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Abstract

In this article, we have studied the reports of lunar occultations by this project observation's teams (named APTO) in comparison with other observations of the objects. Thirteen binary stars were selected for this study. All the previous observations of these stars were also collected. Finally, an analysis of O-C of all reports were performed.

Keywords: Lunar Occultation, Occult 4, O-C

Introduction

A lunar occultation occurs when the Moon passes in front of stars, planets or other objects in the sky. Many astronomers have been observing occultations over the past two centuries. However, observations made from the Earth has its limitations. Larger telescopes are able to provide data on fainter stars, thus the more the optical device is capable of collecting the light and the higher its resolution, the more stars and fainter objects can be observed. However, it would also depend on the degree of the sky darkness, atmospheric extinction, and seeing conditions. Apart from that, the lower amount of humidity or dust

along the horizon or sky during the observation would lead to a better recognition of fainter objects (Poro, 2018). The higher the lunar elevation the better the sky conditions might be expected.

The accurate timing of lunar occultations is performed regularly by astronomers using different methods. Visual observations are the least accurate but can be timed to an accuracy of a few tenths of a second. These so have a benefit in helping to refine our knowledge of lunar topography. Since human reaction time is involved, a personal equation (PE) needs to be developed and incorporated for each observer.

Our measurements of the Moon's topography is related to those made by a spacecraft called KAGUYA. The Japanese lunar explorer KAGUYA (also called SELENE) was launched successfully on September 14th, 2007 by the Japan Aerospace Exploration Agency. KAGUYA is in polar orbit around the Moon and uses onboard sensors to research gravity and topography (S. Sasaki, 2009).

Since the “edge of the Moon” is what is being observed from the Earth when an occultation occurs, it is possible that due to erosion, there are likely to be some very minor changes over long periods of time. The amount of change is calculated from the profiles produced by KAGUYA. Therefore, the calculations are based on the occultation timing by observations compared against KAGUYA profiles which is shown by what we refer to as the O-C parameter. O-C (Observed minus Calculated) implies a temporal aspect which is used when discussing cyclic phenomena where the times of occurrence of a given event are subject to irregularities (C. Sterken/ 2005).
Before KAGUYA profiles began being provided, the reference for calculated O-C for lunar occultation reports was from a document popularly known as the Watt’s charts published in 1963. They are presented in the form of charts of the liberation frame each 0.2 degrees of position angle measured from the Moon’s axis of rotation. Since the Moon is not a sphere but presents a roughly spherical shape with continuing limb irregularities, these features are presented to the Earth at different aspect angles over time.

Occult 4 software is used to make predictions for the occultation observation as well as the reporting and O-C calculation based on KAGUYA profile. Occult 4 is a software program for predicting the circumstances of many types of astronomical occultations. Occult 4 will predict the circumstances of lunar occultations (total and grazing), asteroid occultations, occultations of planetary moons, etc. (Poro, 2011). This open-access software was developed by David Herald.

This article is based on the results of a project called "Astronomical Project on Timing Occultation" (APTO). The project was started in February 2019 in partnership with nine Iranian teams and observatories. The first purpose of this project was to time lunar occultations comparing O-C with previous timing reports of those stars. For this purpose, we selected thirteen binary stars as targets. We extracted observations and timing reports from Occult 4 software going back in time to the year 1833 to compare against APTO’s observations.

Data Sets

The following targets for the APTO observations are: SAO 139834, SAO 139794, SAO 187426, SAO 118892, SAO 98511, SAO 99185, SAO 98265, SAO 98488, SAO 139427, SAO 98673, SAO 79480, SAO 119447, XZ 43302.
These targets and their occultation opportunities were selected given the following limitations: The stars are defined to be double (Table 1); the lunar phase for predictions is between 10% to 90% and -90% to -10%; lunar elevation above the local horizon during the occultation period should be more than 20

degrees; star visual magnitudes are between +5 and +9; only the occultation disappearances were timed (reappearances were not measured).

Table 1. Details of all observed stars collected from the Simbad database[1]

Star	RA.	Dec.	M(v)	Sp.	Dia. (")
SAO 139794	14 13 18.6579408076	-08 26 40.683175535	7.15	K0	0.0007
SAO 187426	18 54 10.1776767186	-22 44 41.427261350	4.84	K1	0.0035
SAO 98673	09 37 02.5811258036	+16 26 16.627284928	5.73	K1	0.0011
SAO 119447	12 31 14.61	+01 19 37.0	7.63	A5	0.0002
SAO 79480	07 32 22.7663411126	+21 06 15.249116287	8.11	A2	0.0001
SAO 139427	13 35 24.48454	-04 56 03.5580	8.7	F3	0.0001
SAO 98488	09 18 58.8570535656	+17 42 18.952268371	6.64	F5	0.0003
SAO 98511	09 20 38.1911603913	+17 07 38.430767874	7.76	F2	0.0002
XZ 43302	18 4 17.4234	-22 29 39.961	8.71	B3	0.0001
SAO 118892	11 29 39.9952266114	+07 35 57.748681014	6.73	F5	0.0003
SAO 98265	08 58 18.2919146861	+18 18 29.789018923	6.55	A0	0.0002
SAO 99185	10 34 07.2818934159	+12 22 27.974286167	7.86	A3	0.0001
SAO 139834	14 16 48.7344774535	-08 53 04.109883483	6.47	K1	0.0012

Based on these limitations, predictions and observations for the 13 target stars by the teams and observatories from March to July 2019 were made in different parts of Iran. A total of 19 observations were report (Table 2).

