A Tale of Two U(1)s: Kinetic Mixing from Lattice WGC States

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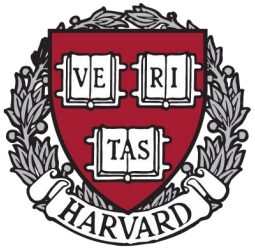
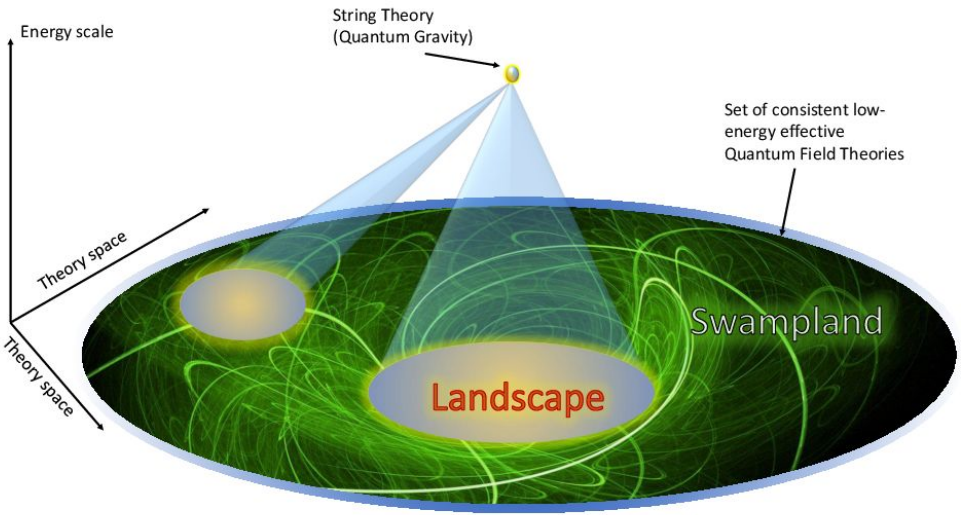


In collaboration with G. Obied

What is the Swampland?

- Consistency
  - Exists a plethora of apparently consistent effective QFTs
  - The Swampland consists of the set of QFTs which develop inconsistencies when UV completed into quantum gravity
- Conjectures
  - Certain criteria must be satisfied by the low energy QFTs for them to be in the Landscape



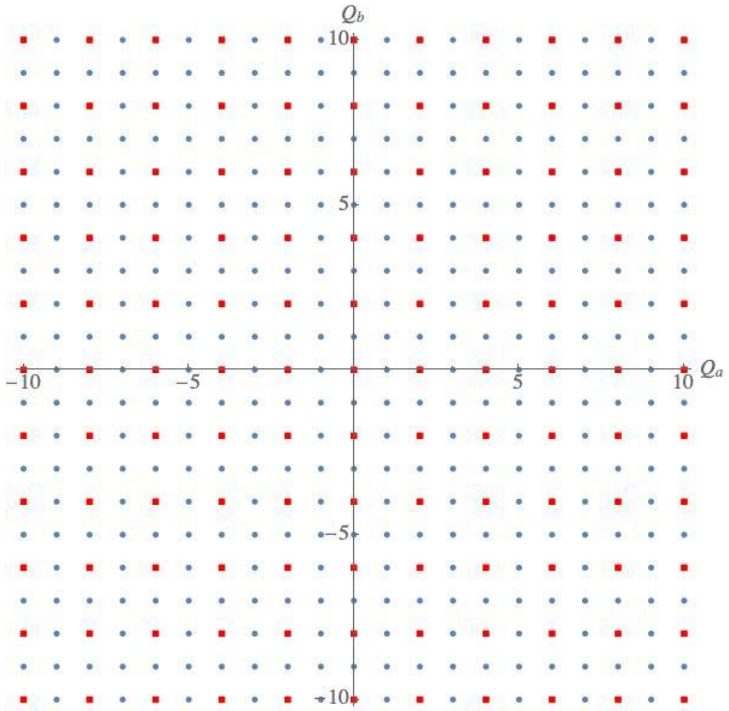
Palti [1903.06239]

