Time of culmination of Alpha Ophioukos on June 20, −353

An Approximate Calculation

A. It is first necessary to learn the Julian Day Number of June 20, −353. e shall also use 1900.0 as an epoch; its Julian Day Number, according to the 1992 *Explanatory Supplement to the Astronomical Almanac*, is JD 2415020.0.

The Julian Day Numbers begin with the beginning of the year − 4712.0. The year −353 is later by (4712−353) = 4359 years. Each Julian year contains 365.25 days, so the first day of −353 has the Julian Day Number 4359×365.25 = 1592124.75. June 20 is 171 days farther along, so its JD number is 1592295.75.

2. The right ascension (R.A.) of Alpha Ophi. in 1900 is given in the catalogue FK4 (Dorrit Hoffleit, *Bright Star Catalogue*) as $17^h 30^m 17^s.5$. We need to find the precession from 1900 back to June 20, −353. The formula given by the *Explanatory Supplement* for the rate of precession per century is

$$4612''.4362 + 2''.79312T - 0''.000278T^2, \qquad (1)$$

where T is the number of Julian centuries of 36525 days from 2000.0 (=JD2451545.0). We shall compute the average of the rate in 1900 and the rate on June 20 in − 353 (=JD 1592295.75). We shall treat the variation as linear, ignoring the quadratic term.

The centennial rate in 1900, one Julian century before 2000.00 so that $T = 1$, is

$$4612''.4362 - 2''.79312 = 4609''.6431.$$

To find the number of Julian centuries between 2000.0 and − 353 on June 20, we take the difference in Julian Day Numbers of the two dates, 2451545.0 − 1592295.75 = 859249.25, and divide by 36525, the number of days per Julian century. The answer is −23.52496235 centuries. Using this number in Equation (1), we get the centennial rate of precession on June 20 in − 353; it is 4549".5210. The average rate of precession over the period from June 20, − 353 to 1900.0 is

$$\frac{4609''.6431 + 4549''.5210}{2} = 4579''.5821.$$

This result, multiplied by the number of Julian centuries from June 20, − 353 to 1900, or (2415020.0 − 1592295.75)/36525 = 22.52496235, gives the total precession over the period, namely,

$$4579''.5821 \times 22.52496235 = 103154''.9144 = 28^\circ.65414288.$$

To get from degrees to hours, with 24 hours per 360°, we divide this number by 15; the result is 1.91027619 hours, or $1^h 54^m 36^s.99$.

As stated previously, the R.A. of Alpha Ophioukos in 1900 was $17^h 30^m 17^s.5$. We must now subtract the amount of precession that we found for the −22.524 Julian centuries to obtain the R.A. of Alpha Ophioukos on June 20, − 353. The result is $15^h 35^m 40^s.51$.

$$\tau = 18^h 38^m 45^s.836 + 8640184^s.542T + 0^s.0929T^2, \qquad (2)$$

where T is the number of Julian centuries from 1900.0. So T is − 22.52496235. Inserting this number in Equation (2) and subtracting out multiples of 24 hours, we get

$$\tau = 18^h 38^m 45^s.836 - \left(13^h 3^m 51^s.516\right) + 47^s.135$$
$$= 5^h 35^m 41^s.46.$$

This is the R.A. of the Sun at Greenwich mean noon on June 20, −353.

But we have previously found that the R.A. of Alpha Ophioukos on June 20, − 353, is $15^h 35^m 40^s.51$. This is $10^h 01^m 46^s.19$ eastward of the Sun. So Alpha Ophioukos will culminate on the meridian of Greenwich, 0° longitude, at about a second less than 10:00 o'clock pm.

3.Athens is east of the zero longitude line passing through Greenwich. Just where east of the later established 0° longitude line were our philosophers observing? The longitude of the modern Athens Observatory is given as −23°43′, the minus sign indicating eastern longitude. Thus Alpha Ophioukos must have culminated on the meridian of the Athens Observatory 23.7166/15 = $1^h.58$ = $1^h 35^m$ before it culminated on the Greenwich meridian of longitude, or at about 8:25 0'clock, Athens mean solar time.

Given the long twilight on a summer's evening close to the solstice, this would be a little after the stars 'came out.'