Table 2. Details of lunar occultation observations during APTO

Date	Star	Observer	Location			Alt. (m)	Tel. (cm)	Timing method	Time source	O-C	PE or Accuracy
			City	Longitude	Latitude						
2019 3 17	SAO 98265	I. Safaei	Kashan	+ 51 8 26.9	+33 58 19.3	1774	25	Stopwatch	NTP	-0.08	0.4
2019 4 12	SAO 79480	I. Safaei	Kashan	+ 51 8 26.9	+33 58 19.3	1774	25	Stopwatch	NTP	-0.14	0.5
2019 4 14	SAO 98673	S. Paknejad	Tabriz	+ 46 19 44.8	+37 52 23.8	2343	20	Tape recorder	GPS	0.19	0.4
2019 4 14	SAO 98673	S. Memarzadeh	Tabriz	+ 46 19 44.8	+37 52 23.8	2343	20	Stopwatch	GPS	0.11	0.4
2019 4 15	SAO 99185	I. Safaei	Kashan	+ 51 8 26.9	+33 58 19.3	1774	25	Stopwatch	NTP	-0.17	0.5
2019 4 16	SAO 118892	A. Halavati	Kerman	+ 57 1 11.8	+30 16 56.0	1782	25	Video	GPS	0.08	0.016
2019 4 16	SAO 118892	H. Khezri	Bushehr	+ 51 3 21.1	+28 56 53.4	15	41	Stopwatch	NTP	-0.66	0.5
2019 4 24	XZ 43302	S. Hamedian	Tabriz	+ 46 19 37.0	+38 3 5.3	1500	18	Tape recorder	GPS	0.35	0.3
2019 4 24	SAO 187426	A. Halavati	Kerman	+ 57 1 11.8	+30 16 56.0	1782	25	Video	GPS	-0.16	0.016
2019 4 24	XZ 43302	J. Ebrahimzadeh	Tabriz	+ 46 19 37.0	+38 3 5.3	1500	18	Stopwatch	GPS	0.38	0.4
2019 5 11	SAO 98488	M. Piri	Tabriz	+ 46 19 36.3	+38 3 5.2	1524	15	Tape recorder	GPS	0.60	0.3
2019 5 11	SAO 98488	J. Ebrahimzadeh	Tabriz	+ 46 19 36.3	+38 3 5.2	1524	18	Tape recorder	GPS	0.37	0.3
2019 5 11	SAO 98511	S. Ebadi	Tabriz	+ 46 19 36.3	+38 3 5.2	1524	18	Tape recorder	GPS	-0.25	0.3
2019 5 11	SAO 98511	S. Hamedian	Tabriz	+ 46 19 36.3	+38 3 5.2	1524	18	Stopwatch	GPS	-0.28	0.3
2019 6 12	SAO 139427	H. Khezri	Bushehr	+ 51 3 21.1	+28 56 53.4	15	41	Stopwatch	NTP	-0.04	0.3
2019 7 8	SAO 119447	A. Mohandes	Kashan	+ 51 8 26.9	+33 58 19.3	1774	25	Stopwatch	NTP	-0.32	0.4
2019 7 8	SAO 119447	H. Khezri	Bushehr	+ 51 3 21.1	+28 56 53.4	15	41	Stopwatch	NTP	-0.22	0.4
2019 7 10	SAO 139794	M. Kazemi	Ahvaz	+ 48 42 10.5	+31 21 54.8	30	25	Stopwatch	NTP	-0.18	0.5
2019 7 10	SAO 139834	F. Hesampor	Shiraz	+ 52 34 50.	+29 34 19.	1528	20	Stopwatch	NTP	-0.04	0.4

[1] http://simbad.u-strasbg.fr/simbad/

Comparative observations based on selected double stars collected from Occult 4 (Version 4.7.2.0) software. These 528 observation reports are from 1833 to 2018 (Table 3). Details of the selected observation reports are also included in appendix A.

Table 3. List of occultation reports based on Occult 4 without APTO observations reports

Star	Mv	Number of Reports	Year of First Report	Year of Last Report
SAO 139794	7.15	39	1944	2001
SAO 187426	4.84	85	1898	2010
SAO 98673	5.73	81	1833	1988
SAO 119447	7.63	30	1927	2002
SAO 79480	8.12	30	1982	1991
SAO 139427	8.70	10	1998	2001
SAO 98488	6.64	35	1852	2007
SAO 98511	7.77	8	1970	1981
XZ 43302	8.71	8	1982	1982
SAO 118892	6.73	48	1926	2018
SAO 98265	6.56	92	1934	2008
SAO 99185	7.87	5	1968	1982
SAO 139834	6.47	57	1907	2001

Timing Method

Lunar occultation timing measurements can be useful when there is an overall accuracy of a few tenths of a second in order to provide confirmation or improvement of knowledge of lunar topography. The methods of timing used by the APTO teams and observatories who gathered this data were primarily visual though there were a few video observations.

The base time references used in this project have been both the Network Time Protocol (NTP) and The Global Positioning System (GPS). NTP observers used the North American Asteroidal Occultation Program website[2] and the SkyTiming.1 mobile application[3] was used for GPS based time.
Timing for a successful observation of occultation events has a long history. Since the early 1960s, scientists were using cassette tape recorders to record the sound of short-wave time signal broadcasts from radio station WWV, WWVB, CHU, WWVH or some other stations as well as the sound of their voice calls as occultations were seen to occur. Stopwatches were also used. Today, there are other methods for timing an occultation such as using NTP servers or GPS as time references. However, each one has some problems (Lesani, 2017).

The NTP and GPS based time was used for visual timing. Observers in this project used each of them for timing by stopwatch or voice record ways. In many of the observations, both have been used by observers to reduce the error rate. In two reports, the video method was used by Kerman team. This method uses a DSLR camera. Both NTP and SkyTiming application (GPS) were used for the base time, which it was found that the SkyTiming application based GPS time was less error.

[2] www.asteroidoccultation.com/observations/NA
[3] http://iota-me.com/skytiming.html

The GPS is the best time reference base. The whole system's rationale is based on time. Most (but not all) GPS receivers have a feature called One Pulse Per Second (1PPS) referenced to Universal Time (UT) to an accuracy measured in microseconds and that if this signal is used appropriately, a GPS receiver can be used to give times to an accuracy of ±0.001 seconds or better (Gault, 2017). However, even video measurements cannot achieve an accuracy better than .033 based on frame rate recording and this has no impact on visual measurement accuracies.

The most important errors in observation and timing are the base time error and the Personal Equation (PE) error. PE is the time the observer takes to react to the occultation. It is required for visual observers. Typical values are 0.3 to 0.5 for a disappearance as the star is first occulted by the Moon. The term D (or d) is used for disappearance and R (or r) for reappearance. Experienced observers always try to improve PE in their visual timing. If the star is not easily visible, or the observer is inexperienced, the value will be at the larger end. A visual observer should enter into the PE field a numerical value, which is a best estimate of their personal reaction time. It is only an estimate and not 100% accurate.

The estimated uncertainty (± time range) in the reported time, after any PE, has been applied. Usually, the uncertainty will be smaller than the PE. The ultimate goal is to decrease PE in visual observations. Initially, for observers to gain experience, they must use visual methods to see an occultation with their eyes as it takes place. This is the reason for understanding the concept of PE since it demonstrates that no matter how 'good' an observer thinks he or she is, there is always a delay in estimating a D or (especially an R) in lunar occultations. To eliminate PE entirely one must transition to a more accurate method that does not require the human eye to interpret when a D or R has taken place. Nowadays, video timing methods are used with GPS time embedded in each frame. As mentioned here, two reports of this project used a creative approach based on video timing, based on available facilities (Poro, 2018).