Sublattice Weak Gravity Conjecture

- In a given theory with a charge lattice, there is a finite coarseness sublattice of superextremal particles.
- General Weak Gravity Conjecture

$$\left[\frac{\alpha^2}{2} + \frac{p(d-p-2)}{d-2}\right] T_p^2 \leq e_{p;d}^2 q^2 M_d^{d-2}$$

- Evidence
  - Black Holes
  - KK Towers
  - Perturbative String Theory
  - F-theory Constructions



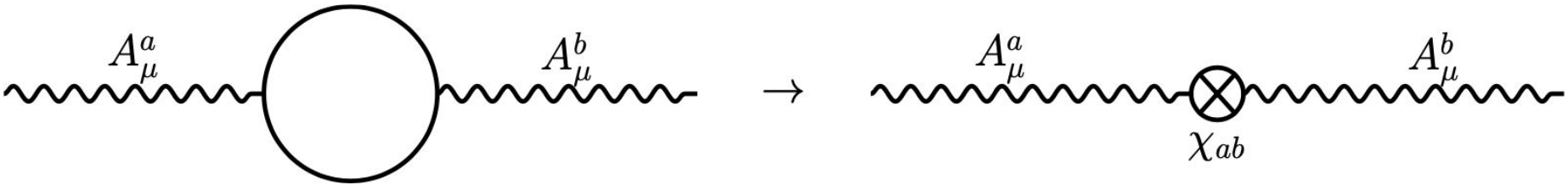
Heidenreich, Reece, Rudelius [1509.06374,1606.08437]; Montero, Shiu, Soler [1606.08438]; Lee, Lerche, Weigand [1808.05958,1810.05169,1901.08065]

Kinetic Mixing in Field Theory

- Bi-charged matter generates kinetic mixing upon being integrated out
- Scalar matter contributes an amount

