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GROUP CORRECTIONS IN ZENITH DISTANCE

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RESUMEN

La distancia zenital verdadera de observación en el astrolabio Danjon es una función del ángulo de prisma y de la variación de la refracción atmosférica durante las observaciones. Las inestabilidades de la distancia zenital impiden la obtención de correcciones de grupo y consecuentemente de las correcciones individuales de las estrellas.

En este trabajo se presentan las correcciones de grupo en distancia zenital libres de efectos sistemáticos instrumentales para los datos del astrolabio de Valinhos ($\phi = -23° 00'$, $\lambda = +3^h07^m$), por medio de dos métodos diferentes: 1) mediciones de ángulo instantáneo de prisma, con la ayuda de un ocular especial de autocolimación, y 2) estimación del gradiente térmico de prisma por la diferencia de temperatura "astrolabio menos aire", el cual está disponible en casi todas las estaciones de astrolabio.

ABSTRACT

The actual zenith distance of observation in the Danjon astrolabe is a function of the prism angle and of the atmospheric refraction variation during the observations. The zenith distance instabilities preclude the obtention of reliable group corrections and, consequently, of the individual corrections to star positions. In this paper we present group corrections in zenith distance for astrolabe data at Valinhos ($\phi = -23° 00'$, $\lambda = +3^h07^m$), freed from systematic effects of instrumental origin by means of two different methods: 1) measurements of the instantaneous prism angle, with the help of a specially made auto-collimating eyepiece, and 2) estimation of the prism thermal gradient by the "astrolabe minus air" temperature difference, which is available in nearly all astrolabe stations.

Key words: **ASTROLABE – GROUP CORRECTIONS**

I. INTRODUCTION

The Danjon astrolabe has been recognized as an invaluable instrument for the computation of star position catalogues. A full description of an astrolabe catalogue compilation can be found in Débarbat and Guinot (1970).

The large closing errors of the differences in zenith distance between successive groups, in the chain method, found in several observatories (Blaser and Cavedon 1959; Scheepmaker 1963; Noël, Czuia, and Guerra 1974; Clauzet 1974, 1976, 1982, Andrei *et al.* 1983) demonstrated that we cannot compute group corrections in zenith distance without a knowledge of the zenith distance variation during the observations.

A complete analysis of the zenith distance instabilities due to thermal effects as well as the practical means to control it can be found in Benevides-Soares and Clauzet (1984).

In this paper we present the zenith distance group corrections, freed from thermal effect, obtained for astrolable data at Valinhos observatory ($\phi = -23°00'05''$ and $\lambda = +3^h07^m52^s.2$).

II. METHODS

The difference between the actual and the thirty degrees theoretical zenith distance of observation, hereafter called radius (R), has its origin in: 1) a constant part due to manufacturing errors, 2) catalogue errors, 3) thermal deformation of the prism, which gives rise to variations in the prism angle, and 4) anomalous departures of atmospheric refraction from its computed mean value.

In the chain method (Guinot 1958) the program comprises groups (usually twelve) of fixed composition, so that catalogue errors can be accounted for by systematic corrections for each individual group (group corrections, C).

The anomalous refraction is not easily measured and will not be considered, except as a source of random error.

Systematic corrections in the chain method are obtained by forming the mean difference of successive group pairs. However, as we have stressed above, the method is not directly applicable to radius differences as a result of systematic variations of the prism shape along the observing hours. Such systematic effects add up to give large closing errors, of 1" and more.

Two different techniques were employed for the computation of the systematic part of the radius due to catalogue errors.

The first one consists of the instantaneous prism angle measurement by means of auto-collimation. The second technique consists of the estimation of the thermal gradient along the prism, by means of the temperature difference (θ) between the astrolabe and the surrounding atmosphere.

As shown by Benevides-Soares and Clauzet (1984) both prism angle measurements and temperature differences can be linearly related to the zenith distance variations.

In these conditions we can write:

$$R = -hv + C + a$$

$$R = g\theta + C + b$$

where R is the actual radius, v is the weighted mean of auto collimation measurements, θ is the astrolabe–air temperature difference, C is the group correction and h, g, a and b are constant coefficients.

By forming the difference between two consecutive groups, observed during the same night run by the same observer, we have:

$$\Delta R = -h\,\Delta v + \Delta C \ ,$$

$$\Delta R = g\,\Delta\theta + \Delta C \ . \qquad (1)$$

Take the mean of (1) over the observations of a given pair and from the term-wise sum over the twelve pairs to obtain

$$h = -F_R/F_v \ , \qquad (2)$$

and

$$g = F_R/F_\theta \ ,$$

where F_R, F_v and F are the closing equations:

$$F_R = \Sigma\,\overline{\Delta R},\ F_v = \Sigma\,\overline{\Delta v} \ \text{and}\ F_\theta = \Sigma\,\overline{\Delta\theta} \ ,$$

and, of course, over a closed chain we have

$$\Sigma\,\Delta C = 0 \ .$$

With the results for h and g in hand we may compute the correction difference of each group pair by means of

$$\Delta C^v = \overline{\Delta R} + h\,\overline{\Delta v}$$

and

$$\Delta C^\theta = \overline{\Delta R} - g\,\overline{\Delta\theta} \ , \qquad (3)$$

where we have ascribed a superscript v or θ to C specifying the technique employed.

