Stages of Discovery
Winter 2011

Pre-class Assignment for physics
Complete before 1 pm on Tuesday January 31

Associated reading: *Quantum* (particularly ch. 8 – 9), *Copenhagen*

1. Nuclear Fission

a) Go to http://phet.colorado.edu/en/simulation/nuclear-fission and Run Now!
b) Make sure you are in the Fission: One Nucleus tab. Use the legend to determine what particles make up the ^{235}U ("Uranium-235") nucleus.
c) Examine the graph and describe as best you can what it tells you.
d) Fire the red button on the gun. What particle does it fire towards the ^{235}U?
e) Use the Reset Nucleus button and the pause button as many times as you need to observe what happens when the particle fired from the gun interacts with the ^{235}U nucleus. Observe both the nucleus and the graph. Make sketches (or take screenshots if you prefer) that supplement your written observations.
f) Go to the Chain Reaction tab. Reduce the number of ^{235}U down to 0, and increase the number of ^{238}U to 1 (you might have to hit return or enter if you type the number in the box).
g) You can aim the gun by using the mouse to move the front of the gun. Aim at the ^{238}U and fire one neutron at it. What happens? Contrast this specifically to the case of ^{235}U.
h) Fire a second neutron at the same particle you just hit. What happens? Does anything change if you fire a third neutron?
i) Use the Reset Nuclei button as needed. Decrease the number of ^{238}U to zero, and increase the number of ^{235}U to around 10. Fire a neutron at one of the ^{235}U nuclei. What do you observe?
j) Use the Reset Nuclei button as needed. Increase the number of ^{235}U nuclei to 25, and repeat.
k) Use the Reset Nuclei button as needed. Turn on the Containment Vessel. Try various mixes of ^{235}U and ^{238}U (no ^{235}U and lots of ^{238}U; half and half; lots of ^{235}U and no ^{238}U; etc.) and see what happens when you fire one neutron (or several).
l) (optional) Go to the Nuclear Reactor tab. See what happens when you Fire Neutrons and use the Control Rod Adjuster to move the blue control rods up and down.

2. Hydrogen Atom

a) Go to http://phet.colorado.edu/en/simulation/hydrogen-atom and Run Now!
b) Turn the knob to Prediction (what the model predicts) by clicking on the knob.
c) (You might have done this before; do it again for review) Choose the Bohr model, without the white light turned on. What do you observe? Then, turn on the white light and watch for a while. Pay close attention. What do you observe?
d) Keep this going, but also click on Show electron energy level diagram. **Use the controls at the bottom to slow things down as much as you can, and also make frequent use of the pause button.** Pay very close attention to what happens when the hydrogen atom absorbs a photon of light. Pay very close attention to what happens when the hydrogen atom changes from a higher energy level to a lower energy level. What do you observe?
e) (You might have done this before; do it again for review) Choose the de Broglie model, without the white light turned on. What do you observe? Then, turn on the white light and watch carefully for a while. What do you observe?
f) Keep this going, but also click on Show electron energy level diagram. Use the controls at the bottom to slow things down as much as you can, and also make frequent use of the pause button. Pay very close attention to what happens when the hydrogen atom absorbs a photon of light. Pay very close attention to what happens when the hydrogen atom changes from a higher energy level to a lower energy level. What do you observe? Make sure to specifically contrast this to what happens in the Bohr model.
g) Choose the Schrödinger model, without the white light turned on. What do you observe? Then, turn on the white light and watch for a while. Pay close attention. What do you observe?
h) Keep this going, but also click on Show electron energy level diagram. Use the controls at the bottom to slow things down as much as you can, and also make frequent use of the pause button. Pay very close attention to what happens when the hydrogen atom absorbs a photon of light. Pay very close attention to what happens when the hydrogen atom changes from a higher energy level to a lower energy level. What do you observe? Make sure to specifically contrast this to what happens in the Bohr model and the de Broglie model.

3. Energy Levels & Emission/Absorption Spectra and Wave Functions

a) Go to http://www.kcvs.ca/site/projects/physics_files/particleBox/particleBox2.swf

b) The system shown is currently in its lowest energy level (E_1). You might notice that the E_1 line (green) is highlighted in yellow/beige and that the n = 1 button is selected. You can select an energy level for the system to transition to either by clicking on the green line or checking the button. Select the n = 2 level either by checking the button or clicking on the green line. Pay careful attention to what happens both in the box and on the spectrum at the top of the page.

c) Select the n = 1 level. What do you notice?

d) As you went from n = 1 to n = 2, did the energy of the system increase or decrease? Was the associated photon absorbed or emitted?

e) As you went from n = 2 to n = 1, did the energy of the system increase of decrease? Was the associated photon absorbed or emitted?

f) Test out various transitions between different energy levels. Do the larger energy transitions correspond to longer wavelengths of light, or shorter wavelengths?

g) Return to n = 1.

h) Click on the right pointing arrow next to Wavefunction.

i) Immediately above the words Energy Level in the bottom row of the page, you will see two green boxes. You should be able to click on the right-most of the two boxes. This should display a green curve that looks the same as the bottom graph displayed under Wavefunction. Change to n = 2, n = 3, n = 4, and n = 5 and you should see the various curves and graphs change shape. Do you notice any connection between the graphs and their associated level number?

j) Return to n = 1.

k) What do these graphs represent? You might have noticed the flickering green dots. These green dots represent repeated measurements of the position[1] of the electron that is trapped in the box of length L = 2.524 nm. It might be hard to see what the flickering dots have to do with the green curve, though some of you might notice the association. To help make the association more clear, click on the Accumulate button, and leave it turned on for about 2 seconds (turn it off by clicking on it again).

l) Go to n = 2, and turn on the Accumulate button for about 2 seconds. Repeat for n = 3, n = 4, and n = 5.

4. Cloud Chamber

a) Go to http://www.kcvs.ca/site/projects/physics_files/cloudChamber3/cloudchamber.swf and click start, and close the Instructions window.

b) Observe for a short time.

c) Click on Options, then Decay, and work your way through Beta, Pair Production, Alpha, Kaon, Neutron, and Random.

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[1] We might think of this either as measuring the position of the electron and then re-setting the system and measuring again, very rapidly, or we might think of this as having many identical boxes and measuring the position of the electrons in each box.