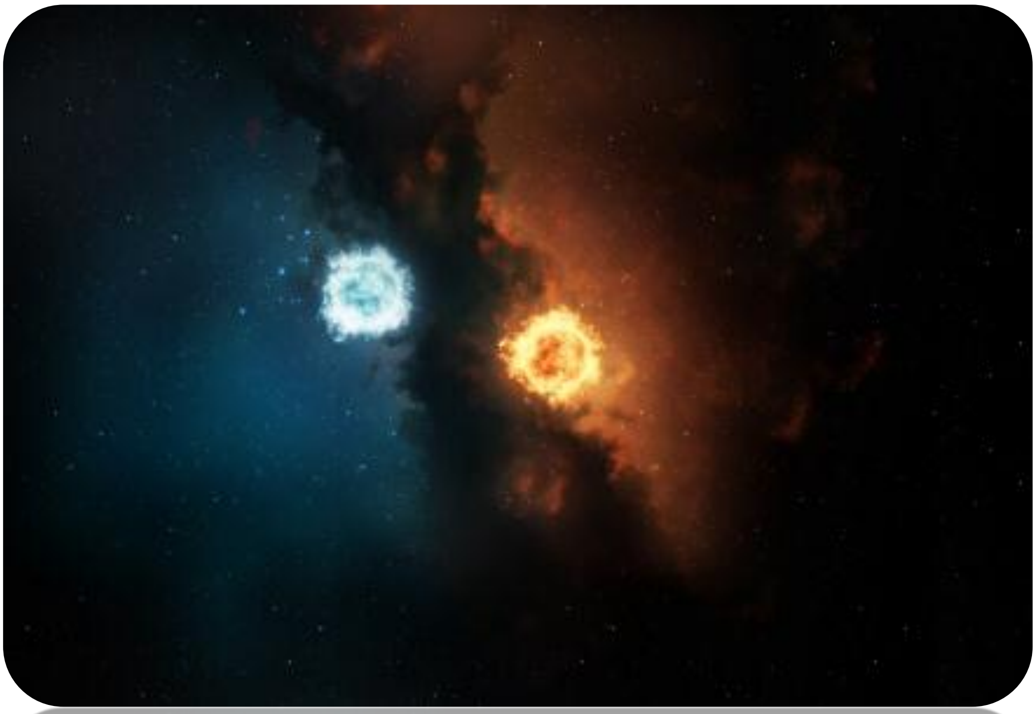
Syrian Arab Republic

Ministry of Higher Education

National center for distinguishes

Seminar in physics entitled :

The Antimatter



Presented by : Taymaa Bteeh.

The supervisor :Mahmoud Nouh.

The class : Third secondary.

Of the year : 2016 _ 2017.

Bibliography:

Introduction :

Antimatter seems like something isn't natural and it fueles the supernatural stories. For example in famous Dan Brown's novel "Angels & Demons" MS Langdon would have to save the Vatican from an antimatter bomb . My be most of us think that it's just an exciting Science Fiction Story , But no, that's not right , we have to know that the antimatter is also the stuff of reality .

Now the antimatter is the most important theme in particle physics universe and a lot of scientists and researchers are doing studies about this topic.

So what's the antimatter ? why don't we know it!!?? And what's the relation between the matter and the antimatter ?.

We will answer about all of these questions and other in this search.

Wish you interesting and useful subject .

Goals :

_*What's the antimatter ?*
_*What are its Characteristics ?*
_*What does it consist of ?*
_*What are the most important theories about it?*

Problematic :

_ *what's the deference between the matter and the antimatter?*

_ *why do we live now with the matter not the antimatter ?*

_ *is the antimatter exist somewhere? & What is the nature of its relationship with the matter ?*

CAPTER 1

First section

What's antimatter ?!

and How did scientists discover it?!

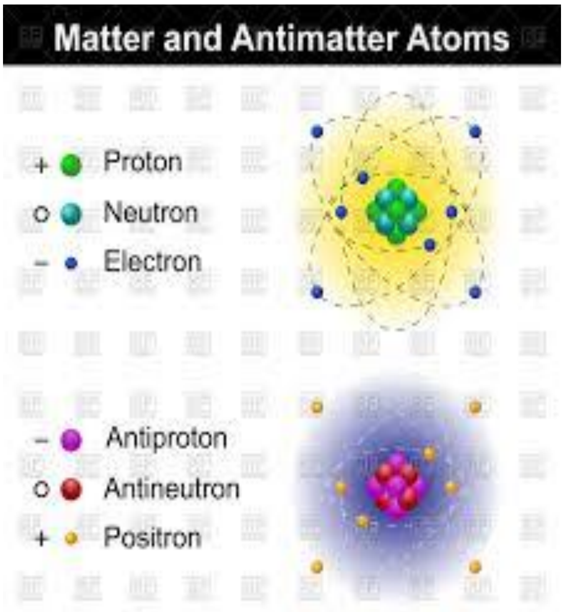
All material things that we see , taste and touch are made up of tiny particles called atoms . as we know ,the atom is the smallest part of an element and it consists of nucleus and electrons .

