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Solar diameter observations at Observatório Nacional in 1998-1999

S. Puliaev[1,2], J.L. Penna[1], E.G. Jilinski[1,2], and A.H. Andrei[1]

[1] Observatório Nacional/CNPq, Brasil
[2] Pulkovo Observatory, Russia

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Abstract. In January 1997, at the Observatório Nacional (ON), Rio de Janeiro, Brazil, digital CCD observations of the solar diameter began with a Danjon astrolabe adapted for solar observations and equipped with a variable angle reflecting prism. The prism enables observations of the Sun several times per day and all year round at the southern latitude $\varphi = -22°54'$.

As of June 1999, about 9000 observations have been made. The mean value of the apparent semi-diameter is $959.''13 \pm 0.''01$.

Here we report on the results obtained between July 1998 and June 1999. In 162 days 4276 observations were made. For this period the mean apparent semi-diameter is $959.''07 \pm 0.''02$. No significant difference between the apparent semi-diameters is found as observed on the East and West sides of the meridian.

The results of the observations are updated every month and available in electronic form in the SIMBAD database and at the World Wide Web page of the ON, Solar Radius Data: http://obsn.on.br/radius/.

Key words: Sun: general, fundamental parameters

1. Introduction

The program for solar CCD observations with a Danjon astrolabe, aiming to monitoring variations of the apparent diameter, has been pursued since January 1997 at the Observatório Nacional (ON), Rio de Janeiro ($\varphi = -22°54'$). First results and analysis of the observations through June 1998 were reported in Jilinski et al. (1998, 1999).

Send offprint requests to: S. Puliaev, Observatório Nacional/CNPq, R. Gal. José Cristino 77, CEP20921-400, Rio de Janeiro, Brasil.
e-mail: puliaev@on.br

Here the results of the campaign from July 1998 to June 1999 are presented. Analogous studies have been made by Noël (1995, 1998) and Laclare (1996).

The observations have been made with a reflecting variable angle prism, between 27° and 58° of zenith distance. A description of the observational method used is given in Chollet & Sinceac (1999).

The images of the Sun are acquired by a CCD camera COHU # 4710. The camera is IR sensitive (4000 – 10000 Å). The effective wavelength is 6400 Å and the bandpass is 3000 Å.

2. Results and discussion

Table 1 gives annual statistics of the observations for the whole observational period. Notice that the errors of the mean daily value of the semi-diameter $\sigma_{\rm day}$ and the error of single observations σ_1, became smaller in 1998 and 1999, than in 1997. This was due to a narrower observation bandpass and to improvements in the observational routine.

Normally, about 20 or more (up to 30) observations, on each side of the Sun's meridian cross are made in summer months. These figures fall to about 10 or less, on each side, in June when the Sun is comparatively low above the horizon. The Summer months, from December to February, are mostly rainy, resulting in less effective observing time than in the Winter, from June to August, but many more diameter measurements.

For the one-year period here considered there are 162 days of observation. In spite of the hard weather conditions of the observations, the astrolabe performed rather stably. No dependence was found of the observed semi-diameter on time length of observations (that vary from 2 to 7 minutes) and azimuth.

An analysis of the apparent semi-diameter and some studies concerning the variation of the astroclimatic conditions at ON are in preparation. Here instead we focus on the monthly average values, whose distribution is approximately normal.

Table 1. Mean values of apparent Sun semi-diameter and errors (in arcsec) for the years 1997, 1998 and from January to June 1999. The *Day* column displays the number of observational days during the year, *Obs* brings the total number of observations, *Diam* - the mean semi-diameter, ε - its error, $\sigma_{\rm day}$ - the error of mean daily value of semi-diameter and σ_1 - the error of a single observations

	East transits						West transits						All transits					
Year	*Day*	*Obs*	*Diam*	ε	$\sigma_{\rm day}$	σ_1	*Day*	*Obs*	*Diam*	ε	$\sigma_{\rm day}$	σ_1	*Day*	*Obs*	*Diam*	ε	$\sigma_{\rm day}$	σ_1
1997	144	1854	959.25 ± .03	.20	.60	69	802	959.32 ± .06	.22	.69	158	2656	959.27 ± .03	.20	.63			
1998	135	1873	959.17 ± .02	.14	.46	140	2044	959.07 ± .02	.13	.44	162	3917	959.12 ± .02	.14	.45			
1999 Jan.-June	70	1125	958.93 ± .03	.15	.53	73	1154	958.96 ± .02	.12	.42	84	2279	958.95 ± .02	.13	.47			
All period	349	4852	959.15 ± .02	.17	.54	282	4000	959.10 ± .02	.15	.49	404	8852	959.13 ± .01	.16	.52			

