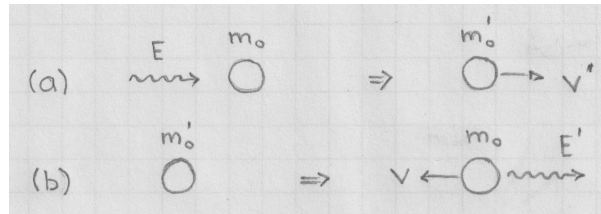## [lex94] Photon absorption and photon emission

Photons are quanta of electromagnetic wave, carrying energy $E = \hbar\omega$ and momentum E/c while traveling at speed c. Photon absorption and emission by atoms involve (i) a recoil motion of the atom due to impulse and (ii) a rearrangement of atomic electrons into states of different energy, which, effectively, changes the rest mass of the atom.

(a) A photon of energy E is absorbed by a stationary atom of rest mass m_0 in a force-free environment. By what amount $\Delta m_0 > 0$ has the rest mass of the atom changed when it is in the excited state? Express $\Delta m_0/m_0$ as a function of $E/m_0 c^2$.

(b) A photon of energy E' is emitted by a stationary atom of rest mass m_0' in a force-free environment. By what amount $\Delta m_0' < 0$ has the mass of the atom changed when it is back in the ground state? Express $\Delta m_0'/m_0'$ as a function of $E'/m_0' c^2$.

(c) Express the energies E and E' of each photon in units of $m_0 c^2$ as a function of $\Delta m_0/m_0$ expanded two second order.

Solution: