11. PHOTON AND ELECTRON ATTENUATION

Photon Attenuation Length

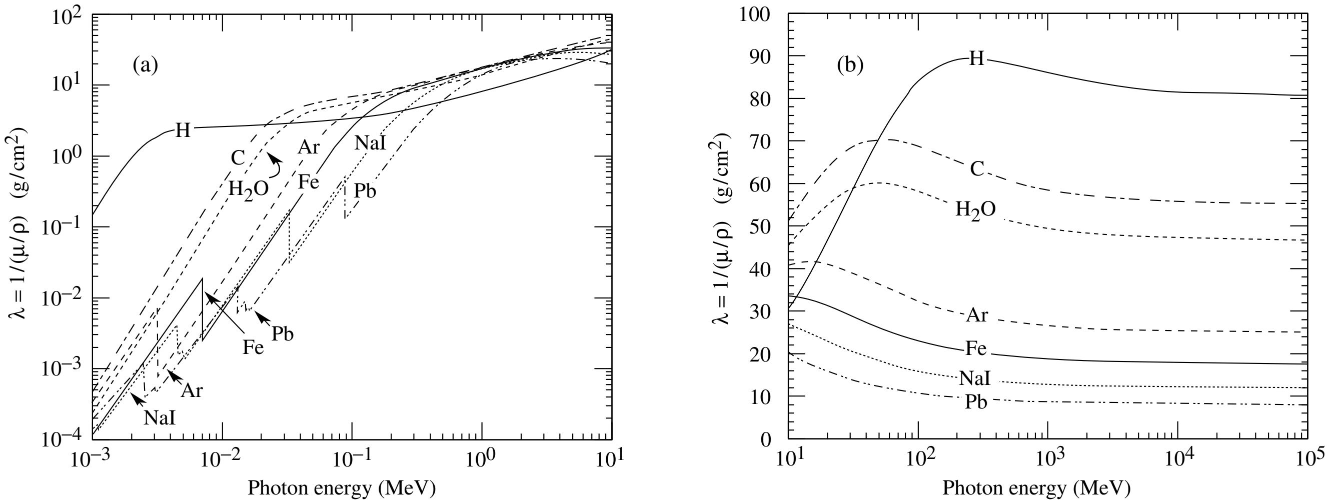

Figure 11.1: The photon mass attenuation length $\lambda = 1/(\mu/\rho)$ (also known as mfp, mean free path) for various absorbers as a function of photon energy, where μ is the mass attenuation coefficient. For a homogeneous medium of density ρ, the intensity I remaining after traversal of thickness t is given by the expression $I = I_0 \exp(-t\rho/\lambda)$. The accuracy is a few percent. Interpolation to other Z should be done in the cross section $\sigma = A/\lambda N_A$ cm^2/atom, where A is the atomic weight of the absorber material in grams and N_A is the Avogadro number. For a chemical compound or mixture, use $(1/\lambda)_{\text{eff}} \approx \sum w_i(1/\lambda)_i$, accurate to a few percent, where w_i is the proportion by weight of the i^{th} constituent. The processes responsible for attenuation are given in Fig. 11.4. Not all of these processes necessarily result in detectable attenuation. For example, coherent Rayleigh scattering off an atom may occur at such low momentum transfer that the change in energy and momentum of the photon may not be significant.

(a) Low-energy region.

(b) The photon mass attenuation length, high-energy range (note that ordinate is linear scale). The attenuation length is constant beyond the range shown for at least two decades in energy.

From Hubbell, Gimm, and Øverbø, J. Phys. Chem. Ref. Data **9**, 1023 (80). See also J.H. Hubbell, Int. J. of Applied Rad. and Isotopes **33**, 1269 (82). Data courtesy J.H. Hubbell.

Photon Pair Conversion Probability

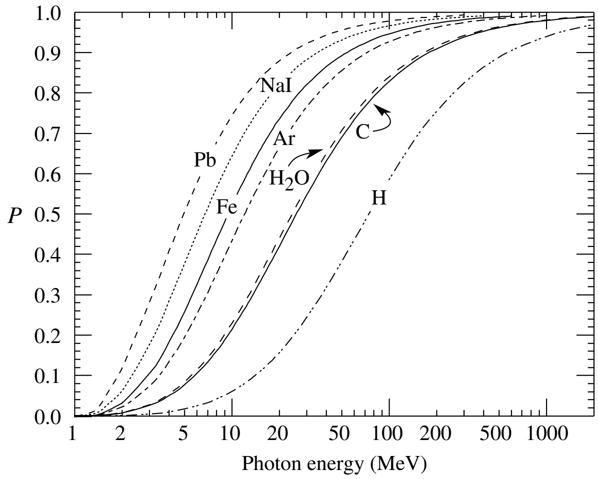

Figure 11.2: Probability P that a photon interaction will result in conversion to an e^+e^- pair. Except for a few-percent contribution from photonuclear absorption around 10 or 20 MeV, essentially all other interactions result in Compton scattering off an atomic electron. For a photon attenuation length λ (g/cm^2) (Fig. 11.1), the probability that a given photon will produce an electron pair (without first Compton scattering) in thickness t (cm) of absorber of density ρ (g/cm^3) is $P[1 - \exp(-t\rho/\lambda)]$.