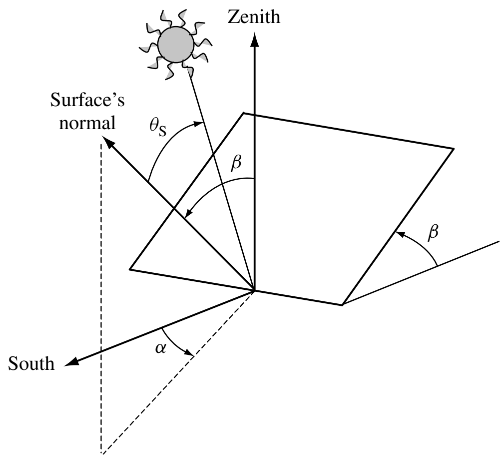


**Figure 20.7** Receiver position (slope $\beta$ and azimuth $\alpha$) and sun's rays incidence angle $\theta_S$

highly accurate trackers for concentrators, more precise equations may be necessary to calculate the relative Earth–Sun position. The interested reader is encouraged to consult Reference [3]. It describes an accurate algorithm and provides a software file for its implementation.

Equations (20.4) and (20.5) give the angles $\theta_{ZS}$ and $\psi_S$ relative to a horizontal surface. However, most practical applications require the position of the sun relative to an inclined plane to be determined. The position of a surface (Figure 20.7) may generally be described by its slope $\beta$ (the angle formed with the horizontal) and the azimuth $\alpha$ of the normal to the surface. The angle of solar incidence between the sun's rays and the normal to the surface may be calculated from

$$\cos\theta_S = \sin\delta\sin\phi\cos\beta - [\mathrm{sign}(\phi)]\sin\delta\cos\phi\sin\beta\cos\alpha + \cos\delta\cos\phi\cos\beta\cos\omega$$
$$+ [\mathrm{sign}(\phi)]\cos\delta\sin\phi\sin\beta\cos\alpha\cos\omega + \cos\delta\sin\alpha\sin\omega\sin\beta \tag{20.9}$$

Although this expression appears quite complicated, it is very convenient to use in most instances. In the case of surfaces tilted towards the equator (facing south in the Northern Hemisphere, or facing north in the Southern Hemisphere), $\alpha = 0$, and it simplifies to

$$\cos\theta_S = [\mathrm{sign}(\phi)]\sin\delta\sin(abs(\phi) - \beta) + \cos\delta\cos(abs(\phi) - \beta)\cos\omega \tag{20.10}$$

## 20.3 SOLAR RADIATION COMPONENTS

Figure 20.8 helps to illustrate the following brief explanation of the different components of solar radiation that reach a terrestrial flat-plate PV surface

To a good approximation, the sun acts as a perfect emitter of radiation (black body) at a temperature close to 5800 K. The resulting power incident on a unit area perpendicular to the beam outside the Earth's atmosphere, when it is 1 AU from the sun, is known as the *solar constant*

$$B_0 = 1367\ \mathrm{W/m^2} \tag{20.11}$$