Warsaw Workshop on Non-Standard Dark Matter:
 multicomponent scenarios and beyond

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Looking beyond the paradigm: an experimental example from the ultra-high energy cosmic-ray physics

Content :

The theoretical effort towards explaining the nature of Dark Matter must well recognize and assimilate the experimental results. However, if these results are taken without an appropriate care and criticism, whole classes of theoretical scenarios might be ruled out prematurely. I'll present an example of such an efficient experimental thinking-blocker: the apparent lack of photons in the flux of ultra-high energy cosmic rays (UHECR), i.e. those above 10^19 eV, observed at the Earth. It has been confirmed by the key observatories (Pierre Auger Observatory, Telescope Array) that the contribution of ultra-high energy photons to the observed flux of cosmic rays is not larger than 1%. Such a limit severely constrains exotic scenarios of the origin of UHECR. These scenarios predict eg. decays or annihilation of hypothetical super-massive particles leading to the significantly increased presence of photons in the observed flux of UHECR which is practically ruled out by the present photon limits. The upper limits on the UHE photon flux constrain also violation of fundamental physics laws like Lorentz invariance. While theoretical implications of non-observation of UHE photons appear serious, it is not commonly understood that the present experimental limits are determined without considering all the thinkable standard or non-standard physics effects leading to the suppression or worse traceability of UHE photons. I'll discuss a simple scenario capable of explaining the non-observation of UHE photons without ruling out the exotic predictions of high photon fractions. The example concerns a hypothetical, frequent interactions of UHE photons initiating large electromagnetic cascades above the Earth atmosphere. Emerging of such a cascade would dramatically affect the development of the corresponding air shower in the atmosphere. I'll demonstrate that air showers induced by large electromagnetic cascades might be hardly distinguishable from air showers initiated by nuclei. If this is the case then we might heavily underestimate the photon component in the observed UHECR flux and the corresponding theoretical predictions should be revised. Although there are no hints about the nature of the mechanism leading to the creation of very large electromagnetic cascades, there is a number of non-trivial possibilities, including both standard and non-standard physics, that have never been discussed in the literature. It therefore seems appropriate to conclude that taking a full scientific advantage of the unprecedented statistics and precision of the UHECR data collected by the top observatories, in

particular by the Pierre Auger Observatory, might require more intense and deeper interactions between the experimentalists and theorists. This talk will be an effort towards facilitating these interactions.

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