LBCEA: A Low-Mass Dark Matter Search with Xenon

Michael Clark for the LBCEA Collaboration
Low-Energy Signals in Xenon

- Energy threshold dominated by detection of the scintillation (S1) signal
- Could push threshold even lower using only the ionization (S2) channel
Low-Energy Signals in Xenon

- Recent results using only S2 signals in XENON1T see unexpected background at low number of electrons, ultimately limiting the threshold

- Single electrons produce a clear signal, should be able to trigger on such signals, if backgrounds are understood
After large energy deposits, single electron signals are observed over several hundreds of milliseconds.
Where do these single electrons come from?

- Photo-ionization of metal surfaces or impurities
- Delayed extraction of ionization electrons...
  - ...at the liquid-gas interface
  - ...trapped on electronegative impurities
Where do these single electrons come from?

- Photo-ionization of metal surfaces or impurities
- Delayed extraction of ionization electrons...
  - ...at the liquid-gas interface
  - ...trapped on electronegative impurities

Drift times indicative of copper field-shaping rings

Signals will be limited to within a maximum drift-time of initial excitation

Michael Clark, Purdue University
Where do these single electrons come from?

- Photo-ionization of metal surfaces or impurities
- Delayed extraction of ionization electrons...
  - ...trapped on electronegative impurities
  - ...at the liquid-gas interface

Electron extraction could be stimulated with an external energy source to quench extraction time.
LBECA: Low Background Electron Counting Apparatus

1. Investigate these hypotheses using several R&D testbeds and XENON1T+LUX data
2. Develop technology in parallel to mitigate backgrounds
3. Make accurate calculations and modeling of expected low-energy signals
4. Build a dedicated xenon TPC incorporating the new technology for low-mass dark matter search

Collaboration

LBNL: P. Sorenson
LLNL: A. Bernstein, J. Xu, S. Pereverzev
Purdue: R. Lang, M. Clark, A. Kopec
Stony Brook: R. Essig, M. Fernandez-Serraj, C. Zhen
UCSD: K. Ni, J. Long, J. Ye
LLNL - XeNu

High electric field to improve electron extraction efficiency

![Graph showing electron extraction efficiency vs. electric field](image-url)
USCD - SanDiX Sealed TPC

Reduction in metal surfaces and plastics to reduce photo-ionization and impurities in the liquid xenon

Measured electron lifetime of >500us after 1 day of circulation
Quenching time-scales of trapped electrons using infrared light

IR light increases signal of alpha events, but the current effect is small
Planned Upgrades to ASTERiX:

- Increase IR Flux by using external laser coupled to optical fibers
- Improve xenon circulation to control impurities faster and increase stability
Integrates cleanliness, extraction field, and electron quenching from R&D detectors

Proposed SiPM array to increase xy-position resolution, and reduce nearby radioactive material

To be operated as a low-background detector for low-mass WIMPs
Outlook and Conclusions

- LBECA will be able to set limits on new parameter space for low-mass dark matter interactions
- Strong R&D program being performed in parallel at dedicated setups
  - Improved extraction efficiency
  - Improved cleanliness
  - Infrared light to quench time-scales
  - Accurate modeling of electron signals
- Design proposal for final LBECA detector submitted and under review

For more information, see A. Kopec at poster session tonight

See also: Essig, Sholapurkar, Yu 1801.10159