

## CALCULATION OF THE RISING AND SETTING TIMES OF THE SUN BY USING THE DATA OF THE FOUR-YEAR CYCLE OF SOLAR DECLINATION AND LOCAL TIME OF THE UPPER CULMINATION

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A mathematical analysis of the existence of a solution of equation for calculating times and azimuths of rising and setting of stars is carried out. For computer calculation of the rising and setting time and azimuths it is offered to use the data files of the four-year cycle of change of declination and local time of the upper culmination of the Sun. It allows avoiding the empirical formulas of calculation of declination and local time of the upper culmination, which introduce additional errors in the calculation of the coordinates of the Sun. Numeric data of files are set to within angular and time minutes. The annual variations of the declination and local time of the upper culmination of the Sun are illustrated. It is shown that the neglect of variations of the local time of the upper culmination of the Sun can result in the errors of calculation of rising and setting times, reaching values about 15 minutes. The corrections are specified in the formula for calculation of the rising and setting times at the use of geocentric coordinates. According to the presented formulas for calculating the sunrise and sunset times by means of the program written in Visual Fortran, the results of calculations within a year are presented, taking into account the refraction of light and the angular size of the solar disk. The calculated values of the zenith distance of the Sun and rising and setting times have errors to 1 minute (angle and time, respectively). It is shown, that the dates having the earliest rising, are shifted for some days from the dates characterized by latest setting in year. Similarly, days with the latest rising differ from days with the earliest setting.

The following picture illustrates the results of calculation of the rising and setting times of the Sun in 2018 at the location of Kharkiv Incoherent Scatter Radar.

