

Question: Why do Di-Neutrons And Di-Protons Not Exist?

A system made up of only two neutrons is not stable, or even somewhat meta stable. It is instantly unstable. Similarly for di-protons, a system made up of only two protons, they are instantly unstable. It is hard to understand why this is so, especially if two other facts are considered.

1. The nuclear force is said to be about 100 times stronger than the electromagnetic force.
2. The nuclear force is independent of whether the nucleons are neutrons or protons.

Given the considerations above, the attractive nuclear force between two neutrons in a di-neutron should be about the same as the attractive force between two protons, minus the much smaller repulsive electric force. Also, since there is no electromagnetic repulsion between two neutrons, the di-neutron should be even more strongly bound. However, di-neutrons and di-protons do not exist; they are instantly unstable. Obviously there are some crucial misconceptions here that have not been addressed by any previous theory of the nuclear force.

Answer:

The question as to why di-neutrons and di-protons do not exist is a very interesting question. As described previously, di-neutron is two neutrons bonded together with no other nucleons in the nuclide. Similarly, a di-proton is two protons bonded together with no other nucleons in the nuclide. Although neither of these configurations exist, a nuclide made up of a neutron and a proton not only exists, but it is stable. This nucleus is called deuteron; the atom is called deuterium, and it symbolized by either ${}^2\text{H}$ or ${}^2\text{D}$.

The nuclear force is that force which hold the nucleons together in a nucleus. It is also called the nucleon-nucleon force.

This question regarding the extreme instability of di-neutrons and di-protons should be simple to answer since there are only two nucleons involved, and one would think that the models of the nuclear force could easily be able to solve a simple two-body problem. However, this is certainly not a question easily answered by most theories of the nuclear force. Of all the various models of the nuclear force, there are only a few models that even *attempt* to answer this question, and certainly none that can give a correct or meaningful answer to it. The answer given is generally points to the extreme complexities of quantum theory, with no substantial explanation given beyond that. Or the answer incorrectly claims it is due to the spin of the nucleus, but there are several misconceptions associated with that answer.

One of the more accepted models of the nuclear force is the residual chromodynamic force model, which claims that the force holding the nucleons together in a nucleus is a residual force of the chromodynamic force outside of the nucleons. This is illustrated symbolically in Figure 1 for the deuteron nucleus.

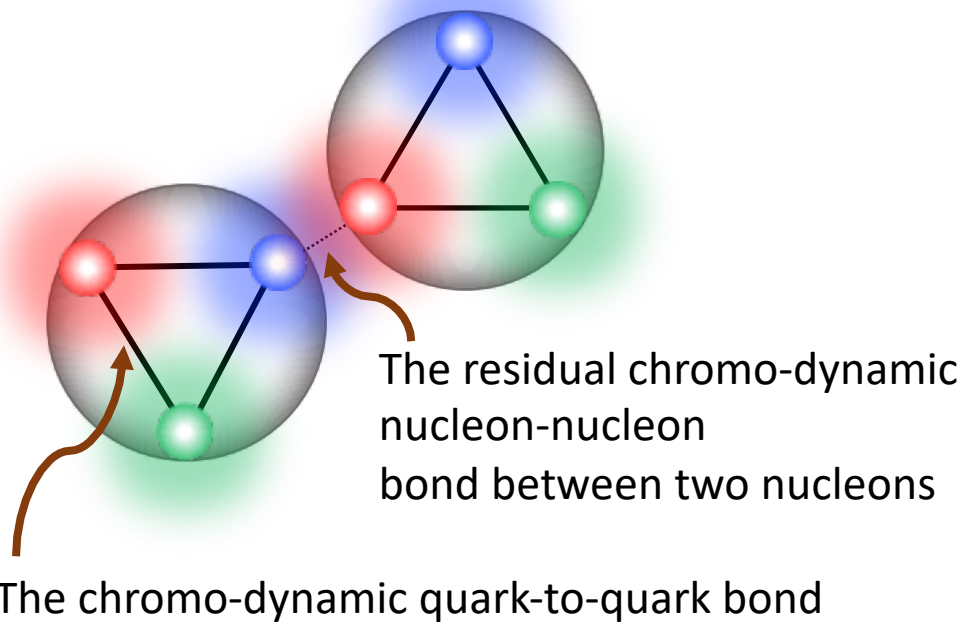


Figure 1: The deuteron nucleus, showing the neutron, the proton, the quarks, and the forces between the quarks.

