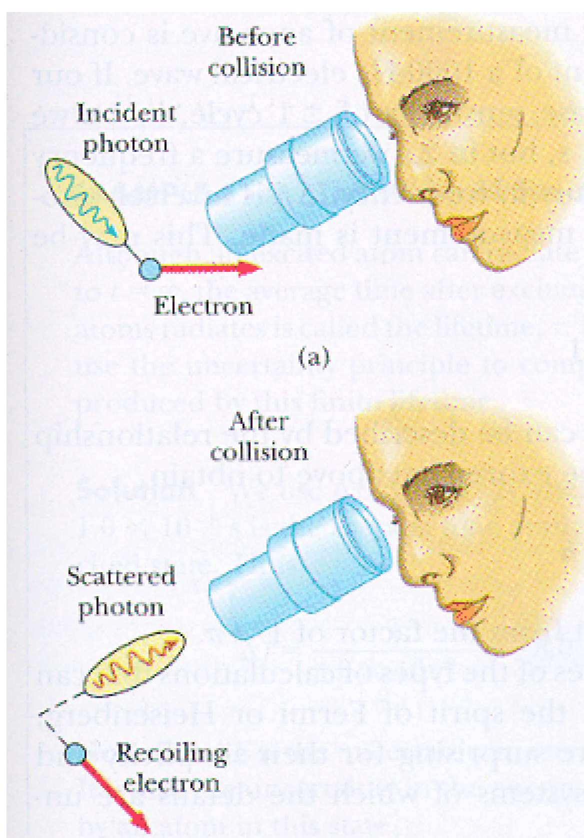
Determining the Position and Velocity of an Orbiting Electron:
Without Directly Altering the Quantum State

By: Joseph Rees (Original Thought in 1990)

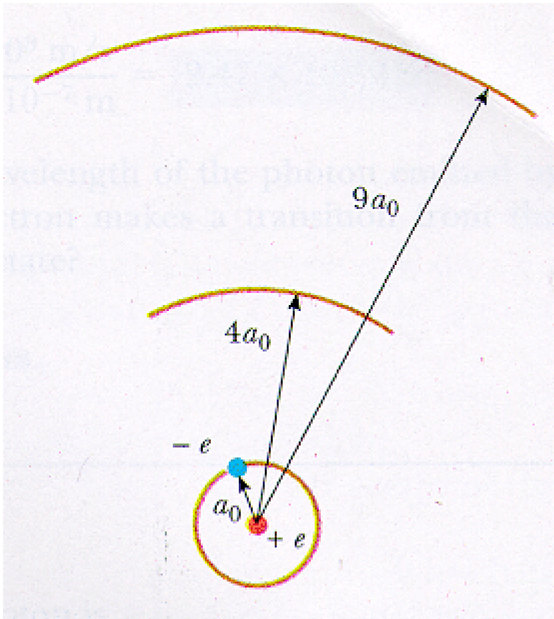
The Uncertainty Principle:

In 1927, Werner Heisenberg introduced the indeterminacy principle, or more commonly known as the uncertainty principle. It appeared in a paper showing how to interpret matrix mechanics in terms of the more familiar concepts of classical physics. Heisenberg proved that if x is the position coordinate of an electron (in a specific state), and p is the momentum of that electron, and that each have been independently measured for many electrons (in the specific state), then: {delta}x {delta}p >= h/2 where {delta}x is the precision of x, and {delta} p is the precision of the momentum coordinates, and h is Plank's constant (6.626176* 10 (sup -27)erg-second). Quantum Interdependency in layman terms, this means that it is physically impossible to measure both the exact position and the exact momentum of a particle at the same time. The more precisely one of the quantities is measured, the less precisely the other is known. Because of the small value of h in everyday units, this principle is only significant on the atomic scale. It is important to note that the uncertainties of {delta} x and {delta} p arise from the quantum structure of matter, and are not due to imperfections in the measurement instruments. One experiment introduced by Heisenberg, which helps clarify this idea, is shown through the following illustration. To see an electron, and thus determine it's position, you might use a powerful light microscope. For the electron to be visible, at least one photon of light must bounce off of it, and then pass through the microscope into your eye. A problem occurs here, as the photon transfers some unknown amount of its momentum to the electron. Thus, in the process of finding an accurately position of the electron (by making {delta} x really small), the same light that allows you to see it changes the electron's momentum to an undeterminable extent (makes {delta}p very large).



Bohr’s Atomic Model Questioned:

According to this Theory, Bohr’s model of the atom is incorrect.



Bohr's model of the hydrogen atom assumes that the electron in the ground state moves in a circular orbit of radius (r) 0.529*10^-10 m, and the speed of the electron in this state is 2.2*10^6 m/s. Given the exact radius, the uncertainty {delta}r in this model is zero. According to the uncertainty principle, the product, {delta} p{delta}r >= h/2, where {delta}p is the uncertainty in the momentum of the electron in the radial direction. Because the momentum of the electron is mv, we can assume that the uncertainty in its momentum is less that this value. That is, {delta}p < mv = (9.11*10^(-31)kg)*(2.2*10^(6) m/s) = 2.0 *10 ^(-24) kg*m/s From the uncertainty principle, the estimated minimum uncertainty in the radial position would be: = h/ (2{delta}p) = 0.26*10^(-10)m The uncertainty in position is so close to the size of the Bohr radius, thus proving that the Bohr model is incorrect. Right?

Einstein Does Not Approve:

The Heisenberg uncertainty principle states that it is impossible to measure either the velocity or position of an electron without disturbing the actual state of the secondary property. In other words, measuring the velocity changes the position and vice versa. From this idea sprang the concept of Quantum Mechanics. Einstein stated that this idea was false and that “God does not play dice with His universe. There is an answer, we just have not found it yet.”

Theory:
A measurement device that is fine-tuned enough to balance its own reaction will not interfere with any measurement. Borrowing from Newton, every action produces an equal and opposite reaction. If a measuring device were capable of determining position through the use of a pair of projectiles of equal velocity and opposite direction, striking at exactly the same time, it could measure the object without interfering with the objects properties.

Device:
A pair of electron lasers could be aligned to be equal and opposite by using the interference pattern developed by direct opposition. This pattern should be tuned using the superposition principle of wave interference, without serious difficulty. At the point of direct interference in the exact center, an atomic particle stream of varying types would be projected on a perpendicular plane. This vector interception would result in a measurement of the exact position of the electrons, which intercept the electron laser configuration. This measurement would neither effect the position or the velocity of the particle stream.

(See Newton's Law of equal and opposite reactions.) The electron-measuring device would simply cancel its own ability to alter the properties of the measured atom (electron).

Analogy:
A billiard ball is rolled across a billiard table. A second white ball is fired at the first ball in order to measure the velocity or position of the first ball. The white ball would surely alter the resultant velocity of the ball, while ascertaining the balls current position. (Figure 1) Consider the second case, where two white balls are fired in exactly the opposite direction and timed to meet the first ball simultaneously. The momentum of the two white balls will cancel one another upon impact, but still giving the measurement of position (like a radar sweep), but will in no way effect the outcome velocity of the ball being measured (Figure 2).

Figure 1

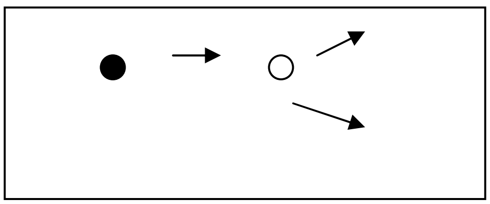


Figure 2