Exercise 4.6 Calculate the equivalent blackbody temperature of the Earth as depicted in Fig. 4.8, assuming a *planetary albedo* (i.e., the fraction of the incident solar radiation that is reflected back into space without absorption) of 0.30. Assume that the Earth is in *radiative equilibrium*; i.e., that it experiences no net energy gain or loss due to radiative transfer.

Solution: Let F_s be the flux density of solar radiation incident upon the Earth (1368 W m^{-2}); F_E the flux density of longwave radiation emitted by the Earth, R_E the radius of the Earth, as shown in Fig. 4.8; A the planetary albedo of the Earth (0.30);

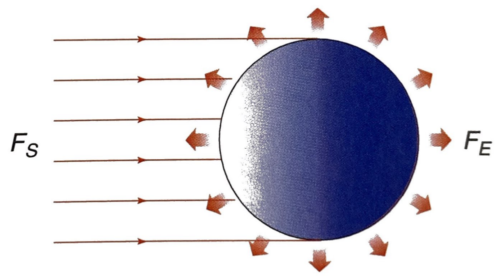

Fig. 4.8 Radiation balance of the Earth. Parallel beam solar radiation incident on the Earth's orbit, indicated by the thin red arrows, is intercepted over an area πR_E^2 and outgoing (blackbody) terrestrial radiation, indicated by the wide red arrows, is emitted over the area $4\pi R_E^2$.

and T_E the Earth's equivalent blackbody temperature. From the Stefan–Boltzmann law (4.12)

$$F_E = \sigma T_E^4 = \frac{(1 - A)F_s}{4} = \frac{(1 - 0.30) \times 1368}{4}$$
$$= 239.4 \text{ W m}^{-2}$$

Solving for T_E, we obtain

$$T_E = \sqrt[4]{\frac{F_E}{\sigma}} = \left(\frac{239.4}{5.67 \times 10^{-8}}\right)^{1/4} = 255 \text{ K} \quad \blacksquare$$