In Figure 1, two nucleons are shown as the large gray spheres. The quarks are shown inside the nucleons, as the red, green and blue spheres. The chromodynamic force inside the nucleons is represented by the bold black lines between the quarks, and by the color of the quarks inside the nucleons. The residual chromodynamic force is shown by the residual color outside the nucleons, and by the lighter dashed gray line between the quarks. This lighter dashed line represents the residual chromodynamic force between nucleons, AKA the nuclear force. The residual chromodynamic force outside of the nucleons is weaker than the chromodynamic force holding the quarks together inside the nucleons.

Quite similar to the residual chromodynamic model, the electromagnetic model claims that the bond between two nucleons is actually a bond between two internucleon quarks. The similarity between the electromagnetic model and the residual chromodynamic model has one exception—the electromagnetic model claims that the internucleon quark-to-quark bond is an electromagnetic force rather than being some type of color-related chromodynamic force. Thus, rather than having a force derived from an exchange of mesons or pions, the electromagnetic model claims that the force between two internucleon quarks is largely electromagnetic. (For a more thorough understanding of the electromagnetic forces within a nucleus, see the paper on this web site, [The Electromagnetic Considerations of the Nuclear Force.](#))

The electromagnetic model claims, very logically, that two nucleons cannot overlap physically. From a quantum physics standpoint, this claim is very much related to the Pauli exclusion principle, which states the same thing--that any physical overlap between two particles is not allowed.

If there are two internucleon quark-to-quark bonds between the same two nucleons, an overlap will occur, as shown in Figure 2.

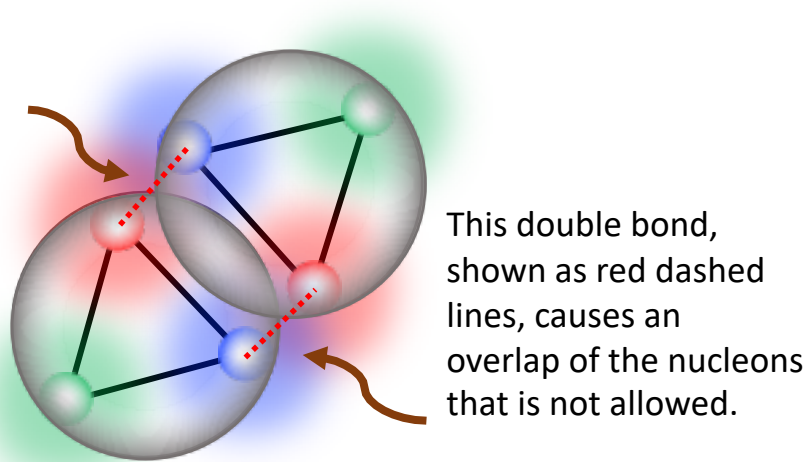


Figure 2: A symbolic representation of a double bond formed between two nucleons. This double bond is not allowed.

Due to this overlap, a double bond between two nucleons is not allowed. This double bond between two nucleons is shown in Figure 2 as a dotted red line, indicating that it is not allowed.

If this double bond were allowed, then we might expect ${}^2\text{H}$ to have a very strong binding energy. Experimentally, we know that each bond is between two internucleon up-to-down quarks is roughly 6 MeV. Thus, if this double bond were allowed, we would expect to see 12 MeV of binding energy for ${}^2\text{H}$. Similarly, if a triple bond were allowed, we would expect to see roughly 18 MeV of energy. Also, if double and triple bonds were allowed, then we would expect to see some high energy states for deuterium. However, experimentally we know that the binding energy of deuterium is 2.224 MeV, and there are no high energy states. Thus, there is only one bond--not two and not three, and one can surmise, as expected, there is no overlap of the nucleons.

By focusing on this one bond between a neutron and a proton, and examining the electromagnetic forces, we can gain more understanding about the deuterium nuclide. Figure 3 is similar to Figure 1, but I have labeled the proton and neutron, the six quarks, and indicated whether the quarks are up or down.

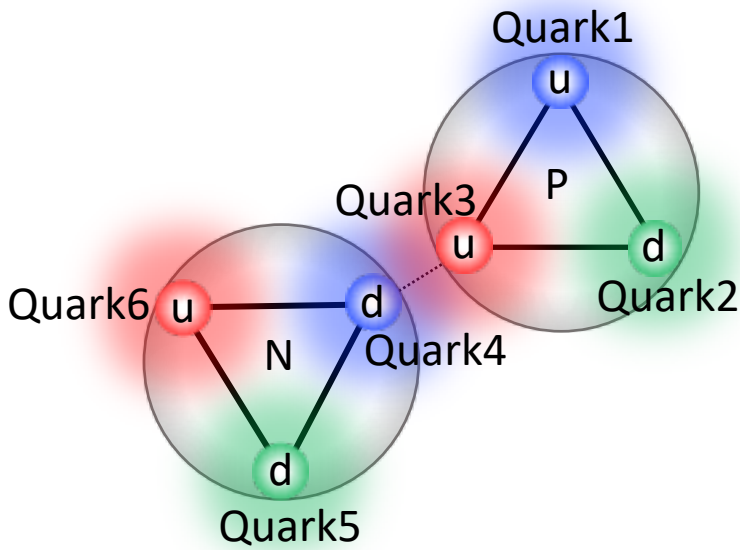


Figure 3. A symbolic representation of the deuteron.

