов показали, что средняя квадратическая ошибка достигла 0.0032 и 0.0034 у двух разных экземпляров. В среднюю квадратическую ошибку включена не только ошибка прибора, но и шум сцинтилляции радиоактивных источников света. В очень хорошие фотометрические ночи с интервалом накопления 10 секунд была достигнута точность 0.0033 при наблюдении звезд.

Автоматизированный фотоэлектрический фотометр используется для наблюдения переменных звезд. Большое внимание уделяется затменным переменным звездам, которые наблюдаются в UVV и в средне-полосной фотометрической системе. Узко-полосная UVV фотометрия используется для наблюдений пекулярных звезд. Для затменной переменной звезды RW Gem мы получили полную кривую блеска в желтых лучах и наблюдения в синих и ультрафиолетовых в некоторых фазах в 1968—1973 гг. Эти наблюдения приводятся в таблице 3. Таблица 3 содержит гелиоцентрическое время наблюдений и Δt между звездой переменной и звездой сравнения HD 40740. Наблюдения велись с фокальной диаграммой 60"9, при которой одновременно с переменной звездой измерялась и слабая звезда поля, которая находится вблизи переменной звезды. В очень хорошие фотометрические ночи наблюдения велись с самой маленькой диафрагмой и измерялась доля блеска третьего тела. Наблюдения редуцировались обычным путем, причем был учтен эффект света третьего тела. Поскольку дуговое расстояние между переменной звездой и звездой сравнения не большое, то не были приняты поправки на дифференциальную экстинкцию.