A FREE ELECTRON CANNOT ABSORB A PHOTON

Link to: physicspages home page.

To leave a comment or report an error, please use the auxiliary blog and include the title or URL of this post in your comment.

Post date: 9 July 2023.

A photon can scatter off an electron in the process of Compton scattering, and an atom such as hydrogen can absorb a photon by bumping an electron up to a higher energy level. However, a free particle such as an electron not bound to an atom cannot absorb a photon.

At first glance, it might seem possible for an electron to absorb a photon; after all, if a photon hits a stationary electron, the momentum of the electron should be conserved if the electron moved off in the same direction as the incident photon, and the energy of the electron due to its motion would account for the energy of the absorbed photon.

However, if we examine the problem in the centre of momentum frame, the situation before the absorption is that the photon is coming in (from the $-x$ direction, say) with momentum $p = E$ (since the momentum of a photon is numerically equal to its energy in units where $c = 1$), and the electron would be moving in from the $+x$ direction, with momentum $-p$ (since the total momentum in the centre of momentum frame is zero).

After the absorption, the total momentum must still be zero, but there is only one particle left, namely the electron. Thus the electron would have to be at rest. Since it's a free electron, its rest energy is fixed at its rest mass, and thus it is not possible to conserve energy, since the energy of the photon would have to vanish.

PINGBACKS

Pingback: Rosseland mean opacity