PHYS4702 Atomic, Nuclear, & Particle Physics   Fall 2015   HW #7

Due at the start of class on Thursday 8 Oct 2015

There is just one homework problem this week, but it will be graded as the equivalent of three problems, so this assignment counts the same as the others towards your final course grade.

(1) Tritium is a form of hydrogen, with a nucleus consisting of one proton and two neutrons. This nucleus is radioactive, decaying to a Helium-3 nucleus (two protons and one neutron) and releasing several keV of energy in the decay products, including an electron from the $n \to p$ transition. When the decay occurs in a tritium atom, the single atomic electron generally remains intact, resulting in singly charged ion of Helium-3.

Show that the time scale for the decay electron to leave the the Helium-3 ion is much smaller than the time scale for the atomic state to evolve. This justifies the "sudden approximation" for the next part of the problem.

Calculate the probability that the resulting one-electron Helium-3 ion is in its ground state. The sudden approximation tells you that the atomic wave function is the same as it was for the tritium atom ground state. However, this is no longer an eigenfunction for the Helium-3 ion because the charge on the nucleus has changed, so the only "hard" part of the calculation is to determine the overlap integral between the "old" and "new" wave functions.