

Predicting Lunar Occultations

This *Numerit* program (`occult`) can be used to predict the local circumstances of lunar occultations of a planet and star. The source ephemeris for this program is SLP96. This software provides the universal times and topocentric coordinates of the Moon at the beginning and end of the lunar occultation. It also displays the event duration.

This program uses a combination of one-dimensional minimization and root-finding to solve this classic problem. The objective function used in these calculations is the topocentric separation angle between the center of the Moon and the object being occulted. The objective function used during the search for lunar eclipses is given by the following expression:

$$f(t) = \cos^{-1}(-\mathbf{U}_m \bullet \mathbf{U}_b) - (s_m + s_b) \quad (1)$$

where

- \mathbf{U}_m = topocentric unit position vector of the Moon
- \mathbf{U}_b = topocentric unit position vector of the object
- s_m = semidiameter of the Moon
- s_b = semidiameter of the object

The semidiameter of the Moon is given by

$$s_m = \sin^{-1}\left(\frac{r_m}{d_m}\right) \quad (2)$$

where r_m is the radius of the Moon (1738 kilometers) and d_m is the topocentric distance of the Moon.

The semidiameter of a star is zero and the semidiameter of a planet is

$$s_p = \frac{s_{p_0}}{r_p} \quad (3)$$

where s_{p_0} is the semidiameter of the planet at a distance of 1 astronomical unit and r_p is the topocentric distance of the planet.

Celestial Computing with Numerit

The following is a typical draft output created with this program. It illustrates a lunar occultation of the star Spica relative to an observer located in Denver, Colorado.

Lunar occultation of a star

begin lunar occultation

calendar date	February 18, 1987
universal time	12 h 27 m 3.88759 s
UTC Julian date	2446845.018794995

lunar azimuth angle	214 d 3 m 46.6015 s
lunar elevation angle	32 d 51 m 54.5059 s

end lunar occultation

calendar date	February 18, 1987
universal time	13 h 17 m 45.9234 s
UTC Julian date	2446845.054003743

lunar azimuth angle	226 d 5 m 11.8468 s
lunar elevation angle	26 d 32 m 29.9466 s

event duration	00 h 50 m 42.0358 s
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star name
SPICA

J2000 right ascension (hours)
13.4198852780

J2000 declination (degrees)
-11.1613083330

J2000 proper motion in right ascension (seconds/Julian century)
-0.2780

J2000 proper motion in declination (arcseconds/Julian century)
-2.8300

parallax (arcseconds)
0.0210

radial velocity (kilometers/second)
1.0