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Nuclear Force

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ABSTRACT

It is well established that the forces between nucleons are transmitted by meson. The quantitative explanation of nuclear forces in terms of meson theory was extremely tentative & in complete but this theory supplies a valuable point of view . it is fairly certain now that the nucleons within nuclear matter are in a state made rather different from their free condition by the proximity of other nucleons charge independence of nuclear forces demand the existence of neutral meson as amongst the same type of nucleolus (P-P) or (N-N). this force demand the same spin & orbital angular momentum. The exchange interaction in produced by only a neutral meson. The involving mesons without electric charge, that it gives exchanges forces between proton & Neutron & also therefore maintains charge in dependence character. It is evident for the nature of the products that neutral mesons decay by strong & weak interaction both. It means that neutral mesons constituents responsible for the electromagnetic interaction. Dramatically neutral mesons plays important role for electromagnetic & nuclear force both.

Keywords: *Rest mass energy, Mesons, Differentiation, velocity of light*

INTRODUCTION

It is well established that the forces between nucleons are transmitted by meson. The quantitative explanation of nuclear forces in terms of meson theory was extremely tentative & incomplete, but this theory supplies a valuable point of view. Yukawa first pointed out that nuclear force can be explained by assuming that particle of mass about 200 times the electron mass(mesons) exist & can be emitted & absorbed by nuclear particles(neutrons & protons) with such an assumption a force between nuclear particles is now obtaining.

Now we have the rest mass energy = $m_0 c^2$

Differentiating with respect to r (Inner radius at which nuclear force comes into play)

$$\frac{d(m_0c^2)}{dr} = \frac{c^2dm_0}{dr} + \frac{m_0d(c^2)}{dr} = \frac{c^2dm_0}{dr} + m_o \frac{d(c^2)}{dc}\frac{dc}{dr}$$

$$= \frac{c^2dm_0}{dr} + \frac{2m_0c.dc}{dr}$$

This force is short range, attractive & along the line joining the two particles (central force).(The wide success of this first application of quantum mechanics to nuclear phenomena gives us confidence in general use of quantum mechanics for the description of the force between heavy particles in nuclei.

Where dm_0c^2 = either rest mass energy of π^0 mesons(For neutral theory),or rest mass energy of π^+, π^- & π^0mesons(for symmetrical theory)

dm_0 =either mass of π^0 mesons or mass of π^+, π^-& π^0 mesons

m_0 = mass of nucleons

m_0cdc = rest mass energy of nucleons

dr= Range of nuclear force, which can be calculated from differentiation of Nuclear radius.(The force between two nucleons is attractive for distance r(radius) greater than dr (range) & is repulsive otherwise).This strongly suggests & is well proved that to some degree of approximation the total isotopic spin T is a constant of the motion & is conserved in all processes, at least with a high probability.

dc= The average velocity of neutron & proton. A large velocity is used in nuclear disintegration.

c = Velocity of light

2 = multiplicity of interacting particles is given by (2T+1), the isotopic spin has no such meaning for leptons or a gamma rays

1 = either multiplicity of π^0 mesons or π^+, π^- & π^0 mesons (evidence of involving of mesons (all type)

Where T= Vector sum of isotopic spin of proton & proton, neutron& neutron, neutron & proton The success of these applications supplies additional support for the hypothesis of the charge independence & charge symmetry of nuclear force. As the nuclear interactions do not extend to very large distances beyond the

nuclear radius & this character is useful to solve the problem. The Full charge independence for any system in which the number of neutrons equals the numbers of protons, this formula give the evidence the charge symmetry, merely means that the neutron-neutron & proton proton interaction are equal but says nothing about the relations of neutron proton interaction to others. Nuclear forces are symmetrical in neutrons & protons. i.e. the force between two protons are the same as those between two neutrons. This identity refers to the magnitude as well as the spin dependence of the forces.