The nucleus is in the center of the atom and it contains two types of particles, Protons which have appositive charge and neutrons which are natural in charge.

And the electrons _ surrounding the nucleus_ have a negative charge.

Now , just suppose that the protons are negatively charged and the electrons are positively charged ? what would we have then!?.

The answer is antimatter . what's antimatter!!!???.[1]

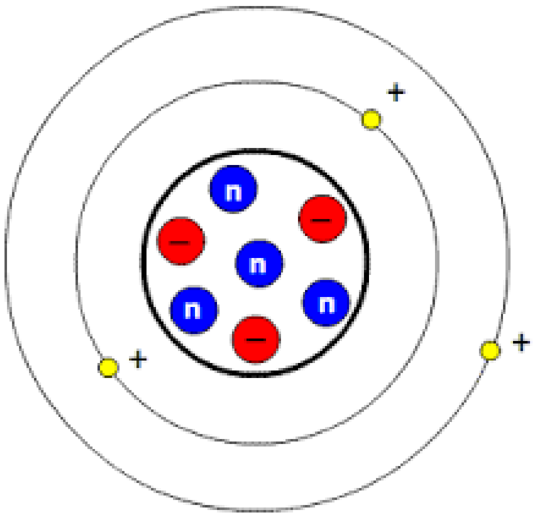


Comparing between matter and antimatter

Antimatter is identical to ordinary matter in nearly every way . Antiparticles have the same mass as their corresponding particles . if an Antiparticle has a spin , like an electron , the spin is as the same as that of the corresponding particle . what differ is the sign of the electrical charge ?. Antiparticles always have a charge that is opposite in sign of the charge on the corresponding particle.

So literally Antimatter is the mirror image of matter .

antimatter atom consists of nucleus and positrons .



Anti-Lithium atom

[1] *http://www.unmuseum.org/antimat.htm -Krystek -Lee cop right- 2001-in 10\11\2016 at:3AM*

the nucleus has antiprotons (which have a negative charge) and antineutrons ,and the positrons (positive electrons) have a positive charge .[2]

the charge of electron and proton is different in antimatter because the quarks in antiatom has different charge (up^- , $down^+$) ,so antielectrons are positive because they have two positive quarks ($down^+$) and one negative quark (up^-).

Likewise antiproton is negative because it consists of(up^-, up^-, $down^+$).

An antineutron is different from neutron because it consists of two types of quarks(up^- , $down^+$) .

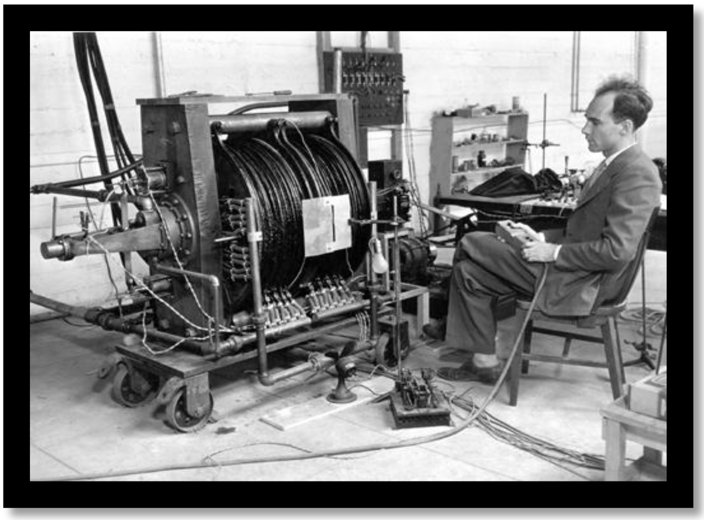
But how scientists can detect antimatter!?

In 1928 young British physicist named Paul Dirac created an equation to describe the behavior of an electron $(i\, \gamma^{\mu}\, \partial_{\mu} - m\,)\psi$.

But he found that it could have two solutions , one for the electron and one for an almost identical particle ,with opposite electric charge .

And It stayed a theory for four years , but four years later Dirac's theory was proved right and The big surprise happened , But how!!??.

In 1932 , the first antiparticle was discovered by" Carl Anderson" ,a physicist from Caltech . he discovered antielectrons while he was studying the effect of cosmic rays in the atmosphere on the nuclei of atoms . He noticed that some particles were identical in every way to charge.