Analyses and results

The most important problem in the visual observation part of the project was the reduction of the PE for each observer. This error can occur for a variety of reasons. Some of the things that have been reported to have caused this error, according to observers, are:

- Effect of cold temperatures lowering the timing accuracy
- Response of the eye/brain to an occultation impacted by the age of the observer
- Observer's hands are not free for controlling the telescope.
- Observer cannot comment on some conditions concerning the observation directly.
- Eye fatigue and lack of consistent focus
- PE even for the same observer can vary
- Other problems which reduce the accuracy of timing such as instrumentation issues

Despite the low experience of observers at the beginning of this project, the average PE for the observations is calculated: 0.3901. This error rate is within the range of 0.3 to 0.5.

Once we have found that the PE of reports was acceptable for this project, we proceeded to comparative study of O-C. As mentioned earlier, O-C can be an indicator of timing accuracy, according to the KAGUYA satellite profile. If this parameter's range for visual timing is between +0.1 to -0.1 it means that the observer has done an accurate time measuring.

Figure 1 shows O-C parameters during over years for all of the reports that studied in this project. This chart is based on a fit where a "Curve-Fit Robust Straight Line" was drawn.

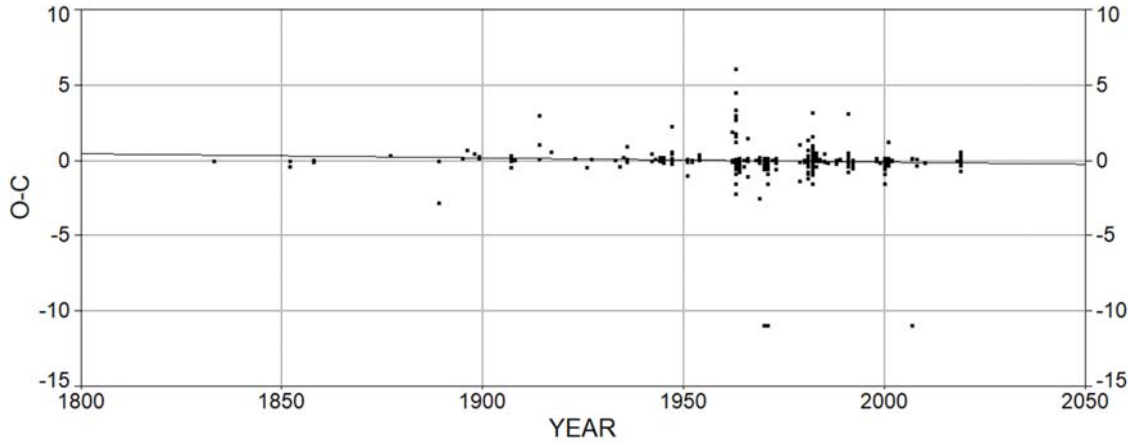

Figure 1. O-C parameter for all reports over time

As shown in figure 1, the fit of the O-C diagram started at +0.37 and ended at -0.14, which shows how the visual timing of the observations have good accuracy. Since 1935 the O-C value has been around the range ±0.1.

We analyzed the reports of this project, and a similar fit was done to obtain the line equation (figure 2). According to this fit for our observation, it started at +0.07 and ended at -0.16.

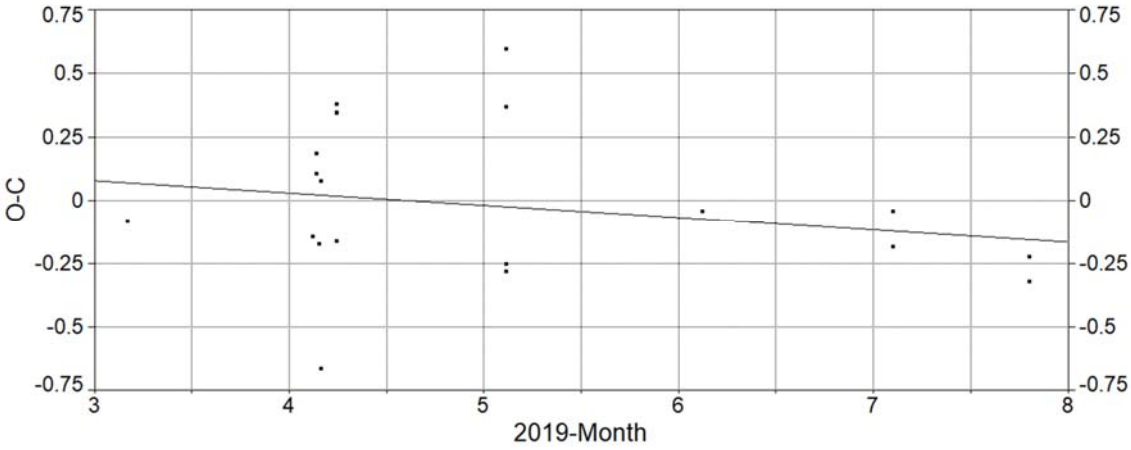

Figure 2. O-C changes derived from this project reports

The specifications of the fits of figures 1 and 2 are given in Table 4.

Table 4. Fit specifications for data

Reports	Line equation	r^2	Adj r^2	FitStdErr
Total	Y= -0.0027803391 x + 5.4629043	0.0049850001	0.0013268567	1.0292405
This project	Y= -0.048778689 x + 0.22512559	0.050501821	0	0.303635

Conclusion

Thirteen binary stars were selected for observation and comparison. Only disappearances were timed. Apart from the observations by the teams involved in this project, historical observational reports on these 13 stars were also collected from the Occult 4 software. As with other observations extracted from Occult 4, different timing methods were used, though 89.5% of these observations were visual with 0.3901 Personal Equations. In all the observations of this project, we used NTP or GPS for based time.

Based on the fits and calculations for O-C (table 4), the mean error of deviation from zero for total observations (figure 1) is 0.255 and for observations in this project (figure 2) is 0.115. Therefore, given a similar fit, it can be concluded that the average timing accuracy in this project reports was acceptable than average timing accuracy for total O-C diagram for previous observations. It should be noted that although total previous observations have used more of the visual timing type, the average error rate of them is acceptable.

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References

Poro A., 2018, Introducing some effective parameters in the types of Occultations, Journal of Occultation and Eclipse (JOE).

S. Sasaki, N. Namiki, H. Hanada, H. Araki, T. Iwata, Y. Ishihara, K. Matsumoto, H. Noda, S. Goossens, 2009, KAGUYA topography gravity team, Global Topography and Gravity of the Moon Observed by KAGUYA, European Planetary Science Congress.

C. Sterken, 2005, The O-C Diagram: Basic Procedures, Virje University Brussel, Belgium.

Atila Poro and Paul Maley, 2011, Astronomical Occultation Book, Daneshpajuhan Javan.

Z. S. Lesani and A. Poro, 2017, SkyTiming; A New Mobile Application for Submit and Timing, Journal of Occultation and Eclipse (JOE).

Dave Gault, 2017, Applying UT to Visual Timing in Occultation Observations, Journal of Occultation and Eclipse (JOE).

