Open charm production in diffractive proton-proton interactions with the ATLAS experiment

At the ATLAS experiment at CERN, scientists are delving deep into the mysteries of the universe by studying what happens when protons collide at incredibly high energies. Using a state-of-the-art equipment, they are analyzing the properties of the particles produced in these collisions, hoping to gain new insights into the structure of matter and the forces that govern its behavior.

One particularly fascinating area of study involves "diffractive open charm production". In essence, this refers to the processes in which the protons interact with a force significant enough to create a charm quark and antiquark pair, but somehow they are not destroyed in the collisions and remain totally intact in the aftermath of such collision! Note, that the charm quark itself is heavier than the proton and all the energy needed for its creation comes from the kinetic energy of the proton (which travels nearly at the speed of light). How is possible that the proton survives such a collision? That is precisely the main interest of these studies.

Now, why the charmed quarks are of particular interest to scientists? After all, these particles are incredibly rare and only produced in a small fraction of all proton-proton collisions. In even rarer events it happens so that the proton interacts in such a way, that it leaves the collision unscathed – these collisions are called "diffractive" and the way that happens is by an exchange of a very mysterious object called the Pomeron. It is a complicated structure, consisting mostly of gluons, but also some quarks, and its nature and composition are one of our top interests.

These rare events, in which the Pomeron mediates in the creation of charm quarks, can provide invaluable insights into the structure of matter and the forces that hold it together. For one thing, such studies can shed light on the nature of strong nuclear forces. These forces are responsible for binding together the protons and neutrons in an atomic nucleus, and understanding how they work is key to understanding the structure of matter at its most basic level.

But studies of the interactions that produce charm quarks are interesting for one more special reason – the charm quarks are heavy enough that in the theoretical calculations we can use certain approximations allowing us to directly compare the results from experiment with the predictions from theory. This is an invaluable insight, which will help us understand the behavior of strong nuclear forces and how they contribute to the overall structure of matter.

The study of diffractive open charm production is just one small piece of the puzzle when it comes to understanding the mysteries of the universe. However, by delving deep into the structure of matter at its most basic level, scientists at the ATLAS experiment are helping to shed light on some of the most fundamental questions in physics, and pushing the boundaries of our understanding of the cosmos.