Lab 1: Reference systems

Transformation ICRS $\longrightarrow$ topocentric coordinate system

The objective of this exercise is to determine the azimuth A and elevation E of Venus, Mars and Jupiter for astronomical observations. The Cartesian coordinates of these planets with respect to the ICRS (i_0) can be computed with the MATLAB function `planetes` for any epoch t_{eph}.
Your task is to perform the successive transformations from ICRS to the instantaneous local astronomic g and eventually determine the position of the different planets in the local system, that is, their azimuth and elevation.
The transformation is given by the following formula:

$$\begin{aligned} \mathbf{r}^g &= \mathbf{S}_1\, \mathbf{R}_2(90^\circ - \Phi)\, \mathbf{R}_3(\Lambda)\, \mathbf{R}_3(GAST)\, \mathbf{N}\, \mathbf{P}\, \mathbf{r}^{i_0} \\ \text{with} \quad \mathbf{S}_1 &= \text{the reflection matrix turning the x-axis into its opposite} \\ \mathbf{N} &= \mathbf{R}_1(-\epsilon - \Delta\epsilon)\, \mathbf{R}_3(-\Delta\psi)\, \mathbf{R}_1(\epsilon) \\ \text{and} \quad \mathbf{P} &= \mathbf{R}_3(-z)\, \mathbf{R}_2(\theta)\, \mathbf{R}_3(-\zeta_0). \end{aligned}$$

a) Give the expression of A and E as a function of the coordinates of $\mathbf{r}^g$.

b) Program sequentially the coordinate transformations from ICRS (i_0) to the instantaneous local astronomic g.

c) Then compute the azimuth and elevation of the three planets for an observer in Stuttgart ($(\Phi = 48^\circ 46' 39'', \Lambda = 9^\circ 10' 43'')$) for a period spanning from September 1^{st} 2019 to November 30^{th} 2019, everyday at 5:30 am CET.

d) In order to visualize the observed motion of the planets in the night sky, plot the tim series of A (`plot(t, A)`) and E (`plot(t, E)`). Plot as well the parametric curve of (A,E) in polar coordinates with `skyplot(A, E)`. Note that this function plots an elevation defined as: $90^\circ - E$.

to compute the nutation angles $\{\epsilon, \Delta\epsilon, \Delta\psi\}$ and precession angles $\{z, \theta, \zeta_0\}$ make use of the provided functions `nutwink` and `prezwink`. You might also need the functions `julianjh` and `jul2gast`.
All the aforementioned MATLAB functions are available in the lab folder on ILIAS.

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GIS

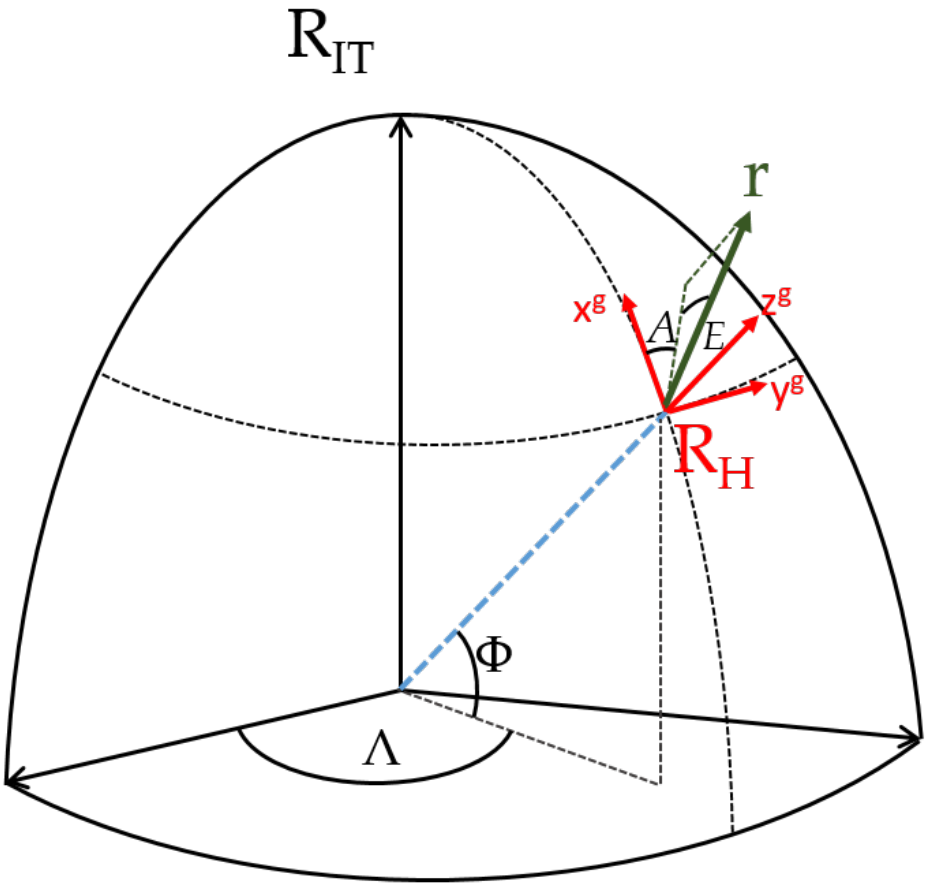

Abbildung 1: Local astronomic system with the definition of azimuth A and elevation E.