Recall that an up quark has a positive electric charge and a down quark has a negative electric charge. For ease of visual understanding, this figure is re-drawn without the distraction of the color and shading, and with the electric charged of the quarks being indicated next to the quark. The “++” indicates that the quark has an electric charge of $2/3$ an elementary charge, and the “-” indicates that the quark has an electric charge of $-1/3$ an elementary charge. This is shown in figure 4.

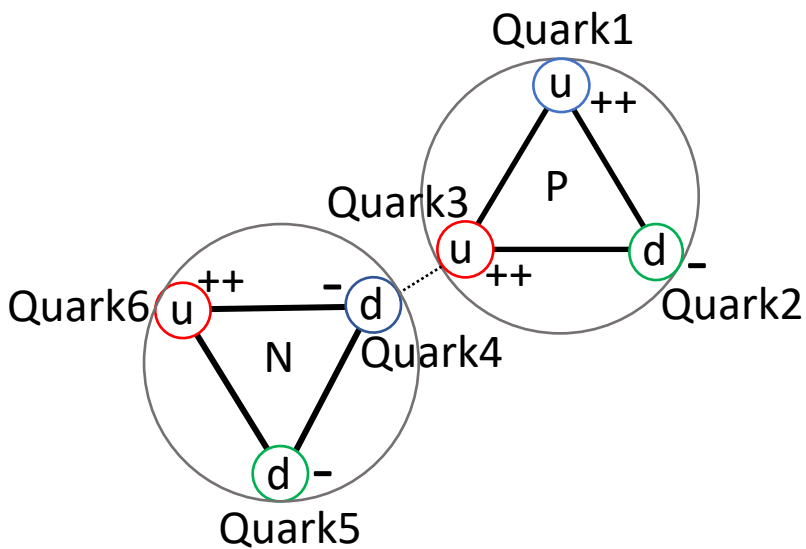


Figure 4: The deuteron with electric charges shown.

As can be readily seen in this representation of Figure 4, the up quark3 and the down quark4 are electromagnetically attracted to each other, the strength of this electric bond depending only on the distance between the two quarks involved. Also, the two unbonded up quarks, quark6 and quark1, are electrically repulsive, and they would not try to bond. Similarly for the two unbonded down quarks, quark5 and quark2, no bond between them would be formed.

Now that we have examined the deuteron, with one bond shown between the proton and the neutron, let's look at two neutrons, the di-neutron. In Figure 5, quark1 has been changed from an up quark to a down quark. As a result of the quark change, the proton has become a neutron. This is shown in Figure 5.

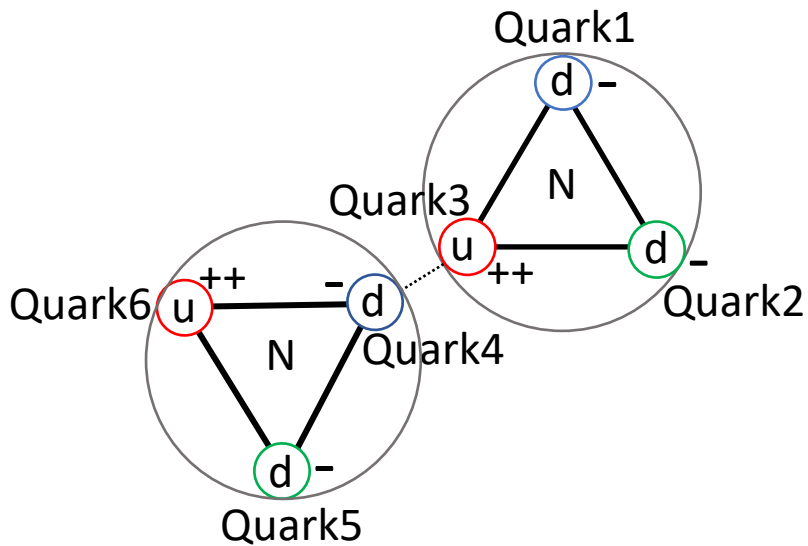


Figure 5. A di-neutron, quark1 has changed to a down quark with a negative charge and the proton is now a neutron.

