15.3: Radiant Energy from the Sun

The sun is the ultimate source of most of the energy that we use. How much energy does Earth receive from the sun? If the sun were to abruptly "go out" (not to worry, it won't happen for another billion years or so) we would quickly find out, because within hours Earth would become a frozen rock in space. In fact, the **solar flux**, which is the rate at which solar energy is transmitted through space at Earth's distance from the sun is 1.34×103watts/m2. What this means, as illustrated in Figure 15.2, is that a 1 square meter area (a square just over 3 feet to the side) with the sun shining perpendicular to it just above Earth's atmosphere receives energy at a rate of 1,340 watts. A watt is a measure of power, that is, energy per unit time. A power level of 1,340 watts is enough to easily power an electric iron or toaster and would provide the energy equivalent to 13100-watt incandescent bulbs plus a 40-watt bulb.

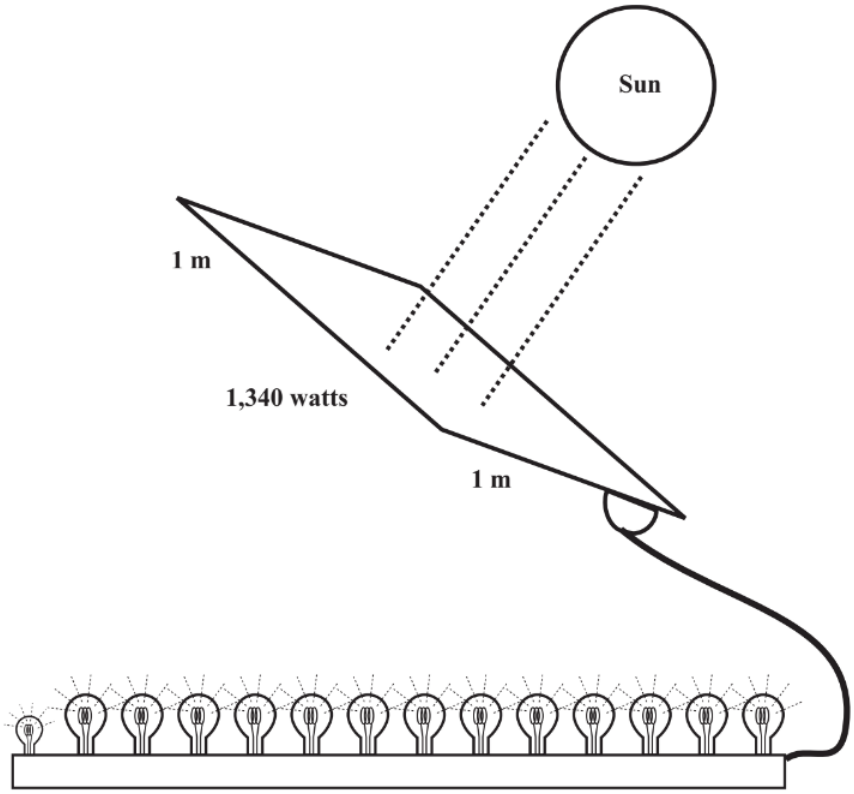

Figure 15.2. The solar flux at the distance of Earth from the sun is 1,340 watts/m2. This amount of power is equivalent to that consumed by 13 100-watt incandescent light bulbs plus a 40-watt bulb

Where does the sun get all this energy? It gets it by consuming itself in a gigantic thermonuclear fire, the same basic process that gives a "hydrogen bomb" its enormous destructive force. The fuel for the sun is ordinary hydrogen. But the energy-yielding reaction is not an ordinary chemical reaction. Instead, it is a **nuclear reaction** in which the nuclei of 4 hydrogen atoms fuse together to produce the nucleus of a helium atom of mass number 4, plus 2 positrons, subatomic particles with the same mass as the electron, but with a positive, instead of a negative, charge. There is a net loss of mass in the process (in nuclear reactions mass **can** change) and this loss translates into an enormous amount of energy. The fusion of only 1 gram of hydrogen releases as much energy as the heat from burning about 20 tons of coal. Using superscripts to express mass number and subscripts for charge, the thermonuclear fusion of hydrogen in the sun may be expressed as follows:

$$4\,{}_{1}^{1}\mathrm{H} \rightarrow {}_{2}^{4}\mathrm{He} + 2\,{}_{+1}^{0}\mathrm{e} + \text{energy} \tag{15.3.1}$$