$$\frac{\chi_{ab}}{g_a g_b} = -\frac{Q_a Q_b}{48\pi^2} \ln \frac{m^2}{\mu^2}$$

- Require a mass splitting

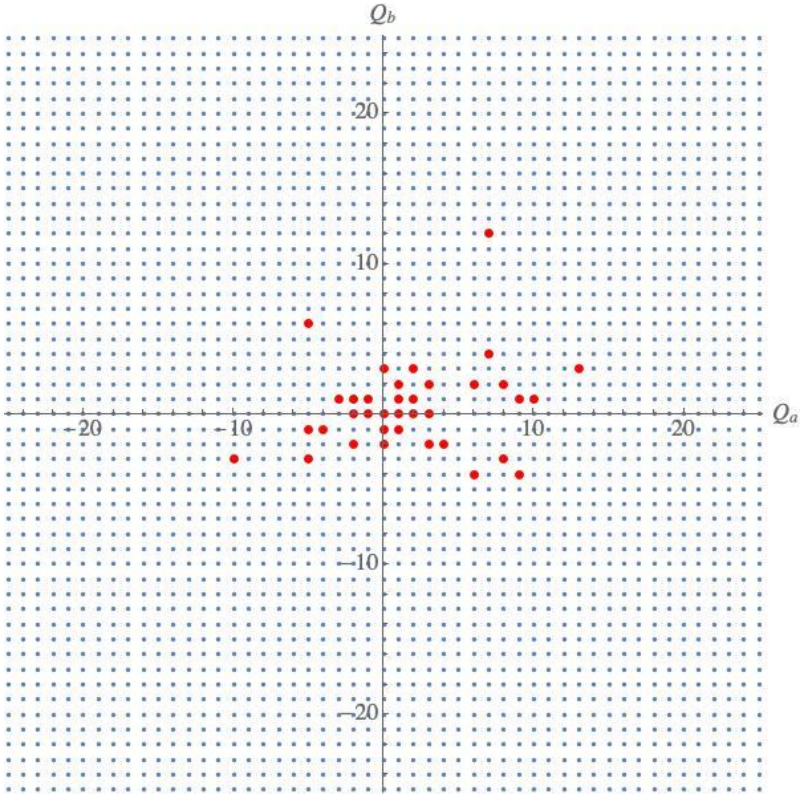


sLWGC Estimate for Mixing

- In the presence of two U(1)s, the WGC postulates that the mass is given by✦

$$\frac{m_{ij}}{M_{\rm 4D}} = c_{ij}\sqrt{(g_a Q_a^{ij})^2 + (g_b Q_b^{ij})^2}$$

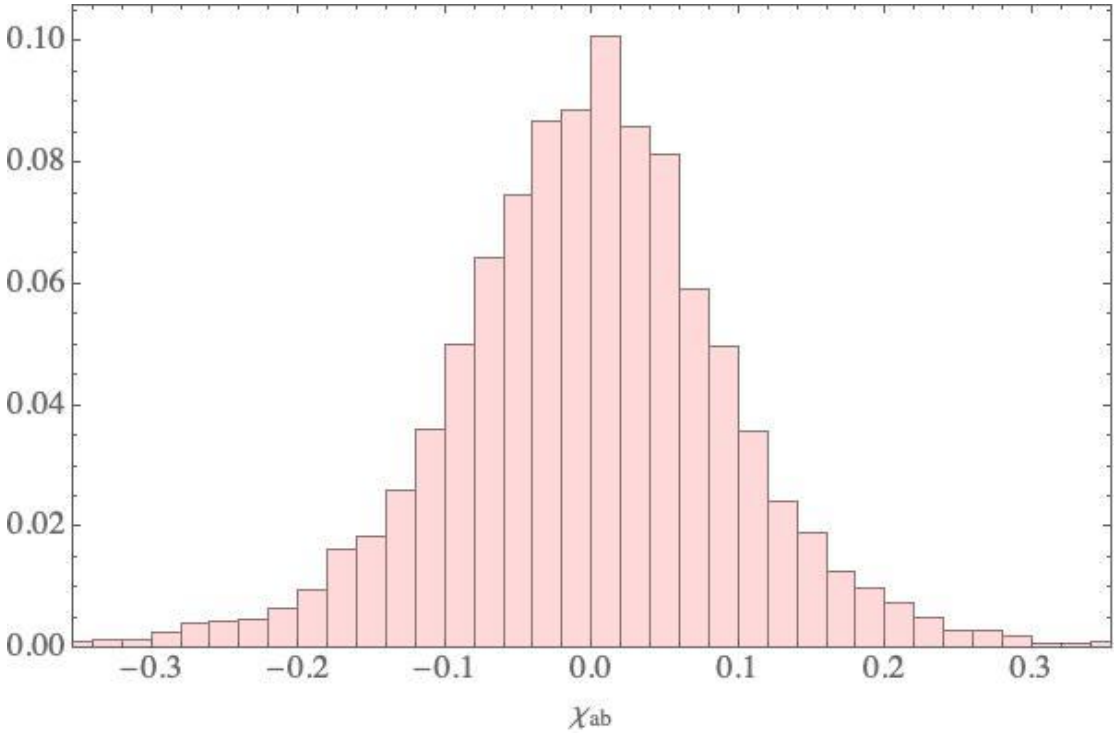
- Coefficient c_{ij} chosen to be less than unity to ensure superextremality.
- Species Scale



✦ Sum with the metric on field space. Assumed diagonal for simplicity

sLWGC Estimate for Mixing

- Generate a probability distribution for the kinetic mixing.
- Centered at 0 due to our choice of PDF from which we draw the coefficients
- $g_a = 0.1$, $g_b = 0.2$



