

Quantum Mechanics I

Problem Set 4

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Due: Monday, February 10th 2014

Problem 4.1

We are working with the three dimensional Schroedinger Equation.

- (a) Calculate

$$\frac{d}{dt} \langle \mathbf{r} \rangle$$

and express the results in terms of $\langle \mathbf{p} \rangle$. Note that because we are in three dimensions, both the \mathbf{p} and \mathbf{r} operators have three components.

- (b) Calculate

$$\frac{d}{dt} \langle \mathbf{p} \rangle.$$

Problem 4.2

Let us work in cartesian coordinates and assume that the potential is given as

$$V(x, y, z) = \begin{cases} 0 & \text{if } |x| < \frac{a}{2} \text{ and } |y| < \frac{a}{2} \text{ and } |z| < \frac{a}{2} \\ \infty & \text{otherwise} \end{cases}$$

- (a) Use an Ansatz in the following form to find all solutions to the three dimensional time independent Schroedinger equation with the above potential.

$$\psi(x, y, z) = \psi_x(x)\psi_y(y)\psi_z(z)$$

- (b) What are the allowed energy levels of those states?
- (c) What is the degeneracy of the first 6 energy levels (how many different states have the same energy)?

Problem 4.3

When solving the time-independent Schroedinger Equation in spherical coordinates, we separate variables:

$$\psi(r, \theta, \phi) = R(r)Y(\theta, \phi) = R(r)\Theta(\theta)\Phi(\phi).$$

Show that

$$\Theta(\theta) = A \ln(\tan(\theta/2)), \quad A \in \mathbb{R}$$

satisfies the equation for Θ (see lecture notes or equation 4.25 in Griffiths) for $l = m = 0$. Why is it not a physical solution?