Physik, M. Sc.

Astronomische Beobachtungsmethoden

First lab - Determination of the Geographical Latitude

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Gruppe 02

Informationen

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1 Introduction

The aim of this laboratory session is to determine the geographical latitude of the experimenter by simply measuring the zenith angle of the sun. This is done using a device called a theodolite. The theoretical background and the setup are explained below.

2 Theoretical description

A theodolite is used to measure the angles of the horizontal coordinate system: the zenith angle z_b (90° - altitude) and the azimuth ϕ. In this lab only the zenith angle is of interest and via its measurement the geographical latitude can be derived. The theoretical background for this is given in the following. First, the relation between the horizontal coordinate system and the τ -δ coordinate system is of interest. The hour angle τ can be determined as follows:

$$\tau(t,l,\alpha) = \Theta(t,l) - \alpha = \Theta_\mathrm{G}(t) - l - \alpha = \Theta_\mathrm{G}(0) + t\left(\frac{366.24}{365.24}\right) - l - \alpha, \tag{2.1}$$

where $\Theta_\mathrm{G}(t)$ describes the Greenwhich sidereal time, α and δ describe right ascention and declination respectively, t is the observation time in UT, and l and b are the coordinates of observation site. This equation has three solutions for b:

$$b = \begin{cases} \pi - arcsin(cosz/X) - Y, & (b+Y) > \pi/2 \\ arcsin(cosz/X) - Y, & -\pi/2 \geq (b+Y) \leq \pi/2 \\ -arcsin(cosz/X) - \pi - Y, & (b+Y) < -\pi/2 \end{cases}$$

where $X = \sin\delta\sqrt{1 + (\cos\tau/\tan\delta)^2}$ and $Y = \arctan(\cos\tau/\tan\delta)$. Which of these three solutions will be used is determined by calculating Y with our measured data and looking up b according to GPS.

As right ascention and declination are only given for the 5th of May 0 UT and the 6th of May 0 UT (according to the Astronomical Almanac), a linear Interpolation for UT = t - Δt and Δt=2h for CEST is needed:

$$\alpha^{sun}(t) = \alpha_1^{sun}(0UT) + \frac{UT}{24\mathrm{h}}(\alpha_2^{sun}(0UT) - \alpha_1^{sun}(0UT)) \tag{2.2}$$

$$\delta^{sun}(t) = \delta_1^{sun}(0UT) + \frac{UT}{24\mathrm{h}}(\delta_2^{sun}(0UT) - \delta_1^{sun}(0UT)) \tag{2.3}$$

Additionally, there are several correction factors which have to be taken into account. As the observed light has to pass through the Earth's atmosphere, a change in the direction of the light beam occurs. Therefore, the measured zenith angle is smaller than the real zenith angle. The average refraction for T = 10degC and pressure of 101kPa is given by:

$$\bar{R}(z_\mathrm{b}) = 1/\tan\left((90\,\mathrm{deg} - z_\mathrm{b} + \frac{7.31\,\mathrm{deg}^2}{90\,\mathrm{deg} - z_\mathrm{b} + 4.4\,\mathrm{deg}})\right) \tag{2.4}$$

leading to the Refraction correction:

$$R(z_\mathrm{b}, T, p) = \bar{R}(z_\mathrm{b}) \left(\frac{p\,[\mathrm{kPa}]}{101} \cdot \frac{283}{273 + T\,[^\circ\mathrm{C}]} \right) \tag{2.5}$$

Next, the index error i has to be taken into account. The latter is defined as follows:

$$i = \frac{360\,\mathrm{deg} - z_0 - z_{180}}{2} \tag{2.6}$$

The index error is the consequence of the displacement of the vertical circle towards the zenith which is defined by the alignment of the tubular spirit level. Additionally the correction for the horizontal parallay φ_2 and the transformation to the centre of the sun (φ_1) has to be taken into account. Combining all, the real value for the zenith angle is obtained as follows:

$$\boxed{z = z_\mathrm{b} + i + R(z_\mathrm{b}, T, p) \pm \varphi_1 - \varphi_2}. \tag{2.7}$$

3 Procedure

4 Interpretation

4.1 Calculation of geographical latitude

4.2 Questions

5 Results and Discussion

A Append A

A.1 Teilanhang X

Literaturverzeichnis