

PHYS 5260: Quantum Mechanics - II

Homework Set 6

Issued April 11, 2016

Due April 25, 2016

Reading Assignment: Shankar, Ch.20

1. Derive particle continuity equation for the Dirac equation, identifying the relativistic particle number and current densities in terms of the Lorentz spinor, $\vec{\psi}$.
2. Starting with the 3d Dirac equation in a magnetic field, $\mathbf{B}$ derive the corresponding nonrelativistic Schrodinger, i.e., the Pauli equation, showing how the spin emerges and gives Zeeman interaction with the $\mathbf{B}$ field (in addition to the orbital effect of the field). Identify the g factor (showing that $g = 2$) and the relation between the electron's magnetic moment and its spin $\mathbf{S}$.
3. Using your solution to the above problem and your knowledge of the spectrum (from previous homeworks) for a nonrelativistic particle in a constant magnetic field, find the exact spectrum of a relativistic electron in a constant B -field.

Hint: for the interpretation of the negative energy solutions, see the end of Ch.20.