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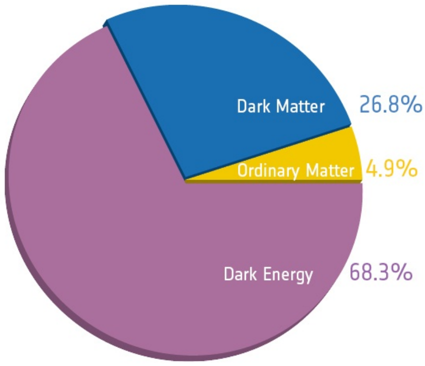
A New Search for Dark Matter

Dark matter has long been a mystery in astronomy as well as in particle physics. One of the first to find evidence was astronomer Fritz Zwicky when he was observing galaxy clusters in 1933 and made the discovery that in order to explain their gravitational motion there had to be a large amount of unseen mass. Since this matter does not emit light he called it dark matter. A new experiment is now being developed to find dark matter.

The amount of dark matter is actually much larger than the amount of ordinary matter. Ordinary matter only constitutes 5% of the total mass-energy while dark matter makes up approximately 27%. The remaining 68% is dark energy, which is thought to accelerate the expansion of the universe. Thus far, particle physics can describe the building blocks of ordinary matter and their interactions in the so-called Standard Model (SM). Dark matter does not fit within this model and would be something new. However dark matter might be a particle or a set of particles, which we would be able to discover.



Hypothesis for dark matter particles

From astrophysical observations like the one Zwicky performed we have strong reason to believe that dark matter exists. But what type of particle (or particles) could it be? The model we are interested in states that there will be a new mediating particle (like a photon in the SM) which would be the connection between the SM particles and the dark matter particles. This mediating particle is called the dark photon, which would be able to interact with SM particles, but also decay into dark matter particles.

LDMX experiment

The Light Dark Matter Experiment (LDMX) is still in its development phase but it will be the new set of eyes to look for dark matter with a lower mass then previous searches. It will do this using the missing momentum technique, where the momentum of the ingoing particle is compared with the momentum of the outgoing particles that have been measured. A discrepancy between the two indicates an unseen particle. Neutrinos are an example of particles that were discovered using the missing momentum technique. The experiment requires an electron beam, which will hit a thin fixed target after which the energy of the outgoing particles will be measured. LDMX will use this very effective technique to try to find dark matter and contribute to explaining the mysterious 27% of all the matter.

Since the creation of dark matter would be a very rare event a lot of events will need to be measured. This creates a lot of data and makes it important to select the interesting events. The focus of this thesis was the use of machine learning to make a differentiation between events where dark matter is created and other events. A specific type of machine learning called a Boosted Decision Tree is trained on simulations of these events in the detector, where two beam electrons hit the target. It was able to distinguish events where dark matter is created from events with a background interaction with an accuracy of 98%.

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Image from: https://www2.physics.ox.ac.uk/research/dark-matter-dark-energy