Now we can see the following reaction

$P+ P\text{-----}P+P+\pi^0$
$P+N\text{-----}P+N+\pi^+$
$N +P\text{-----}\ N+P + \pi^-$

These reactions are soon as $Y + P$ -- $P + \pi^0$

$P + P$ --- $P + P + \pi^0$
$P + N$ ----- $P + N + \pi^0$

It is found that only two assumptions are in agreement with theoretical & experimental facts, notably the equality of the forces between two like & two unlike nuclear particles in the singlet state. These assumption are either(1) that nuclear particles interact only with neutral mesons(neutral theory) or(2) that they interact equally strongly with neutral, positive & negative mesons(symmetrical theory). It is obvious that the part of the force which does not depend on the spin of the nuclear does not fulfill any useful function in the theory. The force between proton & neutron result from the transfer of positive meson from the former to the latter or a negative meson in the opposite direction. So their vector sum of component of isotopic spin of these particle must be zero.

The charges on charged mesons must be equal in their magnitude.

Charge independence of nuclear forces demand the existence of π^0 meson as amongst the same type of nucleons (p-p) or (N-N).This force demands the same spin & orbital angular momentum. Positive pions are not able to surmount the nuclear coulomb barrier & therefore undergo spontaneous decay while negative pions are captured by nuclei. The exchange of a pion is thus equivalent to charge exchange. we can think of nucleons as exchanging their space & spin co-ordinates In the neutral theory, therefore neutron & protons are completely equivalent & indistinguishable as far as the associated meson fields are concerned. Such particle decay into two gamma rays. These gamma rays are π^0 – rest systems are emitted in opposite direction & therefore spin π^0 must be Zero as the spin of photon is unity. It is evident from the nature of the products that neutral mesons decay by the electromagnetic interaction while charged pions decay by both strong & weak interaction. It means that neutral mesons constituents are responsible for the electromagnetic interaction. We know that neutron & proton can change into one another by meson capture. Protons &neutron can transform into each other by capture of positive & negative pion respectively, or get transformed into the same particle through neutral meson interaction. During these transformation either an emission or an absorption of meson is essential. The attraction between any nucleons can arise from the transfer of a neutral meson from one nucleon to the other. If the meson were assumed to be charged (positive or negative) the resulting force between nuclear particles turned out to be of the exchange type which had been successful in the interpretation in nuclear physics. The mesons must obey Bose statistics because they are emitted in the transformation of a neutron into a proton(or vise versa) both obey Fermi statistics.

Important point--

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1. *.Also, Strongly, The velocity of light depends upon the range of the nuclear force. The velocity of light equal like photons, lack mass & force carrying particle of other forces like strong force. Because the range is variable, the velocity of light must be variable. As, velocity of light= Range of nuclear force(distance travelled by meson)/ Life time of its resonance(this resonance is called the excited state of nucleon.It is clear that these resonance are produced for a short time & decay through strong interactions. In this relation we can see that the velocity of light must be variable. It is clear that the fundamental particles are not wholly independent, The neutron is observed to change spontaneously into a proton. Neutron decay takes on the average of some thousands seconds for free neutron, whereas within a nucleus the characteristic time between nucleon-nucleon collisions is 10^{-24} seconds. For a satisfactory picture it is often enough to think of the nucleus as a grouping of protons & neutrons interaction, with the appearance or disappearance of photons. It should be noted that this relation holds only inside the nucleus. Outside the nucleus the evidence is to the contrary. . From this formula we can find the nuclear force acts between the pair of nucleons & is not influenced by the presence of neighboring nucleons. It is necessary that any one particle must bring the velocity of light. We know that the nuclear force is short ranged. Outside of the range it is repulsive.

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*Range of nuclear force :- To show that the range of force is related to the mass of exchanged particle, It is assumed that the π^0-meson is contained virtually in a proton. If this virtual particle travels with the velocity of light as might be expected for a field particle, then the greatest distance the meson could travel in this time is also known as range of the pion exchange force.

