5.4: Optical Depth

The product of linear extinction coefficient and distance, or, more properly, if the extinction coefficient varies with distance, the integral of the extinction coefficient with respect to distance,

$$\tau = \int \kappa(x) dx \tag{5.4.1}$$

is the *optical dep*th, or *optical thickness*, τ. It is dimensionless. Specific intensity falls off with optical depth as

$$I = I^0 e^{-\tau}. \tag{5.4.2}$$

Thus optical depth can also be defined by $\ln(I^0/I)$. While the optical depth $\ln(I^0/I)$ is generally used to describe how opaque a stellar atmosphere or an interstellar cloud is, when describing how opaque a filter is, one generally uses $\log_{10}(I^0/I)$, which is called the *density* d of the filter. Density is 0.4343times optical depth. If a star is hidden behind a cloud of optical depth τ it will be dimmed by 1.086τ magnitudes. If it is hidden behind a filter of density d it will be dimmed by $2.5d$ magnitudes. The reader is encouraged to verify these assertions.