Phys 651 Fall 2023

Homework #5

(due Wednesday, November 8, 2023)

1. (10 pts) Sakurai 1.23. Comment on your result – what happens with the uncertainties in excited states?

2. (20 pts) Sakurai 1.29.

3. (20 pts) Consider a Gaussian wave packet. Find expectation values of X^2 and P^2 using two approaches (i.e. expressing the states in terms of p-basis and x-basis), similar to what we did in class in the case of <P>.

4. (20 pts) A particle of mass *m*, which moves inside an infinite 1D potential well of length *a*, is described by the following wave function at t = 0:

$$\psi(x,0) = \frac{A}{\sqrt{a}}\sin\left(\frac{\pi x}{a}\right) + \sqrt{\frac{3}{5a}}\sin\left(\frac{3\pi x}{a}\right) + \sqrt{\frac{1}{5a}}\sin\left(\frac{5\pi x}{a}\right),$$

where *A* is a real constant.

(a) Find *A* so that $\psi(x,0)$ is normalized

(b) If measurements of the energy are carried out at t=0, what are the values that will be found and what are the corresponding probabilities?

(c) What is the average energy?

(d) Find the wave function $\psi(x,t)$ at a later time *t*

(e) Determine the probability of finding the system at a time *t* in the state

$$\varphi(x,t) = \sqrt{\frac{2}{a}}\sin\left(\frac{5\pi x}{a}\right)e^{-iE_5 t/\hbar}$$

(f) The same as (e) but for the state $\chi(x,t) = \sqrt{\frac{2}{a}}\sin\left(\frac{2\pi x}{a}\right)e^{-iE_2 t/\hbar}$

5. Reading assignment: Sakurai 1.6, 2.1-2.2.