WHAT IS ANTIMATTER?

In the early decades of the 20th century, the discovery of something called antimatter raised a significant problem. This new substance called into question how our matter-filled universe could exist at all. Let me explain.

In 1928, Paul Dirach came up with a new and elegant equation to describe how particles, like electrons, behave when they travel close to the speed of light. Surprisingly, Dirach found that his equation always had two solutions, sort of, how a square root of a positive number always has two answers.

Dirach recognized that one solution described the electron, but the other? Well, that was a mystery which he first dismissed as a mathematical artifact. He later said it took him three tortured years to summon the courage to claim that this other solution was describing something real - antimatter.

That is, the first solution described an electron, the second described an anti-electron. The anti-electron would have the same mass and spin as the electron, but would have an opposite electric charge. Now since the electron has a negative charge, the anti-electron would have a positive charge, which is why we also call it a positron.

Dirach's equation says that the same thing is true for all particles. Quarks have anti-quarks. And just as quarks can make up protons, anti-quarks can make up anti-protons. And anti-protons and anti-electrons? They can make anti-atoms, and so on.

Dirach's theory was a remarkable achievement. If proven correct, it would double the number of known particles in the world. Just 4 years later in 1932, Carl Anderson took this picture of a particle racing through a bubble chamber. His measurements show it had the same mass as an electron, but a positive electric charge. The first detection of antimatter verifying Dirach's mathematical prediction.

Now we come to the puzzle. When matter and antimatter come together, they annihilate. And this raises a big question: why is there any matter left? After all, if matter and antimatter are identical except for having opposite electric charge, and since as far as we can tell, the laws of physics don't have a preference for a plus sign over a minus sign, we would expect equal amounts of matter and antimatter to be created at the Big Bang.

And then as they intermingled, the matter and antimatter would all annihilate, leaving a sea of structure-less radiation. But if this were the case, the universe as we know it, wouldn't exist. So what's going on?

Physicists have been puzzling about this for more than half a century. Some have wondered whether the antimatter got separated from matter and might still be out there, existing as antiplanets, anti-stars, anti-galaxies, maybe even anti-universes. Others have imagined that just after the Big Bang, a tiny imbalance between matter and antimatter somehow crept in.

Indeed to avoid total annihilation, scientists have calculate that for every billion anti-protons, there must've been a billion plus one protons. That's a tiny imbalance. It would've left just enough matter to make all we see in the universe today.

To figure out which of any of these theories might be right, scientists are undertaking a range of experiments to understand antimatter with a far greater precision. And all this is part of a grand quest to answer a question that is as simple as profound. Given that matter and antimatter annihilate, how is it that we exist?