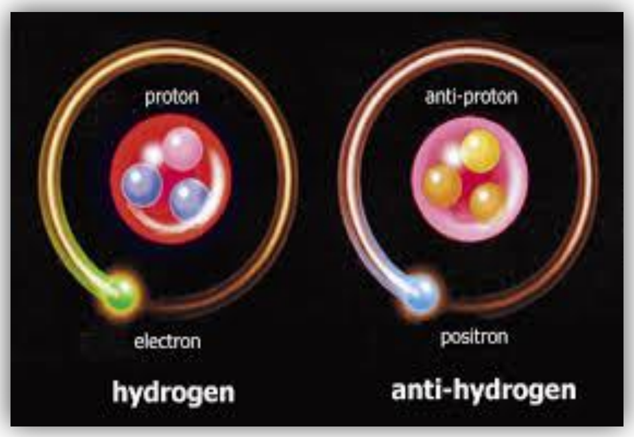


Carl Anderson with the magnet cloud chamber with which he discovered the positive electron, or positron. For this work he won the Nobel Prize in physics in1936. Caltech Archives.

Rohrin- http://chemisty.org/education/chemmatters.html \ April 2005_in 11\11\2016_at:11:30AM [2]
Brian

He dubbed these positive electrons" positrons". That means that every type of particle has its counterpart .

In 1995 the first antiatoms were created at the European Centre for Nuclear Research (CERN)[3] in Geneva , Switzerland .Anti-hydrogen was created by forcing an antielectron around a nucleus composed of an antiproton . in all nine anti-hydrogen atom were created in 1995, But after seven years later ,experiments at CERN began to make anti-hydrogen atoms by the thousands.



Hydrogen and anti-hydrogen atom

But until now no other antiatoms besides hydrogen have been created. [(4)]

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(3)*CERN the European Organization for Nuclear Research, was founded in 1954. It has become a prime example of international collaboration, .with currently 20 Member States. It sits astride the Franco-Swiss border near Geneva and is the biggest particle physics laboratory in the world*

[(4)] *the same sourse*

Second section:

The relationship between matter

And antimatter and the most important theories about antimatter

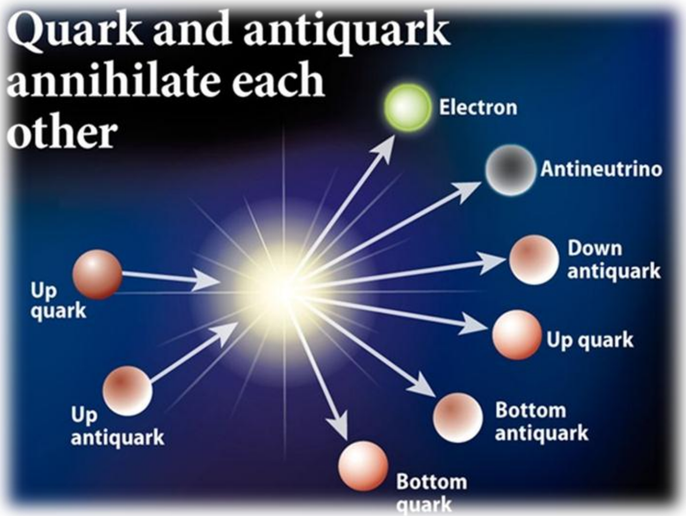
after discovering Antimatter and studying its characteristics , scientists began to study the relation between the antimatter and the matter , why hadn't we ever met it in our universe and where is it now!?.

what does happen when antimatter contacts with matter ??

when matter and antimatter come into contact they completely annihilate because they have an opposite charge, so quarks and antiquarks annihilate each other and this make a big explosion.

just guess what will happen if you meet anti-you?

If you ever met an anti-you, in the blink of an eye , you would both vanish ,destroying one another and leaving behind a flash of energy.



How Matter and antimatter annihilate each other.

Why are we here?

