ON THE DETERMINATION OF ANOMALOUS REFRACTION OUT OF ASTROMETRICAL MEASUREMENTS IN THE ZENITH ZONE

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Abstract. The method is given for the analysis of the anomalous refraction in the zenith zone. Connected with this the observations of the same zenith stars in the meridian and the prime vertical are used. The moment of passage through the eastern and western part of the prime vertical is registered, while the difference of zenith distances in the meridian passage is measured – always in two instrument position.

The method practically eliminates coordinate errors influences of observed stars. For the succesful employment of this method, we must use the high quality instruments and, especially, correct apparatuses for the carreful determination of the inclinations of instrumental parts.

1. Teleki (1971) has analysed the possibility of the determination of the real influence of anomalous refraction directly from the astrometrical measurements. On the basis of the results of the astrometrical measurements and meteorological investigations, it is concluded that this determination is practically impossible.

To our mind, the main causes of this fact are: variable nature of the meteorological elements, incorrect formation of air layers around the observational instruments, variable size of the instrumental influences (systematic and accidental) and errors in coordinates of the stars used.

According to the above explanation, we would point out that the astrometrical methods for the determination of the size of anomalous refraction should be capable of fulfilling the following conditions:

(1) the shortest possible time for the measurements of the observational values required;

(2) the use of high quality instruments, whose characteristics and constants are practically unchangeable;

(3) the elimination of the star coordinate errors; and

(4) the analysis of only a narrow zone, at the zenith distance.

Hence the astrometrical methods cannot give us the interpolational or extrapolational results either for time or for space.

All these conditions cannot be achieved, and the suggestion (Teleki, 1971) for a strictly meteorological method, which does not use results of star observations, is quite justified. The astrometrical methods, however, can also give useful data on anomalous refraction if they are correctly organized.

We came to the conclusion that observation of the zenith stars in the meridian and

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the prime vertical might give us very important data about anomalous refraction in the zenith zone. This method, however, may be used for the analysis of instrumental constants too.

2. In the recommended method, zenith stars are observed, whose upper culmination is south from the zenith (at the maximum zenith distance of 10′). Every star is observed three times: at both parts of the prime vertical and in the meridian – always in two instrument positions. The moment of passage through the prime vertical is registered (as in the Struve method), while the difference of zenith distance in the meridian passage is measured (as in the Talcott method). We obtain two latitude values in this way. From observations in the prime vertical

$$\varphi_v - \delta = \sigma$$

and from observations in the meridian

$$\varphi_m - \delta = \Delta$$

where φ_v and φ_m are the latitudes from the prime vertical and the meridian observations respectively, δ the apparent declination of the star used, σ and Δ the known values of the quantities measured.

Ideally the difference between these values

$$\Delta\varphi = (\varphi_m - \delta) - (\varphi_v - \delta) = \Delta - \delta$$

should be zero, but this practically never happens. Both methods give, in the sense of accidental errors, nearly equal accuracies, but the influences of different systematic errors may be important. Analysis has shown that in meridian observations (by the Talcott method) the possibility of influence by instrumental and measuring errors is larger.

The difference $\Delta\varphi$ can be used for the analysis of the instrumental constants and after that for the analysis of the possible anomalous refraction.

3. Let us suppose that the $\Delta\varphi$ contains only non-calculated refractional influences. In this case, we can write

$$\Delta\varphi = \Delta\varrho - \Delta\varrho_v + \Delta\varrho_m$$

where $\Delta\varrho$ is the systematic error because of the incorrect calculation of normal refraction in the meridian, and $\Delta\varrho$, $\Delta\varrho_m$ are the corresponding systematic corrections owing to the influences of anomalous refraction at the prime vertical and the meridian respectively.

Using the classical expressions of the influences of anomalous refraction (Teleki, 1967), we conclude that, at places with moderate latitude, in the first approximation at least,

$$\Delta\varphi = \Delta\varrho_m .$$

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Consequently, we obtain the influence of anomalous refraction in the meridian. At this point we need not make any supposition about the mathematical model for the influence of anomalous refraction; this is very important.

4. Let us come back to the conditions stated in paragraph 1. The proposed method satisfies fully the conditions under points (3) and (4) – which we understand as very important – and the condition (1) partially too. The condition (1) is satisfied partially because the accuracy of the value determined from the observations of one star is insufficient, and therefore we ought to observe several stars, which naturally prolongs the duration of the process.

In our opinion the condition (2) is very important, because unless this is fulfilled, it would be impossible to obtain a genuine value of anomalous refraction, which is relatively a small value.

The proposed method, on condition that we fulfil the demands mentioned, makes it possible to analyse the refraction influence in the zenith zone, which is chiefly used for latitude observations. In our opinion, the results obtained about the anomalous refraction in the narrow zenith zone cannot be extrapolated for the other zones.

Also on the present occasion we do not forget that the size of the influence of anomalous refraction is relatively small, and that therefore if we want to single out this value from the astrometrical observational results, we must satisfy a good number of conditions. Undoubtedly it is very hard to determine these influences. But it is obvious from our investigations that it can be done.

References

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DISCUSSION

P. Melchior: Does the astrolabe not fulfil already all the conditions you have enumerated and eliminate anomalous refractions?

B. Guinot: A shift of the zenith due to a tilting of the equal index layers cannot be detected in the astrolabe results because it gives rise to a common translation of all the position lines: only the time and latitude results are affected. As far as systematic anomalies in the refraction in the same azimuths are concerned, they were not observed and that is the reason why a determination of the errors $\Delta\alpha_\delta$ of the catalogues with the astrolabes was possible.

W. Fricke: I wonder what amounts of errors are to be expected due to anomalous refraction. I would think that they are smaller than about 0.″1.

G. Teleki: We suppose that at the zenith zone the maximum anomalous refraction influences are 0.″1–0.″2.