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BELGRADE VERTICAL CIRCLE: NEW DETERMINATION OF INCLINATION OF MICROSCOPE-MICROMETERS

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Abstract. Repeated after 12 years, determination of inclination of the Belgrade Vertical Circle's microscope-micrometers revealed an appreciable increase of the inclination by about $10'$ in three microscopes (I, II and IV) whereas one of them (III) preserved practically the same inclination it had at its original installing. It should be borne in mind that meanwhile no interventions have in effect been undertaken on the microscopes.

1. INTRODUCTION

In order to establish what is the current state regarding inclinations of four visual microscope-micrometers of the Belgrade Vertical Circle (VC) with respect to the ones from May 1984, determined immediatelly after their mounting in their present positions, a re-determination of inclination of all four microscopes has been carried out in May 1996 in the parts of the circle as previously.

Before starting the measurements provision has been made of 4 glass plates (30×5×2.86 mm), 8 very thin somewhat longer ring-like rubber bands and 16 paper clips. On the day of measurements the rubber bands were fixed with paper clips on 8 desired positions on the circle. The remaining 8 paper clips were pinned on the rubber bands and could be pulled a little making thereby place between the rubber band and the circle for the glass plate. The glass plates are so pressed against the circle that one is able by a slight hand move, stratching at the same time with the other hand the rubber band, to cover or uncover the desired part of the circle graduation. The measurements proceeded according to the following scheme: readings with all four micrometers are made twice of three division lines, the division lines are then covered with glass plate, being again red twice. The graduated circle is then turned through 90° so that now the measuring proceeds first with the division lines covered with the glass plate act.

All the measurements involved by 32 inclination determinations made with and without glass plates, as well as their putting into position, were executed by Dj. Bozhichovich and R. Pavlović. A little less than 3 hours were spent to complete all this work. (However, the data processing, in spite of computers, drew out considerably longer).

2. METHOD APPLIED

The method of determining the microscope inclination is based on the plan- parallel glass-plate effect. The deriving of the needed expression started from the formula yielding the correction to the microscope reading as given by Podobed (1968)

$$\Delta M = \frac{\Delta d}{d}(M - I) \tag{1}$$

where $\Delta M = M_0 - M$; M_0 – the unknown true reading corresponding to the mean circle position; M – the actual reading requiring correction; d – the distance of the microscope object-glass from the circle; Δd – the actual deviation of the measured part of the circle from he mean position, resulting from the irregularities of the circle plane and the axis of rotation and from the corrugation of the circle plane, determined with the contact indicator; I – the known or required inclination if the given microscope (by this always ment is the tangential component of the micrometer inclination).

The above formula (1) was transformed by Bozhichovich (1985) by introducing the plane-parallel glass plate effect ($(\Delta d = -\Delta d_g(n-1)/n)$ – by that amount the circle division line covered by the glass plate is apparently nearer to microscope object-glass) into

$$M - M_g = -\frac{\Delta d_g}{d}\frac{n-1}{n}(M_g - I)$$

i.e. into the following expression yielding the microscope inclination

$$I = M_g + \frac{d}{\Delta d_g}\frac{n}{n-1}(M - M_g) \tag{2}$$

where now M_g – the mean reading of three division lines, under the index and on both its sides, before their covered with the glass plate, M – the mean reading of these same division lines after their being covered with the glass plate; Δd_g – the thickness of the glass plate (2.86 mm); n – the refraction index of the glass plate (assumed 1.52); d – the mean distance of the microscope object-glass from the circla plane (about 230 mm).

3. RESULTS AND ANALYSIS

The inclination (I) determined, according to the expression (2) of all four microscopes, from the old (o) measurements from 1984 and from the new measurements in 1996, are summarized in Table 1. A cursory look at them already makes evident that the inclinations, save for the microscope III, have considerably increased, approximately by 10′. It is to be borne in mind that in the course of the last 12 years of work with the VC, apart from rather rare minor interventions aimed at the harmonizing the micrometer drum readings (up to ± 5° at most), there have been no other interventions on the microscopes.

In Fig. 1 are illustrated the differences of the measured and the mean inclination values of all microscopes depending on the place of the cicle wherein they have been determined. The mean values of these differences (ΔI) according to the place of their

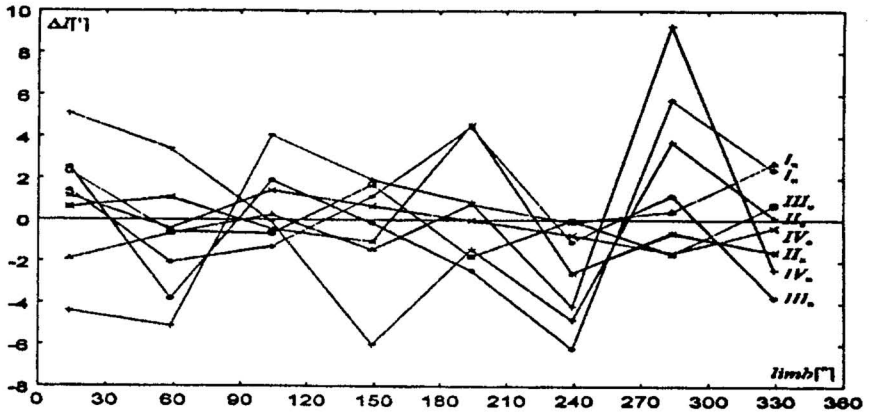

Fig. 1. Inclination deviation from the mean value for each microscope.

determination are given for all the microscopes in Column 10 of Table 1. As evident from Table 1 and Fig. 1 the inclinations are in some places on the circle on the average somewhat higher or somewhat lower. Although small, these quantities in Column are not accidental. Namely, somewhat lower inclination values (negative mean values) are obtained in places on the circle very near the middle of the circle spokes, whereas the slightly higher values are associated with the places near the middle of the interspace between the neigbouring spikes (there are 12 spokes, on every 30° starting at 0°.

