Problem Set 2 (due Sep 19, 2017)

1. **Scattering Theory** Compute, in the first Born approximation, the differential and the total scattering cross-section for an atractive exponential potential,

$$V(\mathbf{r}) = -\lambda e^{-\kappa r}, \lambda > 0, \kappa > 0 \ . \tag{1}$$

   Discuss the criterion of validity. Analyze the energy dependence of the total cross-section and the energy dependence of the angular distribution.

2. T**-matrix** Write down the series equation in momentum space for the T-matrix for two particles interacting via a potential of the form

$$V(\mathbf{r}) = \int \frac{d^3q}{(2\pi)^3} e^{i\mathbf{q}\cdot\mathbf{r}} V(\mathbf{q}) \ . \tag{2}$$

   Sum the series if

$$V(q) = \begin{cases} \lambda & q < \lambda \\ 0 & q > \lambda \end{cases} \ . \tag{3}$$

3. **Field operators** Write down the Hamiltonian for a multi-particle system in terms of the field operator $\psi(\mathbf{r})$ and its conjugate for a system of particles in the presence of a background potential $U(\mathbf{r})$, with particles interacting with a two-body potential $V_2(\mathbf{r_1}, \mathbf{r_2})$ and a three body potential $V_3(\mathbf{r_1}, \mathbf{r_2}, \mathbf{r_3})$. What are the constraints on the potentials if the system is translationally invariant? Use the constraint to write $V_2(\mathbf{r_1}, \mathbf{r_2})$ in momentum space. What is the additional constraint on V_2 if the system is rotationally invariant?

4. **(Galilean invariance of non-relativistic quantum mechanics)** Problem 1, Chapter 2, *Quantum Field Theory* by Lowell S. Brown