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Study and mitigation of spurious electron emission from cathodic wires in noble liquid time projection chambers

Noble liquid radiation detectors have long been afflicted by spurious electron emission from their cathodic electrodes. This phenomenon must be understood and mitigated in the next generation of liquid xenon (LXe) experiments searching for WIMP dark matter or neutrinoless double beta decay, and in the large liquid argon (LAr) detectors for the long-baseline neutrino programmes. We present a systematic study of this spurious emission involving a series of slow voltage-ramping tests on fine metal wires immersed in a two-phase xenon time projection chamber with single electron sensitivity. Emission currents as low as 10^{-18} A can thus be detected by electron counting, a vast improvement over previous dedicated measurements. Emission episodes were recorded and observed to have complex emission patterns with outbreaks as high as $\sim 10^{6}$ c/s for some wires and also fainter, less variable type of emission. We find no evidence for an intrinsic threshold particular to the metal-LXe interface which might have limited previous experiments up to fields of at least 160 kV/cm and we confirmed that the choice of wider wires to reduce the field do not help to mitigate the emission. The general phenomenology is not consistent with enhanced field emission from microscopic filaments, but it appears instead to be related to the quality of the wire surface in terms of corrosion and the nature of its oxide layer. This study concludes that some surface treatments, in particular nitric acid cleaning applied to stainless steel wires, can bring about at least order-of-magnitude improvements in overall electron emission rates; this strategy has been undertaken for the production of the grids of the LUX-ZEPLIN detector grids.

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