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PHYSICS & ASTRONOMY

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As we passed the winter solstice (we hope you caught the lunar eclipse this year!), we were reminded that the new year is near. To celebrate the new year, in this issue we are covering two major stories: the trapping of antihydrogen for the first time in history, as well as a recap of our Faraday Show on December 12. In addition, TRIUMF is announcing the CAP Award for Excellence in Teaching High School/CEGEP physics, which TRIUMF is a national sponsor for. Don't forget to submit your nomination by February!

We hope that you enjoy the newsletter and have a wonderful holiday season!

You can subscribe to our newsletter at our web site:
http://outreach.phas.ubc.ca/emailList/index.php

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Other Outreach Opportunities

TRIUMF
Canada's National Laboratory for Particle and Nuclear Physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

Physics in Action video series

TRIUMF is creating a video series which will use the cutting-edge science at the world's largest cyclotron to teach basic concepts in secondary school physics.

Two of four planned videos have been released. Order your copy today !

http://www.triumf.ca/physicsinaction/

CAP Award for Excellence in Teaching High School/CEGEP physics

TRIUMF is honoured to be a national sponsor for these awards to a teacher in each of Canada's five regions who possess an exceptional ability to motivate their students to high academic achievement in physics.

Nominations are now open until February 14, 2011. Visit the CAP website for details.

http://www.cap.ca

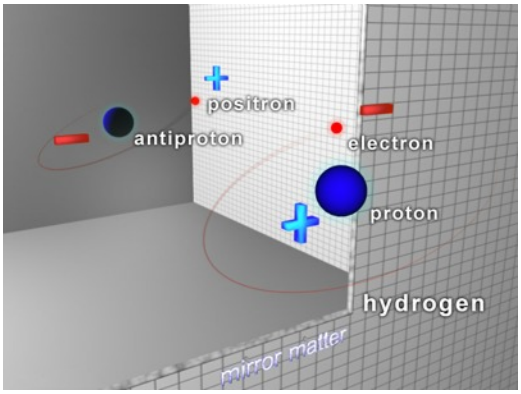
This Just In!

Mind Over Matter…or Antimatter?

If you are a fan of the TV series Star Trek, enjoyed Dan Brown's novel "Angels & Demons" (or its movie version starred by Tom Hanks), or if you simply have a curious mind for particle physics, then you must have heard of the term "antimatter". What exactly is antimatter? And does it really have the power as portrayed in movies and novels? How much is fact, and how much is fiction?

To answer these questions, let's first ask the question - what is ***matter***? Based on the Merriam-Webster dictionary, matter is

> "Material substance that occupies space, has mass, and is composed predominantly of atoms consisting of protons, neutrons, and electrons, that constitutes the observable universe, and that is interconvertible with energy"

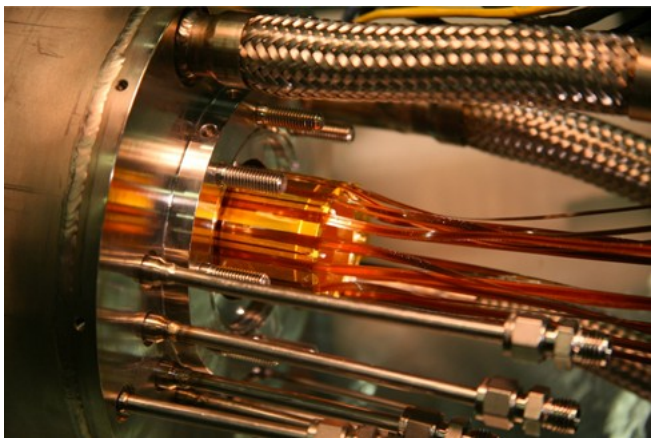


3D rendition of hydrogen and antihydrogen[1]
(image by US National Science Foundation)

The basic building block of matter is an atom. Let's take hydrogen, the simplest atom we can find. A hydrogen atom has a negatively charged electron (e-), and a positively charge proton (p+). Since its discovery by Henry Cavendish in the 1700's , this simple atom has been studied so well (both because of its simplicity and its abundance in the world… it's in every single water molecule!) that scientists love to use it as a standard atom to study. Now here is a crazy idea - Instead of having an e- and a p+ in a hydrogen atom, how about changing the charges so that this special "hydrogen" has a positively charged electron, and a negatively charged proton?

