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THE SYSTEMATIC INFLUENCE OF APPARENT MAGNITUDE OF STARS ON LONGITUDE-DIFFERENCE DETERMINATION WITH DANJON ASTROLABE

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Abstract. In 1988 precise observations were performed for the purpose of determining the longitude differences between stations Munich, Vienna and Graz. The observations were carried out with the Danjon Astrolabe by using the method of equal zenith distances. Based on these observations the authors study the influence of apparent magnitude of stars on the determiration of the zenith distance used in the further treatment aimed at obtaining the longitude differences.

1. INTRODUCTION

For the purpose of establishing the new astronomical longitude network covering the European Region – ELN (European Longitude Network) several campaigns comprising precise measurements of longitude differences between the national referential stations had been undertaken. Among more recent is the one carried out in 1988 including stations Munich, Vienna and Graz. The observations were made by W. Wende with the DGFI Danjon astrolabe by applying the method of equal zenith distances. He observed FK5 stars within an interval of apparent magnitudes $m_v = 2$ to $m_v = 6$. The present observational material was kindly put at our disposal in 1996 by Academician R. Sigl and ing. W. Wende (Perovic and Cvetkovic, 1998).

At all three stations during 23 nights in the summer 1988 all the three star groups were observed in 52 series. The treatment of the observations and the determination of longitude differences were done by W. Wende (the results - Wende, 1992). In the "observed" zenith distance z_b Wende introduced the corrections K_ν , $\nu = 1, ..., 9$, in his paper given as formulae (3.1) - (3.9). The treatment was performed in two ways: 1) by series and 2) the common treatment of the campaign as a whole.

The corrections v_i, obtained by the authors in treating the observations of individual series by using Wende's model (Wende, 1992), are analysed in different regressors (azimuth, latitude, nights, groups, series, apparent magnitude, outer temperature, instrument temperature and air pressure). A dependence of the observed corrections on apparent magnitude was established and this dependence is the subject of the present paper.

2. ANALYSIS OF CORRECTIONS OBTAINED BE SMOOTHING THE OBSERVATIONS

The observational material was received by the authors on disquettes and two series could not be read. These are series 36 and 37 observed in Graz. Therefore a total of 50 series containing 1601 star transits was available for the analysis. The stars were observed in the eastern and western transit through almucantar $z \approx 30^o$. There were 800 eastern transits and 801 western ones.

In treating individual series Wende introduced in the "observed" zenith distance a correction for the influence of apparent magnitudes. This is the correction K_8 given as formula (3.8) of Wende's (1992) paper, it reads

$$K_8 = b_H \cdot dH1 - b_H^2 \cdot dH2$$

where $b_H = m_v - 4.0$; m_v is the apparent magnitude; $dH1$ and $dH2$ are unknown parameters which can be determined from the model of measurement treatment.

The values $dH1$ and $dH2$ were obtained by Wende from the general treatment comprising the whole campaign whereby the correction equation for a single observation is

$$\begin{aligned} l_p + v \;=\; & b_\varphi d\varphi_i + b_\lambda d\lambda_i - dz_k \\ & + \Delta T\, b_\varphi\, \Delta\varphi_G + \Delta T\, b_\lambda\, \Delta\lambda_G \\ & + b_{IT}\, dIT + b_{IA}\, dIA + b_{HD_2}\, dHD_2 \\ & + b_H\, dH1 + b_H^2\, dH2 + b_F\, dF \\ & + \sum_{n=1}^{m}(-b_\lambda\, d\alpha_n)\ , \end{aligned}$$

the indices i and k are referred to the station and the star group, respectively, m being an *a priori* unknown number of variable parameters. The parameters $d\varphi$, $d\lambda$ and dz were called by Wende (1992) *compulsory*, those appearing in corrections K_5 - K_9 and variations in time of latitude and longitude ($\Delta\varphi_G$ and $\Delta\lambda_G$) – *optional* and those appearing in right- ascension corrections ($d\alpha$) – *variable.* In the covariance analysis, which comprises these problems, the compulsory parameters belong to the group of *basic* parameters, whereas the optional and variable ones belong to the group of *additional* parameters. Wende calculated the observation weights assuming equal observation variances within each observational star group (formula (10) of his paper).

