SCPY322 Nuclear and Particle Physics
MUSC, Second Semester 2020-21
Final Examination (Take Home) Date: Friday 14, May 2021
Due date: Wednesday 19, May 2021 (Within 4.00 pm.)
(Submit your exam solution via my email)

1. (30 pt.) Relativistic kinematics

   (a) For an electron with total energy of 2 MeV calculate a) its momentum (in MeV/c), b) its kinetic energy (in MeV) and c) its velocity (in c)

   (b) The decay $\bar{K}^0 \to \mu^+ + \mu^-$ is a rare decay predicted by Glashow–Iliopoulos–Maiani (GIM) mechanism. Evaluate the kinetic energy of $\mu^\pm$ in the rest frame of $\bar{K}^0$. (Find all masses from the internet.)

2. (30 pt.) Symmetry principle

   (a) Show that if O is an operator of symmetry transformation, it must satisfy a condition $[O, H] = 0$, where H is system Hamiltonian.

   (b) Let $H = \frac{p^2}{2m} + V(r)$ is the Hamiltonian of central potential system, show that this system has rotational symmetry.

3. (40 pt.) Fundamental interactions

   (a) Draw Feynman diagrams of the following electromagnetic interactions, a) $e^- e^+ \to e^- e^+$, b) $e^- e^+ \to \gamma\gamma$, and c) $\gamma\gamma \to \gamma\gamma$

   (b) Draw Feynman diagrams of the following weak interactions, a) $d \to u e^- \bar{\nu}_e$, b) $u \to d e^+ \nu_e$, and c) $e^- \bar{\nu}_e \to e^- \bar{\nu}_e$

   (c) Draw Feynman diagrams of the following strong interactions, a) $p^+ \bar{p}^- \to n^0 \bar{n}^0$, and b) $p^+ \pi^- \to n^0 \pi^+ \pi^-$