The strong nuclear force | essay

- Youssef El Laithy

One of the most extraordinary simplifications in physics is the fact that only four distinct forces are responsible for all the known spectacles that go on in the universe. These four basic forces are the electromagnetic force, the gravitational force, the weak nuclear force and the strong nuclear force. Since the weak and the strong force act over an extremely short range, (less than the size of a nucleus), we do not experience them directly. Even though we don’t directly experience these forces they are vital to our existence. These forces determine whether the nuclei of certain elements will be stable or will deteriorate, and they are the basis of the energy release in many nuclear reactions. The forces determine not only the stability of the nuclei, but also the abundance of elements in nature. The properties of the nucleus of an atom are determined by the number of electrons the atom has. The number of electrons in an atom, therefore, determines the chemistry of the atom. The gravitational force is responsible for holding together the universe at large, the atmosphere, water, and us; humans, to the planet. The electromagnetic force governs the atomic level phenomena, binding electrons their atoms, and atoms to other atoms in order to form molecules and compounds. The weak nuclear force is responsible for certain types of nuclear reactions. The fourth and last force, the strong nuclear force is responsible for holding the nucleus together.

The Strong Forceis also one of the four fundamental forces of nature, experienced byparticles called quarks and sub particles made up of quarks. It is theforce that causesthe interaction responsible for binding and holding protons and neutrons together in the atomic nucleus of a given element. The strong force is the strongest of among all the other forces forces, being approximately 100 times as strongas the electromagneticforce. It has the extremely short range to which it has an effect. A range of approximately 10^-15 m, less than the size of the atomic nucleus. The strong force is ‘ carried’ by particles called gluons; that is, when particles interact through the strong force, they do so by exchanging gluons. The protons in a nucleus must experience a repulsive force from the other protons in the nucleus. This is where the strong nuclear force comes into play. The strong nuclear force is created between the nucleons (protons and neutrons) by the exchange of particles called mesons. This exchange can be compared to constantly hitting a tennis ball or a footballback and forth between two people. As long as these particles (mesons) are in motion back and forth, the strong force is able to hold the participating nucleons together. Thenucleons, however; mustbe extremely close to each other in order for this exchange of mesons to occur. The distance requiredfor the force to take place and have an effectis roughly about the diameter of a proton or a neutron. Thus, if a proton or neutron can get closer than this distance to proton on neutron, the exchange of mesons occurs normally and the force has an effect. However, if they can’t get that close, the strong force is too weak to make them bind together and thus the force won’t have an effect and the nucleus would rapture.

The range of the Strong Force varies from where it takes place. The strong interaction is apparent in two areas:

1. On a large scale (about 1 to 3femtometers), it is the force that bindsprotonsandneutrons(nucleons) together to form thenucleusof anatom.
2. On a smaller scale (less than about 0. 8 femtometers, the radius of a nucleon), it is the force (carried bygluons) that holdsquarkstogether to form protons, neutrons, and otherhadronparticles.

The discovery of the Strong of the nuclear force was a remarkable discovery and cleared up lots of mysteries that haunted many physicists in this era. The discovery force wasn’t all at once; meaning that the discovery was based on the work of more than once scientist and physicist all over the years. The first discovery was by James Chadwick. In 1932, British physicist Jamesdiscovered that the nucleus of atoms contain neutrons. Soon after this discovery, the American-Hungarian physicist, Eugene Wigner suggested that the electromagnetic force wasn’t the force responsible forholding the nucleus together and he also suggested that there are two different nuclear forces not just one. Later on, In 1935 Japanese Yukawa Hideki reasoned that since the strong nuclear force and weak nuclear force had never been noticedor observed by the bare eye or even by microscopesthey must act over a range smaller than the diameter of the atomic nucleus. Yukawa developed the first field theory ofthe strong force with a new particle he called ‘ mesons’ as the force carryingsimulated particle. From these facts and hypothesizes, Hideki Yukawa concluded that there exists a force that binds nucleons (protons and neutrons) together. He named the force the “ strong nuclear force” because it had to be stronger than the electromagnetic force that would otherwise push the nucleons apart.

In everyday life and our day to day life, we’re only aware of two fundamental forces: gravity and electromagnetism. Physicists know about two more forces, which are carried out within the atom itself (inside atoms): the strong nuclear force and the weak nuclear force. Try and imaginetwo protons (positive charge), they are pulled together by the strong nuclear force (as long as they are within range to start with). But the electromagnetic force pushes them away from each other, because they both have the same positive electric charge.

When we talk about the uses if the strong nuclear force we can’t really find a direct use in which humans use the force. The only direct use is that the binding energyrelated to the strong nuclear force is used innuclear powerandnuclear weapons. The strong nuclear force is crucial to our everyday survival, God created this force exactly to suit our survival. Following this notion two questions are raised:

1. What would happen if the strong nuclear force were a bit weaker?

If the strong force were even slightly weaker than what it is, it would not be able to hold the atomic nuclei together against the repulsion of the electromagnetic force. According to Barrow and Tipler: `Ifthe Strong Force was decreased by 50% its normal power thiswould adversely affect the stability of all the elements essential to living organisms and biological systems.’A bit more of a decrease, and therewouldn’tbe any stable elements except hydrogen.

2. What would happen if the strong nuclear force were a bit stronger that what it is?

According to Borrow and Tipler:

“ If the strong nuclear force was just a bit stronger compared to the electromagnetic force, two protons could stick togetherdisregardof their electromagnetic repulsion (forming a diproton). If this happened, all the hydrogen in the universe would have been burned to helium. If there were no Hydrogen in the universethere would be no water, for a start, and there would be no long-lived stars like the sun. (Stars made from helium burn up much more quickly than stars made from hydrogen).”

In conclusion, The Strong Nuclear force is one of the four fundamental forces found in nature. The strong nuclear force is responsible for holding the neutrons and protons in the atomic nucleus. The interactions are experienced only by particles called quarks and by elementary particles made from quarks (mesons, gluons). The discovery of the strong nuclear force was possible by the collective work of many physicists over many years. The strong force isn’t of that much of direct use for humans. However, the force is crucial to our everyday life. If the strong nuclear force was slightly even weaker than it is, all the chemical elements needed for life would not be stable, and we, humans, would not seize to exist. The strong force isn’t of that much of direct use for humans. However, the force is crucial to our everyday life. Ifthe strong nuclear force was weaker than it is, the chemical elements needed for life wouldn’t be stable, and we would not be here. On the other hand, if it were even slightly stronger than it is, all the hydrogen in the universe would have been burned in the big bang. As a result, there would be no prolonged stars like the sun, and no molecules like water. There would probably be no complex chemistry in the universe, and we would not seize to exist.

Citations

- “ Fundamental Forces.” Fundamental Forces. N. p., n. d. Web. 29 Nov. 2013. .
- “ The Nucleus.” The Nucleus. N. p., n. d. Web. 10 Dec. 2013. .
- “ The Four Fundamental Forces.” ThinkQuest. Oracle Foundation, n. d. Web. 9 Dec. 2013. .
- “ The Strong Nuclear Force.” The Strong Nuclear Force. N. p., n. d. Web. 1 Dec. 2013. .
- “ The Strong Nuclear Force.” The Star Garden. N. p., n. d. Web. 13 Dec. 2013. .
- “ Nuclear Forces.” Nuclear Forces. N. p., n. d. Web. 13 Dec. 2013. .