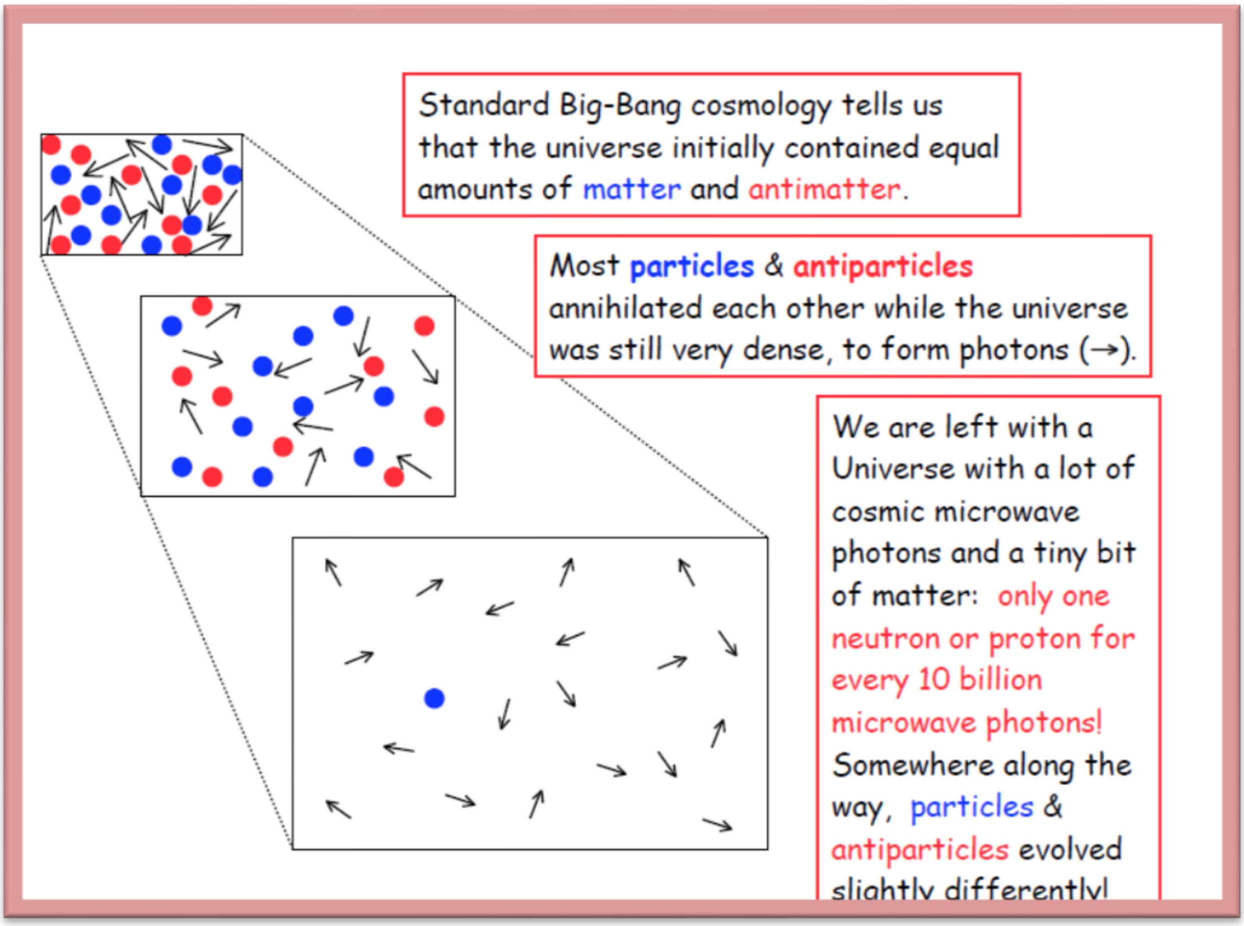
From the beginning of the Universe, it seems there was a subtle favoritism for the matter that makes up the world we live in today. Without it we would not exist - there would be no stars, no planets and no people – just energy.

It all started in the intense heat of the Big Bang, where particles of matter were forged out of pure energy. But for every particle of matter created, a 'twin' was also born - an 'antiparticle' identical in mass but with opposite electric charge.

For the first few instants of its existence the Universe was balanced, with matter and antimatter created in equal abundance. Then just one second after the Big Bang, the antimatter had all but disappeared, together with almost all the matter, leaving a minute amount of matter alone to form everything that we see around us – from the stars and galaxies, to the Earth and all life that it supports.

So what happened to all the antimatter?! This is one of the great puzzles of particle physics [(5)].

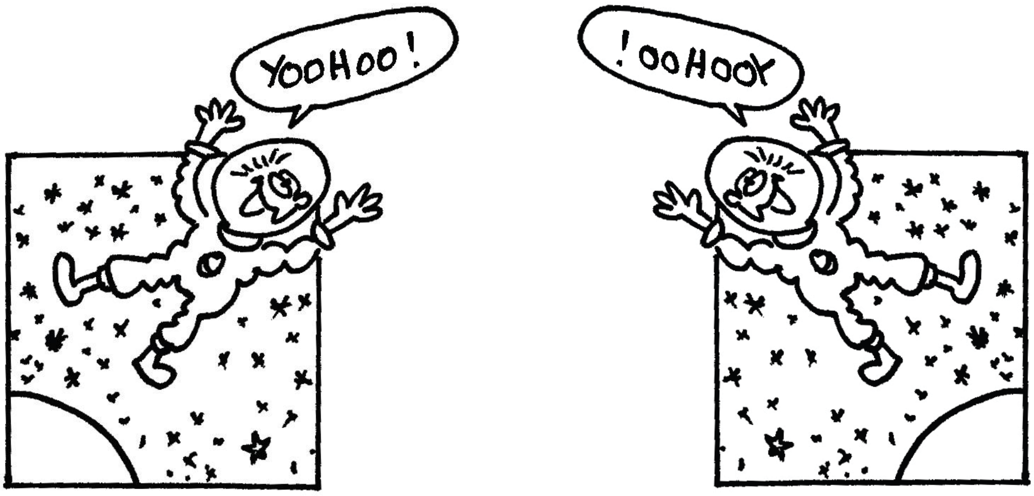
[(5)] *www.cern.ch communication group ,February 2009 , cern_brochure _2009_001_eng*



Matter and antimatter at the Big Bang

Paul Dirac suggested that there could be a whole region in the world which consist completely of antimatter ,but we couldn't never live there.