1. It would seem that in a nucleus consisting of the many nucleons the binding energy per nucleon should increase with the increase of the mass number A . In reality evidence is to the contrary, The binding energy per nucleon decreases with the increasing mass number A, The binding energies of the different nucleon placed at various depths are not identical but depend upon the states of their actual binding in the potential well. The binding energies of the different nucleon placed at various depths are not identical but depends upon the state of their actual binding in the potential well. The range also depends upon mass number A & binding energy. The total rest mass energy also depends on the mass number A. For increasing of rest energy, we must increase the mass number A. obviously, the rest mass energy must be depend on the radial distance.

This is purely a quantum mechanical effect. If the mass number A increases the range decreases, & the force is stronger. This binding energy displays saturation effect. This property of the nuclear force can be explained in term of exchange nature of nuclear force. It should be noted that nucleons attract each other strongly only if they are in the same orbital state. This formula is prove the pauli hypothesis. This formula usually attributed to the effect of higher-order interactions in which two or more mesons are simultaneously transmitted between the nucleons.

2. We can find the effective range of nuclear force in terms of the Compton wave length of pi—meson. Evidently, if the meson interacted with nucleons strongly enough to be responsible for the nuclear force . The forces responsible for binding the individual particle inside the nucleus must therefore be exceptionally strong.If the particle has motion then the material body has physical significance otherwise not. It means the force between elementary particles depends on the velocity of the body as well as the mass of body. It can be remarked that the particles traveling with velocity of light are not conservable quantities. In quantum theory, every field must be quantized. These quanta produce a field, which is responsible for different forces.It is obviously thought that the nuclear force is due to its velocities of the particle either of mesons or nucleons which are arise from the tension of nuclear particles or elementary particles.

Of course, we see that those particles travels with velocity of light can be absorb or emitted & can effects the another particles. If the velocity of light is constant, then they can not be effected by another particles & medium. Like, gravitational constant, coulomb constant. The associated particles(intermediate particle) of all interaction will be depends on each other. After study of these particle we will find the unified theory, because all these p article travel with velocity of light.

3. The emission of a charged meson will be accompanied by a change of charge of the emitting nuclear particle, Thus a neutron can only emit a negative meson or absorb a positive meson & will thereby be transformed into proton. When we consider the emission of one meson by a nuclear particle & reabsorbion by another.It is obvious that in this way no force will be obtained between two nuclear particles of the same kind i.e. two neutrons or two protons. For the same kind of particles, there is a neutral meson responsible for interaction.This solution would make the interaction caused by neutral meson alone, Since for unlike particles the charged mesons gives an additional contribution, while for like particles they do not, the total interaction will not be the same for like & unlike particles in S-first state.This will lead to the forces between a neutron & a proton.The negative & positive charge & meson comes to close together, they can neutralize each other then the force between neutron & proton comes into play. So obviously we can say that only neutral meson plays an important role in charge independent nuclear force. The mesons(positive & negative) can be absorbed by the nucleus of an element or it may combine with another meson then the sum of the masses of these mesons are converted into energy. This process is called annihilation of matter. Before this process one positive meson & one negative meson unite to make neutral particles called k^0 meson.The process of mutual annihilation of the particles & anti –particles are important for the electromagnetic interaction * charge independent nuclear interaction. The process of construction & destruction has proved very helpful in considering the origin of the universe. The neutral K-- mesons is a stable particle but stability lasts for a small time. Its half life is of the order of micro seconds. This particle is an essential constituent of the nucleons of all elements.We know that neutral—meson decay into two photons & never into three photons. It is clear that the neutral pions have

been produced by bombarding hydrogen & deuteron with high energy photons. Gamma rays have sufficient energy to maintain the energy of nucleons then the nucleons produce the neutral mesons.One can speak of the meson field associated with a proton(or a netron) because the nature (charge) of the nuclear particle does not change by emitting or absorbing a neutral meson. It has helped develop a theory of nuclear forces in which neutral way the equality of the forces between like & unlike nuclear particles. operate the theory involves charged meson only giving no forces between two like nuclear particles. It is obvious that the negative meson & positive meson gave the symmetrical force between protons & neutrons & they interact equally strongly with these meson. An alternative way of explaining this equality is to assume interaction with neutral meson only. Then the charge of the nuclear particles(whether it is a proton or a neutron) becomes entirely irrelevant & the equality of forces follows immediately. If the particles are not at rest but are moving, the field will not only be can electric field but would be new one depending on the velocity & magnitude of the charge, when the charge is accelerated. The energy is radiated out in the form of an electric & magnetic pulses. The pulses is photon & travel with velocity of light. This plays important role in the capture of photon & can affect the production of mesons by an electromagnetic interaction. If the electromagnetic interaction are not occurs inside the nucleus then nuclear force has no meaning.

