the component of momentum flux normal to dA, we multiply by another factor of $\cos\theta$. Integrating, we then obtain

$$p_\nu(\text{dynes cm}^{-2}\,\text{Hz}^{-1}) = \frac{1}{c}\int I_\nu \cos^2\theta\, d\Omega. \tag{1.4}$$

Note that F_ν and p_ν are *moments* (multiplications by powers of $\cos\theta$ and integration over $d\Omega$) of the intensity I_ν. Of course, we can always integrate over frequency to obtain the total (integrated) flux and the like.

$$F(\text{erg s}^{-1}\,\text{cm}^{-2}) = \int F_\nu\, d\nu \tag{1.5a}$$

$$p(\text{dynes cm}^{-2}) = \int p_\nu\, d\nu \tag{1.5b}$$

$$I(\text{erg s}^{-1}\,\text{cm}^{-2}\,\text{ster}^{-1}) = \int I_\nu\, d\nu \tag{1.5c}$$

Radiative Energy Density

The specific energy density u_ν is defined as the energy per unit volume per unit frequency range. To determine this it is convenient to consider first the energy density per unit solid angle $u_\nu(\Omega)$ by $dE = u_\nu(\Omega)\,dV\,d\Omega\,d\nu$ where dV is a volume element. Consider a cylinder about a ray of length ct (Fig. 1.4). Since the volume of the cylinder is $dA\,c\,dt$,

$$dE = u_\nu(\Omega)\,dA\,c\,dt\,d\Omega\,d\nu.$$

Radiation travels at velocity c, so that in time dt all the radiation in the cylinder will pass out of it:

$$dE = I_\nu\, dA\, d\Omega\, dt\, d\nu.$$

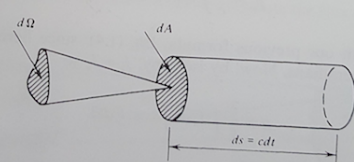

***Figure 1.4** Electromagnetic energy in a cylinder.*

Equating the above two expressions yields

$$u_\nu(\Omega) = \frac{I_\nu}{c}. \tag{1.6}$$

Integrating over all solid angles we have

$$u_\nu = \int u_\nu(\Omega)\, d\Omega = \frac{1}{c}\int I_\nu\, d\Omega,$$

or

$$u_\nu = \frac{4\pi}{c} J_\nu, \tag{1.7}$$

where we have defined the *mean intensity* J_ν:

$$J_\nu = \frac{1}{4\pi}\int I_\nu\, d\Omega. \tag{1.8}$$

The total radiation density (erg cm^{-3}) is simply obtained by integrating u_ν over all frequencies

$$u = \int u_\nu\, d\nu = \frac{4\pi}{c}\int J_\nu\, d\nu. \tag{1.9}$$