Appendix A

A1. Observations of star SAO139794

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1944	0.05	Spain, San Fernando	R. Garofano	1983	0.09	Trentham	A.W. Dodson
1944	0.20	Spain, Madrid Obs.	D. Loron	1998	0.06	Taylor Range Obs.	P.E. Anderson
1945	0.03	Australia, Sydney	D. Connel	2000	0.16	Tomar	R. Goncalves
1945	-0.04	Australia, Sydney O.	H. Wood	2000	0.12	Tomar	R. Goncalves
1945	0.16	S. Africa, Cape, S.	R. de Kock	2000	0.02	Fillmore, CA	C. Morris
1945	0.17	S. Africa, Cape, S.	J. Turner	2000	0.03	Val Verde, CA	F. A. Anet
1945	0.17	S. Africa, Cape, S.	H. Davies	2000	0.02	Val Verde, CA	G. Goodman
1945	0.19	S. Africa, Durban	A. Cousins	2000	0.02	Val Verde, CA	G. Goodman
1945	0.15	S. Africa, Johannes	J. Churms	2000	0.03	Val Verde, CA	G. Goodman
1981	0.12	Tucson, Arizona	D. D. Nye	2000	0.02	Val Verde, CA	D. Dunham
1981	-0.38	McDonald Obs.,Texas	-	2000	0.01	Val Verde, CA	D. Dunham
1981	0.07	Kurashiki, Okayama	K. Terai	2000	0.01	Val Verde, CA	D. Dunham
1981	-0.01	Hyd.Dept.Obs.	T. Hanzawa	2000	0.02	Val Verde, CA	D. Dunham
1981	-0.11	Hitati, Ibaraki	H. Tomioka	2000	-0.06	Val Verde, CA	D. Dunham
1981	-0.16	Lisboa Astro. Obs.	-	2001	-0.03	Presov	M. Sochan
1981	0.09	V.N.De Gaia	J. P. Osorio	2001	-0.07	Rockhampton Qld.	S. Kerr
1982	0.68	Breach Observatory	J. V. Vincent	2001	-0.05	Bundaberg, Qld.	G. Walters
1983	0.05	Auckland	M.F. Stoker	2001	0.00	Taylor Range Obs.	P.E. Anderson
1983	0.09	Blenheim	B. Loader	2001	-0.12	Upper Hutt	J. O'Kane
1983	-0.38	Upper Hutt	J. O'Kane				

A2. Observations of star SAO187426

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1898	0.47	S. Africa, Cape, S.A.A.Obs.	A. Morrisby	1991	-0.08	Ashfield	C. S. Bembrick
1899	0.19	U.S.A., Evanston, Dearborn Obs.	-	1991	3.15	Rua Capitao	W. J. Maluf
1899	0.31	U.S.A., Cambridge, Harvard Obs.	-	1991	0.11	Uberlandia-Mg	R. F. Silvestre
1907	-0.03	Poland, Cracow Univ. Obs.	-	1992	-0.51	Oeiras	J. S. Garcia
1907	0.29	U.S.S.R., Kazan Engelhardt	-	1992	0.04	St. Margarethen	C. Sauter
1907	-0.43	U.S.S.R., Kazan Engelhardt	-	1992	-0.20	Milano	F. Sergio
1907	0.37	U.S.S.R., Kazan Univ. Obs.	I. Chugunov	1992	-0.30	Rokycany	K. Halir
1917	0.60	S. Africa, Cape, S.A.A.Obs.	J. Turner	1992	-0.10	Lodz	R. Komorowski
1935	0.21	S. Africa, Cape, S.A.A.Obs.	A. Cousins	1992	0.00	Pleasanthill, Calif.	J. P. Disch
1936	0.09	France, Bordeaux (Univ. Obs.)	-	1992	0.02	Campbell, California	Baldridge
1936	-0.01	Poland, Poznan Univ. Obs.	H. Hurnik	1992	0.02	San Jose, California	Van Nuland
1936	-0.05	Poland, Poznan Univ. Obs.	F. Koebske	1992	-0.11	Leduc, Alberta	A. P. Abbott
1936	-0.07	Poland, Poznan Univ. Obs.	Witkowski	1992	-0.25	Afton, Minnesota	J. H. Fox
1936	0.96	U.S.S.R., Vilna, Lithuania	-	2000	-0.06	Arcen	H. G.J.Rutten
1936	0.94	U.S.S.R., Vilna, Lithuania	-	2000	0.07	St. Margarethen	C. Sauter
1936	0.94	U.S.S.R., Vilna, Lithuania	-	2000	0.01	Stuttgart	H. Marx
1944	0.02	Switzerland, Berne Univ. Obs.	M. Schurer	2000	0.05	"Studium" Obs,Milano	S. Baroni
1945	-0.13	Argentina, Cordoba Obs.	-	2000	-0.04	Pompiano	C. Cremaschini
1945	-0.01	Argentina, La Plata	M. Agabios	2000	-0.22	Lhota U Dobran	M. Schuster
1945	0.22	S. Africa, Cape, S.A.A.Obs.	H. Davies	2000	-0.07	Plzen-Slovany	L. Smid
1954	0.04	Australia, Perth Obs.	-	2000	-0.13	Druztova	Z. Brichta
1954	0.38	Australia, Sydney Obs.	H. Wood	2000	-0.11	Rokycany	K. Halir
1954	0.20	Brazil, Rio de Janeiro	-	2000	-0.12	Zbiroh	J. Kubanek
1954	0.16	India, Hyderabad Nizamiah	M. Bappu	2000	-0.02	Barrandov	M. Jan
1972	0.04	Argentina, Cordoba Obs.	-	2000	-0.26	Praha-Petrin	V. Cejka
1973	-0.03	U.S.A., China Lake, Calif.	G. Thomas	2000	-0.07	Policka,Chech Rep.	Ehrenberger
1973	0.14	U.S.A., China Lake, Calif.	McLaughlin	2000	-0.03	Vienna, Austria	T. Weiland
1973	-0.04	U.S.A., San Francisco, Calif.	-	2000	-0.12	Zlin	V. Kafkova
1973	-0.06	U.S.A., Brentwood, California	W. Skeen	2000	-0.17	Banska Bystrica	J. Karabas

