Rich Dark Sectors

SLAC Dark Sectors Workshop
April 30, 2016
Rich Dark Sectors (RDS)

1. Dark Sector Masses and Naturalness
   Thursday, 4:30pm-6:00pm
   Where do light masses come from?
   Are they natural? Are there additional states to discover?

2. Exotics
   Friday, 10:00am-11:30am
   What should we look for beyond the minimal portals?
   Are we missing any experimental opportunities?

3. Non-Minimal Dark Matter
   Friday, 1:30pm-3:00pm
   Is DM self-interacting/inelastic/exitable/asymmetric/...?
   Are there ways to combine DM and other searches?
Is this all there is to (dark) life?
Minimal Invisible Dark Photon

Is this all there is to (dark) life?
Provocative Example: “Minimal” SUSY

Not the whole story for SUSY searches!
Going Beyond the Minimal Pictures

“Occam’s Razor does not apply to the dark sector”
- BJ Bjorken

- Multiple motivators for non-minimal dark sectors:
  - origin of dark photon masses and naturalness
  - astrophysical hints of non-minimal dark matter
  - other “anomalies”
  - the visible sector is definitely not minimal

- But what should experiments look for?
  LOTS of theories...
Point #1: minimal searches can be sensitive to non-min.

e.g. Bound-State Dark DM

[An, Echenard, Pospelov, Zhang 2015]
Point #2: sometimes new searches are needed.

e.g. Dark Higgs for Dark Photon Mass

\[ e^+ e^- \rightarrow A' h' \rightarrow 6\ell \text{ (or } 2\ell + MET) \]

[Belle 2014]
Point #3: theory experiment communication is key!

• But how?

• For theorists:
  • MC tools needed for experimental signal simulation
  • specific motivated benchmarks, experimental searches

• For experimentalists:
  • report results in general way (e.g. model-independent, detector efficiencies, ...)
  • consider more general final states, beyond $\epsilon \rightarrow m_A$

• Forum for sharing ideas? (wiki?)
Point #4: Complementarity is Complicated

- Many experimental/astrophysical/cosmological limits.
- Connecting them is model-dependent.
- A central repository of relevant searches would be useful.
- Exclusions in minimal models may not apply to more general theories.

e.g. protophobic avoids NA48 due to couplings
Rich Dark Sectors Goals

• Many theories, but how best to connect to experiment?
• How can searches for minimal dark sectors be applied to more general scenarios?
• Complementarity of different search methods? Constraints on minimal scenarios may not apply.
• Do minimal searches miss interesting, testable physics?
• New experiments to probe motivated RDS scenarios?
Dark Sector Masses and Naturalness

- Where do light dark sector masses come from?
  - Stueckelberg?
  - Dark sector Higgs mechanism? Strong coupling?

- Are the masses natural?
  - SUSY? Strong coupling/warping? Dark Anthropic?
  - Is there a connection to SM Higgs naturalness (and decays)?

- What does this imply for experimental searches?
  - Are there additional states to discover?
  - What can existing/planned experiments do?
Exotics

• What should we consider beyond the standard portals?
  • Non-abelian dark forces? Direct coupling with small charges?
  • Connections through higher-dimensional operators?
  • ???

• What does this imply for experimental searches?
  • Are there additional states to discover?
  • What can existing/planned experiments do?
  • Can the LHC/ILC/FCC help?
Non-Minimal Dark Matter

• Is DM self-interacting/inelastic/excitable/asymmetric/…?
  • What does astrophysics suggest?
  • Hints from indirect/indirect detection, LHC searches?

• What does this imply for experimental searches?
  • Are there additional states to discover?
  • What can existing/planned experiments do?
  • How can laboratory searches be related to DM searches?