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Dark Matter or how to detect the undetectable

Looking into the night sky has always fascinated mankind. All who have observed the stars have asked themselves what is out there. Better and better telescopes have enabled us to take an ever deeper look into the universe, and with it a look into the past. Now we know that what we can see, however, only accounts for a small percentage of what is out there. Only about 15% of the total matter in the universe is ordinary matter as we know it and of which we ourselves are made. The rest is called Dark Matter, and even though we know it must be there, we actually have no idea what it is. The term "dark" is somewhat misleading, as Dark Matter is not dark, but invisible, as it does not interact electromagnetically.

But how do we know that it is there when we cannot see it? We mainly know of its existence because it interacts with ordinary matter through gravity. One of the first pieces of evidence came from the Swiss astronomer Fritz Zwicky. In 1933, he measured how fast different galaxy clusters, that is a group of gravitationally bound galaxies, rotate and figured out that they rotate so fast that the galaxies should not keep together. Like on a playground roundabout that is spinning too fast, they should drift apart. There must be something that keeps them together, namely Dark Matter. Over time, many other pieces of evidence have been added that all speak in favour of Dark Matter.

The problem is, we know it is there, but we do not know what it is. All particles - so the most elementary building blocks everything is made of - that are known to us are summed up in the *Standard Model of Particle Physics*. It consists of *fermions* and *bosons*. Fermions are the particles all matter known to us (so you, too) is made of. Fermions can interact with each other through forces. One force most people will know is the electromagnetic force, it is the one that makes your hair all fuzzy when you rub a balloon against it. There are four known elementary forces, three of which are mediated through bosons. One can imagine it this way: one particle gives away a boson, the other particle takes it in, and in doing so they feel a force between them.

Scientists are looking for Dark Matter in the ATLAS experiment at CERN in Switzerland, the largest laboratory of its kind in the world. In ATLAS, protons - which, together with neutrons, make up atoms' cores - are shot together at very high energies to create new particles, for example Dark Matter particles. This may be odd for people who are not familiar with it; after all it is as if two ducks crash and come out as cars. This can, however, not happen directly but needs a boson (we talked about these before) to do so. Actually, we must look deeper. A proton is a bag of quarks (this is what they are made of). When two of these quarks collide, they can form a boson together, and the boson splits up into two Dark Matter particles. The Dark Matter particles can not be seen or otherwise detected, so what should we do? We are lucky: if two quarks can make a boson, the boson can not only make Dark Matter particles, but can also split up back into two quarks. When this happens, the quarks are so fast that they can create many more particles and we get two cones of particles. These cones - they are called jets - can then be detected and from their properties, the mass of the boson can be deduced. The hope is to find a new, yet unknown boson which can give a hint to Dark Matter. This search is like hunting for an invisible deer by searching for its footprints in the snow.

But there is a problem: every second, thousands of millions protons collide. Everyone can imagine that this creates a huge amount of data. If all these data would be saved on CDs, the stack of CDs needed every year would reach twice to the moon and back again. It is obvious that some kind of trigger is needed that tells us if an event (that is what it is called when a collision takes place) is interesting to look at or not. My thesis is looks at a new way how this can be done and in how far it has advantages to how it is done currently. If it is successful, it might also help to examine events that would otherwise be lost, even though they might be interesting.