For the purpose of eliminating observations containing gross errors Wende used the test by deviations from the mean value for individual $d\alpha$ values referred to the same star assuming a significance level of $\alpha_o = 0.01$. After the application of the gross-error test it remains 1486 correction equations with 68 parameters in the model. For the parameters entering the apparent-magnitude correction for the "observed" zenith distance the following values were obtained (Wende, 1992)

$$dH1 = 0''.041 \quad \text{i} \quad dH2 = 0''.013\ .$$

The present authors carried out a treatment by series following the procedure used also by Wende in his paper, but without applying K_8 correction to z_b and also unlike Wende, the star positions used here are not from FK5 but from Hipparcos. The obtained corrections of the treatment v_i are divided into eight groups according to the apparent magnitude. In each group one calculates the mean value $\bar{v}_i$. This is seen in Table 2.1 and Fig. 2.1 where the intervals of the mean errors are also given. The form of the line in this Figure indicates a second-order curve.

Table 2.1 The mean values of the corrections $\bar{v}_i$ within the groups of apparent magnitude m_v, intervals of their mean errors $\sigma_{\bar{v}_i}$ and number of corrections within a group N.

m_v	$\bar{v}_i$	$\sigma_{\bar{v}_i}$	N
2.0 – 2.5	$0''.056284$	$0''.016539$	67
2.5 – 3.0	$0''.079374$	$0''.022938$	38
3.0 – 3.5	$0''.066784$	$0''.011718$	174
3.5 – 4.0	$0''.068785$	$0''.010414$	255
4.0 – 4.5	$0''.043306$	$0''.010072$	266
4.5 – 5.0	$-0''.028290$	$0''.009169$	305
5.0 – 5.5	$-0''.058075$	$0''.011380$	243
5.5 – 6.0	$-0''.115246$	$0''.015233$	141