But is that really so crazy? Not as much as you think! In fact, the first ever antihydrogen was synthetically generated in 1995 at CERN - the European Organization for Nuclear Research (yes, this was mentioned in the novel Angels & Demons…this place does exist). Nowadays scientists start with making the negatively charge protons (called antiprotons) by smashing regular protons into a piece of iridium . Then positively charge electrons (called positrons) are generated by the decay of radioactive sodium-22. Finally the two are mixed together and voilà, we now have a special hydrogen atom…this is now called an ***antihydrogen atom***!

So in principle, hydrogen and antihydrogen are supposed to be the same except the charges are flipped - ***matter consists of atoms with positive protons and negative electrons, while antimatter has atoms with negative protons and positive electrons***. While the making of antihydrogen atoms sounds like it is straight out of science fiction, this is real and it is actually a lot of work - definitely not like mixing egg and flour into a batter. The hardest part of all is that the antihydrogen atoms generated are so high energy (they travel almost at the speed of light) that it is nearly impossible to keep them still. Just about immediately they bounce into the walls of the container. And since the container is made of "matter" - guess what happens? Antihydrogen atoms are annihilated and you get nothing but a shower of particles that decay into pure energy.



The electrodes (gold) for the ALPHA Penning trap being inserted into the vacuum chamber and cryostat assembly. This is the trap used to combine or "mix" positrons and antiprotons to make anti-hydrogen. (Credit: Niels Madsen, ALPHA/Swansea.)

Not to worry - where there is a problem, there is a solution! Just recently, and we are talking about very recently, like in November 2010, a group of physicists (the ALPHA team) at CERN were able to trap antihydrogen atoms by "cooling" the positrons and antiprotons (reducing its energy level) all the way down so that the slightly more stable antihydrogen atoms could be generated when antiprotons and positrons were combined. And because the antihydrogen atoms were "cooler," physicists were able to trap the atoms in a special magnetic chamber - suspending the atoms so that they wouldn't touch the walls of the container.

This Just In! (con't)

This is a huge scientific development. The first time ever in history that we are able to trap antihydrogen! But why is this so interesting to physicists? Well, this doesn't have as much to do with making explosives or looking for a new energy source (like described in Angels & Demons or in Star Trek). Overall only 38 antihydrogen atoms were generated after mixing 10 million antiprotons and 700 million positrons. If we do some simple calculations here:

1 mole of hydrogen = 6.02×10^{23} atoms

1 mole of hydrogen weighs 1 gram

Each hydrogen atom = $1 / 6.02 \times 10^{23} = 1.66 \times 10^{-24}$ grams

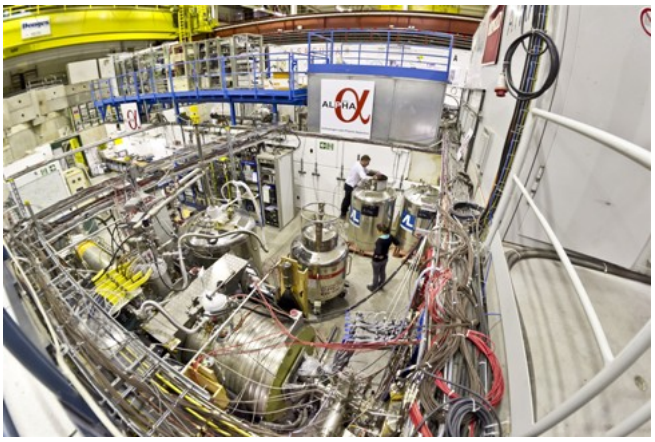
Assuming 38 antihydrogen atoms will weigh the same as 38 hydrogen atoms, then in total we have:

$1.66 \times 10^{-24} \times 38 = 6.31 \times 10^{-23}$ grams of antihydrogen

(To be honest, I doubt we will even be able to feel a tingle if this amount of antihydrogen comes in contact with matter, not to mention an explosion…)

Also, the amount of energy put into the production and cooling of the positrons, antiprotons, and antihydrogens is enormous (a lot of electricity is needed to run the machines!). Because of this, antimatter cannot really serve as a source of energy. So why go through all the trouble? The main reason why physicists are interested in making antihydrogen is to actually study this really cool question: ***why does the universe consist entirely of matter, instead of antimatter?*** The currently accepted laws of physics predict symmetry - when the universe began with the Big Bang, supposedly an equal amount of antimatter and matter were generated. But if that was the case then I wouldn't be sitting here writing this and you wouldn't be here reading this - antimatter and matter would have come into contact with each other and everything is then annihilated! So something must have happened, and that is what physicists are interested in finding out. Another question is whether antimatter and matter are exactly the same, other than the sign of their charges. Technically they should be - they should have the same weight, for example, as predicted by the standard model of particle physics (a model used by physicists to predict the behaviours of subatomic particles). By generating the antihydrogen atoms, we can also test whether gravity acts on both hydrogen and antihydrogen the same way, as one of the key steps to evaluate similarities and differences.

