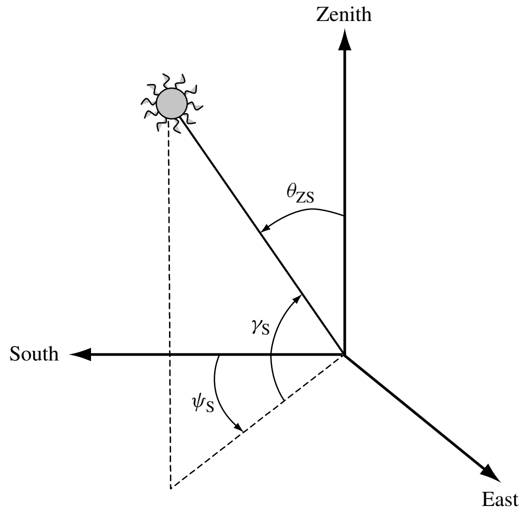

Figure 20.5 Position of the sun relative to a fixed point on the Earth

in 24 h. $\omega = 0$ at the midday of each day, and is counted as negative in the morning and positive in the afternoon. [sign(ϕ)] means "1" for northern latitudes and "-1" for southern latitudes. The true solar time ω is related to the local official time, *TO*, also called local standard time (the time shown by a clock) by the equation

$$\omega = 15 \times (TO - AO - 12) - (LL - LH) \tag{20.6}$$

where *LL* is the local longitude and *LH* is the reference longitude of the local time zone (positive towards the west and negative towards the east of the Greenwich Meridian). *AO* is the time by which clocks are set ahead of the local time zone. In the European Union, *AO* is usually one hour during winter and autumn, and two hours during spring and summer. In this equation ω, *LL* and *LH* are given in degrees, while *TO* and *AO* are given in hours.

Figure 20.6 presents the sun's trajectory on the celestial sphere for (a) a winter and a summer day and (b) the corresponding plots of solar altitude versus azimuth. We will return to such plots later on.

Equation (20.4) may be used to find the *sunrise angle*, ω_S, since at sunrise $\gamma_S = 0$. Hence

$$\omega_S = -\arccos(-\tan\delta\tan\phi) \tag{20.7}$$

In accordance with the sign convention, ω_S is always negative. Obviously, the sunset angle is equal to $-\omega_S$ and the length of the day is equal to $2 \times abs(\omega_S)$. In the polar regions, during the winter the sun does not rise ($\tan\delta\tan\phi > 1$) and equation (20.7) has no real solution. However, for computing purposes, it is convenient to set $\omega_S = 0$. Similarly, during the summer, $\omega_S = -\pi$ is a practical solution for the continuous day. It is also interesting to note that just at noon, $\omega = 0$, and the solar altitude is equal to the latitude