1973	-0.11	U.S.A., Napa, California	-	2000	-0.20	Banska Bystrica	J. Skvarka
1973	-0.08	U.S.A., Colfax, CA	B. Fisher	2000	0.03	Lublin	Z. Rzepka
1973	0.02	U.S.A., Durango, Colorado	W. Browne	2000	-0.10	Worth, Illinois	R. H. Hays Jr.
1973	-0.54	U.S.A., Skokie, Illinois	-	2000	0.00	West Chester, Penna.	C. J. Bader
1973	-0.06	U.S.A., Calumet Park ,Ill.	-	2000	-0.56	Quezon City	S. G. Quirimit
1982	-0.09	Brisbane	McDougall	2000	0.00	Nakaku,Hiroshima	T. Oono
1982	0.00	Sydney, Nsw.	-	2000	-0.02	Bisei Obs.	T. Kurokawa
1982	0.03	Allawah, Nsw.	McNamara	2000	-0.04	Souja, Okayama	K. Kenmotsu
1982	-0.04	Cronulla, Nsw.	L. Pagano	2000	-0.02	Simosato Obs.	K. Sawada
1982	0.02	Sydney Nsw.	R. H. Giller	2000	-0.03	Simosato Obs.	K. Sawada
1982	-0.04	Edenvale, Tvl.	Overbeek	2000	-0.01	Yokkaichi	Y. Nakamura
1982	0.76	Breach Observatory	Vincent	2000	-0.08	Hitati, Ibaraki	H. Tomioka
1982	0.35	Monte Grande	Camponovo	2010	-0.14	Thornton, Rd3 Whakatane, Nzl	D. Watson
1982	-0.03	Blenheim	B. Loader				

A3. Observations of star SAO98673

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1833	-0.02	Poland, Cracow Univ. Obs.	-	1982	-0.26	Praha, Czech	L. Suchanek
1877	0.35	Australia, Windsor	J. Tebbutt	1982	-0.03	Markgrafneusied, Austria	M. Schmid
1889	-2.78	England, Gillingham, Kent	-	1982	-0.16	Dresden Techn. Univ., Germany	D. Bohme
1895	0.17	U.S.S.R., Moscow Univ. Obs.	-	1982	0.10	Dresden, Germany	W. Hohle
1896	0.71	Australia, Windsor	J. Tebbutt	1982	0.03	Dresden, Germany	R. Noack
1914	3.01	U.S.A., Wa., U.S.Naval Obs.	-	1982	-0.38	Dresden, Germany	P. Lipski
1914	1.10	U.S.A., Wa., U.S.Naval Obs.	-	1982	-0.84	Dresden, Germany	Stegemann
1914	0.12	U.S.A., Wa., U.S.Naval Obs.	-	1982	-0.11	Prostejov, Czech	P. Svoboda
1933	0.02	S. Africa, Johannesburg Obs.	J. Churms	1982	-0.04	Olomouc, Czech	J. Pogoda
1951	0.12	Poland, Cracow Univ. Obs.	Szafraniec	1982	0.01	Berlin, Germany	H. Pachali
1951	-1.01	Poland, Cracow Univ. Obs.	Stankiewski	1982	-0.04	Berlin, Germany	-
1963	-0.11	Italy, Turin	B. Ouglielmi	1982	0.31	Berlin, Germany	P. Enskonatus
1963	-2.21	France, Sturzelbronn	-	1982	-0.61	Biesenthal, Germany	D. Ewald
1963	-0.35	U.S.A., Seal Beach, Calif.	-	1982	-0.15	Sternbedeckungen, Germany	R. Koschack
1963	-0.36	U.S.A., Seal Beach, Calif.	-	1982	-0.09	Ziar Nad Hronom	J. Vana
1969	-2.53	U.S.S.R., Nikolaev Obs.	Voronenkov	1982	-0.03	Kolding, Denmark	-
1969	-0.04	Yavne	-	1982	-0.05	Ringsted, Denmark	O. Klinting
1969	-0.09	Spain, Las Cabezas de San Juan	J. Fernandez	1982	-0.03	Rodovre, Denmark	P. B. Darnell
1969	-0.05	Spain, Las Cabezas de San Juan	F. Gutierrez	1982	0.01	Virum, Denmark	C. Grunnet
1969	-0.02	Spain, Las Cabezas de San Juan	F. Gutierrez	1982	-0.18	Tisvildeleje, Denmark	W.-Knudsen
1969	-0.01	Spain, Las Cabezas de San Juan	L. Quijano	1982	0.07	Ronne, Denmark	O. Olesen
1969	-0.02	Spain, Las Cabezas de San Juan	Salazar	1982	-0.43	Hasseris, Denmark	K. W. Fabrin
1969	-0.13	Spain, Las Cabezas de San Juan	Salazar	1982	-0.55	Tuchola, Poland	M. Szulc
1969	-0.01	Spain, Las Cabezas de San Juan	A. Orte	1982	-0.01	Warszawa, Poland	-
1969	0.22	Spain, Las Cabezas de San Juan	A. Orte	1982	-0.11	Warszawa, Poland	R. Kurianowicz
1969	0.13	Spain, Las Cabezas de San Juan	A. Orte	1982	-0.08	Warszawa, Poland	A. Malinowski
1969	0.09	Spain, Las Cabezas de San Juan	A. Orte	1982	0.53	Horsens, Denmark	E. Pedersen
1970	-0.23	Furfooz, Belgium	J. Bourgeois	1982	0.00	Leduc, Alberta, Canada	A. P. Abbott
1970	-0.12	Brightlingsea, Essex, England	Middleton	1982	-0.17	Dresden Techn. Univ., Germany	D. Bohme
1970	-0.04	Leicester, England	D. Hall	1982	-0.04	Dresden, Germany	P. Lipski
1981	-0.72	Zoetermeer, Netherlands	H. J.J. Bulder	1982	3.22	Vienna, Austria	T. Weiland
1981	1.38	Bantega, Netherlands	De Lange	1982	-0.34	Oeiras, Portugal	R. Goncalves
1981	0.06	Appingedam, Netherlands	-	1982	0.89	Victoria, Canada	J. Pazder
1981	-0.13	Karlovy Vary, Czech	J. Marz	1982	0.03	Swanpool, Australia	J. Blanksby
1981	-0.21	Karlovy Vary, Czech	M. Micek	1982	1.00	Swanpool, Australia	J. Blanksby
1981	-1.15	Jindrichuv Hradec, Czech	M. Safranek	1982	-0.45	Porto Alegre, Rs., Brazil	V. H. Milanez
1981	-0.08	Chemnitz, Germany	F. Seidel	1982	-0.03	Uberlandia, Mg, Brazil	R. F. Silvestre
1981	-0.09	Praha, Czech	V. Pribyl	1982	0.05	Araxa, Mg, Brazil	O. S. Correa
1982	-0.10	Praha, Czech	V. Cejka	1982	0.00	Ogitu-Cyo, Hitachi-Si, Ibaraki	T. Hiroyuki

1982	-0.14	Praha, Czech	J. Manek	1988	0.04	Blue Springs Missouri, U.S.A	R. Sandy
1982	-0.14	Praha, Czech	E. Jindra				