One thing to mention is that the making of antihydrogens is no simple task and requires the collaboration of many physicists - the ALPHA team has a group of 43 researchers, of which 15 are from Canada (yay!), and more than half of them came from the Vancouver area - among them, Dr. Walter Hardy is a professor at the UBC Department of Physics & Astronomy; Dr. Fujiwara of University of Calgary (also the spokesperson for the ALPHA-Canada team) and Dr. Michael Hayden of Simon Fraser University are both alumni of the department. ***With the successful generation and trapping of the antihydrogen atoms, the ALPHA team will continue to work together to find answers to big questions asked about the universe and our world.***



View from the top of the ALPHA experiment (Photograph: Maximilien Brice, CERN)

From left to right: Dr Makoto Fujiwara, Research Scientist, TRIUMF and Adjunct Assistant Professor, University of Calgary; Andrea Gutierrez, PhD student, University of British Columbia; Dr Walter Hardy, Professor, University of British Columbia; Tim Frieser, PhD student, University of Calgary; Dr Michael Hayden, Professor, Simon Fraser University; Mohammad Dehghani Ashkezari, PhD student, Simon Fraser University. (Credit: Niels Madsen, ALPHA/Swansea.)

This Just In! (con't)

Acknowledgement

We would like to thank Dr. Walter Hardy for reviewing this article.

References

1. Wikipedia, The Free Encyclopedia. (November 25, 2010). *3D image of Antihydrogen.jpg*. Retrieved December 14, 2010 from http://en.wikipedia.org/wiki/File:3D_image_of_Antihydrogen.jpg

Want to learn more? Check out the following

- Original Research Article: http://www.nature.com/nature/journal/v468/n7324/full/nature09610.html (might require subscription)
- The ALPHA Collaboration: http://alpha.web.cern.ch/alpha/
- Angels & Demons: The Science Revealed by Dr. Joel Fajans (also a member of the ALPHA team): http://www.youtube.com/watch?v=_sqYh8puZ-I
- *Antimatter: Gotcha!* from the Economist: http://www.economist.com/node/17519521
- *Antimatter trapped for the first time* from Gizmodo, the Gadget Guide: http://gizmodo.com/5692614/antimatter-trapped-for-the-first-time
- *Upping the Anti: CERN Physicists Trap Antimatter Atoms for the First Time* from Scientific American: http://www.scientificamerican.com/article.cfm?id=antimatter-confined

December 12, 2010 - UBC 7th Annual Faraday Show

"Physics of Light and Colour!"

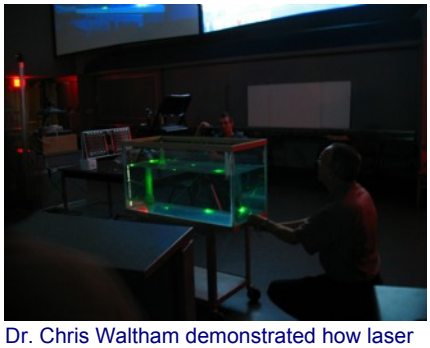
In 1826, physicist Michael Faraday founded the Children's Christmas Lectures at London's Royal Institution. His goal was to communicate to children the excitement of scientific discovery. In keeping with the spirit of those lectures, every year students and faculty at the Department of Physics and Astronomy present the Faraday Show - this year our topic was the "Physics of Light and Colour." 320 parents and children joined us to learn how optical illusions work and how we can create lights of different colours. We also found out which type of Christmas light decorations consumes the least amount of energy, and how we can use light to generate electricity. Interesting student and faculty projects were presented, and the show ended with a demonstration of the reflection and refraction of laser in water.

This year we collected donation of non-perishable food items for the Greater Vancouver Food Bank

Did you miss it this year? The Faraday Show is an annual event - remember to check our web site in December and mark it down on your calendar next time!

Dr. Georg Rieger discussed the wave properties of light

"What did you see through the telescope?"



Dr. Chris Waltham demonstrated how laser passes through water with reflection and refraction