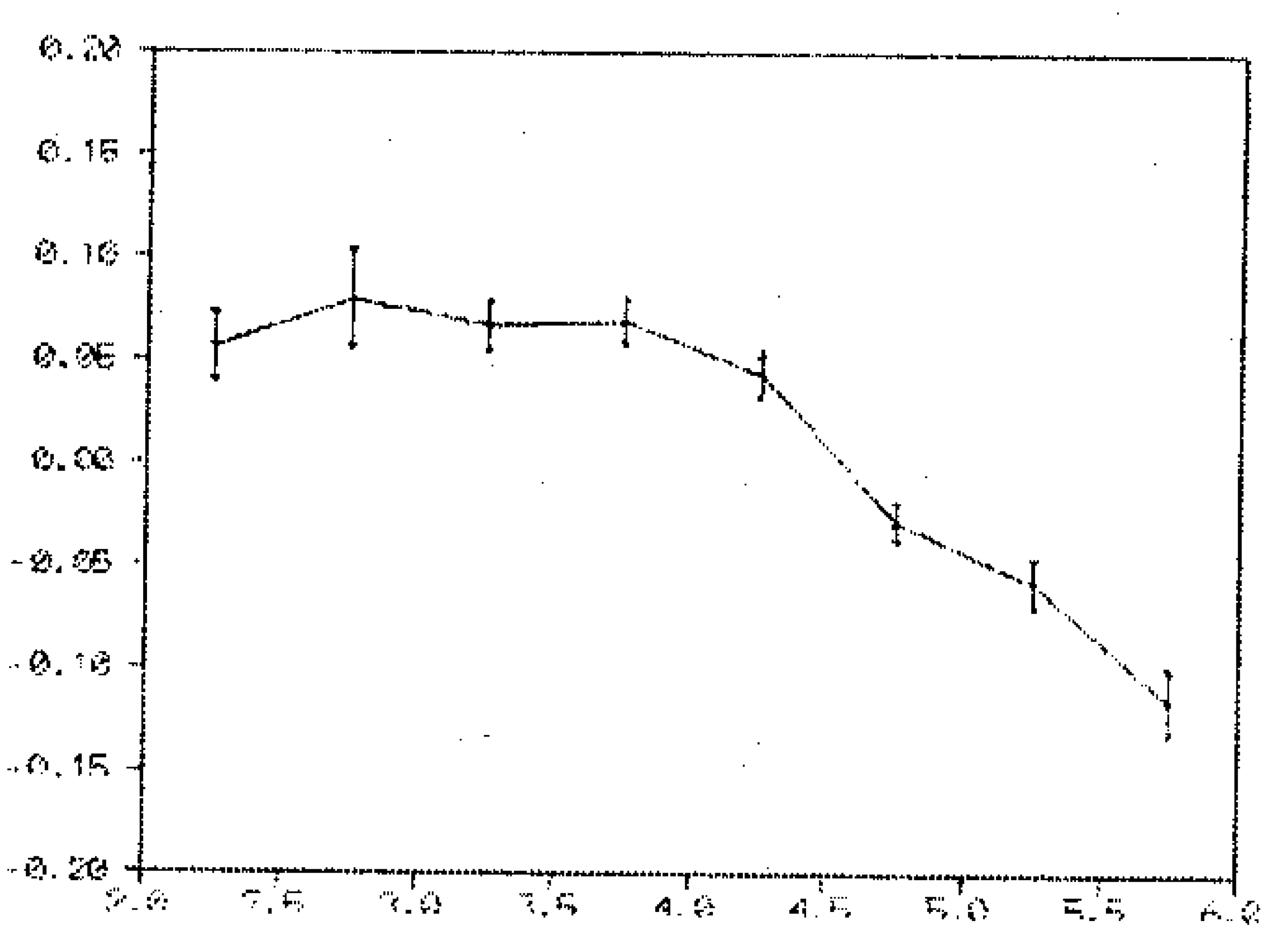

Fig. 1. The mean values of the corrections within the groups of apparent magnitude and intervals of their mean errors.

In treating together the observations of the whole campaign in order to calculate the weights the first step was to estimate the components of the observation variances. For the variances one finds that they depend on the velocity of star transit and apparent magnitudes of the stars. So one obtains

for I star group: $\sigma_l^2 = 0.002477 + 0.016860 \cdot (\cos\varphi \sin a)^2 + 0.0004722 \cdot m_v^2$
for II star group: $\sigma_l^2 = 0.007238 + 0.016860 \cdot (\cos\varphi \sin a)^2 + 0.0004722 \cdot m_v^2$
for III star group: $\sigma_l^2 = 0.007286 + 0.016860 \cdot (\cos\varphi \sin a)^2 + 0.0004722 \cdot m_v^2$

with $f = 1390$ degrees of freedom. The linear model (used by Wende) is modified, i.e. extended by introducing, instead of one parameter dIT and one parameter dIA, 23 ones in either case (one per each night) comprising the whole campaign. At the beginning the parameters $d\alpha$ for all observed stars are included in the model to exclude afterwards iteratively those for which $t_{\hat{d\alpha}} = \hat{d\alpha}/\sigma_{\hat{d\alpha}}$ is less than 2.0.

For the purpose of detecting gross-errors in the observations we used the *data snooping* method (Baarda, 1968) with a significance level for the tests of onedimensional hypotheses $\alpha_o = 0.01$. After applying the gross-error test the model contains 1489 correction equations with 99 parameters.

From such a model, with $\sigma_o^2 = 0.05$, we obtained for the parameter vector of the apparent-magnitude influence $\mathbf{dH} = [dH1\ dH2]^T$ and its cofactor matrix $\mathbf{Q_{dH}}$

$$\mathbf{dH} = \begin{bmatrix} 0.044956 \\ 0.034796 \end{bmatrix} \qquad \mathbf{Q_{dH}} = \begin{bmatrix} 0.00066081 & -0.00009990 \\ -0.00009990 & 0.00050331 \end{bmatrix} .$$

Both criteria, the global one with statistics

$$F_{dH} = \frac{R_H/2}{\sigma_o^2} = 66.019 > 6.9078 = F_{0.999}(2,\infty) \tag{2.1}$$

where $R_H = \mathbf{dH}^T \mathbf{Q}_{\mathbf{dH}}^{-1}\ \mathbf{dH} = 6.6019$, and the partial one, with statistics

$$F_{dH1} = \frac{dH1^2/Q_{dH1}}{\sigma_o^2} = 1360.63 > 10.8288 = F_{0.999}(1,\infty) \tag{2.2}$$

$$F_{dH2} = \frac{dH2^2/Q_{dH2}}{\sigma_o^2} = 1382.69 > 10.8288 = F_{0.999}(1,\infty) \tag{2.3}$$

are in favour of introducing a part of the model $(m_v - 4)\ dH1 + (m_v - 4)^2\ dH2$ with which the apparent-magnitude influence in the "observed" zenith distance z_b is described.

3. CONCLUSION

The dependence of the corrections obtained in the treatment of the observed zenith distances z_b, in the determination of longitude differences, on the apparent magnitude indicated also by Wende (1992) is studied here and confirmed.

Through tests (2.1) - (2.3) the introducing becomes justified of the part $(m_v - 4)\ dH1 + (m_v - 4)^2\ dH2$ in the linear model by which this dependence is described.

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