Then, the horizontal irradiance is equal to the integration of the contribution of each solid angle, and can be written as

$$D(0) = \int_{\text{sky}} L(\vartheta_Z, \psi) \cos \vartheta_Z \, d\Omega \tag{20.30}$$

where the integral is extended to the whole sky, that is, $0 \leq \theta_Z \leq \pi/2$ and $0 \leq \psi \leq 2\pi$.

When we are dealing with an inclined surface, a similar reasoning leads to

$$D(\beta, \alpha) = \int_{\propto} L(\vartheta_Z, \psi) \cos \vartheta'_Z \, d\Omega \tag{20.31}$$

where ϑ'_Z is the incident angle from the solid angle element to the inclined surface, and $\propto$ means the integral is extended to the non-obstructed sky. The general solution of this equation is difficult because, under realistic skies, the radiance is not uniform and varies with the sky condition. For example, the form, brightness and position of clouds strongly affect the directional properties of the radiance.

The distribution of radiance over the sky is not measured routinely. Nevertheless, a number of authors [25, 26] have developed instruments to measure it and have presented results for different sky conditions. Some general patterns may be discerned from these.

With clear skies, the maximum diffuse radiance comes from the parts of the sky close to the sun and to the horizon. The minimum radiances come from a region at an angle of 90° to the solar zenith (Figure 20.15). The diffuse radiation coming from the region close to the sun is called *circumsolar radiation* and is mainly due to the dispersion by aerosols. The angular extent of the sun's aureole depends mainly on the turbidity of

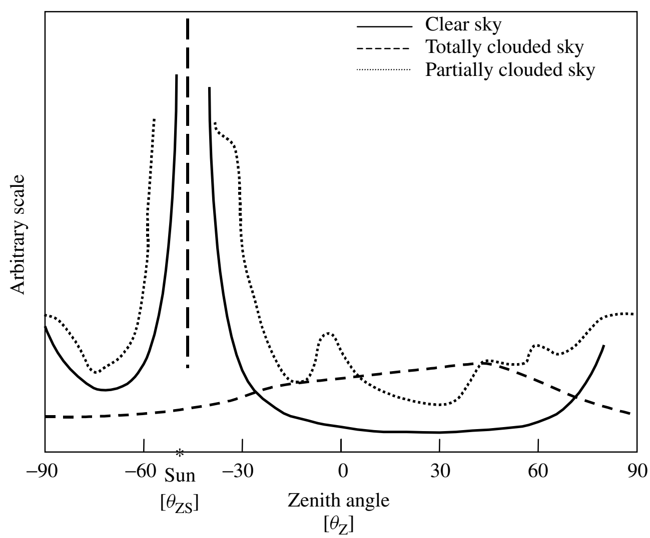

Figure 20.15 Typical angular distribution of the sky irradiance. The values are taken along the length of the meridian containing the sun, $\psi = \psi_S$