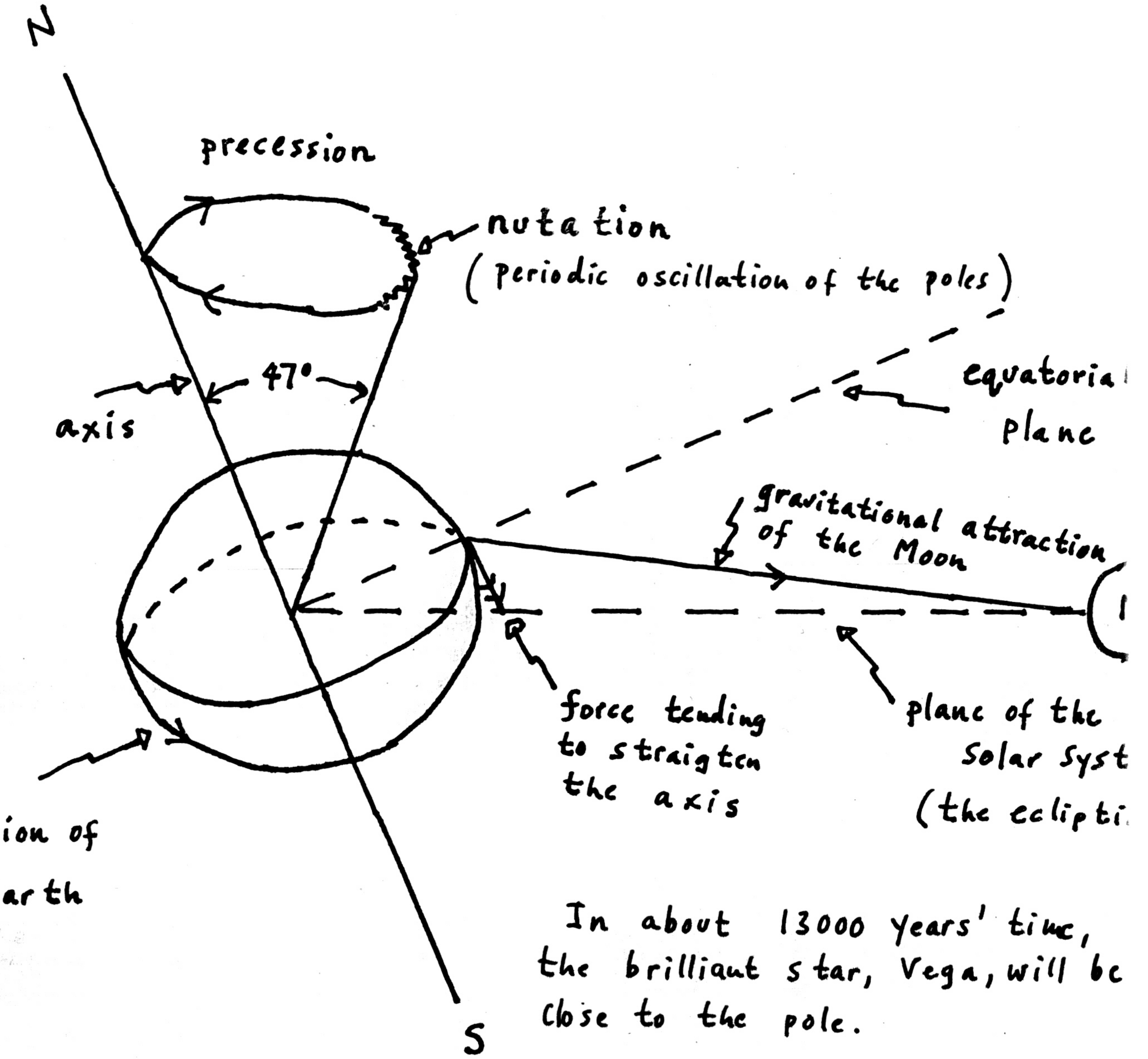
The precessional motion of the Earth

$(T_p \simeq 26{,}000 \text{ Years})$

Rotation
Revolution
