COMPARISON OF INSTRUMENTS AND METHODS OF POSITIONAL OBSERVATIONS OF THE SUN AND MAJOR PLANETS

A.S.Kharin
Main Astronomical Observatory
Academy of Sciences of the Ukrainian SSR
Kiev, U.S.S.R.

During the last decades, regular meridian observations of the Sun and major planets have been mainly carried out at Washington and Greenwich observatories. However, after 1960 position observations of Solar system bodies were initiated at many observatories throughout the world. The photographic and the equal altitude methods are widely used at this time, besides the meridian method. According to available information, during the time interval from 1960 to 1980,altogether 19 meridian instruments, 12 astrographs and 5 astrolabes took part in observations of the Sun and the major planets. More than 40.000 observations of single coordinates - right ascension and declinations have been obtained.

At the same time only the Washington and Greenwich observations are used for determining the position and the motion of the equinox. In this connection, it is interesting to asses the usefulness of the optical observations of the Solar system bodies during the last two decades towards this goal. Particularly, it is interesting to find out which of the instruments observation methods appear to be the most accurate and thus preferable.

A simple calculation of the number of observations and their distribution by solar longitude (by seasons) as well as by the orbital longitude makes it possible to obtain a complite characteristic of each method. The meridian method was used for the largest number of observations accounting for about 80% of all observations.The smallest contributions, less than 2% of the total number, was made by observations with astrolabes.

Fig.1 shows that the meridian observations with regard to uniformity of distribution also have advantages over other distribution of observations of Venus (Fig.1b,c)

H. K. Eichhorn and R. J. Leacock (eds.), Astrometric Techniques, 685–689.

which appeared to be bi-model for photographic observations for lack of good observing conditions in summer and winter.

The obtained estimates for the precision of disk-objects is also an interesting characteristics of the different methods. These estimates are given in Tabs.1-4. σ_1 is the standard error obtained by the residual differences v_i relative to Newcomb's theory as improved by the differential method.

$$\sigma_1 = \sqrt{\frac{\sum_{i=1}^{n} v_i^2}{n-1}},$$

σ_2 is the dispersion of the residual differences relative to their mean value $\bar{v}_i$ for given series of observations, i.e.

$$\sigma_2 = \sqrt{\frac{\sum_{i=1}^{n} (v_i - \bar{v}_i)^2}{n-1}},$$

finally, estimates of σ_3 were obtained from the deviations of the individual (O-C) from their monthly means, i.e.

$$\sigma_3 = \sqrt{\frac{\sum_{i=1}^{n} [(O-C)_i - (\overline{O-C})]^2}{n-1}}.$$

Thus, the estimate σ_1 measures the total error of an observation, including random and systematic parts, while σ_3 measures the random errors only.

The tables show, that photographic observations and the astrolabe method are the most precise, while the total error σ_1 of photographic observations in individual cases happens to be not cmaller than those of meridian observations. In our opinion, this is due to large errors in the reference material used for observations. Among meridian observations, those of Mars made at Perth with a photoelectric meridian circle showed the highest precision, while the Tokyo transit circle observations of planets appear to be the least precise.

The analysis leads to the following conclusions:
1. Meridian observations of the Sun and the major planets, in spite of their smaller precision, are as before, basic

for obtaining position and motion of the equinox.

2. In view of the high precision of photoelectric meridian observations of planets at night, a more extensive application of this method is recommended.

3. Astrolabe and photographic observations of major planets are very precise and may be a valuable supplement to the meridian observations.

4. Photographic observations must be related to the system of the fundamental catalogue.

Table 1. Precision of observations of the Sun with meridian instruments

Instruments		α σ_1	α σ_2	α σ_3	α n	δ σ_1	δ σ_2	δ σ_3	δ n
Washington	MC	0"73	0"71	0"60	1565	0"80	0"79	0"63	1485
Greenwich	MC	0.86	0.74	0.58	822	0.99	0.78	0.61	781
Nikolaev	TI	1.12	1.03	0.85	1595				
	VC					1.01	0.98	0.94	1787
	MC	1.87	1.83	1.92	98	1.95	1.62	1.50	83
Tashkent	MC	1.14	1.13	0.93	954				
Pulkovo	VC					0.95	0.83	0.81	175
	MC	1.26	1.25	0.85	55				
Goloseevo	VC					0.90	0.86	0.72	265
GAISH	MC	1.43	1.42	0.98	169				

Table 2. Accuracy of Venus observations with meridian instruments and astrographs

Instruments		α σ_1	α σ_2	α σ_3	α n	δ σ_1	δ σ_2	δ σ_3	δ n
				Meridian observations					
Washington	MC	1"24	1"22	0"76	1118	0"95	0"94	0"81	1063
Greenwich	MC	0.90	0.83	0.58	465	0.96	0.69	0.60	430
Tokyo	MC	2.17	2.15	0.91	109	1.31	1.11	0.97	109
Nikolaev	TI	1.28	1.18	0.93	1336	-	-	-	-
	VC	-	-	-	-	1.02	1.02	0.80	1313
	MC	1.74	1.72	1.46	81	1.27	1.25	1.14	92
Tashkent	MC	1.68	1.65	0.91	661	-	-	-	-
Pulkovo	VC	-	-	-	-	0.79	0.72	0.58	136
	MC	1.38	1.21	1.37	47	-	-	-	-
Goloseevo	VC	-	-	-	-	0.89	0.87	0.75	252
GAISH	MC	1.35	1.34	1.12	128	-	-	-	-

