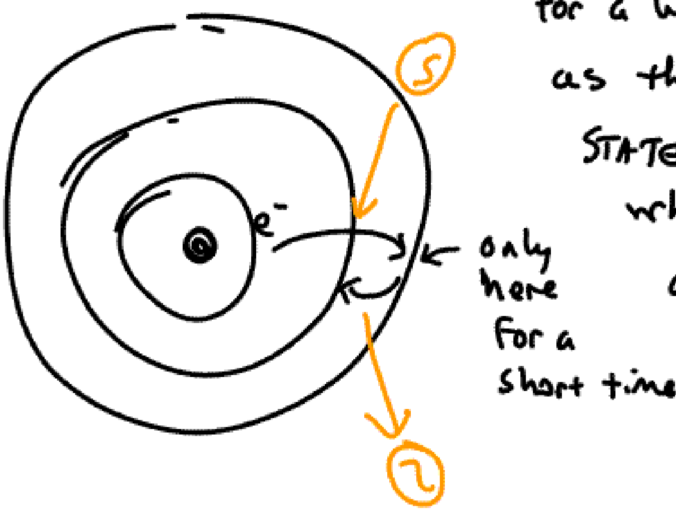
Physics 102 - Fall 2009 - Recitation 6

① How well can you measure the speed of an electron in a hydrogen atom (in principle)?

Hint: The size of the atom is $\sim 10^{-10}$ m

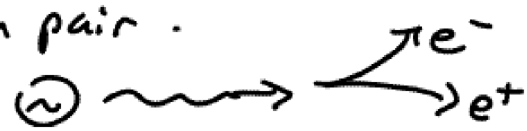
② Most excited STATE orbitals in an atom only exist for a very short Time (known as the lifetime) before the STATE decays emitting a photon while the e^- jumps to a lower energy orbital.



What does Heisenberg's uncertainty Principle tell you this will do to the color of the emitted photon?

Radiation such as α, β and γ rays are potentially harmful to living things because the $\alpha/\beta/\gamma$ particles can ionize (rip apart) the molecules in human tissue, killing cells and causing long-term DNA damage. If the radiation dose is high enough the cell damage can kill the living thing. If the damage is not that severe, the DNA damage can lead to cancer and/or birth defects many years later.

Only particles that are charged can cause ionizing damage as they pass through tissue. The larger the electrical charge of the ionizing radiation, the heavier is the ionizing damage and the shorter the range of the radiation in the material. γ-rays pass harmlessly through materials except when they pair-produce into an electron-positron pair.



This is what happens to γ-rays when they eventually interact with matter.

α particles can be stopped by a sheet of paper.

β particles are stopped by the outer layers of skin.

γ-rays can pass through living tissue and other materials. Typically they are stopped by a thick layer of lead.

(3) If I told you that you had to spend the night sleeping in a bed laced with an α source, a β source or a γ source ... which would you choose? Why? (Assume similar activities for the sources)

(4) Suppose you had 3 stupid friends...

Friend 1 drinks a glass of water laced with an α source.

Friend 2 " " " " " " β source.

Friend 3 " " " " " " γ source.

Assume similar activities for the materials in the drinks.

Which friend should you be most worried about? Why?

In quantum mechanics we usually cannot predict the outcome of a single measurement, but we can often predict the correct average of many measurements.

(5)

Quantum Dice 1 :

Do in groups of 2 to 4

One person (The experimentalist) should toss a single die 48 times keeping track of the values on top face of the die for each toss.

A different person (the oracle) should move where they cannot see the die being thrown and they should predict the value seen for each of the 48 throws and record their predictions

How often does the oracle correctly predict what the experimentalist measures?

How often would you expect the oracle to get it right just due to random luck?

How much variation is there among all the oracles in your section in terms of the number of correct predictions they make?

What is the average value of all the measurements made by the experimentalist?

What would you expect to find for the average value of all 48 measurements?

(6) Quantum Dice 2:

Do in groups of 2 to 4

Throw two Dice sequentially 50 times. When the 1st Die comes up as a one or a two, record the value of the second die.

Compare the distribution and average values of your measurements with what you observed in the Quantum Dice 1 exercise.

What do you see from this comparison?

Now repeat the exercise ... but instead of throwing the second die take as your measured value the number on the bottom face of the first die (remember ... only take those where the 1st die comes up one or two). Compare the distribution and average of your measurements with what you saw earlier.

Can you explain the difference you see?

How might this situation be similar to what is meant by "quantum entanglement"?