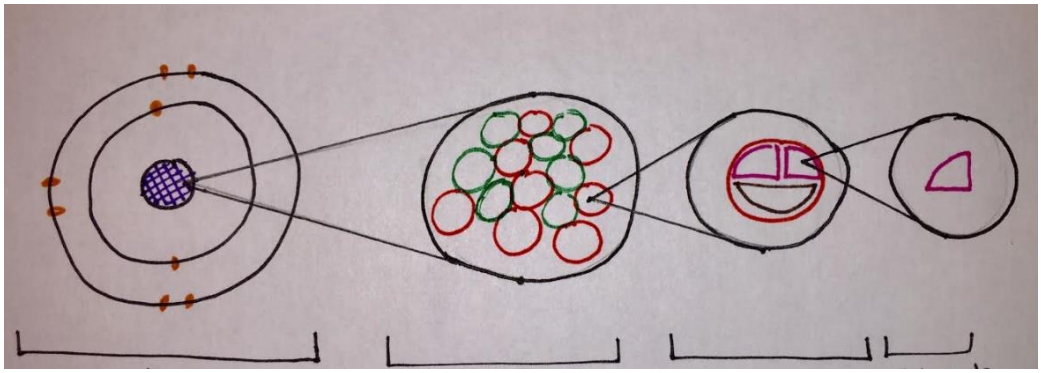
Matter antimatter asymmetry

Everything in the universe is made of matter. Matter is any physical substance which occupies space and has a mass. Matter is classified as either hadrons or leptons, with CERN's focus being on hadrons at the LHC. Within hadrons there are baryons (made of three quarks) and mesons (made of two quarks). Commonly known baryons include protons and neutrons.



Atom | Nucleus | Baryon | Quark

Antimatter is matter's counterpart. Antimatter has the exact same mass yet has opposite properties to its matter pair such as spin and charge.[1] Each subatomic particle has a counter particle. Up quarks become anti-up quarks, down quarks become anti-down quarks and electrons become positrons. This is similar to the idea of north and south, heads and tails or left and right as they are equal and opposite yet they cannot be both. Matter cannot be the same as antimatter as a left cannot be the same as a right.

Antimatter and matter are oppositely charged so they are electrostatically attracted to each other. However, when matter and antimatter collide they annihilate each other and produce photons. The frequency of the photon's produced depends on the mass and velocity of the particles that collided. This is similar to the idea of magnets but if they touch they explode.

The opposite process can also occur when high energy gamma rays spontaneously produce matter and anti-matter pairs. In all observable interaction matter and antimatter have been created in equal amounts in order to conserve baryon number. Baryon number is the number of baryons in any interaction. Normal matter baryons have a baryon number of +1 whereas antimatter baryons have a baryon number of -1. Baryon number is strictly conserved in all particle physics. So in theory, matter and anti-matter should have been created in equal amounts during the big bang in order to conserve baryon number. However, we can see that this is not true as if they were created in equal amounts all matter and antimatter baryons should have been annihilated and the universe would be full of high frequency gamma rays. As there clearly is more matter in the universe than antimatter there must be an asymmetry between matter and antimatter – that is to say that the amount of matter and antimatter created in the big bang is not actually equal.

Theoretically, the chemistry of anti-atoms with other anti-atoms should be the same as the chemistry of atoms with other atoms due to the idea of CP symmetry between the particles. Should they not behave in the same manner it would suggest that the laws of physics are not the same for both matter and anti-matter particles.[2] It is possible to have antiatoms, antimolecules and even antipeople.

Recent experiments at LHCb has found evidence that matter and antimatter may not be created in equal quantities which violates CP symmetry.[2] The LHCb (Large Hadron Collider beauty) experiment at CERN specialises in studying a "beauty quark (b quark)" to analyse the difference between matter and antimatter.[3] LCHb collides normal matter protons together at extremely high velocities and when the collide they annihilate. LHCb then measures the products of these interactions with a string of sub-detectors to track the b quarks and their decay. [2]

It has been seen that matter and antimatter are not being created in equal amounts during these sub atomic interactions 'with differences in some cases as large as 20 percent.' Which is a large enough difference to provide evidence for a mechanism leading to matter-antimatter asymmetry [2] and also supports the knowledge that the universe is mainly matter which we can observe as things exist. This research is still in its infancy and there many competing theories for why there is more matter than antimatter in the universe. It is still yet unknown what causes this asymmetry between matter and antimatter. One alternative theory is that matter and antimatter were actually created in equal quantities in the big bang but over have time have spread apart so galaxies of matter and galaxies of antimatter both exist but separated far apart enough that they do not collide and annihilate. This is quite a satisfying explanation but is lacking evidence. The boundaries between these matter and antimatter regions of the universe should be annihilating each other and producing high energy photons but these regions of space are nowhere to be seen.

In summary the universe seems to be made of only one type of matter although current understanding suggests it should be made of two – both antimatter and normal. The true answer to this problem is still a hotly researched area of physics.

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[1] https://home.cern/topics/antimatter/matter-antimatter-asymmetry-problem

[2] https://phys.org/news/2017-01-source-asymmetry-antimatter.html

[3] https://home.cern/about/experiments/lhcb