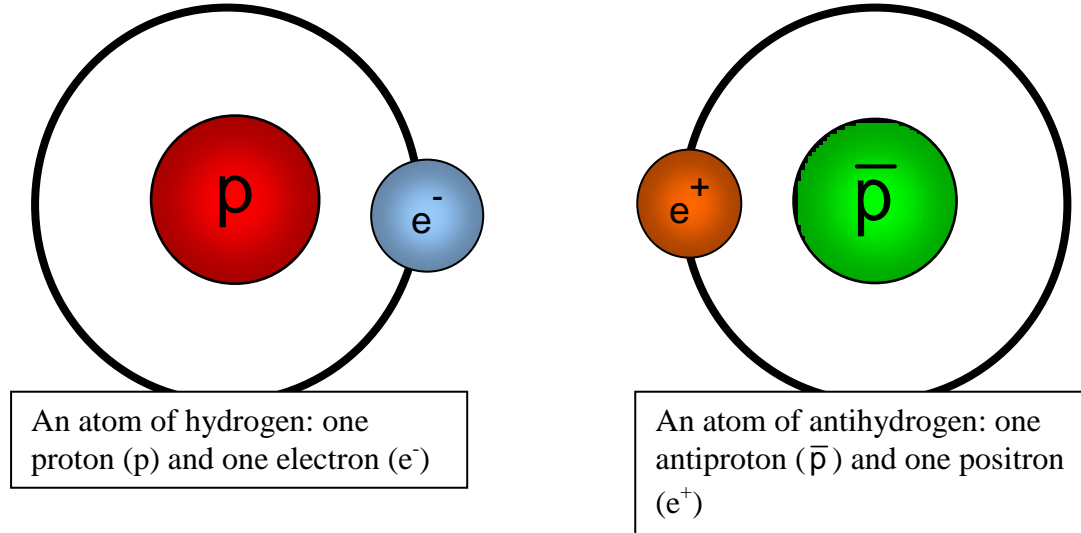


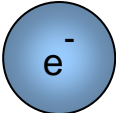
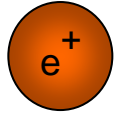
Antimatter

You'll be aware that all matter in the universe are made up of *atoms*, which in turn are made out of *particles* like *protons*, *neutrons* and *electrons*.



However, you might not have known that each of these particles has a corresponding *antiparticle*. Antiparticles are like particles, having *the same mass* – but they have the *opposite electric charge*.

Paul Dirac predicted the existence of antiparticles in 1928, and it was only a few years until the first antiparticle was observed in 1932. While there aren't many antiparticles out there in the universe compared to normal particles, they definitely exist.

Electron		Positron	
Charge = -e		Charge = +e	
Mass = $\frac{1}{1836}$ mass of a proton		Mass = $\frac{1}{1836}$ mass of a proton	

Here's an example: the electron. The electron has a negative charge, but its antiparticle, the *positron*, has positive charge (as the name suggests!). However, the electron and the positron have the same mass. There's an antiparticle for the proton too: the *antiproton*, which has negative charge (the opposite of the proton's positive electric charge). It's possible in theory to put antiparticles together into atoms and even molecules like with ordinary matter – so an antiproton with a positron orbiting around it would be an atom of antihydrogen.

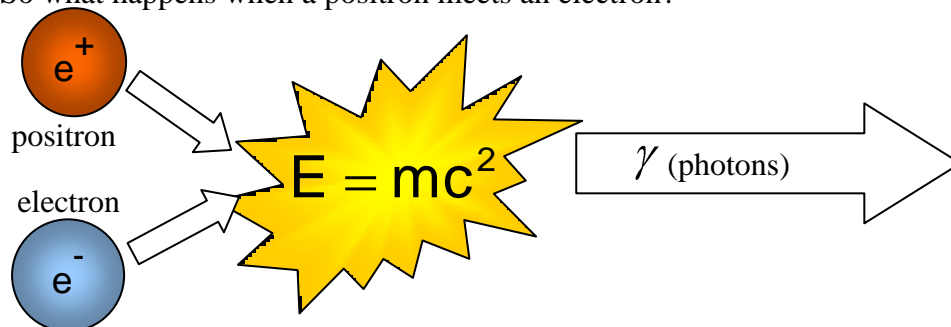
Making Antimatter

Now that we know that antimatter exists, how can we find some? Well, there doesn't seem to be much of it about – you certainly can't buy it in the shops! Indeed, scientists think that the universe is nearly totally dominated by matter.

So how do we find any antimatter at all? It's often produced by *high-energy particle collisions* – when very fast moving particles hit other particles. This happens naturally, such as when *cosmic rays hit the Earth's atmosphere*. It also happens in the laboratory in *particle accelerators*. In addition, *certain types of radioactive decay* produce antiparticles.

Annihilation

So what happens when a positron meets an electron?



When a particle collides with its antiparticle, both of the particles get *annihilated* – they both disappear. However, *the energy and momentum the particles possessed must be conserved* and the mass of the annihilated particles has to go somewhere too.

What happens to it? *All the mass of the particles is converted into energy* (as shown by Einstein's famous equation $E = mc^2$), and then all of the energy and momentum the particles had is given to new particles – usually *photons*, the particles from which light is composed.

A Cosmic Mystery

In the universe around us we observe very little antimatter. Our planet, solar system and surrounding galaxy all seem to be made of normal matter. As we've seen, part of the reason for this is that if matter encounters antimatter, the two together annihilate each other. So maybe all the antimatter has been annihilated? However, there's clearly a lot of normal matter left over – enough to make all the stars and planets in the universe out of! Clearly *the early universe must have had much more normal matter than antimatter*.



NGC6744, a galaxy similar to our own, the Milky Way

Why? *Scientists still don't know for sure*. The answer may lie in conditions in the very early history of the universe – *the Big Bang*.

Further Reading

Quinn, H.R., 2008. *The mystery of the missing antimatter*. Princeton, New Jersey, USA: Princeton University Press.

Close, F.E., 2004. *The particle odyssey: a journey to the heart of the matter*. New edition. Oxford: Oxford University Press.