5D Abelian Gauge Theory on S^1

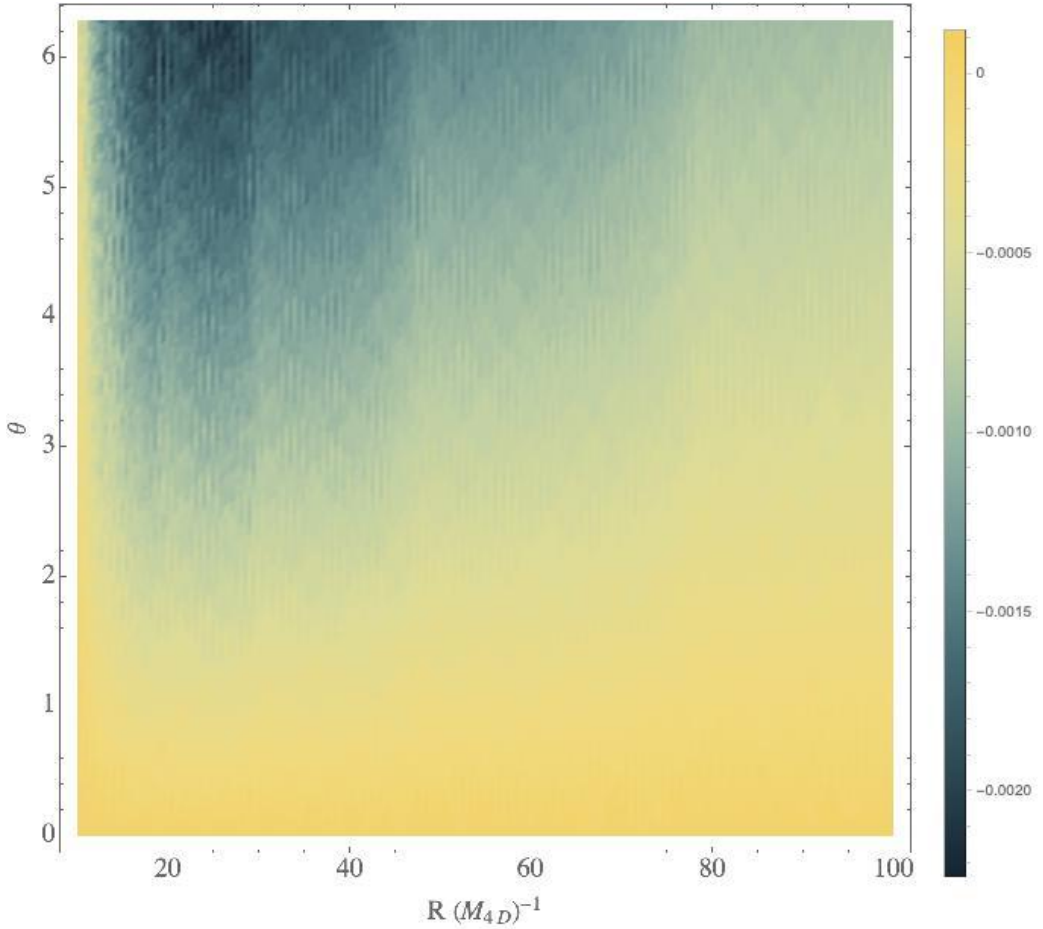
- We consider a 5D Abelian gauge theory with a lattice of charged scalars whose 5D masses are dictated by the General WGC
- Compactification on a circle of radius R generates a KK tower for each of these scalars

$$m^2 = \frac{3}{2} e_{4\mathrm{D}}^2 q^2 M_{4\mathrm{D}}^2 + \frac{1}{R^2}\left(n - \frac{q\theta}{2\pi}\right)^2$$

- 5D and 4D parameters are related

$$e_{5\mathrm{D}}^2 = 2\pi R e_{4\mathrm{D}}^2 \qquad M_{4\mathrm{D}}^2 = 2\pi R M_{5\mathrm{D}}^3 \qquad e_{\mathrm{KK}}^2 R^2 = 16\pi G$$

- θ induces a mass splitting between states of opposite charge
- Increasing R amounts to decreasing e_{KK}. Eventually, we lift the WGC tower of one U(1) above the species bound cutoff of the other U(1)
- $e_{4D} = 0.01$



Conclusions

- The states required by the (sub)Lattice Weak Gravity Conjecture along with certain genericity conditions imply the existence of non-vanishing kinetic mixing between massless Abelian gauge groups in the low-energy effective theory.
- We estimate this using a lattice of states as well as a KK compactification of a 5D U(1) gauge theory on S^1.
- Introduces a portal to the dark sector that is required by consistency when considering UV completions to quantum gravity

