Quantum Field Theory for Non-specialists
Examination, 2019 Spring
Instructor: H. Yamamoto

Handed out on Aug 5, 2019 (Monday) in class to be submitted to our secretary Kaori Kobayashi at Bldg H34 room 105 or directly given to me by one week later on Aug 12 (Monday) at 5 PM. You may also send me a scanned file by E-mail, or as a last resort, send me a photo file. You can consult any books, articles, etc. You have to, however, work on your own (e.g., you cannot ask your friends for help). Enjoy!

1. Special relativity. (20 pnts)
A parent particle with mass M decays to two daughter particles with mass m each, where $M > 2m$. In the laboratory system, the parent particle has energy E and momentum P. The decay occurs uniformly in all directions in the rest frame of the parent particle. Use a unit system where the speed of light c is unity.
(a) When the energy of the parent particle E is greater than a certain value E_c, the daughter particles cannot be moving backward in the laboratory system with respect to the direction of the parent particle - more precisely, the momentum component the daughter particle along the direction of the parent particle cannot be negative regardless of the direction of the decay in the rest frame of the parent particle. Express E_c in terms of M, and m.
(b) Assume that the daughter particles are massless; namely $m = 0$. What is the fraction of the decays where in the laboratory system one daughter particle is moving backward with respect to the direction of the parent particle? Express it in terms of E, P and M.

2. Exercise 5.1 and 5.2 (30 pnts)
Trace theorems are used extensively when rates are calculated including the next problem. This is something you would like to be familiar with. The formulae in Ex 5.2 are often used in calculations of quantum electro-dynamics..

3. Problem 5.2: Charged Higgs decay
Charged Higgs appears in many models beyond the standard model. The evaluation of the decay rate proceeds the same way as the Higgs decay to fermion pairs in the text. This problem is intended to be a review.