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Space charge effects in liquid argon detectors and ion feedback experimental evidences

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In a noble gas time projection chamber, the electrons produced in the ionization are drifted to the anode for position reconstruction of the event, while the ions move in the opposite direction. The drift velocity of ions in liquid argon is five orders of magnitude slower than electrons, and a positive volume region is created by the accumulated ions, known as space charge. We studied the effects of the space charge for the next generation of liquid argon multi-tonne experiments for neutrino physics and dark matter searches

The space charge can modify the drift lines, the amplitude of the electric field, and ultimately the velocity of the electrons, thus, a displacement in the reconstructed position of the ionization signal can be produced. The constant recombination between free ions and electrons can produce a quenching of the charge signal and a constant emission of photons, uncorrelated in time and space to the physical interactions. In dual-phase detectors with charge amplification, where the electrons are extracted to the gas phase and multiplied, these effects can be worsened by the ion feedback from gas to liquid phase.

In this talk, the predictions of the space charge effects for multi-ton argon detectors, with drift lengths of several meters, are presented, evidencing some potential concerns for this kind of detectors particularly when operated on surface. Finally, recent experimental results regarding the direct measurement of the ion feedback from the gas into the liquid phase, obtained with a dedicated setup in our laboratory, will also be discussed.

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