PHYS 485 Materials Physics **Spring 2019**

Read: Chapters 7

Homework 09

Due date: 26 Apr 19

Work problems 6.3, 6.4, 6.5, 6.7, 6.8, 6.9, 6.14, 7.1, 7.2, 7.3, 14.1, 14.2, 14.9, 14.10, 14.18 i n the text.

AQ 1: The velocity of a rifle bullet is about 900 m/s. If the bullet's mass is 30 g, and the uncertainty in its momentum is 0.10%, how accurately can the position of the bullet be measured?

AQ2: For a particle in a 1-D box of length *a*, the possible values of the total energy are $E = h^2 n^2/(8 m a^2)$. Calculate the splitting between the energy levels 1 and 2 (*i.e.* corresponding to $n = 1$ and $n = 2$) for

i. an electron in a box of the length $a = 1$ *nm.*
ii. yourself in a box of a size $a = 1$ *nm.* What is the implication of this latter result? Can your quantum nature (quantization of energy spectrum) be observed in the box of this size? Are you classical or quantum, in these conditions?

AQ 2: *Quantum square*: Below is an STM (scanning tunneling microscopy) image for Fe atoms on a Cu(111) surface, obtained by Dr. Eigler's group at IBM Almaden Research Center in 1993, and is called a "quantum square"—the 1st man-made artificial molecule. What you see is the image of $|\Psi|^2$ for a one electron wavefunction.

We will approximate the "quantum square" as a "particle (electron) in a 2-D box" quantum system. We will denote the length of the sides of the square box by a (the shorter side) and b (the longer side), and the effective mass of the electron by m.

i. Write down the time-independent Schrodinger equation for this quantum system (no explanation/derivation needed).
ii. Write down the eigenfunctions and eigenvalues for the quantum square's Hamiltonian operator (no explanation/derivation needed).
iii. For the specific state imaged below, what are the values of the n_x and n_y quantum numbers? Hints: remember that this is an image of $|\Psi|^2$, and count the number of nodes in the x- and y-directions.