Note that there is now an electromagnetic attraction between quark6, a positively charged up quark, and quark1, a negatively charged down quark. The attractive electromagnetic force will bring the two quarks together, attempting to form a double bond, as shown in figure 6.

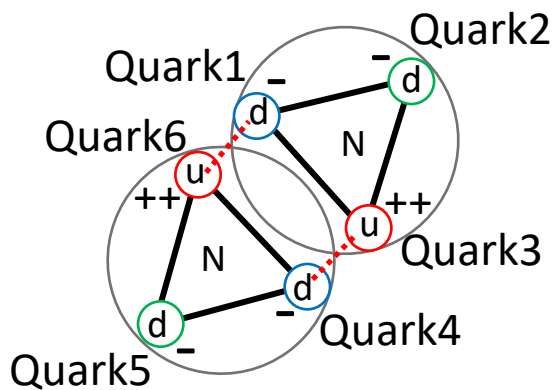


Figure 6.

However since this attempted double bond is not allowed, as soon as the quarks 1 and 6 attempt to double bond, the two nucleons will spontaneously break apart as a result. Thus, a di-neutron cannot exist as a stable configuration, and if it is attempted to form, it will spontaneously break apart.

The same effect happens with two protons that are configured as a di-proton, as explained in Figures 7 and 8. Figure 7 shows a di-proton with only one bond. However, as before with the di-neutron, there is an electromagnetic attraction between quark1 and quark6.

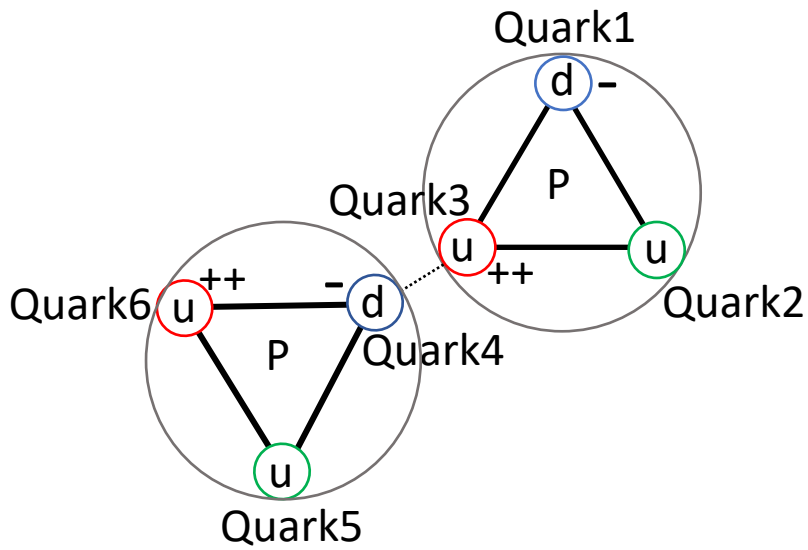


Figure 7.

As a result, the electromagnetic attraction between quark6 and quark1 will cause them to attempt to form double bond, shown in Figure 6. As a result, the two nucleons will spontaneously break apart.

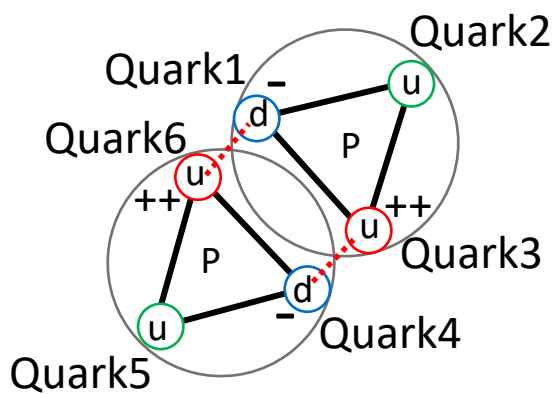


Figure 8.

In the cases for both the di-proton and the di-neutron, there is an electromagnetic attraction between two quarks that attempt to double bond and thereby cause an overlap, in violation of the

Pauli Exclusion principle. This is why a nuclide made up of only two neutrons or only two protons can not normally exist in nature.

One of the most important concepts here is that the forces which hold the nucleons together in a nucleus, the nuclear force, can be BOTH attractive and repulsive. This is a concept that other nuclear models do not consider, and thus they have a difficult time explaining why a nucleon might emit particles like protons or neutrons. In the electromagnetic model, it is very easily seen that the attempted overlap of nucleons will cause the nucleons to break apart.

Thus this question, which has long been unresolved by other nuclear models, can now be very easily understood with a very simple and concise explanation, simply by examining the electromagnetic forces within the nuclei.