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The Dark-PMT: A Novel Directional Light Dark Matter Detector Based on Vertically-Aligned Carbon Nanotubes

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We present the latest results on the development of the Dark-PMT, a novel light Dark Matter (DM) detector. The detector is designed to be sensitive to DM particles with mass between 1 MeV and 1 GeV. The detection scheme is based on DM-electron scattering inside a target made of vertically-aligned carbon nanotubes. Carbon nanotubes are made of wrapped sheets of graphene, which is a 2-dimensional meterial: therefore, if enough energy is transferred to overcome the carbon work function, the electrons are emitted directly in the infra-tube vacuum. Vertically-aligned carbon nanotubes have reduced density in the direction of the tube axes, therefore the scattered electrons are expected to leave the target without being reabsorbed only if their momentum has a small enough angle with that direction, which is what happens when the tubes are parallel to the DM wind. This grants directional sensitivity to the detector, a unique feature in this DM mass range. We will report on the construction of the first Dark-PMT prototype, on the establishment of a state-of-the-art carbon nanotube growing facility in Rome, and on the characterizations of the nanotubes with XPS and angular-resolved UPS spectroscopy performed in Sapienza University, Roma Tre University, and at synchrotron facilities. This project was recently awarded a PRIN2020 grant with which we aim, over the course of the next three years, to construct the first large-area cathode Dark-PMT prototype with a target of 10 mg of carbon. The main focus of the R&D will be the development of a superior nanotube synthesis capable of producing optimal nanotubes for their use as DM target. In particular, the nanotubes will have to exhibit high degree of parallelism at the nanoscale, in order to minimize electron re-absorption.

Collaboration

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