Solutions

Each answer shows the steps, then the **result**.

2.1

- the **total power** of radiation emitted by the star (in all directions)

2.2

- $F = L/(4\pi d^2)$

2.3

- $F = L/(4\pi d^2)$

$$F = \frac{3.8 \times 10^{26}\ \text{W}}{4\pi(1.5 \times 10^{11}\ \text{m})^2} = \mathbf{1.4 \times 10^{3}}\ \text{W m}^{-2}$$

2.4

- an object of **known luminosity**

3.1 C

- $F \propto 1/d^2$, so doubling d makes F **one quarter**

3.2

- $d = \sqrt{L/(4\pi F)}$

$$d = \sqrt{\frac{4.0 \times 10^{28}\ \text{W}}{4\pi(2.0 \times 10^{-9}\ \text{W m}^{-2})}} = \mathbf{1.3 \times 10^{18}}\ \text{m}$$

3.3

- find an object in that galaxy whose **luminosity is known in advance** from its type — a Type Ia supernova or a Cepheid variable
- **measure** the radiant flux intensity F arriving at Earth
- then $F = L/(4\pi d^2)$ gives $d = \sqrt{L/(4\pi F)}$
- the method assumes the radiation spreads out evenly and nothing absorbs it on the way

3.4

(a) **luminosity** is the total power radiated by the star in all directions

- **radiant flux intensity** is the power received per unit area at the observer, perpendicular to the direction of the star

(b) $F = L/(4\pi d^2)$, so $d = \sqrt{L/(4\pi F)}$

$$d = \sqrt{\frac{6.5 \times 10^{27}\ \text{W}}{4\pi \times 2.9 \times 10^{-9}\ \text{W m}^{-2}}} = \mathbf{4.2 \times 10^{17}}\ \text{m}$$

(c) $L = 4\pi r^2 \sigma T^4$, so $r = \sqrt{L/(4\pi\sigma T^4)}$

$$r = \sqrt{\frac{6.5 \times 10^{27}\ \text{W}}{4\pi(5.67 \times 10^{-8}\ \text{W m}^{-2}\,\text{K}^{-4})(9600\ \text{K})^4}} = \mathbf{3.3 \times 10^{9}}\ \text{m}$$

(d) at the same radius and distance, $F \propto T^4$

- so halving T gives $(1/2)^4 = \mathbf{1/16}$ of the flux intensity

(e) interstellar dust and gas **absorb and scatter** some of the light on the way

- and the Earth's atmosphere absorbs part of it too, so a ground-based measurement is lower still