BSM @ HIEPAF

(High Intensity Electron Positron Accelerator Facility)

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- 3 motivations for BSM at HIEPAF

3 BSM scenarios

- SM-like Higgs boson was discovered in 2012 indicated that SM is very successful.
- Seeking BSM failed is possibly due to

(1) no BSM at all,

(2) the energy scale of BSM is too high to be probed at current experiment and

(3) the energy scale of BSM is not high but the new sector interacts very weakly with SM sector.

Scenario 1: no BSM at all

- This scenario is quite strange provided that the SM-like Higgs boson has been discovered and one faces fine-tuning issue, at the same time one is still puzzled by many mysteries, for example the flavor problem, the origin of CP violation, dark matter etc.

Scenario 2: the energy scale of BSM is too high

- This scenario is commonly believed and the search for the next scale is the main goal of LHC and other high energy frontier facilities. One drawback is that no one knows where the next scale is, provided that the consistence among SM predictions and the past measurements.
- For one hand HIEPAF can probe the even higher energy scale than that of at LHC, though indirectly, for the other hand it can cross-check the BSM if it is discovered at the LHC and other high energy frontier facilities.

Scenario 3: light new sector interacts very weakly with SM

- HIEPAF and alike the best place to study the new sector.
- In fact in order to explain why the BSM is so weakly interacting with SM sector, new higher scale is likely to be introduced. In this sense, even higher energy collider might be needed in order to fully explore the whole scenario.

Current status of BSM@Low Energy

- Snowmass2013 （arXiv:1401.6075, more than 1000 US particle physicist involved）：9 topics

Planning the Future of U.S. Particle Physics

Report of the 2013 Community Summer Study

1 Summary of the 2013 Community Summer Study

Snowmass-2013: Intensity Frontier

- Neutrino （mass hierarchy, CPV）
- …
- New light, weakly coupled particles appear in many theoretical models, especially those of the cosmic dark matter. Some searches for these particles are feasible with intense beams and comparatively modest detectors at existing facilities. The Snowmass studies identified a rich, diverse, and low-cost program with a potential for high-impact discoveries, illustrating the importance of modest-scale experiments to complement large-scale efforts.

New physics beyond the Standard Model at High Intensity Electron Positron Accelerator Facility (HIEPAF)

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3 BSM motivations

Contents

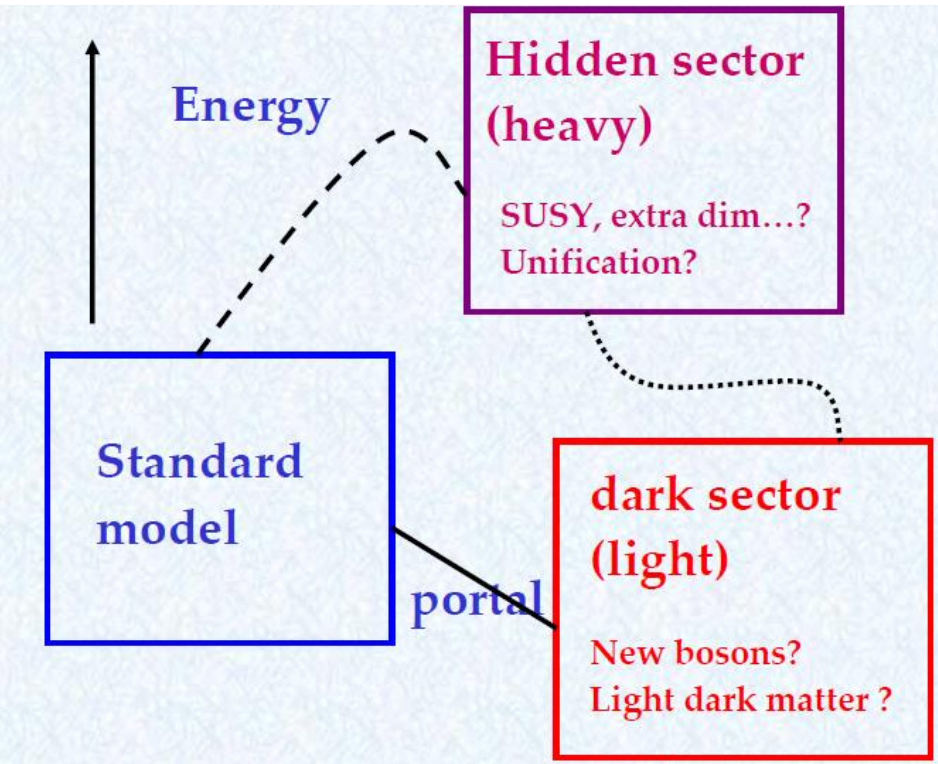
1: Forbidden and rare decays

- Whether are the baryon and lepton numbers strictly conserved? Big question!
- Rare FCNC processes for quark and lepton sectors. Any deviations? D-meson and tau as the main objects?!