These systematic differences enable the computation of the zenith distance group corrections as (see Débarbat and Guinot 1970):

$$C_k = \frac{1}{M}\sum_{r=0}^{M-1}\left[r\cdot\Delta C_{k+r,k+r+1}\right] \qquad (4)$$

where k refers to the group and M to the total number of the different programme groups.

III. RESULTS

Both techniques were applied to Valinhos astrolabe observations during the time interval from 1974 until 1980. These data originated the First Astrolabe Catalogue at Valinhos (VL1) (Clauzet 1983). Results in time and latitude for this period, can be found in Benevides-Soares *et al.* (1979).

The values obtained are:

$$F_v = +\,0.1099$$

$$F_\theta = +\,7^\circ 54$$

$$F_R = +\,2''\!.16$$

which yield the results

$$h = -\,19''\!.7$$

$$g = 0.20''/^\circ C \ .$$

With these coefficients we have correctedy by (3) all individual differences and have obtained the systematic part inherent to catalogue errors. Table 1 displays these results by auto-collimation (ΔC^v) and temperature difference (ΔC^θ) techniques. Column Gr identifies the consecutive k and k + 1 group differences and Column ΔC will be explained below. The last column, N, refers to the number of observed pairs employed. We can see that ΔC^θ and ΔC^v agree well, both in sign and magnitude, except for pairs 1.2 and 2.3, where the discrepancies are well within the standard errors.

The ΔC^θ precisions seem slightly better than those of ΔC^v. This is probably due to the poor quality of the auto-collimating reflected images, which may introduce significant dispersion in the readings.

As both techniques are available at Valinhos, we have computed the best estimates of the radius thermal

TABLE 1

SYSTEMATIC DIFFERENCES IN ZENITH DISTANCE

	Systematic	Differences[a]		
GR	ΔC^v	ΔC^θ	ΔC	N
1	+ 4.9 ±8.6	− 2.8 ±6.8	− 0.4 ±4.8	10
2	+ 2.2 8.0	− 4.3 8.4	− 2.8 4.6	11
3	+ 18.8 6.3	+ 11.2 4.7	+ 16.3 5.1	9
4	− 2.9 5.0	− 1.3 4.4	− 5.1 5.1	9
5	− 3.0 5.0	− 0.2 4.2	− 1.4 4.4	12
6	− 2.3 5.0	− 5.8 3.0	− 4.2 3.4	22
7	+ 5.2 4.1	+ 6.1 3.2	+ 6.4 3.5	20
8	− 15.2 2.8	− 5.2 2.7	− 7.4 3.3	24
9	+ 12.6 3.0	+ 10.4 2.1	+ 12.1 3.0	29
10	− 15.7 5.1	− 9.0 3.3	− 9.8 3.2	25
11	+ 15.5 5.4	+ 19.8 5.0	+ 17.8 4.4	12
12	− 20.1 7.1	− 18.9 5.0	− 21.3 4.8	10

a. In units of 0\".01.

effects by intervening simultaneously both measurements. These results are shown in column ΔC of Table 1. We can see that the results are intermediate between the other columns as we would have expected.

These values were employed for the computation of the group corrections by (5) which are displayed in Table 2 (C). These values were employed in the VL1 computation.

TABLE 2

GROUP CORRECTIONS IN ZENITH DISTANCE

	Group Corrections[a]	
GR	C	C
1	− 6.1 ±4.5	+ 20.0 ±6.8
2	− 6.5 4.6	− 14.0 7.5
3	− 9.3 4.7	− 31.8 7.3
4	+ 7.0 4.6	− 34.4 6.2
5	+ 1.8 4.3	− 24.7 5.4
6	+ 0.4 3.9	− 15.7 4.7
7	− 3.8 3.7	− 11.4 4.3
8	+ 2.6 3.6	+ 5.7 4.2
9	− 4.8 3.6	+ 9.0 4.3
10	+ 7.2 3.6	+ 33.0 4.4
11	− 2.6 3.8	+ 25.8 5.0
12	+ 15.6 3.6	+ 38.6 6.0

a. In units of 0\".01.

For the sake of comparison the second column of Table 2 (C′) displays the zenith distance group corrections, without due account of thermal effects, whose large values and obvious trends clearly reveal the need of special procedures in this case.

V. CONCLUSION

From Table 2 we can see that the group corrections in zenith distance are strongly affected by the thermal gradient across the prism. As these group corrections are employed in the astrolabe catalogue computations, practical means to control the zenith distance variation must be considered.

The good agreement between the systematic differences, shown in Table 1, leads to the conclusion that both techniques presented may be employed with confidence.

The temperature difference is particularly useful since the necessary data are available in nearly all astrolabe stations. This fact is highly important since one can recuperate old observations in order to compute individual positions of the stars.

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