IOSR Journal Of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 13, Issue 3 Ser. I (May – June. 2021), PP 26-29
www.Iosrjournals.Org

Basics of Nuclear Physics

DR.J.M Kalyani

Abstract
Nuclear Physics start with the equation $E=mc^2$.Nucleus consists of protons and neutrons called nucleons. Electrons are orbiting around the nucleus. The total mass of a stable nucleus is always less than the total mass of the individual protons and neutrons put together. The energy of the mass that disappears from the universe is converted to the energy of photons. A very large amount of energy is released even when a very small amount of mass disappears. Supposewe arrange different nuclei in a row based on their weight, with the lightest nuclei on the left and the heaviest nuclei on the right.

As we move along the graph from left to right, the general trend is initially the amount of mass that disappears per proton and neutron to increase as we move to the heaviest nuclei. But after a certain point on the graph, the trend reverses. For elements heavier than iron ,as we move further to the right on the graph ,the amount of mass that disappears per proton and neutron , decreases as we move heavier elements. When the nuclei of certain elements on the left part of the graph fuse together, and the energy of the mass is released in the form of photons.

But the elements on the right side of the graph, the opposite is true. It means that if the heavier elements spilt apart, mass decreases, thereby releasing energy. This is called fission reaction, which releases most of its energy. However nuclei can absorb incoming neutrons sometimes, that causes fission reaction.

Keywords: *Protons, neutrons, $E=mc^2$,fusion,fission.*

Date of Submission: 29-05-2021 Date of Acceptance: 12-06-2021

I. Introduction

I wrote this because people should know about the basics of nuclear physics, and about the elements in the periodic table, and about how fusion fission reactions take place. This also explains how nuclear power plants work and gamma rays are produced.

II. Theory

Nuclear Physics is the field of physics that studies atomic nuclei and their constituents and interactions.Other form of nuclear matter is also studied.Nuclear Physics should not be confused with atomic physics, which studies the atoms as a whole, including the electrons.

Particle physics evolved out of nuclear physics and the two fields are typically taught in close association.Nuclear astrophysics,the application of nuclear physics to astrophysics, is crucial in explaining the inner workings of stars and the origin of the chemical elements.

Carbon atoms have atomic no 6 –proton or neutron and mass number -12 – 6+6=12

One unified atomic mass unit is 1.6605×10^{-27} kg. It is important to know the masses of different nuclei, since nuclear interactions are all about mass- energy conversion. The unified mass mass-unit U. For helium atom (2 protons, 2 Neutrons + 2 electrons) the unified mass atomic unit is 4.002603 U.

But the total mass of the helium atom is 4.032980 U. The difference in mass is 0.030377 U. This is the binding energy of the helium atom. There is a strong nuclear force, an attractive force that acts between protons and neutrons in a nucleus.

Radioactive decay
Alpha decay: When an unstable nucleus loses two protons and two neutrons, becoming a different element in the process.Example: Paper

Beta decay : When an unstable nucleus emits beta particle which is just an electron .
Example : ThinAluminium

Gamma decay : Results when a nucleus emits high powered photons in what are known as gamma rays.
Example : Lead highest penetrating power.

The fusion of the nuclei of heavier elements ends up consuming energy, rather than generating energy. In general, nuclei cannot typically fuse together because the positively charged protons cause the two nuclei to electrically repel each other. Nuclei can fuse together if the repulsive forces of the positively charged protons are overcome as they are inside the intense pressure and temperature of a star. The stars generate light and release energy by fusing the lighter elements together. The fusion of the heavier elements occursonly at the moment of a star's death in the form of a supernova explosion.

During a stars normal life span only elements lighter than iron can fuse together. The lightest of all elements is hydrogen, and it's fusion also occurs in thermonuclear weapons which was referred to as hydrogen bombs, which are far more powerful than the bombs that were dropped on Hiroshima and Nagasaki. Hydrogen bombs involve two nuclear explosions. The primary explosion compresses the hydrogen together causing it to fuse into helium. The hydrogen fusing into helium releases a very large amount of energy, thereby creating a much larger secondary explosion.

Nuclei fusing together, which we refer to as nuclear fusion, only plays a role in the secondary explosion.

The primary explosion is created through the opposite phenomenon, that of a nucleus splitting apart, which we refer to as nuclear fission. The original atomic bombs were dropped on Hiroshima and Nagasaki were based entirely on nuclear fission.

Nuclei typically do not split apart on their own because the neutrons and protons inside the nucleus are held together by the strong nuclei force. However nuclei can sometimes absorbs in coming neutrons. Certain types of uranium and plutonium contain just the right combination of protons and neutrons where absorbing one additional neutron makes the nucleus unstable, thereby causing it to split apart.

This can generate additional neutrons whichare then absorbed by other uranium of plutonium nuclei, thereby causing a chain reaction and releasing large amount of energy. Nuclear weapons use an uncontrolled version of this type of chain reaction to generate an explosion.

Nuclear power plants use a controlled version of this chain reaction to generate electricity. Nuclear power plants help control this chain reaction by inserting control rods, which contain nuclei that absorb neutrons without becoming unstable and splitting apart. Even if a nucleus doesnot become unstable when it absorbs a neutron , the nuclei is nevertheless placed in what we call an exited energy state. If a photon is generated by the nucleus of an atom then we refer to this photon as gamma ray.