2. (New) CP violation, especially CPV in lepton sector

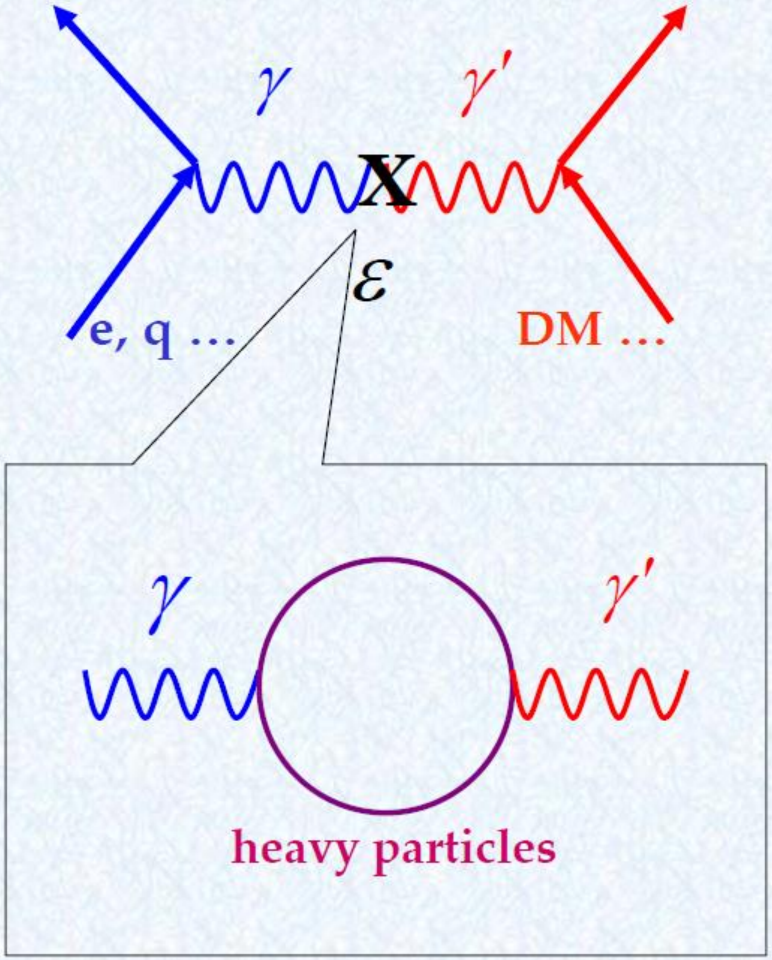
- Well motivated by accounting for matter-dominant Universe
- CPV of D-meson
- CPV of Tau Lepton in decay and production processes $\mathcal{L}_{\rm eff} = \mathcal{L}_{\rm SM} - \frac{i}{2}\bar{\tau}\sigma^{\mu\nu}\gamma_5\tau(d^{\gamma}_{\tau}F_{\mu\nu} + d^{W}_{\tau}Z_{\mu\nu})$
- For the first time, CPV may be discovered in lepton sector or severely constrained. Similar goal for neutrino-program.

3: Weakly interacting light particle



Portal	Particles	Operator(s)
"Vector"	Dark photons	$-\frac{\epsilon}{2\cos\theta_W} B_{\mu\nu} F'^{\mu\nu}$
"Axion"	Pseudoscalars	$\frac{a}{f_a} F_{\mu\nu}\widetilde{F}^{\mu\nu}$, $\frac{a}{f_a} G_{i\mu\nu}\widetilde{G}_i^{\mu\nu}$, $\frac{\partial_\mu a}{f_a}\overline{\psi}\gamma^\mu\gamma^5\psi$
"Higgs"	Dark scalars	$(\mu S + \lambda S^2)H^\dagger H$
"Neutrino"	Sterile neutrinos	$y_N L H N$

Kinetic mixing



- **Kinetic mixing between dark photon and photon**
- **Mixing can be generated by quantum loop mediated by some heavy particles**
- **Mixing is expected to be small**

$$\varepsilon \sim \frac{g_D g_Y}{16\pi^2} \log \frac{\Lambda^2}{m_X^2} \sim 10^{-4} - 10^{-3}$$

- **In the SUSY model, the $U(1)_Y$ D term would get vev after EWSB, and induce effective FI term for U(1)′ via mixing operator. This term would give masses of particles in the dark sector ~ GeV**

