Teaser Question
Basic Training in Condensed–Matter Theory
Erich Mueller; Due Wednesday, Feb 18, 2009

How opaque can a gas be?

When light travels through any medium it becomes attenuated. The intensity $I(z)$ falls off as

$$I(z) = I(0)e^{-z/z_0}$$

where z_0 is the attenuation length.

Suppose the medium is an extremely dilute gas, with arbitrarily small density n. Logic tells us that z_0 cannot be arbitrarily small: it would be ridiculous if a single atom in a small glass cell could completely block any incoming light. How small can z_0 be. [I don't care about factors of 2 or π or the like – just how does the minimum z_0 scale?]

Hint: Is there a limit on the cross-section for photon-atom scattering?

Answer: