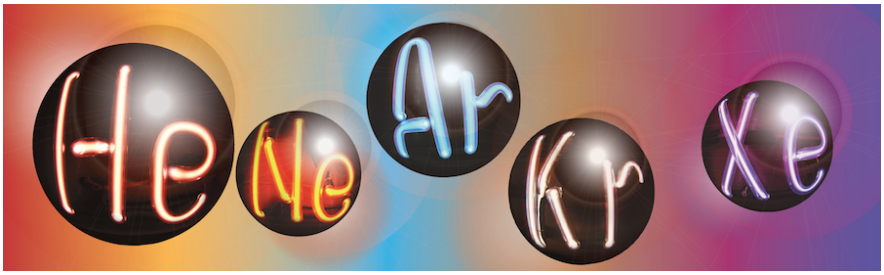

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High-Voltage Delivery and Breakdown Studies in Liquid Xenon for Next-Generation TPCs

Next-generation liquid xenon (LXe) time projection chambers (TPCs) aim to push direct dark matter searches to the neutrino fog and support a broader rare-event physics program, including neutrinoless double-beta decay.

Building on these advancements, the next-generation XLZD observatory would scale this technology to an LXe-TPC with a height and inner diameter of nearly $3\,\mathrm{m}$, containing about $60\,\mathrm{tonnes}$ of LXe in its first stage. Scaling to this size requires increasing the voltage delivered to the cathode to maintain the required drift field. This makes it important to understand both how to deliver this voltage reliably and what limits the maximum usable voltage before high-voltage (HV) breakdown occurs.

However, although LXe is predicted to sustain bulk fields of approximately $1\,\mathrm{MV/cm}$, experimental observations consistently show breakdown at lower fields, closer to detector operating fields, around $100\,\mathrm{kV/cm}$. This issue becomes particularly important as LXe-TPCs are scaled up.

To address these challenges, the MOTION detector, a $70\,\mathrm{kg}$ LXe setup at the Karlsruhe Institute of Technology, serves as a dedicated testing platform for HV delivery and breakdown studies in LXe. It aims to systematically study factors affecting the breakdown voltage, including conductor surface quality, xenon purity, and other relevant variables.

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