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The Force is Strong with this One

While you might think of a galaxy far, far away, particle physicists are more inclined to think of the strong force. However, both approaches are reasonable in this case. While it may not be a galaxy far, far away, the strong force is linked to a forerunner form of galactic matter in the early Universe, right after the Big Bang.

The origin of the Universe is a mystery. Even though the Big Bang Theory gives us a fairly good idea of how this happened we are still unsure about the details and why it happened. Recent research has found a new state of matter, called the quark-gluon plasma (QGP). It is believed that during the first few micro-seconds (1/100000 of a second) of the Big Bang, the universe resembled this QGP state.

So, how does the strong force fit in with the QGP? Well, the strong force is in charge of keeping the world together (in a way) by keeping the fundamental particles together. Protons and neutrons in the nucleus of an atom are made of quarks and gluons, where gluons are the particles that *mediate* the strong force - they are like the workers of the strong force. To make it simple, gluons are the “glue” that keeps quarks together in one particle. This strong force is described by a theory, called quantum chromodynamics (QCD), which has a property that only allows quarks to exist within particles, called hadrons. This is called confinement. However, QCD also predicts that at a very, very high temperature and density, the matter involved in the strong force, quarks and gluons are freed from this confinement and exist as free particles in a plasma, the quark-gluon plasma.

This plasma can be reconstructed for an extremely short time when large nuclei are put in extreme situations of high temperatures and densities. This is possible in particle accelerators such as the Large Hadron Collider at CERN in Switzerland by colliding two heavy nuclei (heavy-ion collision). So far, this plasma has mainly been observed in heavy-ion collisions, such as lead-lead collisions, in which two lead atoms are smashed together and create the circumstances in which the plasma can exist. Now, research is shifting its focus to see whether the QGP can be observed (and thus is created) in proton-proton (pp) collisions, also referred to as “small-systems”.

A feature of the QGP can be observed in the way the particles expand after the collision. An odd property of the QGP is that it expands *anistropically* (or non-evenly) after the collision and so observing this odd flow indicates the QGP. This thesis attempted to find this odd flow in pp-collisions. If it were found it could mean two things: either the odd flow is not necessarily the plasma or the plasma can be created in pp-collisions.

While you might think “Ok, so how is this helpful?”, it would actually reveal information about the first few microseconds of the Universe and in the end, don’t we all just want to know what happened a long, long time ago, when the Universe came into existence?

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