Phys 651 Fall 2023

Homework #8

(due Wednesday, December 6, 2023)

1. (20 pts) Consider 1D harmonic oscillator. Find the matrix element of the position operator X (i.e. x_{nm}) using:

(a) x-representation (and therefore, Hermite polynomials)

(b) number representation (and therefore, creation and annihilation operators).

2. (10 pts) Consider 1D harmonic oscillator. By setting up an eigenvalue equation in the momentum space and direct comparison with that in the position space, infer the momentum space eigenfunctions $\Phi(p)$ (you don't have to solve anything here !).

3. (10 pts) Consider 1D harmonic oscillator. Using the number representation, find the expectation value of X^4 in an arbitrary state |n>

4. (10 pts) Sakurai 2.20. (check your edition – "show for the 1D h.o….")

5. (20 pts) Consider a particle which behaves as 1D harmonic oscillator. Now imagine that your particle is also charged (has an electric charge q) and apply uniform electric field $\boldsymbol{\mathcal{E}}$ along x-axis.

(a) Find the allowed energy levels and corresponding eigenfunctions. **Hint: you don't need to solve anything to be able to do it ! Add the appropriate term in the Hamiltonian and see how you can reduce the problem to that of a regular harmonic oscillator we discussed.**

(b) At $t < 0$ the particle is in the ground state. At $t = 0$ the electric field is suddenly turned off. What is the probability to find the particle in the ground state and in the first excited state?

6. Reading assignment: Sakurai 2.3-2.5; papers regarding coherent states, review Ch.1-2.