Precession
Nutation

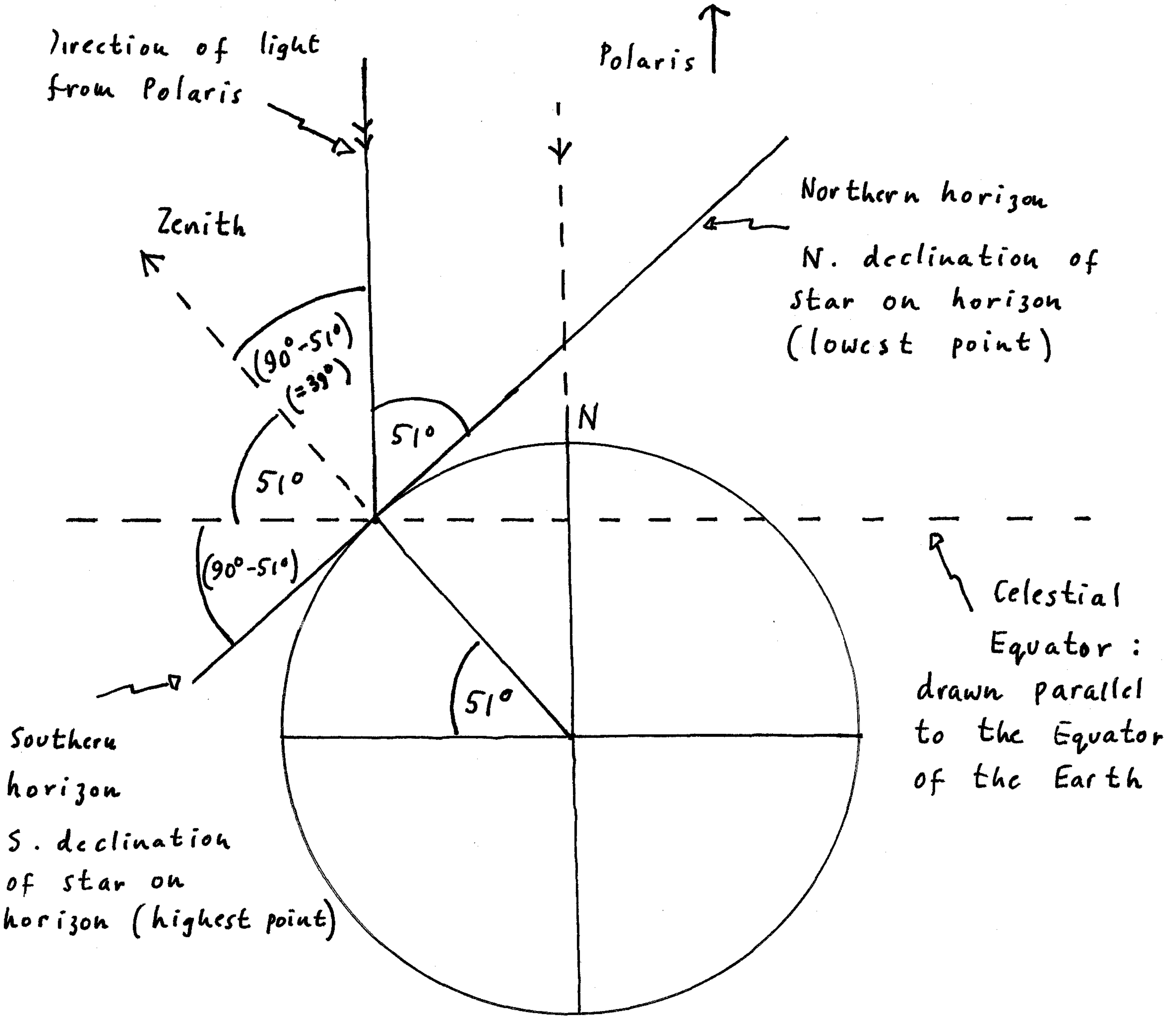


In about 13000 years' time, the brilliant star, Vega, will be close to the pole.