A4. Observations of star SAO119447

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1927	0.13	France, Strasbourg, Univ. Obs.	P. Bacchus	1985	-0.04	Blenheim	B. Loader
1943	0.09	S. Africa, Radcliffe Obs.	H. Knop-Shaw	1999	-0.12	Pretoria	J.A. Smit
1965	-0.37	Japan, Kurasiki Obs.	H. Saito	2000	0.11	Larissa	N. Stoikidis
1982	-0.11	Yladssen	P. Mortensen	2001	0.15	Horsens	E. Pedersen
1982	-0.16	Tisvildeleje	Wieth-Knudsen	2001	0.14	Wijdenes	E. Edens
1982	-0.34	Tuchola	M. Szulc	2001	-0.05	Amsterdam	J.W. Bruin
1982	-0.38	Dresden	P. Lipski	2001	0.12	Almen	R. Boschloo
1982	-0.04	Praha	V. Pribyl	2001	-0.23	Arcen	H. G.J.Rutten
1982	-0.12	Praha	V. Cejka	2001	-0.09	Druztova	Z. Brichta
1982	-0.44	Halifax, Nova Scotia	M. E. Boschat	2001	1.24	Jiri Kubanek	J. Kubanek
1983	0.02	Simosato Obs.	K. Matumoto	2001	-0.31	Jiri Kubanek	J. Kubanek
1983	0.04	Stuttgart	H. Marx	2001	-0.06	Larissa	N. Stoikidis
1983	0.00	Oberehvendingen	X. Willi	2001	-0.01	Oisikogen, Wakayama	H. Geshiro
1983	0.53	Praha	J. Manek	2002	-0.04	Hashinoue	M. Kashiwakura
1984	-0.04	Sakura, Chiba	S. Kaneko	2002	0.02	Hitati, Ibaraki	H. Tomioka

A5. Observations of star SAO79480

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1982	-0.05	San Bruno, Calif.	T. W. Langhans	1991	0.00	Roden	A.A. Schoenmaker
1982	-0.11	Yladssen	P. Mortensen	1991	0.08	Zoetermeer	H. J.J. Bulder
1982	0.50	Tisvildeleje	N.P. Wieth-Knudsen	1991	-0.01	Lubeck	R. Buggenthien
1982	-0.08	Ringsted	O. Klinting	1991	0.14	Almen	R. Boschloo
1982	-0.11	Warszawa	R. Fangor	1991	-0.34	Arnhem	J.H. Keultjes
1982	-0.13	Warszawa	R. Fangor	1991	0.03	Asten	A.H. Scholten
1982	-0.08	Herk-De-Stad	P. Poitevin	1991	0.03	Berg Aan De Maas	H. J. Bril
1982	-0.08	Praha	V. Pribyl	1991	0.11	Biesenthal	D. Ewald
1982	-0.13	Praha	P. Mudra	1991	0.30	Tuchola	M. Szulc
1982	-0.04	Furfooz	J. Bourgeois	1991	0.51	Plauen	D. Brauckhoff
1982	-0.03	Muenchwilen	C. Sauter	1991	-0.17	Schloditz	D. Buttner
1982	-0.42	Belgrad	V. P. Benishet	1991	0.14	Schloditz	G. Lehmann
1991	-0.03	Bergen	R. I. Hansen	1991	-0.06	Kovel	P. Veleschuk
1991	0.00	Ringsted	O. Klinting	1991	-0.73	Rimavska Sobota	J. Gerbos
1991	0.39	South Croydon	S.C. Pattinson	1991	-0.38	Yalta	U. Onishenko

A6. Observations of star SAO139427

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1998	0.15	Whakatane	D. Watson	2000	-0.40	Hvezdaren Humenne	J. Ondrus
2000	-0.06	Zilina	M. Znasik	2000	0.06	Krosno	E. Skrzynecki
2000	0.04	Larissa	N. Stoikidis	2000	-0.04	Sanok	W. Slotwinski
2000	0.00	Krakow	L. Benedyktowicz	2000	-0.07	Darlington, S.C.	F. Parnell
2000	-0.35	Hvezdaren Humenne	S. Gojdic	2001	0.00	Las Cruces	R. A. James

A7. Observations of star SAO98488

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1852	-0.41	China, Zo-Se Obs.	A. Dubyago	1982	0.05	Nakaku, Hiroshima	K. Iino
1852	-0.04	U.S.S.R., Kazan Univ.	-	1982	-1.56	Urawa, Saitama	S. Baba
1858	0.05	Switzerland, Birmenst	T. Winiger	1982	-0.32	Shibasaki, Chofu	S. Kaneko
1858	0.06	Switzerland, Wald	E. Kharadse	1982	0.09	Sakura, Chiba	T. Huzisawa
1858	-0.05	U.S.S.R., Abastumani	A. Smith	1988	-0.06	Sirahama Obs.	H. Noda
1889	-0.01	Canada, Edmonton	E. Eichmann	1988	0.04	Simosato Obs.	H. Noda

1951	-0.07	U.S.A., Hacienda Heig	J. Bourgeois
1970	0.02	Oeiras	D. Wiebling
1970	-0.03	Lubeck	R. Buggenthien
1970	-0.02	Lubeck	O. Sandor
1970	-0.20	Teplice	P. Stastka
1970	-0.54	Teplice	E. Belda
1970	-0.18	Desna	P.E. Anderson
1970	0.06	Taylor Range Obs.	S. Kaneko
1970	0.02	Yamagata	Y. Oba
1981	-0.16	Yamagata	T. Funakoshi
1982	-0.86	Kaminoyama, Yamagata	T. Kurokawa
1982	0.05	Bisei Obs.	T. Oono
1988	-0.18	Simosato Obs.	T. Hayamizu
1988	0.02	Sendai, Kagoshima	M. Szulc
1988	0.00	Lubeck	D. Ewald
1988	0.04	Melchow	M. Zawilski
1988	0.01	Lodz	P. Ossowski
1989	0.04	Ostrow Wielkopolski	J. Speil
1989	0.09	Walbrzych-Ksiaz	E. D.Speil
2007	0.08	Walbrzych-Ksiaz	E. Belda
2007	-11.00	Desna	M. Znasik
2007	0.14	Zilina	A. Siser
2007	0.13	Zilina	R. Sandy

A8. Observations of star SAO98511

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1970	-0.13	Philippines, Manila	D. Yglopaz	1981	-0.32	Salisbury	J. V. Vincent
1981	0.07	Brisbane	B. Bridge	1981	-0.01	Edenvale, Tvl.	M.D. Overbeek
1981	0.01	Taylor Range Obs.	P.E. Anderson	1981	0.17	Nigel, Transvaal	L. Pazzi
1981	0.12	Bulawayo	A.G.F. Morrisby	1981	0.00	Cape Town	K.G. Fuhr

