Stony Brook University
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Abstract

Searching for Dark Sectors

Yi-Ming Zhong

The existence of Dark Matter (DM) suggests the presence of a dark sector, consisting of particles neutral under all Standard Model forces. Various "portals" can connect the dark sector to the Standard Model (SM) sector. Two popular examples are the vector portal, which gives rise to a "dark photon" (A'), and the Higgs portal, which gives rise to a "dark Higgs". Such dark forces appear in many well-motivated extensions of the Standard Model. In some cases, they may resolve discrepancies between experimental data and theoretical predictions, such as the muon anomalous magnetic moment. We show that dark sectors and forces can be constrained from several novel probes in current and future experiments, including mono-photon searches in low-energy positron-electron colliders, rare muon decays in Mu3e, and exotic Higgs decays at the Large Hadron Collider (LHC).

We first investigate the power of low-energy, high-luminosity electron-positron colliders to probe dark sectors with a mass below ~10 GeV, which couple to SM particles through a low-mass dark mediator. DM candidates in this mass range are well-motivated and can give rise to distinctive mono-photon signals at B-factories and similar experiments. We use data from an existing mono-photon search by BaBar to place new constraints on this class of models, and give projections for the sensitivity of a similar search at a future B-factory. We also find that dark photons with masses ~10 MeV-80 MeV can probed in the rare muon decay process $\mu^+ \to e^+ \nu_e \bar{\nu}_\mu A', A' \to e^+ e^-$, in the upcoming Mu3e experiment at the Paul Scherrer Institute without modifying the experimental set-up. The newly discovered 125 GeV Higgs boson is a scalar and has a small SM decay width. Hence it can easily decay to light dark-sector particles with sizable branching ratios. We investigate several possible dark-sector searches at the LHC based on the exotic decays of the Higgs. We also analyze in detail a possible decay to $b\bar{b}\mu^+\mu^-$ via intermediate scalar states. Finally, we show a possible dark-sector interpretation of the recently reported 750 GeV diphoton excess from the LHC 13 TeV run, as the 750 GeV heavy resonance decaying to light dark photons or dark Higgs bosons.

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