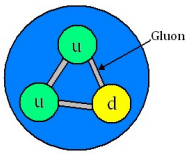
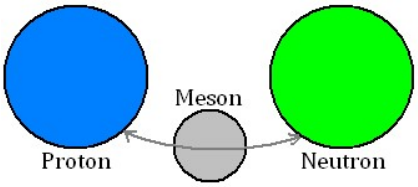
The Strong Interaction



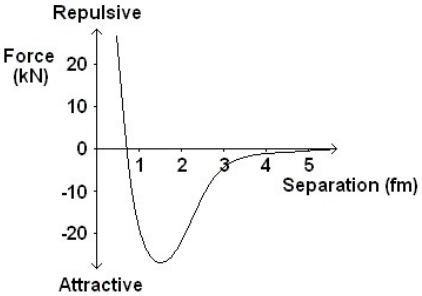
The strong nuclear force ('strong interaction') acts between quarks. Since Hadrons are the only particles made of quarks, only they experience the strong nuclear force.
In both Baryons and Mesons, the quarks are attracted to each other by exchanging virtual particles called 'gluons'.



On a larger scale the strong nuclear force acts between the Hadrons themselves, keeping them together. A pi-meson or pion (π) is exchanged between the hadrons. This is called the residual strong nuclear force.

Force Graphs

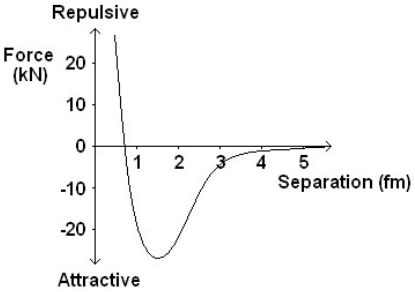
Neutron-Neutron or Neutron-Proton



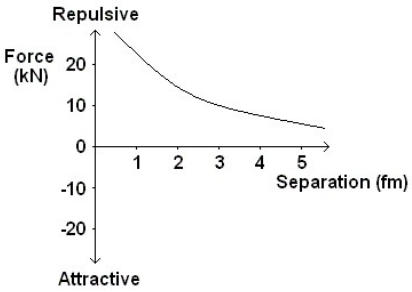
Here is the graph of how the force varies between two neutrons or a proton and a neutron as the distance between them is increased.
We can see that the force is very strongly repulsive at separations of less than 0.7 fm (x 10^{-15} m). This prevents all the nucleons from crushing into each other.
Above this separation the force is strongly attractive with a peak around 1.3 fm. When the nucleons are separated by more than 5 fm they no longer experience the SNF.

Proton-Proton

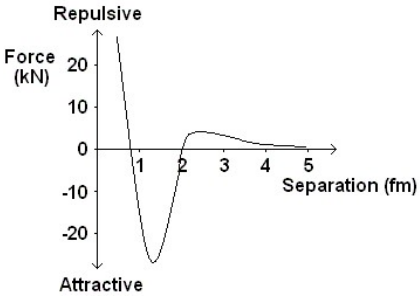
The force-separation graphs for two protons is different. They both attract each other due to the SNF but they also repel each other due to the electromagnetic force which causes two like charges to repel.



Graph A



Graph B

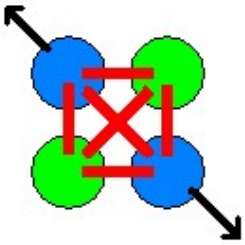


Graph C

Graph A shows how the strong nuclear force varies with the separation of the protons
Graph B shows how the electromagnetic force varies with the separation of the protons
Graph C shows the resultant of these two forces: repulsive at separations less than 0.7 fm, attractive up to 2 fm when the force becomes repulsive again.

Neutrons – Nuclear Cement

In the lighter elements the number of protons and neutrons in the nucleus is the same. As the nucleus gets bigger more neutrons are needed to keep it together.



Adding another proton means that all the other nucleons feel the SNF attraction. It also means that all the other protons feel the EM repulsion.

Adding another neutron adds to the SNF attraction between the nucleons but, since it is uncharged, it does not contribute to the EM repulsion.