A9. Observations of star XZ43302

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1982	-0.08	Edenvale, Tvl.	M.D. Overbeek	1982	-0.06	Cootamundra, Nsw.	-
1982	1.62	Miles	J. Palfreyman	1982	0.09	Cronulla, Nsw.	L. Pagano
1982	-0.90	Oxford	G. B. Evans	1982	-0.04	Jannali	-
1982	0.00	Canberra, A.C.T.	D. Herald	1982	-0.25	Taylor Range Obs.	P.E. Anderson

A10. Observations of star SAO118892

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1926	-0.46	China, Zo-Se Obs.	-	1964	-0.38	Czech., Valasske Mezirici	B. Malecek
1947	-0.11	Yugoslavia, Belgrade Obs.	M. Protitch	1965	0.02	Japan, Simosato	K. Hutigami
1947	-0.17	Yugoslavia, Belgrade Obs.	-	1966	-0.01	Belgium, Kessel-Lo	J. Meeus
1947	-0.22	Yugoslavia, Belgrade Obs.	-	1966	0.14	Portugal, Lisbon Obs.	M. Peres
1947	0.56	Germany, Karlsruhe	W. Malsch	1966	0.06	Portugal, Lisbon Obs.	J. Mndeira
1947	0.19	Switzerland, Berne Univ. Obs.	M. Schurer	1966	1.51	Spain, San Fernando Obs.	M. Lopez
1947	2.28	Portugal, Lisbon Sciences Obs.	I. Silva	1966	-1.07	Spain, San Fernando Obs.	V. Lopez
1947	0.51	Portugal, Lisbon Obs.	A. Botelheiro	1981	0.15	Bulawayo	A.G.F. Morrisby
1947	0.49	Portugal, Lisbon Obs.	J. Mndeira	1981	0.20	Savatorio	P. S. Bretones
1947	0.10	Spain, San Fernando Obs.	R. Garofano	1981	-0.04	Porto Alegre	L. A.L. Da Silva
1962	0.05	New Zealand, Wellington	G. Quinlan	1981	-0.02	Taylor Range Obs.	P.E. Anderson
1962	-0.09	N.Z., Wellington, Carter Obs.	K. Turner	1981	-0.06	Taylor Range Obs.	J. Corkin
1963	-0.02	Japan, Kurasiki Obs.	H. Saito	1981	-0.01	Brisbane	D.S. McDougall
1964	-0.32	Japan, Sirahama	F. Ono	1982	0.12	Ardmore, Oklahoma	C. A. Schweers
1964	-0.24	Netherlands, Heiloo	P. Noomen	1982	0.18	Carol Ann Park, Ark.	-
1964	-0.30	Netherlands, Beverwijk	B. Vastenholt	1984	0.02	Praha	V. Cejka
1964	-0.30	Germany, Braunschweig	Alvensleben	1984	0.08	Green Bay, Wisconsin	R. Parmentier
1964	0.06	Germany, Potsdam Geod. In.	Buschmann	1984	0.08	Foothill Obs., Cal.	R. W. Baldridge
1964	-0.06	Germany, Dresden Tech. Univ.	Steinert	1985	0.01	San Jose, California	J. H. Van Nuland
1964	-0.68	Germany, Dresden	S. Seliger	1985	0.45	Equaforia	A.W. Woodruff
1964	-0.28	Germany, Sonneberg Obs.	H. Schneller	1985	-0.06	Taylor Range Obs.	P.E. Anderson
1964	-0.77	Czechoslovakia, Upice	V. Mlejnek	1986	-0.12	Kingsley	H. W. Moller
1964	-0.45	Czech., Prague People's Obs.	Kadner	2018	0.01	Darfield, New Zealand	B. Loader
1964	-0.30	Czechoslovakia, Olomouc	K. Vanek	2018	-0.01	Manor Park, NZ.	M. Forbes

A11. Observations of star SAO98265

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1934	-0.41	China, Zo-Se Obs.	A. Dubyago	1971	-0.54	Teplice	E. Belda
1944	-0.04	U.S.S.R., Kazan Univ.	-	1971	-0.18	Desna	P.E. Anderson
1944	0.05	Switzerland, Birmenst	T. Winiger	1971	0.06	Taylor Range Obs.	S. Kaneko
1944	0.06	Switzerland, Wald	E. Kharadse	1971	0.02	Yamagata	Y. Oba
1952	-0.05	U.S.S.R., Abastumani	A. Smith	1971	-0.16	Yamagata	T. Funakoshi
1952	-0.01	Canada, Edmonton	E. Eichmann	1971	-0.86	Kaminoyama, Yamagata	T. Kurokawa
1952	-0.07	U.S.A., Hacienda Heig	J. Bourgeois	1971	0.05	Bisei Obs.	T. Oono
1952	0.02	Oeiras	D. Wiebling	1971	0.05	Nakaku, Hiroshima	K. Iino
1952	-0.03	Lubeck	R. Buggenthien	1971	-1.56	Urawa, Saitama	S. Baba
1952	-0.02	Lubeck	O. Sandor	1971	-0.32	Shibasaki, Chofu	S. Kaneko
1963	-0.20	Teplice	P. Stastka	1971	0.09	Sakura, Chiba	T. Huzisawa
1963	-0.54	Teplice	E. Belda	1971	-0.06	Sirahama Obs.	H. Noda
1963	-0.18	Desna	P.E. Anderson	1971	0.04	Simosato Obs.	H. Noda
1963	0.06	Taylor Range Obs.	S. Kaneko	1971	-0.18	Simosato Obs.	T. Hayamizu
1963	0.02	Yamagata	Y. Oba	1971	0.02	Sendai, Kagoshima	M. Szulc
1963	-0.16	Yamagata	T. Funakoshi	1971	0.00	Lubeck	D. Ewald
1963	-0.86	Kaminoyama, Yamagata	T. Kurokawa	1971	0.04	Melchow	M. Zawilski
1963	0.05	Bisei Obs.	T. Oono	1971	0.01	Lodz	P. Ossowski
1963	0.05	Nakaku, Hiroshima	K. Iino	1971	0.04	Ostrow Wielkopolski	J. Speil
1963	-1.56	Urawa, Saitama	S. Baba	1971	0.09	Walbrzych-Ksiaz	E. D.Speil
1970	-0.32	Shibasaki, Chofu	S. Kaneko	1971	0.08	Walbrzych-Ksiaz	E. Belda
1970	0.09	Sakura, Chiba	T. Huzisawa	1971	-11.00	Desna	M. Znasik
1970	-0.06	Sirahama Obs.	H. Noda	1971	0.14	Zilina	A. Siser
1970	0.04	Simosato Obs.	H. Noda	1971	0.13	Zilina	R. Sandy
1970	-0.18	Simosato Obs.	T. Hayamizu	1971	-0.41	China, Zo-Se Obs.	A. Dubyago
1970	0.02	Sendai, Kagoshima	M. Szulc	1971	-0.04	U.S.S.R., Kazan Univ.	-
1970	0.00	Lubeck	D. Ewald	1971	0.05	Switzerland, Birmenst	T. Winiger
1970	0.04	Melchow	M. Zawilski	1981	0.06	Switzerland, Wald	E. Kharadse
1970	0.01	Lodz	P. Ossowski	1981	-0.05	U.S.S.R., Abastumani	A. Smith
1970	0.04	Ostrow Wielkopolski	J. Speil	1981	-0.01	Canada, Edmonton	E. Eichmann
1970	0.09	Walbrzych-Ksiaz	E. D.Speil	1981	-0.07	U.S.A., Hacienda Heig	J. Bourgeois
1970	0.08	Walbrzych-Ksiaz	E. Belda	1981	0.02	Oeiras	D. Wiebling
1970	-11.00	Desna	M. Znasik	1981	-0.03	Lubeck	R. Buggenthien
1970	0.14	Zilina	A. Siser	1982	-0.02	Lubeck	O. Sandor
1970	0.13	Zilina	R. Sandy	1982	-0.20	Teplice	P. Stastka
1970	-0.41	China, Zo-Se Obs.	A. Dubyago	1982	-0.54	Teplice	E. Belda
1970	-0.04	U.S.S.R., Kazan Univ.	-	1982	-0.18	Desna	P.E. Anderson
1970	0.05	Switzerland, Birmenst	T. Winiger	1989	0.06	Taylor Range Obs.	S. Kaneko
1970	0.06	Switzerland, Wald	E. Kharadse	2000	0.02	Yamagata	Y. Oba
1970	-0.05	U.S.S.R., Abastumani	A. Smith	2000	-0.16	Yamagata	T. Funakoshi
1970	-0.01	Canada, Edmonton	E. Eichmann	2000	-0.86	Kaminoyama, Yamagata	T. Kurokawa
1970	-0.07	U.S.A., Hacienda Heig	J. Bourgeois	2000	0.05	Bisei Obs.	T. Oono
1970	0.02	Oeiras	D. Wiebling	2000	0.05	Nakaku,Hiroshima	K. Iino
1971	-0.03	Lubeck	R. Buggenthien	2000	-1.56	Urawa, Saitama	S. Baba
1971	-0.02	Lubeck	O. Sandor	2008	-0.32	Shibasaki, Chofu	S. Kaneko
1971	-0.20	Teplice	P. Stastka	2008	0.09	Sakura, Chiba	T. Huzisawa