It is merely a suggestion which isn't proved until now, but it's a very logical and possible propose .



Chapter 2

First section

Are the laws of physics the same in a universe made of matter and a universe of antimatter?!

Three other important symmetry principles in nuclear science are parity P, time reversal invariance T, and charge conjugation C. They deal with the questions, respectively, of whether a nucleus behaves in a different way if its spatial configuration is reversed (P), if the direction of time is made to run backwards instead of forward (T), or if the matter particles of the nucleus are changed to antimatter (C). All charged particles with spin 1/2 (electrons, quarks, etc.) have antimatter counterparts of opposite charge and of opposite parity. Particle and antiparticle, when they come together, can annihilate, disappearing and releasing their total mass energy in some other form, most often gamma rays.

The changes in symmetry properties can be thought of as "mirrors" in which some property of the nucleus (space, time, or charge) is reflected or reversed. A real mirror reflection provides a concrete example of this because mirror reflection reverses the space direction perpendicular to the plane of the mirror. As a consequence, the mirror image of a right-handed glove is a left-handed glove. This is in effect a parity transformation (although a true P transformation should reverse all three spatial axes instead of only one).

Until 1957 it was believed that the laws of physics were invariant under parity transformations and that no physics experiment could show a preference for left-handedness or right-handedness. Inversion, or mirror, symmetry was expected of nature. It came as some surprise that parity, P, symmetry is broken by the radioactive decay beta decay process. C. S. Wu and her collaborators found that when a specific nucleus was placed in a magnetic field, electrons from the beta decay were preferentially emitted in the direction opposite that of the aligned angular momentum of the nucleus. When it is possible to distinguish these two cases in a mirror, parity is not conserved. As a result, the world we live in is distinguishable from its mirror image.

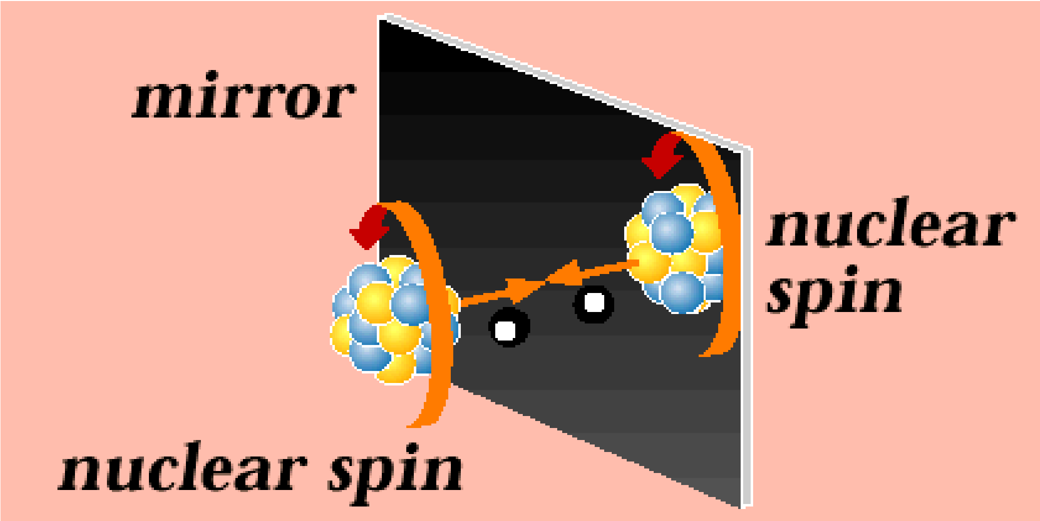


Figure 1

The figure above illustrates this situation. The direction of the emitted electron (arrow) reverses on mirror reflection, but the direction of rotation (angular momentum) is not changed. Thus the nucleus before the mirror represents the actual directional preference, while its mirror reflection represents a directional preference not found in nature. A physics experiment can therefore distinguish between the object and its mirror image.

If, however, we made a nucleus out of antimatter (antiprotons and antineutrons) its beta decay would behave in the same way, except that the mirror image in- Fig1- would represent the preferred direction of electron emission, while the anti-nucleus in front of the mirror would represent a directional preference not found in nature.

The great physicist, Richard Feynman, told a story to illustrate this point: suppose you were in two-way contact with some alien species, but only by "telegraph" (i.e., light flashes or radio signals). The well-known procedures of SETI (Search for Extraterrestrial Intelligence), starting with prime numbers and progressing to pictures, physics, and chemistry information could be used to develop a common language and arrive at a good level of communication. You could tell the alien how tall you are by expressing your height in mutually understood wavelengths of light. You could tell the alien how old you are as some large number of ticks of a light-frequency clock. Now you want to explain how humans shake hands when they meet, and you describe extending your right hand. "Wait a moment!" says the alien. "What do you mean by 'right'?"

