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# How Electrons Behave in an Atom

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**Abstract:** ***For a long time, electron revolving around the atom was an accepted idea that was formulated by Bohr. It later became known that the "planetary model" suggested by Bohr was not true. Now, electrons are assumed to be "clouds" which is a concept derived from their probabilistic location. This is true but electron does exist as a single entity in the nucleus and just their position (that we get form their clouds) does not give information about how the electrons act in the atom. The proposed hypothesis tells how electrons actually behave in an atom and the result of what happens due to its behavior.***

## 1. Introduction

Electrons in an atom are attracted to the proton due to the electrostatic force. Electrons that are in the closest shell of the atom experience greater force of attraction towards the nucleus of the atom. The electrons are attracted by the nucleus and thus gain kinetic energy while moving towards the nucleus. As they are already in the lowest orbit, the potential energy lost while moving towards the nucleus is very low.

## 2. Hypothesis

Electrons repeatedly collide with the nucleus just like a ball collides with the ground that is dropped from a certain height. And just like how the ball bounces back, electrons bounce back the same way. However, if the electron comes to a halt after it hits the nucleus, it will interact with the proton in the nucleus to form a neutron. This also obeys the uncertainty principle as we cannot know where the electron would exactly be during its interaction with the proton in the nucleus. The electron collides with a quark of a proton in the nucleus and uses its energy to push the quark away from the other quarks which results in the formation of more quarks and anti quarks which forms the neutron and an anti-neutron. The proton that the electron collides with is again reformed. The electron must have high energy to push the quark away. The formed neutron sticks with the nucleus due to the strong nuclear force. The strong nuclear force acts on the anti-neutron as well so it can annihilate by interacting with the formed neutron. But if the anti-neutron leaves the nucleus (which depends on the energy of the electron before collision), the newly formed neutron remains in the nucleus and the atomic mass increases. Both the formed particles may leave the nucleus as well (the energy of the electron just before it hits the nucleus must be very high). Another case to consider is that the neutron may leave the nucleus and the anti-neutron may fall back in the nucleus but if this case continued to happen, the atom would lose the neutrons and electrostatic force of the protons would dominate and the nucleus would split apart. The aforementioned phenomenon does not happen which means that strong nuclear force exerts more force on neutron than it does on anti-neutron. The interaction of proton and electron does not occur continuously as photons interact with the electrons and excite them into higher orbital or bump them out of the atom. If the neutron number in the nucleus becomes high enough, the neutrons undergo decay to achieve stability.

Excellent example of this phenomenon is every element with high proton number. There is higher force of attraction between the nucleus and electron in the atom and electrons that are at the lowermost orbital repeatedly interact with protons to form neutron and anti-neutron in the nucleus. The electrons have a probabilistic distribution to be in that space because of their interaction with the nucleus. Every element in nature has isotopes because of this very reason. Electron constantly bouncing off of the nucleus and fusing with protons increases the neutron number. But the neutrons in the atom undergo decay due to instability in the nucleus. This is why all the elements have a high number of isotopes but only some are stable. In Protium atom, only one electron and one proton are present. So, the electron can easily fuse with the proton to produce a neutron and an anti-neutron. But deuterium is not found abundantly as there is less electrostatic force between the electron and proton in the hydrogen atom and the electron cannot gain enough energy to push the quark away.

Two electrons are in the S orbital of the atom. Suppose the nucleus of the atom is stationary. Both the electrons are considered to not interact with a photon during the entire interaction.

1) fep(1) $=\frac{kq1q2}{r1^\wedge 2}$

2) fee(1) $=\frac{kq1q3}{r2^\wedge 2}\times$cosβ1

3) fee(2) $=\frac{kq1q3}{r2^\wedge 2}\times$cosβ2

4) fee(3) $=\frac{kq1q3}{r2^\wedge 2}\times$cosβ3

5) ) fee $=\frac{kq1q3}{r2^\wedge 2}$

k is the coulomb constant. q1, q2 and q3 are the charges of the electron closer to the nucleus, nucleus and another electron in the shell further from the nucleus respectively. r1 is the distance from electron with "q1" charge to the center of nucleus. r2 is the distance between the two electrons in the nucleus. B1, β2 and β3 are the angles made by the electrostatic force of electron (with "q3" charge) with the x-axis, y-axis (direction towards the nucleus) and the z-axis of the electron (with "q1" charge) respectively. The axes are taken with respect to the nucleus.)

L1= $\frac{\mu}{4\pi}\times\frac{q3\times v1(initial)}{r2^\wedge 2(initial)}\times sin\alpha 2(initial)$

L2= $\frac{\mu}{4\pi}\times\frac{q2\times v2(initial)}{r1^\wedge 2(initial)}\times sin\alpha 1(initial)$

L3= $\frac{\mu}{4\pi}\times\frac{q2\times v2(final)}{r1^\wedge 2(final)}\times sin\alpha 1(final)$

L4= $\frac{\mu}{4\pi}\times\frac{q3\times v1(final)}{r2^\wedge 2(final)}\times sin\alpha 2(final)$

µ is the permeability of free space. L1, L3, L4 and L2 are the magnitude of magnetic fields. v1, v2 are the velocity of electron with "q3" charge, nucleus respectively. Since the nucleus is also affected by the electrostatic force it gains some velocity. Initially the nucleus was considered to be at rest. $\alpha 1$ *and* $\alpha 2$ are the angles r1 makes with v2 and r2 makes with v1 respectively.