Table 2 (continued)

Instruments		α σ1	σ2	σ3	n	δ σ1	σ2	σ3	n
Kharkov	MC	1".67	1".46	0".75	31	-	-	-	-
Kazan	MC	-	-	-	-	1".13	1".12	0".80	111
	PHI/Fcm	Astrograph observations							
Pulkovo	10/71	0.89	0.65	0.56	86	0.64	0.57	0.36	86
	33/350	0.88	0.75	0.48	87	0.54	0.37	0.43	87
	65/1040	1.29	1.23	0.78	105	0.82	0.76	0.64	105
Nikolaev	12/104	1.82	1.81	0.39	116	0.67	0.62	0.39	116
Goloseevo	40/550	1.12	1.01	0.71	166	0.76	0.72	0.41	166
GAISH	24/200	0.99	0.99	0.92	1037	0.91	0.90	0.67	1033

Table 3. Precision of observations of Mars with meridian instruments

Instruments		α σ1	σ2	σ3	n	δ σ1	σ2	σ3	n
		Meridian observations							
Washington	MC	0".64	0".64	0".49	366	0".47	0".47	0".36	336
Greenwich	MC	0.55	0.53	0.39	136	0.80	0.58	0.48	125
Tokyo	MC	1.01	0.99	0.73	196	0.76	0.75	0.56	192
Nikolaev	TI	1.24	1.23	0.60	191	-	-	-	-
	VC	-	-	-	-	0.75	0.75	0.61	225
	MC	1.83	1.59	0.67	79	0.52	0.50	0.41	84
Tashkent	MC	1.05	1.04	0.67	53	-	-	-	-
Pulkovo	VC	-	-	-	-	0.46	0.46	0.38	59
	MC	1.01	0.59	0.60	21	-	-	-	-
Goloseevo	VC	-	-	-	-	0.64	0.61	0.51	151
GAISH	MC	1.69	0.41	0.52	5	-	-	-	-
Kharkov	MC	1.58	1.56	1.23	48	-	-	-	-
Kazan	MC	-	-	-	-	0.82	0.81	0.67	89
Perth	PHMC	0.46	0.36	0.24	24	0.37	0.35	0.33	23
Odessa	MC	-	-	-	-	-	0.64	-	4

https://doi.org/10.1017/S0074180900077196 Published online by Cambridge University Press

Table 4. Precision of observations of Mars with astrograph and astrolabes

Instruments		α				δ			
		σ_1	σ_2	σ_3	n	σ_1	σ_2	σ_3	n
					Astrographs				
	PHI/Fcm								
Pulkovo	10/71	0"77	0"76	0"45	156	0"50	0"46	0"27	153
	33/350	0.75	0.73	0.34	114	0.51	0.49	0.25	114
Nikolaev	12/104	0.64	0.63	0.42	191	0.45	0.45	0.28	191
Goloseevo	40/550	0.77	0.76	0.48	416	0.60	0.59	0.38	415
Kiev KAO	8"	0.82	0.81	0.87	69	0.60	0.44	0.58	69
Kazan	16"	1.26	1.20	1.57	11	1.18	1.11	0.72	11
					Astrolabes				
Paris		0.71	0.68	0.60	17	0.31	0.30	0.26	17
CERGA		0.54	0.46	0.43	13	0.41	0.36	0.37	13
Algiers		0.51	0.41	0.38	4	0.32	0.17	0.23	4
San.Fern.		0.35	0.34	0.37	39	0.33	0.29	0.26	39
Besanson		0.62	0.47	0.34	9	0.42	0.14	0.15	9

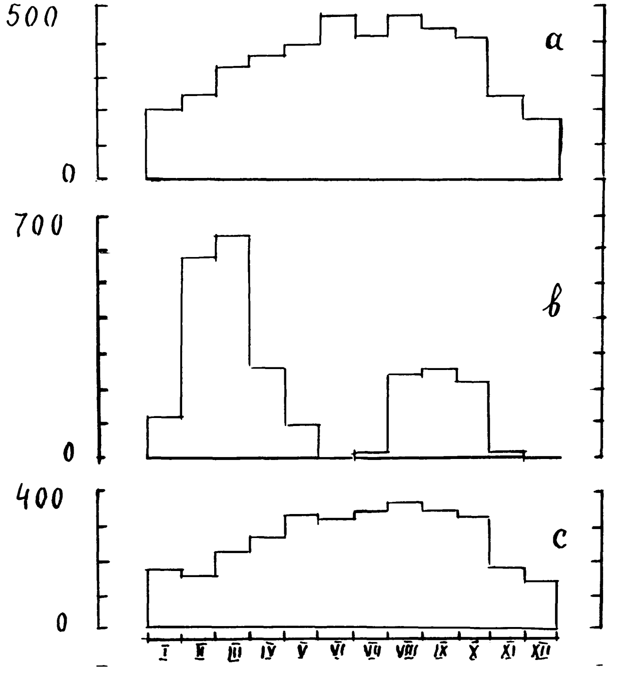

Fig.1. Distribution of observations of the Sun,(a), Venus (b-photogr.,c-visual).

https://doi.org/10.1017/S0074180900077196 Published online by Cambridge University Press