PHYS-4303 Homework 8 Due 21 Nov 2023

This homework is due to `https://uwcloud.uwinnipeg.ca/s/dcYrc2Yys2jsSrz` by 10:59PM on the due date. Your file(s) must be in PDF format; they may be black-and-white scans or photographs of hardcopies (all converted to PDF), PDF prepared by LaTeX, or PDF prepared with a word processor *using an equation editor*.

1. **More Scattering in ABC Theory** *from Griffiths 6.15*

   Consider the scattering process $A + B \to A + B$ in the ABC theory example discussed in class. Work in the CM frame.

   (a) Draw the two tree Feynman diagrams for the process. It may be helpful to note that one of them is sometimes known as "s-channel" while the other is "u-channel."

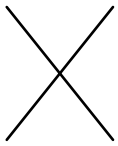
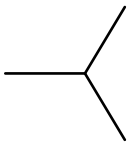
   (b) Using the Feynman rules for this theory, write the probability amplitude for this process. Let the incoming A particle have momentum p_1^μ, the incoming B have momentum p_2^μ, the outgoing A have p_3^μ, and the outgoing B have p_4^μ.

   (c) What is the symmetry factor in the differential cross section for this process?

   (d) Suppose $m_A = m_B = m_C = 0$. Write the CM frame differential cross section in terms of the momentum p of each A or B particle in the CM frame and the scattering angle θ (the angle between the initial and final A particle momenta). *Hint:* Show that the total CM frame energy is $2p$ and see the example of $A + A \to B + B$ scattering from the class notes for $(p_1 - p_4)^2$.

2. **A Scalar with Two Vertices**

   Consider a model with a single type of scalar particle of mass m called ϕ. The ϕ particle has two types of vertices with which it can interact with itself. The Feynman rules are the usual rules for internal and external lines plus the vertices

    $= -i\lambda$,  $= -ig$. (1)

   Draw the Feynman diagrams and find the probability amplitude for $\phi + \phi \to \phi + \phi$ scattering. Use Mandelstam variables as defined on assignment 5 for any relativistic dot products of the momenta. *Hint:* there are 4 Feynman diagrams.