Cornell University

Department of Physics

Phys 651 October 16, 2006

Relativistic Quantum Field Theory, Fall 2006

Homework Assignment # 7

(Due Monday, October 23, after the lecture.)

Lectures and Reading Assignments:

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

- Lec 14, 10/16 (Mon): From S Matrix To Cross Section. **Sec. 4.5**
- Lec 15, 10/18 (Wed): Computing the S Matrix, Part I **Sec. 4.2, 4.3**
- Lec 16, 10/23 (Mon): Wick's Theorem. Feynman Propagator. **Sec. 2.4 ("Klein-Gordon Propagator"), 4.3**
- Lec 17, 10/25 (Wed): Computing the S Matrix, Part II: Feynman Diagrams **Sec. 4.4, 4.6**

Problems:

1. **Three-body phase space**:

   Consider a $2 \to 3$ scattering process, A+B→1+2+3. We will work in the center of mass frame, where $\mathbf{p}_A + \mathbf{p}_B = 0$, and $E_{\rm cm} = E_A + E_B$ is the total energy of the colliding particles. Particles A, B, 1 and 2 are massless, and particle 3 has mass M.

   - (a) Assuming that the invariant matrix element $\mathcal{M}$ is constant (independent of the momenta of the final and initial state particles), compute the differential cross section

     $$\frac{d\sigma}{dE_3} \tag{1}$$

     where $E_3 = \sqrt{\mathbf{p}_3^2 + M^2}$. Sketch the plot of $d\sigma/dE_3$, as a function of E_3. What are the minimum and maximum values that E_3 can take?
   - (b) Repeat the calculation in part (a), assuming now that the invariant matrix element is $\mathcal{M} = s_{12}$, where $s_{12} = (p_1 + p_2)^2$. Sketch the result. **HINT:** The problem can be simplified quite a bit by using momentum conservation in the form $p_1 + p_2 = p_A + p_B - p_3$.