Exploring intense photon/muon beams as Dark Matter detectors

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The presence of Dark Matter is known only through its gravitational pull, which shapes galaxies and holds them together, and it is therefore rarely questioned whether DM could be detected through light.

Previously assumed to be invisible, our study suggests that DM could leave faint, measurable marks on light as it passes through regions where the elusive substance is present — challenging long-held assumptions that the two never interact. We show that despite the fact that DM has no direct coupling to photons, the light-DM cross-section is non-vanishing, albeit small. The cross-section, calculated within the SM framework, is large in the case of heavy WIMPs. Combined with astrophysical observation, these results can constrain existing DM models in favour of lighter DM, , or non-weakly interacting pure gravitational DM. We also show that the energy dependence of light scattering on dark matter should make the DM coloured - red in the case of weak-DM and blue for the gravitational-DM, when a white background light is passing through. Gravitational scattering of light on DM particles also leads to non-trivial polarization effects, which might be easier to detect.

Besides astrophysical observations, we will show that dark matter can interact with high-energy photon and muon beams at hadron facilities and can therefore be detected there. We will discuss how photon beamlines of future facilities can be modified to not only serve its usual purpose of studying hadrons, but also to detect DM particles in a parasitic mode.