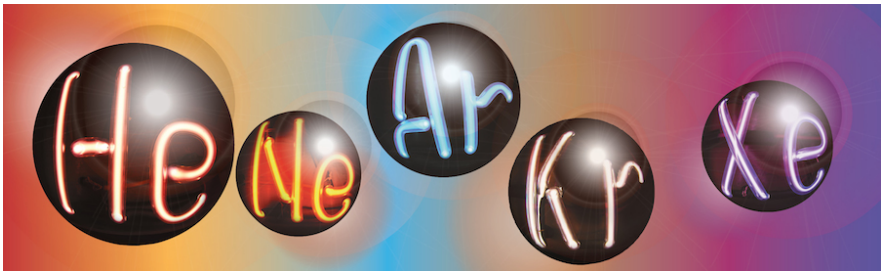

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Feasibility studies of Migdal Effect detection in gases relevant for low-mass dark matter searches

The Migdal effect has recently emerged as a relevant phenomena of potential interest to dark matter searches enabling to extend the sensitivity of direct searches to sub-GeV mass scales. In such cases, the detection of ejecting electrons from accelerating recoiling atoms, the Migdal effect, provides a critical enhancement in signal yield and opens a new detection channel for light dark matter interactions. Its exploitation is particularly relevant for dual-phase and gas-based time projection chambers (TPCs), where high-resolution (spatial and energy) light/charge readout can significantly improve event reconstruction at the keV and sub-keV regime.

In this work, we present feasibility studies of the Migdal effect in argon-based gas mixtures within the context of the DarkSide programme. We investigate a hybrid gas-phase TPC concept instrumented with a high-granularity charge readout based on the Timepix4 bare-ASIC. This approach aims to combine the scalability of noble gas targets with the spatial resolution required to identify low-energy electron signals induced by Migdal processes.

To optimize the detector performance, we have carried out a comprehensive experimental characterization of charge transport properties in candidate argon mixtures, including drift velocity, longitudinal and transverse diffusion, electron extraction efficiency, and charge gain. These measurements provide essential input parameters for detector modeling and are critical for assessing the achievable sensitivity to Migdal-induced signals in future low-mass dark matter searches with Argon.

In addition, these measurements will be complemented with the study of the optical properties of these mixtures. Together, these results will be fed into a dedicated simulation framework designed to optimize detector configuration and performance, enabling a robust evaluation of the potential of argon-based gas TPCs for next-generation light dark matter searches.

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