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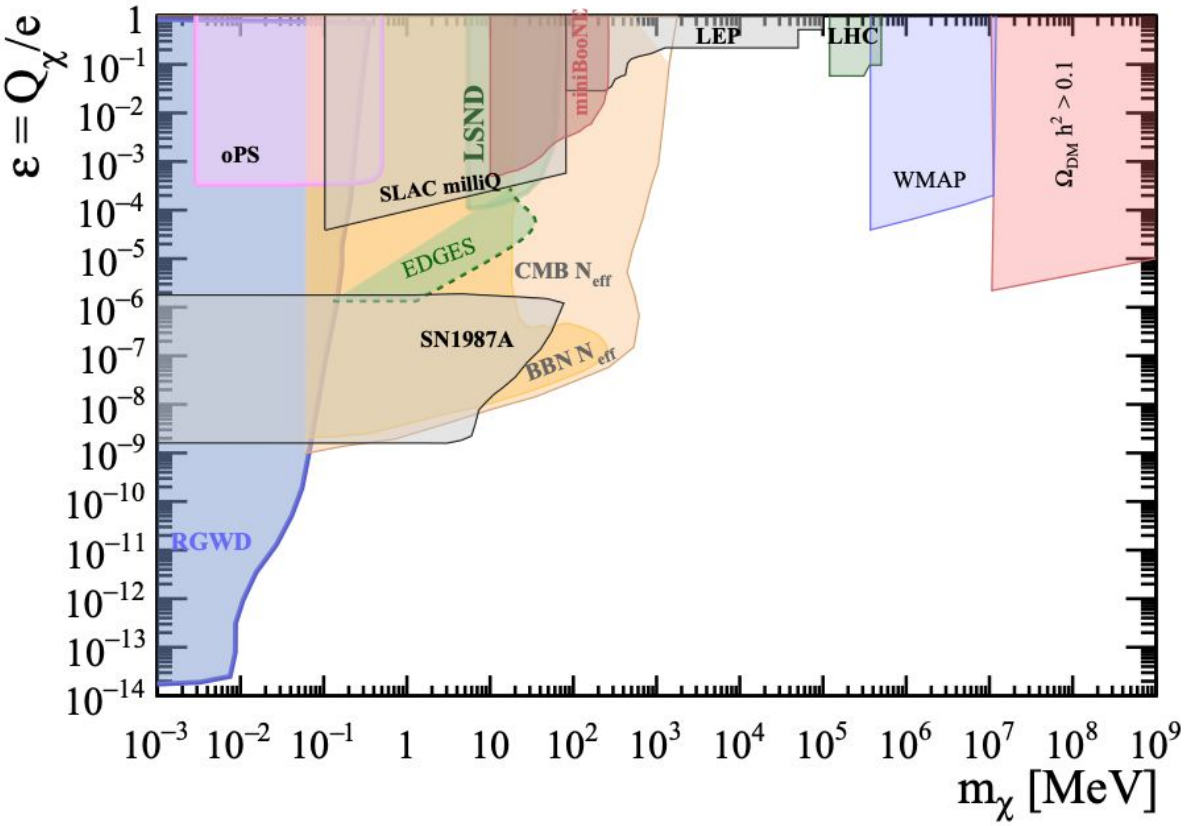
Thank You!

Backup

- Small masses constrained by stellar evolution, supernovae and N_{eff}
- Cosmology constrains the large mass regime
- Intermediate masses constrained using colliders and neutrino experiments



Fabbrichesi, Gabrielli, Lanfranchi [2005.01515]

Species Scale

- Consider a D-dimensional theory compactified to a d-dimensional theory. The quantum gravity cutoff is the D-dimensional Planck mass.
- Gravity propagates in D-dimensions so below the compactification scale, it appears weaker. This in turn implies that our naive estimate for the scale at which gravity becomes strongly coupled is incorrect.
- A d-dimensional gravitational theory with N_s particles below a cutoff scale Λ satisfies the following condition

$$\Lambda < \Lambda_s \equiv \frac{M_p^d}{N_s^{\frac{1}{d-2}}}$$

Palti [1903.06239]