Table 1. The Results of Inclination Determination for Microscope-Micrometers of VC (o – old, n – new measurements.

limb	I_o	I_n	II_o	II_n	III_o	III_n	IV_o	IV_n	ΔI	$\varepsilon_{\Delta I}$
13°50′	5′.3	8′.1	−1′.4	−9′. 1	2′.0	0′.3	−3′.5	−3′.3	0′.8	±1′.0
58 50	−1.1	9.4	−3.1	9.5	−0.9	−3.2	−5.1	2.5	−1.0	±0.9
103 50	4.6	10.3	−6.6	8.0	−1.0	−2.4	−3.3	11.7	0.6	±0.6
148 50	2.6	8.6	−12.5	7.5	1.4	0.0	−4.0	9.6	−0.4	±0.9
193 50	0.3	10.7	−7.9	13.1	−2.1	3.3	−4.7	8.5	0.6	±0.9
238 50	−3.4	9.9	−11.3	5.9	−0.4	−2.2	−5.4	3.5	−2.5	±0.8
283 50	8.5	10.4	−2.7	7.9	−2.0	0.0	−6.3	16.9	2.1	±1.4
328 50	5.1	12.8	−6.4	6.9	0.4	−4.9	−5.1	5.3	−0.3	±0.8
$\bar{I}$	2.7	10.0	−6.5	8.5	−0.3	−1.1	−4.7	7.7		±1.0
$\varepsilon_{\bar{I}}$	±1.4	±0.5	±1.4	±0.8	±0.5	±0.9	±0.4	±1.8	±1.1	±2.7

In Columns 10 and 11 of Table 1 are given the errors in the mean inclinations and the mean differences. At the bottom of Column 11 is given the mean error in inclination determined by the method applied, (± 2′.7).

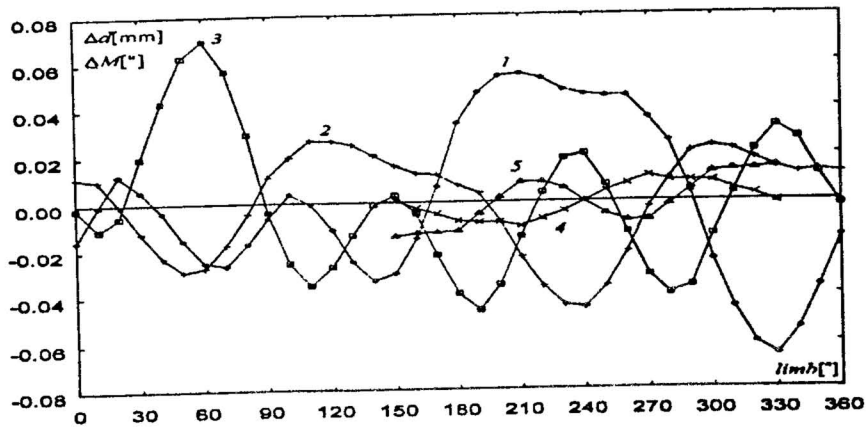

Fig. 2. Variations (Δd) in the mean distance between the circle and corrections (ΔM) of the mean reading of VC as function of the limb division.

In Fig. 2 the curve 1 illustrates the variations of the mean distance Δd of the circle and the object-glass of the microscopes. As may be seen they are relatively small, running between the ± 0.065 limits. The curve's shape indicates that the part of deviations caused by the inclination with respect to horizontal axis on which it is fixed practically equals that part originating from the corrugation of the circle itself. On entering the values into formula (1) along with the mean value of inclination of each one of the microscopes (Column 9) and by averaging the obtained corrections for all the four microscopes, reducing them to the microscope I, one derives the curve 2 (old inclinations) and the curve 3 (new inclinations) in Fig. 2. As evident, the magnitude of the corrections to the mean circle reading with all four microscopes, having regard to the current amount of inclination, already starts requiring in some, true rare, cases its applications or else the removal of the present relatively larger inclinations.

Nevertheless, that the current inclinations of the VC microscopes might still be tolerated is indicated by the curve 5 in Fig. 2 ilustrating the corrections to be possibly applied to the half-differences of two circle readings furnishing the zenith distance, i.e. the star declination.

4. CONCLUSION

As a conclusion resulting from all that has been said above the following should be stated: Upon the near conclusion (in one or two years) of the current cycle of observations of fundamental stars and the outer solar systems planets made with the VC, but before launching a new observational cycle, it is to be strived for, as has been done so far, to have the microscope inclinations as small as possible in addition to the general shifting of all microscopes by about 30′ (in 1984 they have been shifted by about +60′). The performing of this difficult task ought to be facilitated by means of

covering, with the glass plates, half of the division lines over which the microscopes are displaced. From the amount of their drifting one may find out in what direction, how much and which of the microscope's part is to be moved.

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