

Physics 751 Midterm I

October 5, 2007

1. Suppose an electron is attracted towards the origin by a force $F = Cr$, where C is a positive constant, r is distance from the origin.

(a) What is the radius of the smallest circular Bohr orbit?

(b) What is the energy in the n^{th} circular Bohr orbit?

(c) Now suppose the electron oscillated on a line through the origin, so $F = -Cx$. Use the Uncertainty Principle to *estimate* the linear spread Δx of the wave function.

2. (a) Suppose the inner product for real functions defined for $x \geq 0$ is

$$\langle f | g \rangle = \int_0^{\infty} f(x) g(x) e^{-x} dx.$$

Begin with the set $1, x, x^2, \dots$ and construct the first *three* elements of an orthonormal basis.

(b) Find the eigenvalues and the eigenvectors of:

$$\begin{pmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & i \\ 0 & 0 & i & 0 \end{pmatrix}.$$

3. Consider the one-dimensional Schrodinger equation for an electron of mass m in a potential

$$g\delta(x-a) + g\delta(x+a).$$

For what values of g is there a bound state with extremely weak binding energy ϵ ?

(*Hint*: there are two values, one of which is extremely small, the other isn't.)