A12. Observations of star SAO99185

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1968	0.05	U.S.A., Flagstaff	N. White	1982	0.06	Furfooz	Jean Bourgeois
1981	0.70	Adelaide	Vello Tabur	1982	-0.09	Praha	Vaclav Cejka
1981	-0.06	Sydney, Nsw	W.H. Robertson				

A13. Observations of star SAO139834

Year	O-C	Location	Observer	Year	O-C	Location	Observer
1907	0.07	Germany, Jena, Winkler Obs.	-	1964	-0.20	Argentina, Buenos Aires	B. Dawson
1908	0.06	S. Africa, Cape, S.A.A.Obs.	J. Turner	1964	-0.13	Australia, Sydney Obs.	H. Wood
1923	0.17	S. Africa, Johannesburg Obs.	J. Churms	1964	0.15	S. Africa, Pretoria	S. Venter
1942	-0.03	S. Africa, Radcliffe Obs.	H. Knop-Shaw	1964	0.01	Argentina, Buenos Aires	A. Camponovo
1942	0.45	S. Africa, Durban	A. Cousins	1979	-1.37	-	-
1943	0.08	Portugal, Lisbon Obs.	A. Botelheiro	1979	1.09	NZ, Palmerston Nor	-
1943	0.08	Portugal, Lisbon Obs.	B. Abrew	1979	-0.06	-	-
1944	0.16	Portugal, Lisbon Obs.	B. Abrew	1980	-0.10	Green Valley Arizona	Lasch
1944	0.16	Portugal, Lisbon Obs.	M. Peres	1980	0.00	U.S.A., El Campo, TX	Stockbauer
1944	0.16	Portugal, Lisbon Obs.	B. Santos	1980	-0.01	U.S.A., El Campo, TX	Stockbauer
1944	0.08	Spain, Madrid Obs.	D. Loron	1980	0.01	U.S.A., El Campo, TX	Stockbauer
1962	1.90	Yavne	-	1980	-0.04	U.S.A., El Campo, TX	Stockbauer
1963	-0.20	U.S.A., Seal Beach, Calif.	-	1980	0.02	Hale Hoku Obs., Haw.	M. J. Morrow
1963	-0.12	U.S.A., Seal Beach, Calif.	-	1981	0.33	Pahala, Hawaii	W. B. Albrecht
1963	-0.32	U.S.A., China Lake, Calif.	C. Evans Jr	1981	-0.01	San Bruno, Calif.	T. W. Langhans
1963	-0.02	U.S.A., Independence, Missour	D. Dunham	1981	0.08	Tucson, Arizona	D. D. Nye
1963	6.08	U.S.A., Union Grove, WI	Lindemann	1981	-0.88	McDonald Obs., Texas	-
1963	4.53	U.S.A., Union Grove, WI	Schaefer	1981	0.04	Bundaberg	D. Lowe
1963	3.36	U.S.A., Union Grove, WI	Petak	1983	-0.01	Bundaberg, Qld.	P. Kearney
1963	2.82	U.S.A., Union Grove, WI	Glaser	1983	0.07	Taylor Range Obs.	P.E. Anderson
1963	2.98	U.S.A., Union Grove, WI	Mattmies	1983	0.01	Blenheim	B. Loader
1963	2.73	U.S.A., Union Grove, WI	Duvall	1983	0.26	Auckland	B. Menzies
1963	1.61	U.S.A., Union Grove, WI	Halbach	1983	0.01	Auckland	M.F. Stoker
1963	1.25	U.S.A., Union Grove, WI	Brichta	1983	0.16	Pakuranga	G. D. Allcott
1963	1.67	U.S.A., Union Grove, WI	Simandl	1983	0.13	Monte Grande	A. J. Camponovo
1963	1.81	U.S.A., Union Grove, WI	Francis	1983	0.00	Lagoa Santa	A. Rosa Campos
1963	0.09	Japan, Sirahama	F. Ono	1998	0.00	Presov	M. Sochan
1963	-0.09	Japan, Tokyo Hydro Obs.	M. Kawada	2001	0.00	Taylor Range Obs.	P.E. Anderson
1963	-0.03	Argentina, Cordoba Obs.	-				