QFT I exercises - sheet 6

Fill in the blanks

In class we discussed the fermion Feynman rules and the Yukawa model. In this exercise we are going to walk through some of the details of the computation. Most, but not all, of these details are small! Equation numbers refer to Peshkin & Schroeder, section 4.7.

a Check equation 4.107, where the contraction is given by 4.108

b Check Wick's theorem, 4.111, for three fields. Compare to the scalar case and argue the general derivation is the same.

c What are the zero's on the brackets in equation 4.113? Where did the $\frac{1}{2!}$ come from?

d Why are contractions with the external fields such as in equation 4.115 the only interesting contractions?

e Evaluate the contraction in equation 4.115 carefully to arrive at 4.116. Draw the contraction which allows us to drop the $\frac{1}{2!}$

f Check the relative sign on the terms in 4.119 and the overall sign in 4.120

g Write down an explicit Lagrangian for *two* fermions (say Alice, ψ^a, and Bob, ψ^b) with a Yukawa like coupling to a real scalar field to justify focusing solely on the first term in equation 4.119.

h Write down the most general renormalizable Lagrangian for our couple of fermions and a real scalar field (Hint: there are 3 real couplings).

i Argue 4.122 is correct in the non-relativistic limit.

j Why is the sign of the mass term in equation 4.123 '+'?

k Check equation 4.124 up to an overall constant

l Fill in the gaps in the first step of equation 4.126 and the gap between 4.126 to 4.127

m Check the signs in 4.128 and the overall sign of the potential

n Sketch the relevant differences between anti-fermion-anti-fermion scattering and fermion-fermion scattering

- Give the first non-trivial Feynman graphs for decay of the scalar particle, as well as fermion+fermion to scalar-scalar scattering.

For discussion during the exercise session: Which steps in 4.7 not discussed in this exercise seem fishy to you?

4.2

Do Peshkin & Schroeder's 4.2. Based on your solution, guess the result in the non-relativistic limit for decay of the scalar in Yukawa theory.