6) M (1)=$-\alpha 3 \times L3$
7) M (2)=$-\alpha 3 \times L4$
8) M (3)=$-\alpha 3 \times L1$
9) M (4)=$-\alpha 3 \times L2$

M (1), M (2), M (3), M (4) are the magnetic potential energy. $\alpha 3$ is the magnetic moment of electron with "q1" charge.

10) s1x =s1 ×cosβ4
11) s1y =s1 ×cos β5
12) s1z =s1 ×cosβ6
13) s2y=s2×cosβ7

s1 is the displacement of the electron with "q1" charge. B4, β5, β6 is the angle that the displacement makes with the x-axis, y-axis and z-axis of the electron with "q1" charge respectively. Again, the axes are taken with respect to the nucleus. The displacement towards the nucleus (y-axis) is taken as positive when considering the displacement "s1".s2 is the displacement of the nucleus due to the electrostatic force. β7 is the angle between vertical of the nucleus (which is the same as y direction axis of electron with "q1" charge) with s2.

W2=$\int_0^e fep(1)(s2y)\, ds2y$
W3=$\int_0^f fee(s3)\, ds3$

Fep(1)is taken as a function of s2y and fee is taken as a function of s3. W2 and W3 is the work done by the electron with "q1" charge on the nucleus and the other electron in the shell respectively. f is the final total displacement of the electron with "q3" charge and is ***dependent*** on when the electron with "q1" charge is just about to hit the nucleus. e is the total displacement of the nucleus in the y-direction. The forces and displacement must be taken as positive while solving the above equations.

14) P=$\int_0^a fee(1)(s1x)\, ds1x$
15) Q=$\int_0^b fee(2)(s1y)\, ds1y$
16) R=$\int_0^c fee(3)(s1z)\, ds1z$
17) S= $\int_0^b fep(1)(s1y)\, ds1y$

The forces are taken as function of displacement of electron (with "q1" charge) in different axes. Consider the electron (with "q1" charge) to be in (0, 0, 0) during the initial time of interaction. a, b, c is the displacement in x-axis, y-axis and z-axis respectively from (0, 0, 0) of the electron with "q1" charge. Here, the forces in y-direction (that act towards the nucleus) must be considered positive.

18) W1=P+Q+R+S

W1 is the total work done on the electron with "q1" charge. All the work done components are the dot products of the force and displacement vectors.

19) Final M.E. –Initial M.E. = W1-W2-W3

Initial M.E. is the mechanical energy of the electron with "q1" charge as soon as it starts interacting with the other electron and final M.E. is the energy of the electron with "q1" charge just before it hits the nucleus.

Final M.E.=$\frac{1}{2} \times m \times v4^2 + \frac{kq1q2}{d} + \frac{kq1q3}{r2(final\ )} + M(1) + M(2)$ Initial M.E.=$\frac{1}{2} \times m \times u^2 + \frac{kq1q2}{r1(initial\ )} + \frac{kq1q3}{r2(initial\ )}$+M(3)+M(4)

m is the mass of the electron. v4 is the velocity of the electron with "q1" charge just before it hits the nucleus. u is the velocity of the electron with "q1" charge as soon as it starts interacting with the other electron. d is the radius of the nucleus.

*W=W1-W2-W3

Rearranging (19) gives:
Final M.E. = W+ Initial M.E.
Adding rest mass energy on both sides,

20) Final M.E. +$mc^2$=W + Initial M.E. +$mc^2$

which is the total energy of the electron with "q1" charge just before it hits the nucleus. Comparing (20) with the energy-momentum equation of Paul Dirac:

Final M.E. +$mc^2$=W + Initial M.E.
+$mc^2$=$\sqrt{\{m^2c^4 + p^2c^2\}} + N$ (p= momentum, N=Potential energy)

Thus p is the momentum for the electron (with "q1" charge. If p=momentum transferred to the nucleus (mass of electron or a neutron must be included with the original mass of nucleus as it will depend upon the fact if the neutron formation is instantaneous); then after the interaction the momentum of electron with "q1" charge is 0 (conservation of momentum), so the electron has fused with the proton to form the neutron (if anti-neutron escapes the nucleus).Elastic collisions may occur as well.

## 3. Proposed Experiment

An atom of Calcium can be constantly monitored for any changes in its mass. According to the hypothesis, neutron must be formed even if the atom is isolated. Anti-neutron may annihilate with the neutron or escape the nucleus. After the neutron is formed, the atom will gain another electron to be stable. But due to instability in the nucleus, the neutrons in the nucleus undergo decay. So, the atom must constantly be monitored. Calcium is a suitable choice as it has many stable isotopes and its proton number is very close to its neutron number so the nucleus will decay only after a suitable time interval which can make it easier to detect the mass changes than if a random element was chosen.

## 4. Conclusion

It is a simple approach taken to explain the way electrons behave in the nucleus. It gives us an insight as to how the electrons interact in the nucleus. This hypothesis can also explain why the electrons always have a probability that represents their position and are not found in a fixed location around the space of an atom and is also reasoning for why the elements with high atomic number have a lot of neutrons in their nucleus.

## 5. Future Scope

It gives us further understanding of the nature of electrons which may even help explain the true nature of leptons.