

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES SCRUTINY OF ANTIMATTER, AN UNFATHOMABLE SOURCE OF ENERGY

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ABSTRACT

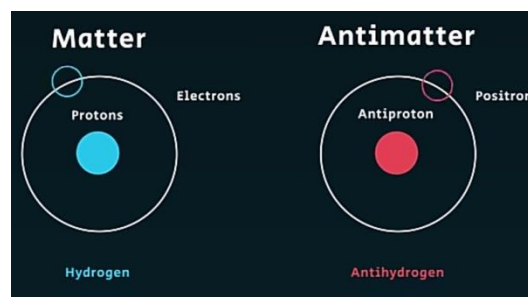
‘Antimatter’, as the name suggests its meaning, antimatter is the antithesis to matter; it is similar to matter having same mass as well as structural specifications but completely reversed in terms of charges. It suggests that as ordinary matter consists of electrons an antimatter atom would consist of ‘positron’ in place of electron. This dissimilarity between the charges of these subatomic particles yields an utterly beneficial property of Annihilation. Annihilation is nothing but a vanishing act which is one of the most unexplained mysteries of the universe. When an antimatter particle touches its counterpart it destroys it in a pyrotechnic flash, an explosive release of all the energy that has been locked within. This energy is released in the form of gamma rays. The energy so released is in so large amount that if harnessed in a proper way would cater to the increasingly high energy demands of the future

Keywords: Antimatter, positron, annihilation, pyrotechnic flash, gamma rays.

I. INTRODUCTION

It is extremely easy to say antimatter as the one ‘opposite’ to matter, but what actually is opposite about it. If we ever come across a substance made up of antimatter it would be immensely troublesome to distinguish between the two. The most basic reason for that is the excessive structural similarity as well as the similarity in the mass of the atoms of these counterparts. So what makes them both different?

The answer to this lies in the outermost orbit of the atoms of these elements. As we know about ordinary matter it consists of the three basic elements viz. protons, neutrons and electrons, but in case of antimatter instead of having an electron in the outermost orbit, it consists of a ‘positron’ and an ‘antiproton’. As the name suggests, it has positive electric charge. So we can formulate antimatter as the oppositely charged form of ordinary matter.



(a) Diff between matter and antimatter

This differing charges result into a vanishing act known as Annihilation when these two elements combine or even come in contact with each other. Both these elements disappear releasing no mass but only the packets of energy. This phenomenon will be studied further in the article.

Due to its annihilation property it is exceedingly difficult to find antimatter in natural environment, as it would vanish in an instant to release energy in the form of gamma rays. But some laboratories like CERN have succeeded in creating antimatter by artificial methods. The method employed for the same is particle collision. But the amount that has been made is in extremely low quantities almost nearing to a few nano-grams which is quite insufficient for any practical applications of the substance.

Another question arising is the storage of this so created 'antimatter', as it destroys all the matter it comes in contact with, so there is need of specialized containers for the safe and sound storage of this material. These topics will be further covered in the article.

Antimatter may also exist naturally in outer space far-far away from us, and as it carries structural properties similar to ordinary matter it would be difficult for us to distinguish. There are possibilities of existence of wholesome galaxies made out of this mysterious stuff. It goes as far as our imagination goes in this way. The existence of this extra terrestrial antimatter has been in search ever since an event occurred in Russia in 1908. As the article goes a farmer in the region reported a blast so bright that it even made sun appear to be dark. The explosion was so powerful that it almost evaporated everything below the blast epicenter. The trees were instantly sent to oblivion. The interesting fact about this explosion was that no debris was found after the blast, so it ruled out possible asteroid strike and weapons in that age were not so developed to create such a blast of this intensity. So one conclusion that comes out is the possible antimatter strike from the outer space which may have occurred. Similar events were observed around the globe ever since.