Table 2. Monthly average apparent semi-diameters (in arcsec) from July 1998 to June 1999. The *Day* column displays the number of observational days during the month, the *Obs* column brings the total number of observations. Columns *Diam* and ε bring the mean semi-diameter and rms error

	East transits				West transits				All transits			
Month	*Day*	*Obs*	*Diam*	ε	*Day*	*Obs*	*Diam*	ε	*Day*	*Obs*	*Diam*	ε
July 1998	14	127	959.33 ± 0.10		16	187	959.12 ± 0.04		17	314	959.22 ± 0.05	
August	13	194	959.15 ± 0.09		13	217	959.08 ± 0.04		14	411	959.11 ± 0.05	
September	9	126	959.12 ± 0.05		12	212	959.08 ± 0.05		13	338	959.10 ± 0.03	
October	6	82	959.13 ± 0.08		8	145	959.12 ± 0.10		9	227	959.12 ± 0.07	
November	8	159	959.28 ± 0.06		10	184	959.14 ± 0.06		11	343	959.20 ± 0.04	
December	11	175	959.45 ± 0.06		12	189	959.34 ± 0.05		14	364	959.39 ± 0.03	
January 1999	13	224	959.06 ± 0.08		13	224	959.16 ± 0.04		15	448	959.11 ± 0.04	
February	10	219	958.78 ± 0.04		12	189	958.85 ± 0.05		13	408	958.82 ± 0.03	
March	14	257	958.88 ± 0.06		12	217	958.94 ± 0.03		16	474	958.91 ± 0.04	
April	14	217	958.88 ± 0.06		13	237	958.83 ± 0.06		15	454	958.86 ± 0.04	
May	9	116	958.07 ± 0.13		13	181	959.02 ± 0.05		14	297	959.00 ± 0.05	
June	10	92	959.04 ± 0.10		10	107	958.94 ± 0.06		11	199	958.99 ± 0.06	
All period	131	1988	959.08 ± 0.03		144	2288	959.05 ± 0.02		162	4276	959.07 ± 0.02	

In Table 2 are presented the number of the days of observation, the total number of observations during a month and the monthly averages. The results of the East and West observations are tabulated as well as an average of all transits.

The error of a single measurement of the solar semi-diameter for the period of 1998-1999 is $0\farcs51$ for the East and $0\farcs43$ for West observations.

Table 1 indicates a decreasing trend of $0\farcs16$ per year for the apparent semi-diameter. The average value for 1998.25 is $959\farcs13$. This represents a difference of $0\farcs4$ for the average value of Calern observations for the period 1975 – 1998 (Laclare et al. 1999a, 1999b). However, similar trends and differences can also be found within the Calern series. On the other hand, discrepancies in the average values can be expected due to differences in the effective observational wavelength, in the operating definition of the solar border and in the prevailing local atmospheric conditions.

Complete results of the daily series are updated every month and can be retrieved in electronic form from the SIMBAD database and from the homepage of ON (http://obsn.on.br/radius/). For the electronic form, the daily data are given: the number of observations, the semi-diameter mean value, its rms error, the date in format YYMMDD, the Modified Julian Date and the error of a single observation.

3. Conclusions

4276 digital CCD observations of the solar diameter during 12 months from July 1998 to June 1999 were made. The mean apparent semi-diameter is $959\farcs07 \pm 0\farcs02$. The difference between mean East and West apparent semi-diameters is $0\farcs03$, which is non significant face the measurements errors.

Since 1997 near 9000 observations have been made. The mean value of the apparent semi-diameter for the entire series is $959\farcs13 \pm 0\farcs01$.

The error of a single observation of semi-diameter for the period of 1998-1999 is $0\farcs51$ for the East and $0\farcs43$ for West observations. The standard error of the daily mean observed semi-diameter is $0\farcs14$.

Further observations are highly desirable to study the measured variations in time of the solar semi-diameter.

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