Astronomy

Turnex

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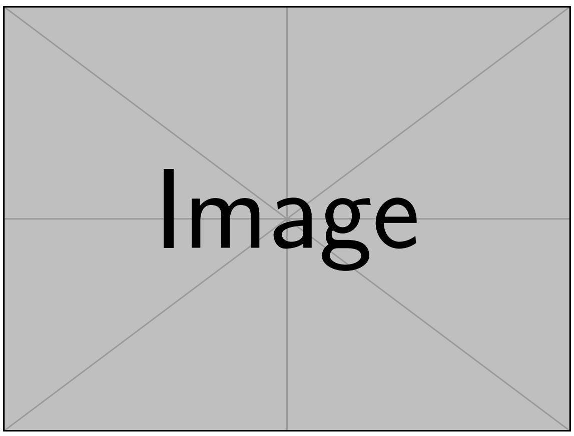

Contents

Chapter 1

The Tools of Astronomy

1.1 The Light Spectrum

1.1.1 Trigonometric Parallax

The distance between Earth and Sun is defined as 1 AU. For this measurement, we have the geometric relation:

$$d = \frac{1\,\mathrm{AU}}{\tan(p)} \approx \frac{1\,\mathrm{AU}}{p} \tag{1.1}$$

In radian form, defining a new unit of distance, **parsec** (pc), leads to:

$$d = \frac{1}{p''}\,\mathrm{pc} \tag{1.2}$$

1.1.2 The Magnitude Scale

Hipparchus invented a numerical scale to describe how bright stars appear in the sky, called the **apparent magnitude**.

Radiant flux F is the total amount of light energy of all wavelengths that crosses a unit area oriented perpendicular to the direction of light's travel per unit time.

The energy received depends on both intrinsic luminosity and distance:

$$F = \frac{L}{4\pi r^2} \tag{1.3}$$

A difference of 5 magnitudes between the apparent magnitudes of two stars corresponds to the smaller-magnitude star being 100 times brighter than the larger-magnitude star:

$$\frac{F_2}{F_1} = 100^{(m_1 - m_2)/5} \tag{1.4}$$

$$m_1 - m_2 = -2.5\log_{10}\left(\frac{F_1}{F_2}\right) \tag{1.5}$$

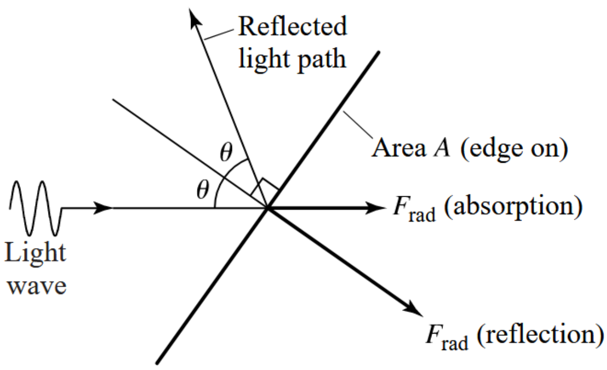

Figure 1.1:

Using the Sun as a reference:

$$100^{(m-M)/5} = \left(\frac{d}{10\,\text{pc}}\right)^2 \tag{1.6}$$

$$d = 10^{(m-M+5)/5}\,\text{pc} \tag{1.7}$$

For two stars at the same distance:

$$M = M_{\odot} - 2.5\log_{10}\left(\frac{L}{L_{\odot}}\right) \tag{1.8}$$

1.1.3 The Wave Nature of Light

Poynting Vector and Radiation Pressure

The Poynting vector is given by:

$$S = \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B} \tag{1.9}$$

For the time average:

$$\langle S \rangle = \frac{1}{2\mu_0} E_0 B_0 \tag{1.10}$$

Radiation pressure for absorption and reflection is given by:

$$F_{\text{rad}} = \frac{\langle S \rangle A}{c}\cos(\theta) \qquad \text{(absorption)}$$

$$F_{\text{rad}} = \frac{2\langle S \rangle A}{c}\cos^2(\theta) \qquad \text{(reflection)}$$

Planck's Function for the Blackbody Radiation Curve

Planck's radiation law:

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5}\frac{1}{\exp\left(\frac{hc}{\lambda kT}\right) - 1} \tag{1.11}$$

The luminosity L of a blackbody of area A and temperature T:

$$L = A\sigma T^4 \tag{1.12}$$

For a spherical star:

$$L = 4\pi R^2 \sigma T_e^4 \tag{1.13}$$

The surface flux is:

$$F_{\text{surf}} = \sigma T_e^4 \tag{1.14}$$

For monochromatic luminosity:

$$L_\lambda d\lambda = 4\pi R^2 B_\lambda d\lambda = \frac{8\pi^2 R^2 hc^2}{\lambda^5} \frac{d\lambda}{\exp\left(\frac{hc}{\lambda kT}\right) - 1} \tag{1.15}$$

Integrating over all wavelengths:

$$\int_0^\infty B_\lambda(T)\, d\lambda = \frac{\sigma T^4}{\pi} \tag{1.16}$$