Exploring EeV Dark Matter through Pierre Auger observatory

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Super heavy dark matter (SHDM) particles in the EeV range seem to be good alternatives to the standard WIMP models, due to the lack of signals until now [1, 2]. They provide the right relic density of dark matter and also may have a lifetime larger than the age of the Universe, providing a good dark matter candidate. SHDM can possibly annihilate producing cosmic rays [3].

The Pierre Auger Observatory is an experiment dedicated to study the most energetic cosmic rays, with energies above 10^{18} eV (EeV), so-called ultra-high-energy cosmic rays (UHECR). In the last years, the Auger has detected [4] and confirmed [5] the existence of a slight anisotropy in the arrival directions of UHECR. This anisotropy manifests itself as a dipolar modulation in the UHECR flux reaching the Earth, whose amplitude increase with energy and is $\sim 7.3\%$ for particles with energies above 8 EeV. The dipole direction points to a direction $\sim 115^\circ$ away from the Galactic center, which reveals that the UHECR in this energy range has a predominantly extragalactic origin.

It is known that the galactic center must have a high density of DM. In a super-heavy dark matter scenario, the DM decay will generate UHECR, generating a galactic component to UHECR. This galactic component could potentially pull the dipole towards the galactic center, contradicting current measurements.

In this work, we expect to constrain the decay rate of super-heavy dark matter with the Pierre Auger Observatory anisotropy measurements. This will be done by combining SHDM models with UHECR propagation of protons inside de Milk Way. The cosmic-ray flux will be computed using the package described in [3]. The proton propagation will be done using the CRPropa[1] or the Galprop[2] frameworks. The resulting anisotropy, which is expected to be extremely significant given the distance of the source, will be tested against current data of the Pierre Auger Observatory, for which only a small deviation of anisotropy is found.

References

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