4. According to the pauli principle only two neutrons & two protons will be found in the same orbital state. Therefore it is possible to find four nucleons strongly bound or Alpha particle structure, also confirm by binding energy curve. The extraordinary stability of the alpha shows that the most stable nuclei are those in which the number of nucleons & photons are equal. We can find it from this formula. It is obviously thought that the full charge independence for any system in which the number of neutrons equal to the number of protons. From this conclusion, we get, Number of photons = number of nucleons= 2(number of neutral mesons).The discovery of the neutral meson & the fact that charge independence is now consistent with all nuclear data, confirm fully the use of the symmetric meson theory, containing positive, negative &neutral mesons described by three way wave functions. With the form of Yukawa potential for scalar mesons, it is easy to see that the pi-meson cannot be scalar. Obviously we can see that two pion exchange interaction predicts a spin orbit term.

Change of Law

Since there is no requirement for the conservation of Pions so there is any conservation law in rest mass energy & even in the universe. This formula shows that there is no meaning of the word' constant. There is no conservation law controlling the total number of K—aons or meson. The energy of formation of mesons comes from binding potential (which has the energy to formation of meson for a long time), but when this potential has not enough energy, the production of pions end & nuclear force does not exist.

*The life time of any radioactive substances depends on the total number of pions production and another particles production. pions are commonly formed in the decay of k—oans, hyperons & resonant states. It should be noted that pions are formed only at high energy.Becouse of their short life time of neutral mesons move only a few atomic diameters before they decay. It should be also noted that in the whole universe there is only mass will be conserved and energy will be destroyed, then the mass which will not change into the energy.

*It is enough to think that π- mesons which form a nuclear cloud around the individual nucleons & are in a virtual state get their requisite rest mass energy from the incident particle & are released from the nuclear binding potential. Nuclear binding potential compensate the rest mass energy. It produces enough energy to maintain the rest mass energy for production of mesons. Since the rest mass energy of π - mesons about 275 Me, the threshold energy for a gamma rays to produce the rest mass energy of these particles should be high. But, if protons projectiles are used to produce mesons, it requires a large threshold as a particle with mass retains some energy in the collision when they compensate the rest energy. The energy required to pull out the nucleons from the nucleus is less than half of rest mass energy. The slow motion neutron plays this role. Similarly if the nucleus brings (from binding potential) sufficient energy for the existing nuclear force. It maintains stability. In order to approach particle to within short range or closer the energy of the approaching particle should be very high.

*Since there is no limitation of formation of Mesons even in strong interaction. This is due to high energy photons (γ - rays) then this cyclic chain should be possible.

$$\pi^0 \rightarrow \gamma \text{ rays}$$
$$\gamma + d \rightarrow d + \pi^0$$

This reaction shows that the kinetic energy as well as potential energy of nucleon in the nucleus will be over and

above of the rest mass energy. In these phenomena the total charge of fundamental particles are conserved.

- It is reasonable to assume that the nuclear force between two protons has the same characteristic as that between neutron & proton. The argument about short range forces involves both proton- proton & neutron - proton forces. The main difference between proton & neutron seems to be the electric charge, & the nuclear force apparently does not arise from charge. We assume therefore that the potential between two protons is confined within some short range as before, although the value of range need not necessarily be the same.
- Finally-- some of the peculiarities of nuclear forces can be enumerated as follows—

a. short range character
b. Large strength, the nuclear potential energies are quite large.
c. Exchange character & saturate nature.
d. Dependence on spin
e. charge independence& charge symmetry

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