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DAY-TIME OBSERVATIONS WITH THE BELGRADE MERIDIAN CIRCLE – REDUCTION OF THE INSTRUMENT PARAMETERS TO THE FK5 SYSTEM

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Abstract. Since 1973 the Belgrade Meridian Circle has been used in day-time observations of the Sun and the inner planets. The instrument parameters have been determined from the observation of the fundamental stars, reduced in the first period to the FK4 system and during the last several years to that of the FK5.

The positions of all the fundamental stars, as listed in the present paper, are reduced to the FK5 system and the $(O-C)$ corrections to the positions of the Sun, Mercury and Venus have subsequently been calculated.

1. INTRODUCTION

In parallel with the night observations with the Belgrade Meridian Circle, since 1973 day-time observations of the Sun and inner planets, conjointly with the appropriate fundamental stars have also been performed. These day-time observations became regular since 1975. In 1981 included in the programme of the observations of the Sun and the inner planets was also Mars. This observing programme has been kept uninterrupted throughout until 1994.

The basic objective of our observations of the Sun, planets and the fundamental stars was, in principle, the improvement of the orientation of the FK4. In addition, from the differences of the observed and the calculated positions of the planets, i.e. from the $(O-C)$ deviations on can derive corrections to the elements of their orbital motion. The results of these observations, i.e. the corrections of the equinox and equator involved by the FK4 catalogue have earlier been published already (Sadžakov et al. 1982; Sadžakov et al. 1992).

An analogous procedure is of course valid when the FK5 catalogue is concerned. For this to be performed all observations had to be reduced to the FK5 system. This is followed by treating the observational results in conformity with the fact that our observations were differential ones.

2. THE INSTRUMENT PARAMETERS AND REDUCING TO THE FK5 SYSTEM

The day-time observations of the Sun and the inner planets were carried out by series. A particular series included the observation of at least one solar system body (Sun,

Mercury, Venus, later Mars) and a few fundamental stars, accessible to observation by day-time. Care has always been taken the stars to be close in time and declination to those of the observed solar sistem bodies. Nevertheless, it sometimes happened that no star, or one only, could be observed. Such series – with no one or with a single star observed, have not been considered. Otherwise, most of the series comprised both the Sun and Venus.

The right ascensions were derived according to Bessel formula. First the values of the parameter n was determined for each one of the series. This parameter was obtained alike from the day-time observations and from the night ones, whereby its variation has been taken into account. Upon introducing the parameter n and calculating the positions of the fundamental stars, particular amounts $(u + m)$ and their means have been deduced.

With the declinations the things are somewhat simpler. From the observations of the fundamental stars one parameter only is to be determined – the equator point M_o.

Bearing in mind that our pervious observations were reduced to the FK4 system, the question arises as to how much the $(O - C)$ deviations are affected if the apparent positions of the fundamental stars, from which the instrument parameters are deduced, are calculated in the FK5 system, i.e. if these parameters are reduced to the FK5 system. To answer this question we poceeded from expressions serving for the calculation of the instrument parameters.

The modified Bessel formula for the right ascension reads:

$$(u + m)\cos\delta + n\sin\delta = (\alpha - T)\cos\delta \ ,$$

where α is the apparent right ascension at the time of observation whose values will vary depending on the system within which the reduction is made. As evident from the above formula these changes in α will be reflected in the $(u + m)$ and n values.

In view of the fact that most of the stars observed during these day-time tours had declinations not much different from those of the Sun and the planets, it follows from the above formula that the changes in the $(u+m)$ parameter will chiefly be due to the changes in the right ascensions α. The correction to the mean value of this parameter in a given series will be:

$$\overline{\Delta(u + m)\cos\delta} \approx \overline{\Delta\alpha\cos\delta} \ ,$$

this all the more so since the n parametar is obtained separately.

Concerning the declination the equator point is obtained from the formula:

$$M_o = M - \delta \qquad \text{at clamp east (CE)} \ ;$$
$$M_o = M + \delta \qquad \text{at clamp west (CW)} \ .$$

Accordingly, the mean value of the equator point position within a series will vary by the amount:

$$\overline{\Delta M_o} = \mp\ \overline{\Delta\delta} \ .$$

The positions of the Sun and the planets as obtained by observing within a particular series are to be corrected by a value equal to the correction to the corresponding instrument parameter, whereby our observations are linked to the FK5 catalogue.