II. RELATION TO COSMOS

Big-Bang explosion:-

Over the years Scientists have predicted the effects of the big-bang explosion. According to the research there was a void and extremely big amount of space with almost nothing, and as the theory goes all of a sudden there was an explosion resulting into release of energy. This energy later coagulated to form matter and antimatter. According to nature's wonderful law of equilibrium matter and antimatter should have been formed into equal amounts. And as we know the fascinating property of annihilation they both would have annihilated in an instant and there would be nothing present at all after that. But due to a slight misalignment, matter was formed in more number of parts than its counterpart and all the universe that we see today is the courtesy of the matter that remained and later led to the formation of the universe.

Presence of antimatter in our own universe!

This may look to be a completely contradictory statement but antimatter is closer to us than we think. Positron can be found in the heart of our very own sun, where there are many electrons. Due to these electrons positron gets annihilated in an instant and turned into gamma rays. These gamma rays try to rush away from the center at the speed of light but are constantly intercepted by electrically charged particles. Due to this interception these gamma rays are constantly absorbed and released further with even less energy by these electrically charged particles. In doing so the gamma rays lose lots of their energy and it takes hundreds to thousands of years for them to reach the surface of the star. In this process the nature of the gamma rays changes from X-rays to ultra-violet and lastly into the rainbow of colors that we see naturally every day. Thus the daylight is the result of antimatter being produced in the center of the sun and its annihilation.

Cosmic rays:-

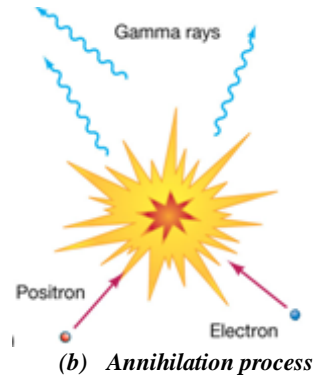
Antimatter also reaches earth in the form of cosmic rays in very small amount. These cosmic rays originate somewhere in deep space and finally reach earth's surface in the form of energized particles creating showers of secondary particles.

III. ANIHILATION

As discussed before annihilation is the process of release of all the atoms energy locked up within in an instant. The energy that can be obtained is given by Einstein's most famous equation $E=mc^2$

Where E = energy released
 m = mass being annihilated
 c = speed of light

So even if we are to annihilate 1 gm of antimatter with 1 gm of matter the energy released would be around 90 terajoules. This is the potential of antimatter energy. We can obtain enormous amount of energy just from a small fraction of the fuel being utilized.



IV. PRODUCTION, STORAGE AND APPLICATIONS:-

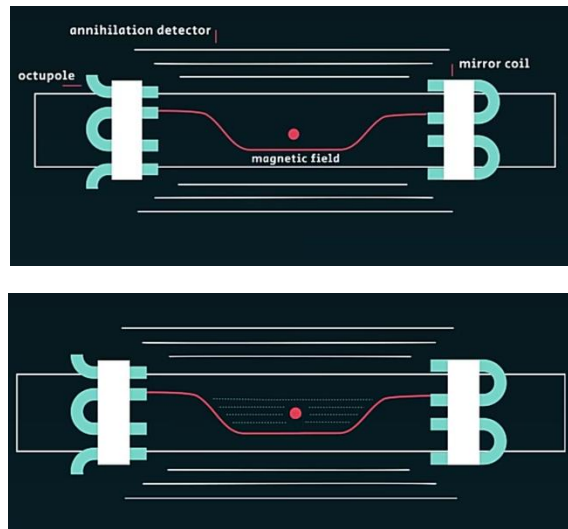
Production:-

There are natural as well as artificial ways of antimatter production:-

1. Natural Production:-Antimatter particles or the positrons are naturally produced by the β decay of radioactive elements. They are also present in the cosmic rays. One more fascinating source of antimatter is Bananas. They contain potassium-40, a naturally occurring isotope of potassium in very small amount. These isotopes of potassium release positrons in a very small amount. Scientists also believe that positrons are released during thunderstorms. Further studies are going on in the matter of artificial sources of antimatter.
2. Artificial Production:-Positrons have been artificially produced in the laboratories like CERN and DESY (in Germany). The method implied for the production in these high tech labs is of particle collision. In these labs long beams of protons are accelerated to a speed approaching speed of light and are made to collide. Two separate beams are forced in opposite directions in a circular particle collider known as LHC (Large Hadron Collider). In the LHC 800 millions of collisions are happening per second and new particles are being formed every instant, so the scientists need to keep a sharp eye on the particles being produced. Positrons have been produced in these labs in similar way. But the amount that has been made is negligible so it can't be utilized for any practical applications.

