Matter and Antimatter

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Particle Physics and Astronomy Research Council
the physics of the universe
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Nicole Chevalier
University of Bristol

The Big Bang created the same amount of matter and antimatter, and mutual annihilation should have converted it into radiation long ago!
Yet now only matter is left, which our current theories cannot fully explain. I work on an experiment called Babar which hopes to learn more about a new model that describes the universe better.

A positron is like an electron but opposite in some ways.

All electrons have negative electric charge.

But all positrons are positive.

Maybe you could say that a positron is like a mirror image of an electron.

But when an electron meets a positron...

This is MUTUAL ANNIHILATION.

BANG!

No more electron

No more positron

Their energy becomes the energy of GAMMA RADIATION.

Gamma radiation is invisible...

...but it is high energy light...

...like X rays

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$E = mc^2$

m is the MASS of the electron and the positron before their mutual annihilation

E stands for ENERGY

c is the SPEED OF LIGHT which is 300,000,000 metres per second.

After the mutual annihilation E is the energy that's carried away by two bursts of gamma radiation.

FAST!

So energy = mass x speed of light squared.

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Mutual annihilation happens when a particle meets its antiparticle ...

...and something similar can happen in reverse.

If a burst of gamma radiation has enough energy...
...then it can sometimes turn into...

Hi, I'm new around here

... a particle and an antiparticle.

The energy of the gamma radiation turns into the masses of a particle and an antiparticle.

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Kate Adamson
University of Durham

I am a theoretical physicist at the University of Durham. When particles meet their antiparticles they destroy each other, producing a lot of energy. This energy then creates new pairs of particles and antiparticles. I work in a team trying to understand what happens in these events.

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Tim Fryer
Wolfson Brain Imaging Centre - Cambridge

Here at the Wolfson Brain Imaging Centre, we use Positron Emission Tomography (PET) scans to produce clear images of brain function. Doctors use these images to help them better understand head injury, dementia, strokes, and other damage to the brain. I am researching ways to produce better, clearer images using PET.

A substance that acts as a source of positrons can be injected into a person's blood. The substance accumulates at the places that are busiest. The positrons meet the electrons in the person's brain, and they annihilate each other.

You won't feel a thing.

SOURCE OF POSITRONS

HOME OF LOTS OF ELECTRONS

They're seeing how my brain works...

...IF it works!

MUTUAL ANNIHILATIONS OF POSITRONS AND ELECTRONS

GAMMA RADIATION

Positrons and electrons are meeting inside my brain... and BANG!...that makes gamma radiation.

Here in the hospital they have gamma cameras to detect the radiation...

...so they can tell which parts of my brain are busiest.

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Paul Dirac

Paul Dirac was a British physicist. He was the first person who thought there could be antimatter.

Paul Dirac (1902 -1984) was one of the greatest scientists of the twentieth century. As well as predicting the existence of antimatter, he helped to develop the theory of quantum mechanics – the theory behind all modern electronics.

He thought of a new theory to predict how electrons behave.

My equation suggests there must be antielectrons as well as electrons.

Electrons have negative charge.

The antielectrons must have positive charge.

Another name for an antielectron is POSITRON.

At about the same time, some other scientists were interested in COSMIC RAYS.

Cosmic rays are high energy particles that hit the Earth from space.

Soon after Dirac's prediction, Carl Anderson discovered tracks of a unusual type of particle.

He realised that the particle was a POSITRON

Positron = positive. Easy!

The particle's pathway curved the opposite way to an electron's in a magnetic field.

This showed that the particle had the opposite charge to an electron.

Otherwise it was a lot like an electron... same mass and everything.

JUST as I Predicted!

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Manny Olaiya
Rutherford Appleton Laboratory

In California, we use an accelerator to generate heavy unstable particles of matter and anti-matter. Using the BaBar detector, I measure how differently the matter and anti-matter behave when they decay.
That could help to explain why we don't see all the anti-matter that was created during the 'Big Bang'.

I'm off to find an antigalaxy.

Maybe I'll find an ANTI EARTH..

... or even an ANTI ME!

You wouldn't want to meet your ANTI SELF!

$E = mc^2$ Your mass would release lots of energy

BANG

MUTUAL ANNIHILATION

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In California today, scientists from lots of different countries get together.

They accelerate electrons and positrons to give them lots of energy.

Then they smash them together.

The electrons and positrons annihilate each other.

Because the electron and positron have so much energy they don't just annihilate to make gamma radiation...

...they also make particles called B PARTICLES and ANTI B PARTICLES.

These are also called B and B-bar...

...so the experiment is called BABAR!

After the cartoon elephant.

As far as we know, almost everything in the Univers is made from matter and not antimatter...

...but we don't know WHY.

The scientists in California have found small differences between matter and antimatter. They're trying to find out more.

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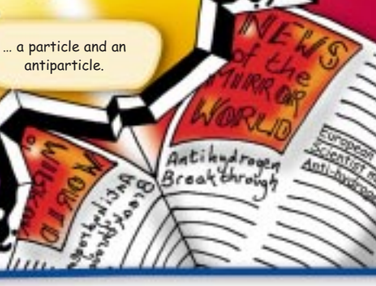
Terri Louise Watson
University of Wales - Swansea

At the ATHENA experiment at CERN in Geneva we hope to make antihydrogen at very low energies by carefully combining positrons and antiprotons. This will allow us to compare the spectrum of antihydrogen with that of ordinary hydrogen to provide very precise tests of some of Nature's fundamental symmetries.



POSITRON

ANTIPROTON

AN ATOM OF ANTIHYDROGEN

ELECTRON

PROTON

AN ATOM OF HYDROGEN