Effects of hydrocarbon admixtures to the electroluminescence yield of He-CF$_4$

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Summary

He-CF$_4$ is a very attractive gas mixture for Optical Readout Detectors in Dark Matter Search [1].

- He extends the sensitivity to low WIMP masses.
- CF$_4$ improves gas scintillation and is sensitive to Spin-Dependent WIMP-nucleon interactions.

Hydrocarbons like methane or isobutane would further improve the sensitivity to low WIMP mass [2].

But won’t they compromise the optical readout?

We evaluated the electroluminescence (EL) yield of methane and isobutane admixtures to He-40%CF$_4$ to find the best ternary mixture.

Setup

A Large Area Avalanche Photodiode (LAAPD) was used to readout the EL produced in the avalanches of a Gas Electron Multiplier (GEM).

- A borosilicate glass window was placed on top of the LAAPD to filter the UV photons (<300 nm) and evaluate the visible EL.

We kept He-40%CF$_4$ flowing at 4 L/h and then added the required percentage of hydrocarbon.

Results

Isobutane Admixtures to He-40%CF$_4$

Small percentages of isobutane and methane quench the visible and UV photons emitted by He-40%CF$_4$, but they do not completely compromise the optical readout.

Isobutane admixtures decrease the maximum attainable EL yield, relatively to He-40%CF$_4$, but the optical readout is possible for concentrations up to 5%.

Methane admixtures increase the electrical stability of the detector, meaning that higher GEM voltages could be achieved. Because of this, methane admixtures up to 7% attain higher maximum EL yields than He-40%CF$_4$.

Conclusions

Using up to 7% methane to increase the WIMP sensitivity of Dark Matter Detectors filled with He-40%CF$_4$ will also improve their optical readout.

References


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