# Nuclear Force

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## Abstract

It is well established that the forces between nucleons are transmitted by mesons. According to the meson theory, the quantitative explanation of the nuclear forces was extremely tentative and incomplete. But this theory presents 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 nucleons (P-P) or (N-N). This force demands the same spin and the same orbital angular momentum. The exchange interaction is produced by only a neutral meson. The involving mesons without electric charge that it gives exchange forces between protons and Neutrons. Also therefore maintains charge independence character. It is evident for the nature of the products that neutral mesons decay by both strong and weak interactions. It means that neutral mesons’ constituents are responsible for the electromagnetic interaction. Dramatically neutral mesons play an important role for both electromagnetic and nuclear forces.

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

## Introduction

It is well established that the forces between nucleons are transmitted by mesons. According to the meson theory, the quantitative explanation of nuclear forces was extremely tentative and incomplete. But this theory presents a valuable point of view. Yukawa first pointed out that the nuclear force can be explained by assuming that the particle of the mass is about 200 times of the electron mass(meson) exists. It can be emitted or absorbed by nuclear particles (neutrons and protons). With such an assumption, a force between the nuclear particles is now being obtained.

Now, we have the rest mass energy = m0 c2

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



This force is short-ranged, attractive and along the line, joining the two particles (the 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 present in the nuclei.

Where dm0c2 = either rest mass energy of π0 mesons (for neutral theory), or rest mass energy of π+, π-&π0mesons (for symmetrical theory).

dm0 =either mass of π0 mesons or mass of π+ ,π-& π0 mesons.

m0 = mass of nucleons.

m0cdc = rest mass energy of nucleons.

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

dc= The average velocity of neutron and 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 gamma rays.

1 = either multiplicity of π0 mesons or π+, π-and π0 mesons (evidence of involving all types of meson).

Where T = Vector sum of isotopic spin of proton-proton, neutron-neutron and neutron-proton .The success of these applications supplies additional support for the hypothesis of the charge independence and charge symmetry of the nuclear force. As the nuclear interactions do not extend to very large distance beyond the nuclear radius and this character is useful to solve the problem. The full charge independence for any system is the number of neutrons equal to the number of protons. This formula gives the evidence that the charge symmetry merely means that the neutron-neutron and proton-proton interactions are equal, but says nothing about the relations between neutron-proton interaction to others. The nuclear forces are symmetrical in neutrons and protons. (i.e. the force between two protons is the same as the ones 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-----P+P+π0

P+N-----P+N+π+

N +P----N+P + π-

These reactions are soon as Y + P -- P +π0,

P + P --- P + P + π0

P + N --- P + N + π0

It is found that only two assumptions are in agreement with theoretical and experimental facts. Notably the equality of the forces between two like and two unlike nuclear particles in the singlet state. These assumptions are either (1) that nuclear particles interact only with neutral mesons( neutral theory) or (2) that they interact equally and strongly with neutral, positive and 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 and neutron results 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 particles must be zero.

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

The charge independence of the nuclear forces demand the existence of π0 mesons as amongst the same type of nucleons (p-p) or (N-N).This force demands the same spin and the same orbital angular momentum. Positive pions are not able to surmount the nuclear coulomb barrier and 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 and their spin co-ordinates. In the neutral theory, therefore neutron and protons are completely equivalent and indistinguishable as far as the associated meson fields are concerned. Such particles decay into two gamma rays. These gamma rays are π0 – rest systems are emitted in opposite direction and therefore spin π0 must be zero as the spin of photon is unit. It is evident from the nature of the products that neutral mesons decay by the electromagnetic interaction while charged pions decay by both strong and weak interactions. It means that neutral mesons constituents are responsible for the electromagnetic interaction. We know that neutron and proton can change into one another by meson captured. Protons and neutrons can transform into one other by capture of positive and negative pions respectively, or get transformed into the same particle through neutral mesons interaction. During these transformation either an emission or an absorption of a 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 mesons were assumed to be charged ( positive or negative) the resulting force between two 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

* + 1\*.Also, emphatically, the velocity of light depends upon the range of the nuclear force. The velocity of light equals photons, lack masses and force carrying particles of other forces. Because the range is variable, the velocity of light must be variable. As, velocity of light= the range of the nuclear force(distance travelled by meson)/ life time of its resonances( which is called the excited state of nucleons). It is clear that these resonances are produced for a short time and decays 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 be changed spontaneously into a proton. Neutron decay takes on the average of few thousands seconds for free neutron, whereas within a nucleus the characteristic time between nucleon- nucleon collisions are 10-24 seconds. For a satisfactory picture it is often enough to think of the nucleus as a grouping of protons and neutrons interactions with the appearance or disappearance of photons. It should be noted that this relation holds only inside the nucleus. Out side the nucleus the evidence will be contrary. From this formula we can find that the nuclear force acts between the pair of nucleons and 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.

\*Range of the nuclear force:- To show that the range of the force is related to the mass of exchanged particle, it is assumed that the π0-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, the greatest distance the meson could travel in also known as this time is range of the pion exchange force.

## Change of Law

Since there is no requirement for the conservation of Pions so there is no conservation law in rest mass energy and 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 mesons. The energy of formation of mesons comes from binding potential ( which has the energy for formation of mesons for a long time). But when this potential has not enough energy, the production of pions ends and nuclear force does not exist.

## References

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