Until 1957 there would have been no way of answering that question. But now you could use the parity experiment shown in- Fig 1-. You could tell the alien to turn the experiment until the electrons come out in the upward direction (the direction opposite gravity), and the front edge of the rotating nucleus will move from right to left or clockwise to make the angular momentum. This works because the parity violation of the weak interaction allows us, at a fundamental level, to distinguish right from left.

Feynman also had a punch line to this story. Suppose, after lots of communication you finally can go into space and meet your alien counterpart. If, as you approach one another, the alien extends its left hand to shake, watch out! He's made of antimatter! This, of course, is because a parity violation experiment constructed of antimatter would give the opposite result.

If the mirror in -Fig 1- not only reversed spatial direction but also changed matter to antimatter, then the experiment in front of the mirror would look just like its mirror image. Changing both C and P preserves the symmetry and we call this CP symmetry. The separate violations of P symmetry and C symmetry cancel to preserve CP symmetry. These symmetry violations arise only from the weak interaction, not from the strong and electromagnetic interactions, and therefore shows up strongly only in beta decay.

There are fundamental reasons for expecting that nature at a minimum has CPT symmetry–that no asymmetries will be found after reversing charge, space, and time. Therefore, CP symmetry implies T symmetry (or time-reversal invariance). One can demonstrate this symmetry by asking the following question. Suppose you had a movie of some physical process. If the movie were run backwards through the projector, could you tell from the images on the screen that the movie was running backwards? Clearly in everyday life there would be no problem in telling the difference. A movie of a street scene, an egg hitting the floor, or a dive into a swimming pool has an obvious "time arrow" pointing from the past to the future. But at the atomic level there are no obvious clues to time direction. An electron orbiting an atom or even making a quantum *jump to produce a photon looks like a valid physical process in either time direction. The everyday "arrow of time" does not seem to have a counterpart in the microscopic world–a problem for which physics currently has no answer.*

Until 1964 it was thought that the combination CP was a valid symmetry of the Universe. That year, Christenson, Cronin, Fitch and Turlay observed the decay of the long-lived neutral K meson, K^0_L*, to p* $^+$ *+ p* $^-$*. If CP were a good symmetry, the* K^0_L *would have CP = -1 and could only decay to three pions, not two. Since the experiment observed the two pion decay, they showed that the symmetry CP could be violated. If CPT symmetry is to be preserved, the CP violation must be compensated by a violation of time reversal invariance. Indeed later experiments with K 0 systems showed direct T violations, in the sense that certain reaction processes involving K mesons have a different probability in the forward time direction (A + B Æ C + D) from that in the reverse time direction (C + D Æ A + B). Nuclear physicists have conducted many investigations searching for similar T violations in nuclear decays and reactions, but at this time none have been found.*

This may change soon. Time reversal invariance implies that the neutron can have no electric dipole moment, a property implying separation of internal charges and an external electric field with its lines in loops like Earth's magnetic field. Currently ultracold neutrons are being used to make very sensitive tests of the neutron's electric dipole moment, and it is anticipated that a nonzero value may be found within the next few years.[(6)]

[(6)] http://www2.lbl.gov *-the antimatter -in 2\12\2016 – at :5:30 PM*

Second section

Making antimatter and storing it in our universe

in laboratories ,antimatter is created in enormous particle accelerators. Particle accelerators can be either linear or circular and contain accelerating particles to nearly the speed of light using powerful electric fields.

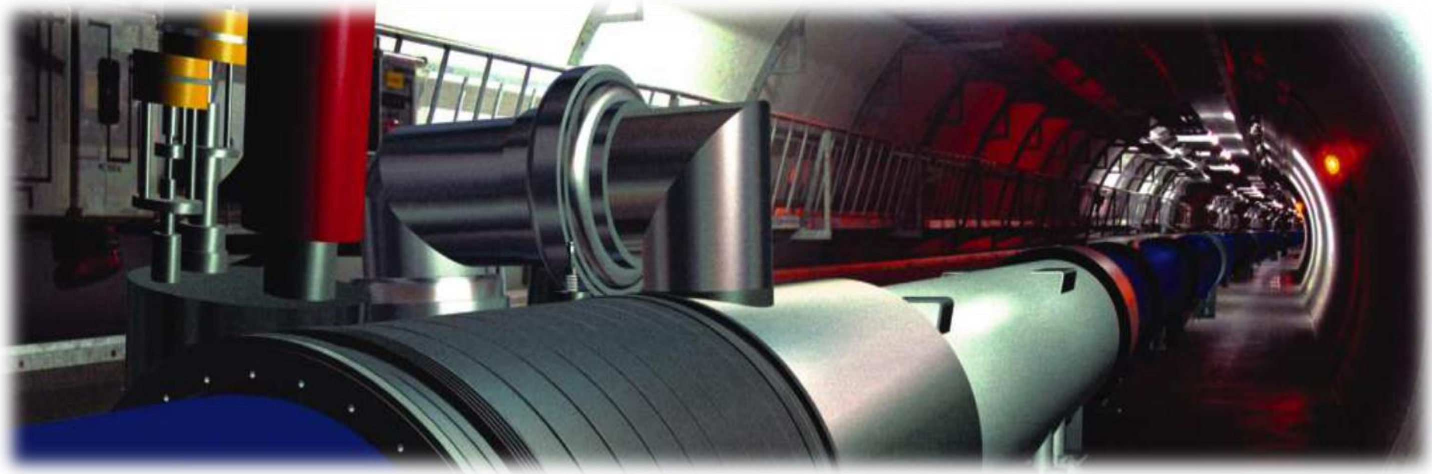
In 1955 the particle accelerator at the university of California at Berkeley , the Bevatron ,product the first antiproton.

