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Equation of Weak Nuclear Force

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Abstract

We present new approach and new equation of treating and calculating weak nuclear force depends on the main physical parameters responsible of forming the weak force. The nucleons (protons & neutrons) with certain masses (1.7×10^{-27} kg) of each particle at very short certain distance (10^{-17} m - 10^{-18} m) is main condition of producing weak nuclear force. So, the weak nuclear force can be calculated by using the two main physical parameters responsible for its existence (mass, distance) in addition to the time of ejecting the particles and radiations from nucleus to enable an unstable nucleus to become energetically stable nucleus which is the main role of the weak nuclear force. The calculated value of weak nuclear force for two nucleons (proton & neutron) to be 3×10^{-5} Newton and consequently the weak nuclear force with increasing number of nucleons is linearly additive as binding energy of atomic nucleus.

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Abbreviations

EWT - Electroweak Theory

QFD - Quantum Flavordynamics

QED - Quantum Electrodynamics

Introduction

The weak nuclear force is a fundamental force in the universe which represents the interaction between nucleons (protons & neutrons) within nucleus and is responsible for radioactive decay of atoms. The weak nuclear force permits neutrons to transform into protons and protons to neutrons during beta decay to keep stability of the nucleus during period of time ranging from small fraction of seconds to many years. This process leads to suggest the neutrino existence for agreement between experimental results with momentum and energy conservation.[1,2]

The first hypothesis or theory of the weak interaction was proposed by Fermi, known as Fermi interaction which is an interpretation of beta decay. The theory

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suggests that the interaction of four fermions involving contact force with no range.[3,4] This interaction interprets beta decay of a neutron by direct coupling of a neutron with an electron, a neutrino and a proton. The Fermi interaction represents a first attempt to the theory of weak interaction where the interaction between proton – neutron and electron – antineutrino is mediated by a virtual W- boson of which the Fermi hypothesis is considered as the low – energy effective field theory.[5] The spin of particles in weak interaction violating law of conservation and symmetry.[6]

Higgs suggested the generation rule of the characteristic mass for gauge bosons.[7-10] The weak nuclear force is only effective at very short distances less than femto meter.[11] Fermions exchanging three types of carries of force, W^+, W^- and Z bosons in weak interaction. The masses of bosons are greater than the proton and neutron mass. The weak nuclear force is described by Electroweak Theory (EWT) which is also called Quantum Flavordynamics (QFD).[11-15]

The case for the minimal model of the symmetry spontaneous breaking for the weak interaction $SU(2)\times U(1)$ is interpreted without the mass for W and Z bosons.[13] Weinberg and Salam applied the Higgs mechanism to the $SU(2)\times U(1)$ gauge theory with unification of the weak and electromagnetic interactions.[14,15]

Materials and Methods

Physical Foundations

The Physical equations and physical principles can be formulated in terms of the physical parameters responsible for their source and origin. All fundamental forces (gravitational force, electromagnetic force, strong force) are produced as a result of existing certain masses at certain distances.[16,17] The weak nuclear force is acting only at distance (10^{-17} m - 10^{-18} m) between nucleons (protons & neutrons). The main role of weak nuclear force is ejecting certain particles and radiations in certain time from nucleus to become stable.

The weak interaction is mediated by gauge bosons $W^{\pm}$ beginning with massless. The Lagrangian for the theory contains terms for massless electrons, muons and neutrinos and is invariant under an internal symmetry group, which is a gauge symmetry. The Higgs field is then introduced with a non-vanishing vacuum expectation value. The resulting spontaneous symmetry breaking gives masses to e, μ and τ and to the gauge bosons, but not to the photon and neutrino. The W bosons were first observed in 1983 in high energy experiments on the CERN pp^- collider where protons and antiprotons collide with a total center of mass energy of 540 GeV. Such a collision leads to a quark and an antiquark combining to form a W boson which may decay via the weak interaction.

Results and Discussions

The modern theory of weak interaction is constructed in analogy with Quantum Electrodynamics (QED), this means that intermediate boson vector is exist. It is known from the experiments that the total energy including both kinetic energy and potential energy of the weak interaction contains charged currents. Therefore, a theory of weak interaction should start with a gouge theory containing fields of charged particles.[18,19]

The mass of nucleons (protons & neutrons), distance between them and the time of ejecting particles and radiations can be connected in the following equation expressing the weak nuclear force

$$F = \frac{m \times d}{t^2} \quad \text{...(1)}$$

$$F = \frac{(m_1 + m_2) \times d}{t^2} \quad \text{...(2)}$$

where
F is the weak nuclear force in N
m is the sum of masses (m_1 + m_2) of any two nucleons in kg
m_1 is the mass of the first particle in kg
m_2 is the mass of the second particle in kg
d is the distance between any two nucleons in m
t is the time of ejecting particles and radiations

By using equation (2) for two nucleons (proton & neutron) with total mass of 3.4×10^{-27} kg, distance 10^{-18} m and the time of ejecting particles and radiations from nucleus in the range of 10^{-20} s, it is found that the value of weak nuclear force to be 3×10^{-5} N. According to the calculations and results by increasing the number of nucleons (protons & neutrons), the weak nuclear force is linearly additive as binding energy of atomic nucleus.

The above calculations and results mean and indicate that the chain of physical processes and nuclear transmutations in converting one chemical element to another element such as the transformation of protons into neutrons and vice versa inside the nucleus of an atom in certain period of time from small fraction of second to many years to permits unstable nucleus to become stable nucleus.

Conclusion

The weak nuclear force is produced as a result of existing nucleons (protons and neutrons) at very short distance (10^{-18} m). The main role of weak nuclear force is keeping the balance of protons and neutrons in a nucleus and can be calculated with main physical parameters (masses of any two nucleons, distance between them and the time of ejecting the particles and radiations). Increasing number of nucleons inside nucleus leading to an increase in the value of the weak nuclear force, this means that this force is linearly additive as binding energy of atomic nucleus.

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This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions

- **M.R. Sanad:** Conceptualization, Methodology, Writing – Original Draft, Analysis, Writing – Review & Editing.

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