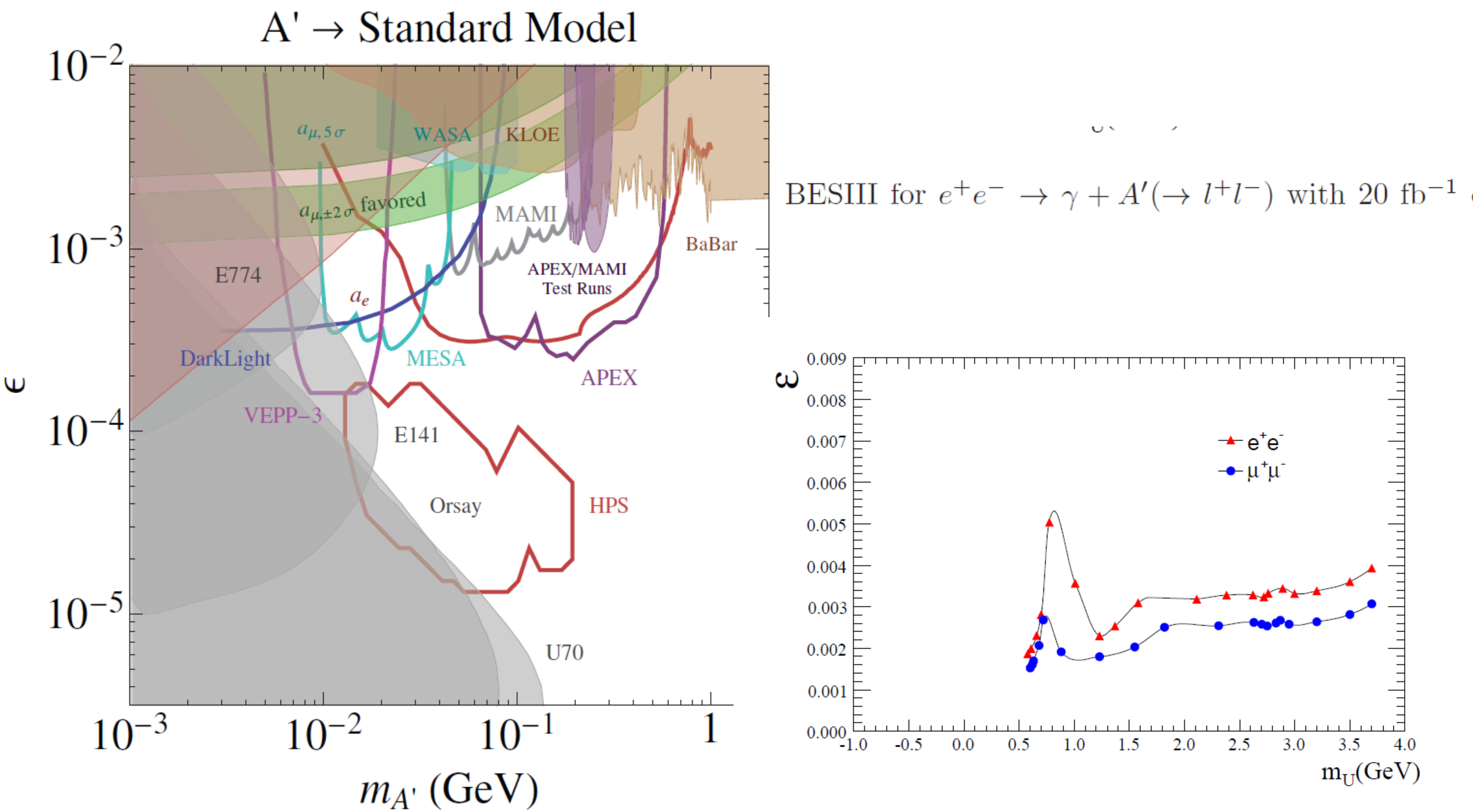


Figure 1. Constraints on the mixing strength ϵ with dark photon mass $m_{A'} > 1$ MeV from the SLAC and Fermilab beam dump experiments [22–24, 45], the electron and muon anomalous magnetic moment [25–27], APEX [28], MAMI [29], WASA-at-COSY [32], KLOE [30, 31], and *BABAR* [33]. Also shown are the parameter spaces can be investigated by some proposed experiments, including APEX [34], HPS [35], DarkLight [36], VEPP-3 [37, 38] , MAMI, and MESA [39] . Produced from Ref. [11].

Perspectives

- Scenario 1: No BSM, dead end?
- Scenario 2: New Physics at higher energy. Possible experiment roadmap: discovery/hints by LHC/CEPC/ILC -> 100 TeV collider
- Scenario 3: New physics at low and possible higher energy beyond LHC reach. Possible experiment roadmap: discovery/hints by high intensity facilities -> 100 TeV collider

Conclusions:

3 BSM motivations for HIEPAF

1. Forbidden and rare decays
2. CP violation, especially CPV in lepton sector
3. Weakly interacting light particle

LHC input was important and will be crucial!

Your contributions are warmly welcome!