this is done by undergoing two beams of particles will a head-on collision. These intense collisions cause the particles to break apart, releasing a shower of secondary particles.

Powerful magnets separate out the antiprotons, which are slowed down to very low velocities and then are exposed to the antielectrons that are naturally emitted from sodium-22. When the antielectrons orbit around the antiprotons, they create anti-hydrogen, since hydrogen is made up of one proton and one electron.
scientists must rely on an image that the smashed particle makes on a special type of film. A chemical reaction occurs on normal photographic film when it is exposed to light, a type of electromagnetic energy. When a particle breaks apart, numerous secondary particles and waves of energy are released. A special type of film can record the paths or tracks left by these particles, and when analyzed, the identities of these particles and the energies they possess can be revealed. According to Einstein's equation ($E = mc^2$), if mass can be converted into energy, then energy can also be converted into mass. Experiments have shown that pure energy in the form of gamma rays can produce matter, if the gamma rays have sufficient energy. And every time this happens, every matter particle is always accompanied by its antiparticle!

In particle accelerators, gamma rays are generated when particles are broken apart at high velocities. If these gamma rays are of sufficiently high energy, they can spontaneously transform into a particle-antiparticle pair. This is the reverse process of what happens when a particle and an antiparticle meet. It may seem like antiparticles are being created out of nothing, but in actuality they are being created from energy. Energy changes forms all the time. When a log burns in a fireplace, potential energy is changed into kinetic energy. The transformation of energy into

matter is no less mysterious in the quantum world inhabited by subatomic particles.
In 1995 CERN made history when it announced that it had created nine anti-hydrogen atoms. Fermi lab soon followed suit by producing one hundred atoms of anti-hydrogen.
At present the enormous particle accelerators at CERN and the Fermi lab outside Chicago have been able to create minute of anti-hydrogen .[7]



enormous particle accelerators

The question that concerns us right now is how antimatter can be stored, transported, and used in reality!!.
Because antimatter and matter destroy each other ,antimatter must be kept in a cage without any contact with material walls.
The solution is to have a vacuum with magnetic and electric fields that keep the antiparticles, positrons, or antiprotons, isolation from matter as circulating beams.
That is in effect what was done at particle physics laboratories such as CERN, where a ring of magnets 27 kilometers in circumference guided bunches of positrons around an evacuated tube for weeks on end. Moving within 55 metres per hour of the speed of light these positrons would have survived for as long as the electricity powering the magnets kept them away from the walls of the vacuum tube, or until they collided with stray atoms of gas inside it.*
But Clearly it is not virtual to build 27 kilometer rings of magnets.

CERN's enormous ring was a pinnacle of scientific achievement, designed specifically to make and control beams of antimatter as near to

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close.F- antimatter – oxford -2009 -pag:80-81-82-83 [7]

the natural speed limit, 300,000 kilometers per second, as possible. The original idea and technology for this type of physics had come years earlier, in 1960.
The inventor was the Austrian Bruno Touschek, though at the time neither he nor anyone foresaw that here was the birth of an antimatter store.
During the Second World War Touschek had been working on radar in Hamburg. One of his colleagues was a Norwegian, Rolf Wideroe, who twenty years earlier had come up with an idea for accelerating particles by a series of small pushes from relatively low accelerating voltages. In Wideroe's prototype, electric fields accelerated the particles in straight lines. Next, Ernest Lawrence, an American, made use of magnetic fields to steer the path of the particles into a circle such that they passed through
the same accelerating gap many times. Lawrence's 'cyclotron' led to the birth of modern high energy physics, and a Nobel Prize. Wideroe's basic idea has remained the principle behind even modern accelerators. It was his next idea that led to the breakthrough.
An American team built two 'storage rings', using magnets to steer electrons around them. In one ring the magnetic fields steered the electrons clockwise, and in the other the fields were reversed so as to send the electrons anticlockwise. It was at this point that Touschek remembered his wartime conversations with Wideroe, and suddenly had his own big idea: positrons have the same mass as electrons but the opposite sign of electrical charge, so a magnetic field that steers electrons to the right, say, will steer positrons to the left. Instead of two sets of magnets to send electrons in opposite directions, why not have just one set of magnets that would send electrons one way and positrons the other! The two beams will follow exactly the same counter-rotating paths provided they have the same energies. Touschek and a group of colleagues at the Frascati Laboratory near Rome designed and built ADA, for Anello d'Accumulazione (accumulation rings). *The whole thing was just a metre in diameter. They successfully stored electrons and also positrons, the first time ever that antiparticles had been tamed. Then this machine that could fit in a suitcase was transported to Orsay near Paris, which possessed a more intense electron beam.*
It was there in 1963 that intense beams of positrons were successfully stored, and also made to pass head-on through beams of electrons.[(8)]

