

# Exercises Astronomical Observing Techniques, Set 1

## Exercise 1

- a) Stars “close” to the pole are *circumpolar*, i.e., always above the horizon for an observer. Calculate the maximum declination for which stars are still circumpolar from Leiden (latitude 52.16N, longitude 4.49E).
- b) Alpha Centauri has a declination of  $-60^\circ 50'$ , at which latitude does this star come above the horizon.

## Exercise 2

- a) Explain the difference between the sidereal day and solar day and give roughly the time difference between the two.
- b) Give the definition of (i) hour angle (HA), (ii) (local) sidereal time (LST), (iii) and right ascension (RA). Explain why LST is useful for observers.
- c) Give the HA (hour angle) of a source above the western and eastern horizon.

## Exercise 3

- a) A point M is fixed in space (on the sky) either by its Cartesian coordinates  $(x_1, x_2, x_3)$  or by its spherical coordinates  $(r, \theta, \phi)$ , where  $r > 0$ ,  $0 \leq \phi < 2\pi$ ,  $-\pi/2 \leq \theta \leq \pi/2$ , we call  $\phi$  the longitude and  $\theta$  the latitude. Both location vectors are unit vectors. Express  $x_1, x_2, x_3$  in terms of  $r, \theta$ , and  $\phi$ .
- b) express  $\theta, \phi$  in terms of  $x_1, x_2$ , and  $x_3$ .
- c) **The Horizontal frame**  $\mathbf{U}(A, h)$ . The  $\mathbf{x}_1$  unit vector points towards the South,  $\mathbf{x}_2$  points to the East, and the  $\mathbf{x}_3$  to the Zenith. Express the unit vector in terms of the angle above the horizon ( $h$ ) and the azimuthal angle ( $A$ ) measured from the South to the East.
- d) Do the same for the **the Hour**  $\mathbf{U}(H, \delta)$  and **the Equatorial frame**  $\mathbf{U}(\alpha, \delta)$ . Using the declination ( $\delta$ ), the Hour angle ( $H$ ), and right ascension ( $\alpha$ ).
- e) Around which axis do we have to rotate to go from the Horizontal frame to the Hour frame? Write down these transformations, for the the latitude on Earth use  $\phi$ .
- f) Do the same but from the Hour frame to the Horizontal frame, i.e., the inverse transformation.
- g) Write down the transformations from Equatorial to Hour frame (use LST).

## Exercise 4

Calculate the height ( $h$ ) and azimuth ( $A$ ) of  $\beta$ Cet, mag=2.1,  $\alpha = 0, \delta = 52$  (in deg) at LST=6h from Leiden.