Abstract

Hidden-sector light bosons can provide simultaneous explanations of dark matter and solutions of recent puzzles in particle physics such as the muon anomalous magnetic moment or the proton charge radius. The TREK project at J-PARC, Japan, provides opportunities to search for light bosons in the mass region below 200 MeV/c² via rare decay of positively charged kaons in several decay modes. A dedicated search for a dark photon below 100 MeV/c² is being pursued with the DarkLight project at Jefferson Lab, Virginia, USA, using electron scattering from a hydrogen gas target internal to an energy recovery accelerator. A large production data set has been acquired with TREK in 2015, while preparations are ongoing for the initial phase of the DarkLight program in 2016-17. The status of both programs will be presented.

This work has been supported by NSF PHY-1438680, PHY-1505934, and DOE DE-SC0012589 and DE-SC0013941.

Dark Photon

- 24% of the universe are Dark Matter (DM)
  - Rotation of galaxies, gravitational lensing, WMAP
  - DM is distributed, could be particles (e.g. WIMPs)

- (U(1)) hidden sector extension of the Standard Model
- Dark Matter interacting with SM via U(1) gauge boson (Fayet 2004)

- Astrophysical motivation for Dark Matter annihilation:
  - position excess – PAMELA, FERMI, AMS-02
  - Muon anomalous magnetic moment $g-2$
  - Kinetic mixing model (Holdom 1986, Pospelov 2009)
  - Be-$\beta$ signal and its implication: protophobic boson

- Beyond kinetic mixing: Proton radius puzzle $R_p$
- Lepton-flavor non-universal interaction (preferred coupling to muons)
- Coupling to right-handed muons (Ballett, McKee, Pospelov)
- Due to constraints from neutrino scattering
- Fine-tuned non-universal couplings (Carlson, Risko)
  - Electrophobic bosons (Miller)

Dark Sector

Standard Model
- quarks, leptons
- $\gamma$ W Z
- $A'$ (massive)

Hidden Sector
- dark matter?

Simultaneous explanation for:
- Cosmic ray positron excess (PAMELA, FERMI, AMS02)
- Absence of anti-proton excess (PAMELA)
- Anomalies in direct detection experiments (e.g. DAMA/LIBRA)
- Natural explanation for muon $g-2$

Comparison of $A'$ searches

TREK/E36

- Stopped $K^+$ beam (target)
- 12-Sector Iron-Core Toroidal Spectrometer

DarkLight

- Dark photons (universal coupling) well motivated by dark matter observations (astronomical, direct, positrons) in combination with $g-2$
- To be run at the Low Energy Recirculator Facility (LERF) at Jefferson Lab
- Search for visible decay modes of $A'\rightarrow e^-\mu^+$ in ep
- Search for invisible decays $A'\rightarrow X$ in ep

DarkLight Solenoid Setup

Three science goals:
1. Accelerator physics: Demonstrate operation of energy recovery beam with internal target at full luminosity
2. Precise measurement of Standard Model processes
3. Search for the $A'$