Cornell University

Department of Physics

Phys 651 September 6, 2006

Relativistic Quantum Field Theory, Fall 2006

Homework Assignment # 2

(Due Wednesday, September 13, before the lecture.)

Lectures and Reading Assignments:

Readings are from *"An Introduction to QFT"* by Peskin and Schroeder.

- Lec 5, 9/11 (Mon): Representations of the Lorentz Group **Sec. 3.1.**
- Lec 6, 9/13 (Wed): Fermions and the Dirac Equation. **Sec. 3.2.**

Problems:

Numbered problems are from Peskin and Schroeder, Ch. 2.

1. Problem 2.1 (a)
2. **The Complex Klein-Gordon Field:**
   - Solve parts (a) through (c) of Problem 2.2.
   - Show that the commutator $\left[\phi(x), \phi^\dagger(y)\right]$ vanishes for spacelike values of $(x-y)$. To gain a better understanding of the cancellation you will discover, read the discussion on p. 29 of P&S.
3. Solve Problem 2.3. Repeat the calculation for *timelike* $(x-y)$. Based on your result, prove that the commutator $[\phi(x), \phi(y)]$ *does not* vanish for timelike values of $(x-y)$.
4. Work out the expression for the physical momentum operator $\mathbf{P}$ (see Eq. (2.19) of P&S) in terms of the creation and annihilation operators $a_{\mathbf{p}}$ and $a_{\mathbf{p}}^\dagger$ in the case of *real* Klein-Gordon field. Compute $\mathbf{P}\left|\mathbf{p}\right\rangle$, where $\left|\mathbf{p}\right\rangle = \sqrt{2E_{\mathbf{p}}}a_{\mathbf{p}}^\dagger\left|0\right\rangle$. Does this calculation support our interpretation of $\left|\mathbf{p}\right\rangle$ as a state with one particle of definite momentum?