PYL431: Relativistic quantum Mechanics
(Major)

21 Nov , 2017
7:00 PM - 9:00 PM

Question 1. This problem is *strictly* in $2+1$ dimensions in ALL aspects (including Maxwell equations). Consider the Dirac equation in $2+1$ dimensions:

(a) (5 marks) Set up the Hamiltonian for a free particle and determine the eigenstates in the basis provided by momentum eigenstates.

(b) (5 marks) Rewrite the equation in covariant form.

(c) (5 marks) Switch on the electromagnetic interaction using gauge invariance in (*in strictly two dimensions lest you forget).* Determine the g value of a point charge.

(d) (10 marks) Perturbatively evaluate the relativistic corrections to the analog of the Hydrogen atom. You are *not* required to evaluate unperturbed energy.

(e) (5 marks) Show explicitly that the γ matrices under a boost along the x direction

Question 2. The interaction hamiltonian for a spin half particle is given by $H_{int} = \lambda\Phi(x)\bar{\psi}\psi$ where $\Phi(x)$ is gauge invariant.

(a) (5 marks) Obtain the equation of motion for the particle.

(b) (5 marks) Verify if the electric charge is a conserved quantity.

(c) (10 marks) Compute the lowest order correction to the Hydrogen atom (nonrelativistic Schrödinger) in the rest frame of the particle. How would the spectrum be different from that of standard correction?

(d) (10 marks) What are the conserved quantities when the particle is (i) massive, and (ii) massless.

The End