

41. Suppose an electron with total energy  $E$  and momentum  $\mathbf{p}$  spontaneously changes into a photon. If energy is conserved, the energy of the photon is  $E$  and its momentum has magnitude  $E/c$ . Now the energy and momentum of the electron are related by  $E^2 = (pc)^2 + (mc^2)^2$ , so  $pc = \sqrt{E^2 - (mc^2)^2}$ . Since the electron has non-zero mass,  $E/c$  and  $p$  cannot have the same value. Hence, momentum cannot be conserved. A third particle must participate in the interaction, primarily to conserve momentum. It does, however, carry off some energy.