[(8)]*michiu. kaku- physics of the impossible –2008 –USA-pag:182*

Chapter 3
First section

Is antimatter useful ??!!
And what's about antimatter bomb ?!!

If we aren't able to deal with the antimatter closely , why do we need it!?

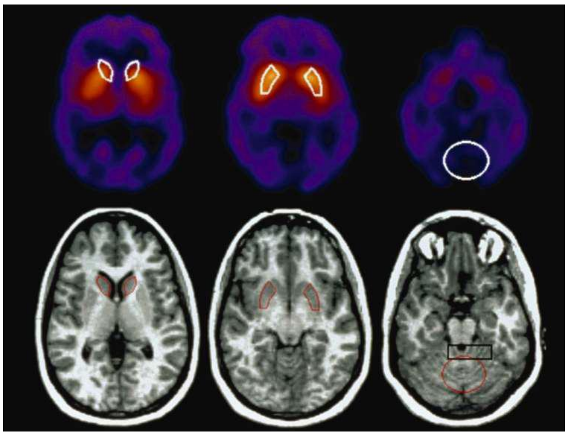
Scientists want the antimatter to study the lows of nature and universe .

They think that Antimatter will help them to know all the secrets about the universe and its development . But their research can lead to new application .

Positron (antielectrons) already used on Positron-Emission Tomography (PET) scanner for medical imagine in hospital .

Scientists expect that it might even be possible to use antiprotons for tumour irradiation , because the ACE (Antimatter Cell Experiment) at CERN has already found that antiprotons are four times more efficient at destroying cancerous cells than protons.

Positron emission tomography scanner.



PET scan of a brain.

A patient is syringed with a compound contain a particular isotope such as C-11 , F-18 , O-15 , or N-13. Dissolved in a liquid such as a glucose solution or water .These isotopes have very short half-lives, but they are strong positron , emitters.

when these positron encounter electrons in the tissue , they are annihilated , producing gamma rays .

Donut-shaped gamma rays .this information is then fed into a computer which makes a three –dimensional image of the patient's body .[9]

May be most of us will ask about using the antimatter as energy source , or could it power vehicles (as starship) in future.

Actually it is along order to use antimatter as an energy source , because we first have to make every single antiparticle , and we have to invest much more energy than we get back during annihilation .

Then what's about "Antimatter Bomb"??!!

an atomic bomb ,for all its awesome power is only about 1 percent efficient. Only a tiny fraction of the uranium , it would convert 100 percent of its mass into energy , making it far more efficient than a nuclear bomb .

Although physicists are able to make antiparticles and store it , they haven't made an antimatter yet .

CERN professes that at the current rate of production it would take over 2 billion years to produce enough antimatter (about one gram) for a bomb with the same destructiveness as a "typical" nuclear bomb.

Also physicist profess that if they had could assemble all the antimatter ever made at CERN and annihilate it with matter , we would only have enough energy to light a single electric light bulb for a few minutes.[10]

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[9] *www.cern.ch communication group ,February 2009 , cern_brochure _2009_001_eng*
[10] *michiu. kaku- physics of the impossible –2008 –USA-pag:181*

Results and propositions:

1. *Matter and antimatter differ in their charge , so while the nucleus of mater contains electrons and protons ,the nucleus of antimatter contains positron and anti-protons.*
2. *also the quarks charge in antimatter differs from matter.*
3. *when matter and antimatter come into contact they completely annihilate because they have an opposite charge .*
4. *the physics laws for matter is not similar with antimatter and this is which is proved by CPT-reversed theory .*
5. *it's so possible that there is an antimatter planet in other place of universe* **.**
6. *scientists made some antimatter nucleus by using large Collider molecules.*
7. *Antimatter will help us to discover the development of the universe, and also it will help us in The medical field .*
8. *Antimatter pomp isn't exist until now, and the scientists excluded it.*

The conclusion:

Of course an antimatter came as a strange thing and maybe it was the biggest surprise in the Particle Physics universe .

Anyway , there is a lot of scientists today who study the antimatter and its behavior and now there are big Scientific research centers which are responsible of studying only antimatter .

In spite of making each of those studies scientists still doesn't know too much about antimatter and they aren't sure until now that all theories of antimatter are true .

Discovering antimatter will help us very much and it will probably be the Primary treatment of the cancer . But it's very Excluded to use antimatter as an energy sources or as bombs , so you have not to be afraid

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