Glimmers from the Axiverse:

Axion-photon couplings in string theory

Naomi Gendler, Harvard University

based on:
hep-th/2309.13145 with Doddy Marsh, Liam McAllister, and Jakob Moritz
and WIP with Junyi Cheng

December 8, 2023, PNU-IBS workshop on Axion Physics: Search for Axions

Summary

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We compute axion-photon couplings in string theory
and compare to observational bounds.

Outline

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1. Setting up the axiverse

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2. Axion-photon couplings in the string axiverse

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2. Axion-photon couplings in the string axiverse
3. Universality of the axiverse

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Axion experiments can teach us about where we live in the string theory landscape.

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calculate explicitly in string theory

I. Axions in string theory

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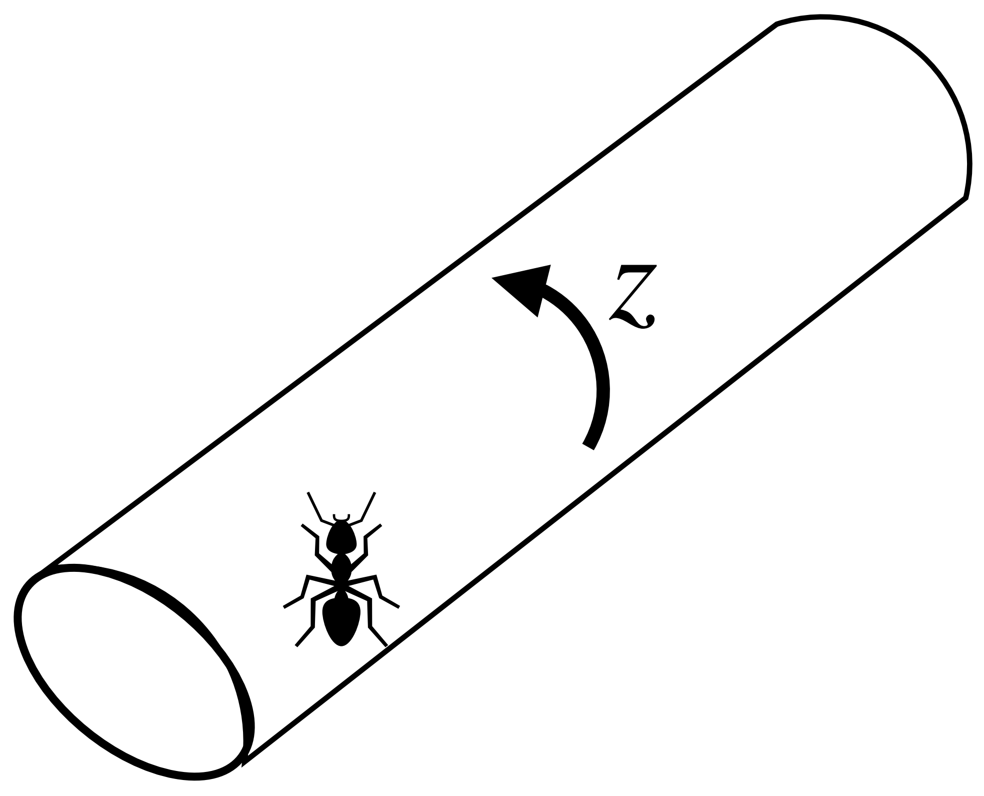

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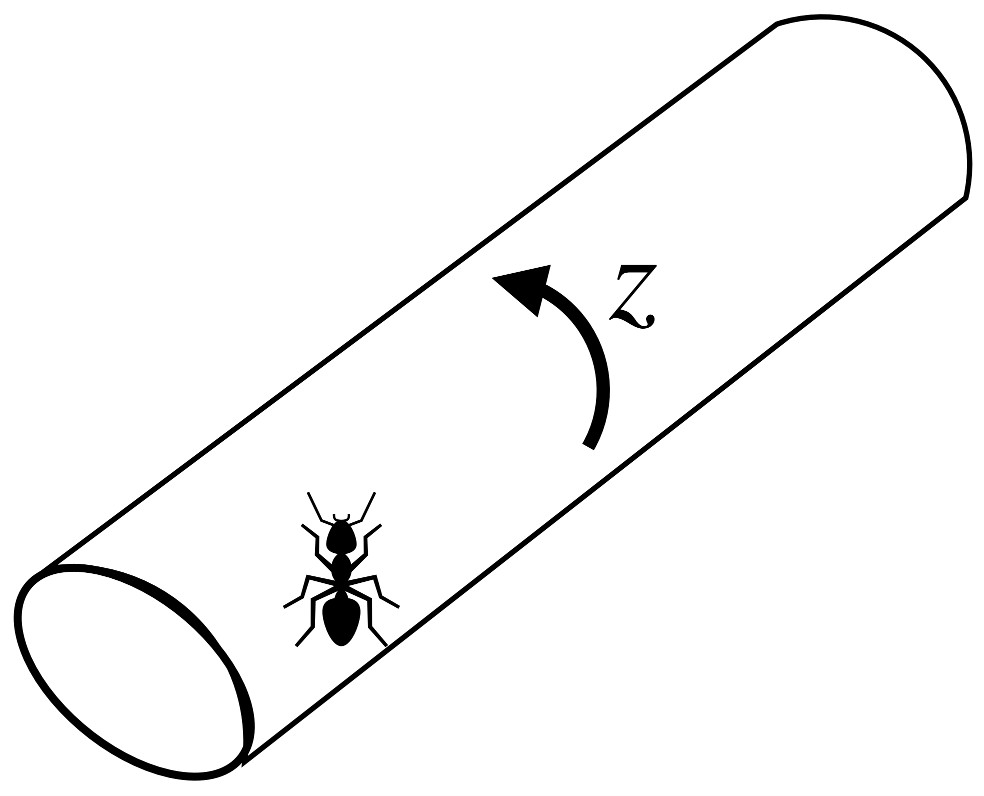

