Due Date: 11-24-08

Nuclear Physics 621

Homework 9 – Nuclear Shell model

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We want to compute the contribution of one nucleon to the total quadrupole moment of the nucleus. We work in spherical coordinates: In the **coupled representation**, the nucleon wave function is characterized by the quantum numbers n, ℓ, j and m. We will denote it by $\psi_{nljm}(r,\theta,\varphi)$. The radial part of $\psi_{n\ell jm}(r,\theta,\varphi)$ is assumed to be some function $f(r)$.

1) From what you know of angular momentum coupling, give the general expression for the wave function $\psi_{nljm}(r,\theta,\varphi)$ in the coupled representation as function of the quantum numbers n, ℓ (orbital angular momentum), m_ℓ (projection of ℓ on the quantization axis), s (intrinsic spin) and m_s (projection of intrinsic spin on the quantization axis).

2) Calculate the expectation value of the quadrupole moment operator Q_{20} for the nucleon in the state $\psi_{nljm}(r,\theta,\varphi)$. Assume that $m = j$ in your calculation.

   Express your result as function of the contribution of that state to the mean square radius.

   What happens if the nucleon is in a s-state ?

Bibliography (you'll need one of those):

- Angular Momentum in Quantum Mechanics, A. R. Edmonds
- Quantum Theory of Angular Momentum, D. A. Varshalovich, A. N. Moskalev
- Quantum Mechanics, C. Cohen-Tanoudji, B. Diu, F. Laloe, Vol. 2