Direct Detection of Leptophilic Dark Matter with XENON1T

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Despite the great experimental efforts, that have been undertaken in recent years, there has been no indication as to the particle nature of dark matter (DM). However, its existence is dictated by a multitude of astronomical and cosmological observations which receive a natural interpretation if seen in the light of a "**Physics Beyond the Standard Model**".

Indeed, from a theoretical point of view, one of the most attractive attempts to elucidate this profound open question of modern physics emerges through supersymmetry theory, under the generic name of **Weakly Interacting Massive Particles** (WIMPs). Nevertheless, all relevant experimental efforts, based on underground detectors, have only excluded part of the parametric space of the theory.

It seems, then, that the mystery's answer could be sought in alternative theories predicting other DM candidates. For instance, there are so-called, "**hidden sector**" models, predicting a leptophilic DM, *i.e.* a DM particle that could interact with atomic electrons causing inelastic atomic processes such as ionization.

But it happens that underground detectors, like the double-phased TPC of XENON1T, filled with liquid xenon (LXe), are characterized by an exceptional sensitivity for detection of small charge signals derived from ionization of xenon atoms, down to the level of one electron! Therefore, the detector is sensitive to the inelastic quantum processes occurring at the atomic level and, *par excellence*, to the ionization process of even a single atom.

And yet, it is in this very region of the leptophilic DM expected signal, that a huge and, so far, incomprehensible background arises, driven by the so-called **single electrons**, small charge signals that appear to derive from a multitude of quantum processes in the atomic level of LXe, for many and yet unknown reasons.

Can we classify the processes that create these backgrounds? What can we infer about leptophilic DM without the possibility of background subtraction? How can state-of-the-art machine learning techniques like Neural Networks mitigate such backgrounds, making use of partial knowledge of them in conjunction with the topological characteristics of the corresponding events? These are some of the questions, about this exciting topic of direct DM detection, that I will try to answer in my presentation.