3. RESULTS OF THE REDUCTION

By analysing the day-time observations, first of all the manner of determining the instrument parameters and the accuracy of calculation of particular positions, it has been inferred that the initial period 1975–1979 should not be taken into account concerning the orientation of the FK5 catalogue. The determination of the positions of the Sun, Mercury and Venus were rather often during this period linked to the night observations. Even though the possible variations of the parameters were taken into account, these have been determined under conditions differing considerably from those prevailing during the day-time observations. In other words the star observations from which the instrument parameters have been derived in many series have not been conjoint with those of the Sun and the planets. An extra problem was the determination of the clock rate. Such a mode of observations and their processing presented one of the principal causes of the very high accidental errors in $(O-C)$ deviations in this period (1975-1979).

The corrections to the instrument parameters expressed through the means of the corrections to the fundamental stars positions are displayed in Tables 1 and 2. Corrections to the parameter $\overline{\Delta(a+m)\cos\delta}$ (corr_a), meaned according to seasons are listed in Table 1, along with the number of observed stars (n) and the number of the series (N). Table 2 contains the meaned corrections to the equator point $\overline{\Delta M_o}$ (corr_δ) and the corresponding data on the number of stars observed (n) and the number of series (N).

Both of Tables are divided into two parts. In the first part, pertaining to the period 1979–1983, the star positions were reduced within the FK4 system. The second part, relating to the period 1984–1987, the reductions were carried out within the FK5 system (without the individual and systematic corrections to the star positions).

High correction ammounts in the first part of Table 1 are a consequence of the corrections to the equinox involved by the FK4 catalogue. A considerably lower amount of this correction is evident in the last year's quartal. As expected, after passing over to the FK5 system (1984–1987), no such season dependent variations do appear. The mean corrections to the equator point in the second part of Table 2 are shifted toward zero – which equally was expected.

It is to be indicated that in some of the seasons the instrument parameters were determined from the observations of well-night the same stars (conditioned by their visibility by day-time circumstances), so that the obtained mean values are practically dependent on the star selection enforced, i.e. on the individual star positions differences in the FK4 and FK5 catalogues.

Table 1. Corrections to the parameter $\overline{\Delta(u+m)\cos\delta}$

Year	Spring			Summer			Autumn			Winter		
	corr_α 0:001	n	N	corr_α 0:001	n	N	corr_α 0:001	n	N	corr_α 0:001	n	N
1979				+52	40	6	+49	38	7			
1980				+55	39	8	+47	30	8	+54	14	3
1981				+57	32	11	+37	17	6			
1982	+38	2	1	+49	12	5	+38	25	10	+62	21	7
1983				+41	2	1	+39	14	5	+54	11	2
mean	+38	2	1	+54	125	31	+44	124	36	+58	46	12
1984	−2	8	2	−6	2	1	−5	15	6	−6	10	4
1985	−3	21	7	−4	83	21	−5	26	11			
1986	−5	44	11	−5	24	9	−5	26	8	−4	21	5
1987	−8	6	3	−5	8	3	−4	28	8			
mean	−4	79	23	−4	117	34	−5	95	31	−5	31	9

Table 2. Corrections to the parameter $\overline{\Delta M_o}$

Year	Spring			Summer			Autumn			Winter		
	corr_α 0".01	n	N	corr_α 0".01	n	N	corr_α 0".01	n	N	corr_α 0".01	n	N
1979				−5	42	6	−2	37	7			
1980	0	5	1	−3	93	16	−3	33	9	−3	15	3
1981				+2	37	12	−3	18	6			
1982	−4	4	2	+2	12	5	−2	26	10	−10	20	6
1983				−6	2	1	−4	14	5	+3	11	2
mean	−2	9	3	−2	184	40	−3	128	37	−5	46	11
1984	+1	8	2	−5	2	1	−3	15	6	−3	10	4
1985	+1	21	7	+1	89	23	−3	26	11			
1986	−1	43	11	−1	24	9	−2	26	8	−1	21	5
1987	−3	6	3	+1	8	3	0	28	8			
mean	0	78	23	+1	123	36	−2	95	33	−2	31	9

4. CONCLUSION

The day-time observations of the Sun, planets and fundamental stars made with the Belgrade Meridian Circle may be used for the correction to the fundamental catalogues. In the present paper it is shown by what amounts, determined from the observations of the fundamental stars, the instrument parameters should be corrected in order to obtain the directly observed Sun and planets positions in the FK5 system. The low accuracy of our observations in the first period (1975–1979) makes them unsuitable for the task we originally envisaged.

References

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