Storage:-

Storage is one of the most concerning issues in the antimatter world as we know about the destructive behavior of antimatter that it annihilate all the matter it touches, so storage of these antimatter particles isn't possible in ordinary containers. Specialized containers are required just for the storage of these particles. They are known as penning traps. These penning traps use magnetic and electric fields to keep the particles confined to the center of the traps thereby not getting it to interact with the walls of the containers. The only issue with penning traps is that it can be used to store only the charged particles and no uncharged particles can be stored as they won't be interacting with the electric and magnetic fields.



(c) Penning traps

Applications:-

1. Medical: - Positrons find a very important application in the field of medical sciences. They are used in PET scans (Positron Emission Topography). PET scans are done to observe the metabolic processes happening in the body. In these scans gamma rays are being injected in the body. Then three dimensional images of the tracer concentration are constructed by computer analysis. These antimatter particles are also used in curing tumors and cancer cells within the body. These particles are focused and directed to these cancer creating cells. They annihilate these cancer causing cells or the tumor cells thereby curing the disease right from its roots.
2. Interstellar travel:- With the fascinating amount of energy released after annihilating the atoms, antimatter can be seen as a probable and most efficient fuel for interstellar travel. If we somehow manage to harness and concentrate the energy released by annihilating the antimatter we can use it as a fuel source for long distance interstellar travel. For this there is need of specialized rockets which annihilate the fuel as and when required and controlling its annihilation. Now-a-days research is going on for the production of these type of rockets by various companies one of which includes 'Positron Dynamics'.
3. Weapons: The energy so released after the annihilation naturally lures one into using it as a probable weapon source. Antimatter bomb is no longer just a term of science fiction. With the amount of research going into the topic it is vastly possible that one day we will see the creation of antimatter bomb by one of the superpowers of the world. The fact that 1 gm of antimatter creates 90 terajoules of energy almost double the energy released during the Nagasaki explosion, certainly gives it an edge over the conventional weapons. Certain countries had already started the research on creating these weapons but currently no one knows about the status of their research as it cannot be made public.

V. LIMITATIONS IN HARNESSING THE ENERGY

The limitations faced in harnessing the energy are

1. High production cost:- the first and foremost hurdle in production is its high cost. It is estimates that a gram of antimatter costs 62.5 trillion \$, which is one high of an amount for any good energy source.
2. High amount of energy for production:- the energy required to produce antimatter is way more than the energy obtained by annihilating it. So till date no efficient way has been found of creating antimatter which would be beneficial

3. Storage issues:- As discussed before storage is one of the most concerning issues in the antimatter world. The penning traps have their own limitations, and till date no other way have been found for the storage.
4. No natural evidence on earth:- Unlike conventional fuels we cannot gather antimatter from our earth, as it can't be present in our environment. So the unavailability of any natural source on earth is one of the limiting factors in harnessing this energy.

VI. CONCLUSION

Antimatter can easily be said as the strangest substances found till date but it has a very high potential of replacing the conventional energy resources and the conventional fuels. There needs to be further research into the topic. There are innumerable possibilities of the applications of the substance. We could even use antimatter fueled cars if proper research is done into the topic. It should be used for the betterment and welfare of the society, but should be used with responsibility and proper care as one wrong step could create an explosion that would destroy our planet. It has the potential of being the most important research and product in near future.

REFERENCES

1. *Antimatter- Frank Close 2009*
2. <https://www.ijer.net/archive/v6i3/11031705.pdf>
3. *The Dirac Equation and the prediction of Antimatter- David Vidmar*
4. *The Quantum theory of Electros- P.A.M Dirac*
5. Wang, Y.N. and Wang, Y.J. (2017) *an Analysis on the Sign of Gravity of Antimatter. Journal of Modern Physics*, 8, 156-162. <https://doi.org/10.4236/jmp.2017.82014>
6. <https://en.wikipedia.org/wiki/Antimatter>