NOVATEUR PUBLICATIONS
International Journal Of Research Publications In Engineering And Technology [IJRPET]
ISSN: 2454-7875
VOLUME 2, ISSUE 11, Nov. -2016

PAPER: NATURE OF COUPLING BETWEEN NUCLEUS AND ELECTRONS IN THE FORMATION AND STABILITY OF ATOMS.

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INTRODUCTION:

In order to explain observed exceptional stability of atoms and discreet line spectra of elements, Bohr postulated the existence of statutory orbits in which electrons are supposed to move around the nucleus, without emission of electromagnetic radiation as demanded by classical electrodynamics, but counterbalancing the pull towards the nucleus due to coulomb attraction by the centrifugal force in agreement with classical mechanics.

The apparent anomaly in rejecting the result of classical electrodynamics, but retaining the principle of classical mechanics in Bohr's Postulate of so called stationary orbits can be traced to the assumption that only forces of electrical attraction operate between positively charged protons in the nucleus and the negatively charged electrons outside it. Due to such assumption, there arose the need to postulate the operation of equal and opposite centrifugal forces due to motion of electrons in agreement with the laws of classical mechanics, counter balancing coulomb attraction towards the nucleus and at the same time, not to obey the result of classical electrodynamics which predicts loss of energy by an accelerated electron which would result in motion of electron along spiral trajectory with decreasing radius ultimately leading to the collapse of the atom.

NATURE OF COUPLING AMONG THE NUCLEUS AND THE ELECTRONS:

In order to account for strong attractive nuclear force among nucleons overcoming coulomb repulsion among protons and binding both positively charged protons and neutral neutrons in a compact nucleus, the concept of exchange of charged and neutral pi-mesons or pions by protons and neutrons among themselves was proposed by H. Yukawa[1] in 1935.

Following the same line of reasoning, it is evident that the force of interaction between nucleus and electrons may arise due to exchange of same particles.

For investigation into the type and properties of such particles, a number of similar features between strong nuclear forces and binding forces operating among the nucleus and electrons in an atom are to be noted.

Firstly, like nuclear forces, forces operating among electrons and nucleus in the atom are non-central or tensor forces depending partly on the spin orientation of the nucleons and electrons.

Secondly, like nuclear forces, such forces display the property of saturation, manifested in the formation of the chemical bonds between valence electrons in atoms due to their strong tendency to attain electronic configuration of inert gases like helium, neon, argon, krypton, xenon, etc. in the atoms of which saturation of such exchange forces is practically complete resulting in absence of any compound formed by such gaseous elements with a few exceptions like xenon hexafluoride, etc. In the absence of saturation, an indefinite number of electronic configuration resulting in the formation of an indefinite number of bonds would be possible.

Thirdly, like inter-nucleon forces, such forces operating among the nucleus and electrons act over short ranges.

All the three features mentioned above strongly point to the exchange character of the forces operating among the nucleus and electrons in the atom.

Rough estimates can be made about energy, momentum and mass of a particle exchanged among nucleus and electrons, using Heisenberg's uncertainty principle.

If ΔE, Δp and m_{ex} are uncertainties in energy and momentum respectively of nucleus and electrons, m_{ex} be the mass of the particle exchanged, then

$\Delta p.\ \Delta x \approx h/(2\pi)$, whence $\Delta p \approx h/(2\pi.\ \Delta x) \approx 10^{-24}$ Kg.m.s^{-1}.

$\Delta E.\ \Delta t \approx \Delta E.\ (\Delta x/c) \approx h/(2\pi)$, whence $\Delta E \approx 10^{-16}$ J $\approx$ 2 KeV.

$m_{ex} .c^2 \approx \Delta E$, whence $m_{ex} \approx 10^{-33}$ Kg, whence h = 6.63 X 10^{-34} J.s & c = 3 X 10^8 m.s^{-1}

and Δx = distance over which the particle travels inside the atom.

Thus, the mass of such a particle should be about one hundred times lesser than the rest mass of electron. Recent investigations carried out during 2009-2014 predict a value of the order of 10^{-36} Kg for the rest mass of neutrino[2,3 & 4].

The value of the order of 10^{-33} Kg for the mass m_{ex} of the exchange particle estimated above is obtained by assuming that the particle travels with speed very close to c, the speed of light in free space, so that the value of Lorentz Factor multiplying its rest mass should be high.

After Pauli's prediction of the existence of neutrino in 1930 in order to account for conservation of energy and momentum in the process of β decay in natural radioactivity, three types (colours) of neutrinos have been identified – namely electron, muon and tau types. Each type of neutrino belongs to lepton family being affected by weak interaction or electro-weak interaction, is a Fermion with half-integral spin and has its own anti-particle. The types are capable of transforming into one another (colour change) during flight.

CONCLUDING REMARKS:

The present view is that nuclear exchange force is a secondary or "spillover" effect of the strong force which binds quarks to form neutrons and protons. It is also suggested that the electron, too, has a complex structure, its central core being surrounded by a system of shells formed by protons, electron-positron pairs, pi-mesons, nucleon-antinucleon and the likes. Therefore, following the same line of reasoning, it is evident that the force of interaction between nucleus and electrons may arise due to exchange of some particles, like electron type neutrino and anti-neutrino pairs, resulting from weak force which is now recognized as a form of electro weak force and dominates over coulomb forces of attraction between unlike charges within the atom. As the protons and neutrons are baryons, while electrons and neutrinos are leptons, such intra-atomic exchange forces must obey the principles of conservation of baryon and lepton numbers in addition to the laws of conservation of energy, momentum, angular and spin momentum including Pauli's exclusion principle for Fermions.

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