A nucleus doesn't necessarily need to absorb a neutron in order to be place in an excited energy state, when a neutron just bounces off the nucleus. A neutron can bounce many times and travel along a long distance through a solid material before it is final absorbed by one of the nuclei. The probability of a neutron being absorbed during the collision with a nucleus of an atom depends on the type of atom and on the neutron speed. An example of a good neutron absorber is 5 10 B. Some atoms are much better of absorbing neutrons than others. Also the general rule is that the slowerneutrons are more likely to be absorbed. A neutron will slow down more rapidly when it bounces off the nucleus of an hydrogen atom. A neutron bouncing off the nuclei of an element other than hydrogen is similar to a small ball bouncing off a large ball. The small ball bounces off the large ball with almost the same speed as it had before. On the other hand, the ball is likely to lose the most speed if it collides with another ball with the same mass. This is what happens when a neutron collide with a hydrogen nucleus, since a hydrogen nucleus consist of a single proton, which has about the same mass as a neutron. Although a neutron loses some of its speed each time it bounces off a nucleus of an atom this never causes the neutron to stop completely. This is due to the fact all atoms have thermal vibrations. Not all combinations of neutrons and protons form a stable nucleus.A nucleus can be unstable if it contains many or too few neutrons for the number of protons. Some types of nuclei are much more unstable than others. The more unstable the nucleus is the more likely it is at any given moment to decay. Each type of unstable nucleus has its own methods for decaying. One method for an unstable nucleus todecay is for a cluster of protons and neutrons to break away the main nucleus. The most common type of cluster to break away from a main nucleus is a cluster consisting of two protons and two neutrons, which is the helium of a helium nucleus. Another common method for an unstable nucleus to decay is for one of the neutrons to turn into a proton by emitting an electro and a particle called an "electron and antineutrino". Another possibility is for a neutron to into a proton by emitting a positron and a particle called an "electron neutrino" . Another possible event is for the nucleus to capture an electron, causing on of the protons to transform into a neutron and to emit an electron neutrino. When the nucleus of the atom decays thought one of the se mechanisms, it is transformed into a type of nucleus having different combinations of protons and neutrons. This new nucleus may itself be either stable or unstable depending on what combinations of protons and neutrons it has. If it is unstable then it will keep decaying until it is eventually transformedinto a stable nucleus.

III. Results Of Discussion:

Regardless of the newly produced nucleus is stable or unstable, it may be in an excited energy state when it is created. As if it was discovered earlier if a nucleus is in excited energy state, then it will eventually fall into a lower energy state and emit a photon which we refer to as a gamma ray. When an incoming gamma ray interacts with an atom, one of four things can happen.

A gamma ray can pass through the atom with no effect. A low energy gamma ray may be absorbed by one of the atom's electrons causing the gamma ray to disappear and into transfer all its energy to the electron. A higher energy gamma ray may just transfer some of its energy to one of the atoms electrons thereby causing the gamma ray to change direction.

When an extremely highenergy gamma ray passes near the nucleus of an atom, the gamma ray can be transformed into an electron-positron pair. In this case the gamma ray disappears, and two new particles are produced. These two newly created particles are said to be enlanged with one another

IV. Conclusion :

Nuclear physics starts with the equation $E= mc^2$(Nucleus consists of protons and neutrons called nucleons). Nuclear physics is the field of physics that studies atomic nuclei and their constituents and interactions. Nucleus fusing together , which we refer to as nuclear fusion , only plays a role in the secondary explosion. The primary explosion is created through the opposite phenomenon, that of a nucleus splitting apart, which we refer to as nuclear fission.

The fusion of the nuclei of heavier elements ends up consuming energy, rather than generating energy.

In general the nuclei cannot typically fuse together because the positively charged protons cause the two nuclei to electrically repel each other.Nuclei can fuse together if the repulsive forces of the positively charged protons are overcome as they are inside the intense pressure and temperature of a star.The stars generate light and release energy by fusing the lighter elements together.The fusion of the heavier elements occurs only at the moment of a star's death in the form of a supernova explosion.

Nuclear Reactor Physics is the branch of science that deals with the study and application of chain reaction to induce a controlled nuclear rate of fission in a nuclear reactor for the production ofenergy.

Most nuclear reactors use a chain reaction to induce a controlled rate of nuclear fission in fissile material releasing both energy and free neutrons. The physics of nuclear fission has several quirks that affect the design and behavior of nuclear reactors. Hence you can extend the work to study and the use of nuclear reactors.Nuclear reactors are used at nuclear power plants for electricity generation and in propulsion of ships.

You can also extend this work for experimental nuclear physics which is the practical investigation of the process that occurs at the heart of an atom. This includes building a better fundamental understanding of fusion and fission, and harnessing them for sustained energy generation. Other areas of study are the creation of super heavy elements and the application of radioactive substances in medicine.

Acknowledgement

I thank my uncle Mr. PazhaNedumaran for his encouragement in making this possible.

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DR.J.M Kalyani. "Basics of Nuclear Physics." *IOSR Journal of Applied Physics (IOSR-JAP)*, 13(3), 2021, pp. 26-29.