The Earth does not simply rotate about its own axis and orbit around the Sun. Due to the gravitational attractions of both the Sun and the Moon, the Earth's axis of rotation traces out a conical figure in space. This motion is called <u>precession</u> of the axis, and takes place because the Earth's axis is at an angl of 23·5° to the plane of the ecliptic, and because the Eart is not exactly spherical.

The gravitational attractions of the Sun and the Moon tend to pull the equatorial bulge into the plane of the ecliptic. If the Earth were not rotating, then, the equat simply line up with the ecliptic, in much the same way a child's spinning-top falls on its side when it stops spinn It is its rotation that causes the Earth, instead, to process. For the same reasons, the axis of a spinning-top m slowly around in a circle, if it is not exactly vertical.

The Celestial Sphere for an observer at 51° N



We can find out which stars will be circumpolar and which will not. If we are observing from a latitude of (say) 51°, Polaris will be 51° above our horizon (neglecting its slight displacement from the celestial pole)

It follows that the distance (angular) between Polaris and our zenith is (90° - 51°) = 39°. To an observer in the Northern hemisphere of the Earth, a star is at its lowest point in the sky when it lies due North (it is at its highest point when it lies due South — its culmination point).

Any star which is "below" the Pole by the angular amount of one's latitude will just scrape the →

northern horizon at its lowest point. If it is nearer the pole than that, it will never set, and will be circumpolar. As Declination is measured from the Equator towards the Pole, we can calculate the limiting declination for a circumpolar star by subtracting our latitude from 90°, which gives us the angle downwards from the Pole.

From latitude 51° N, then, a star will be circumpolar if its Declination is $(90° - 51°) = 39°$, or greater. The brilliant star Capella, with its Declination + 45° 57', is circumpolar from a latitude of 51°; Betelgeuse (α Orionis), at a Declination of + 7° 24', is not.

Similary, a star which lies at any Declination south of − 39° will never rise from a latitude of 51°.

To sum up: to an observer at latitude 51° N (+ 51°) a star with a Declination $> +39°$ will never set; a star with Declination below − 39° will never rise. Similar calculations can be made for any other latitude. From Lerwick, in the Shetland Islands, where the latitude is just over 60°, the limiting Declination will be 30°, so that a star the Declination of which is $> +30°$, will be circumpolar.

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2010, February 8

Stellar and Terrestrial Co-ordinates

The polar axis of the Earth is tilted at an angle of 66·5° to the Ecliptic. It follows that the latitudes of the Tropic of Cancer and Capricorn are 23·5° N and 23·5° S, respectively.

Assume that Polaris lies at the North Celestial Pole, i.e., its declination is + 90°. We have shown that the angle of elevation of Polaris is equal to the observer's latitude.

For the questions concerning apparent differences in time due to differences in observers' longitude, remember that, in a time interval of four minutes, the Earth rotates one degree.

① From a latitude of 55° N, a star is observed directly overhead. Determine the declination of the star.

Ans. Projection of latitude 55° N on the celestial sphere is a declination of + 55° ∴ declination = + 55°

② At what angle above the horizon will the Sun be at local noon to an observer on the Tropic of Capricorn on the date of the summer Solstice?

Ans. At the summer Solstice, the declination of the Sun is + 23·5°. The latitude of the Tropic of Capricorn = $23\frac{1}{2}°$ S ∴ the Sun is 47° from the zenith ∴ 43° above the horizon.

③ Two observers differ in their longitudes by 12°. One observer who is farther East sees a given star culminate at 21:30. At what time will the other student see the culmination of the same star?

Ans. 12° longitude ≡ 48 minutes.
∴ "Western" observer sees the star culminate at 22:18

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