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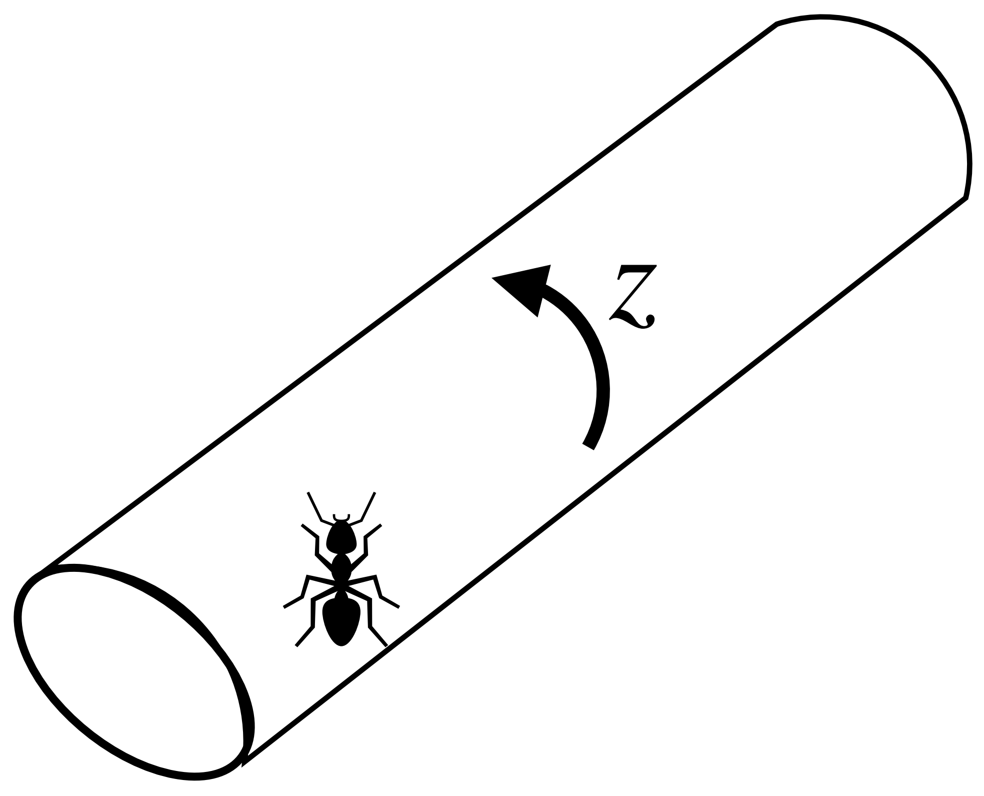

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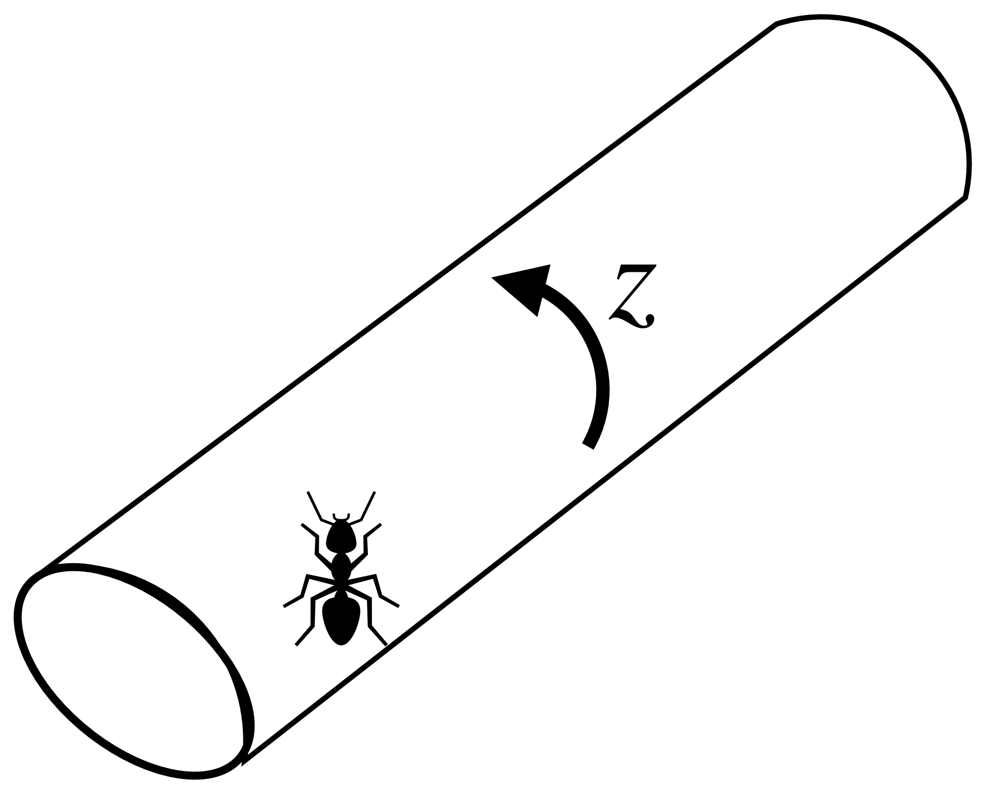

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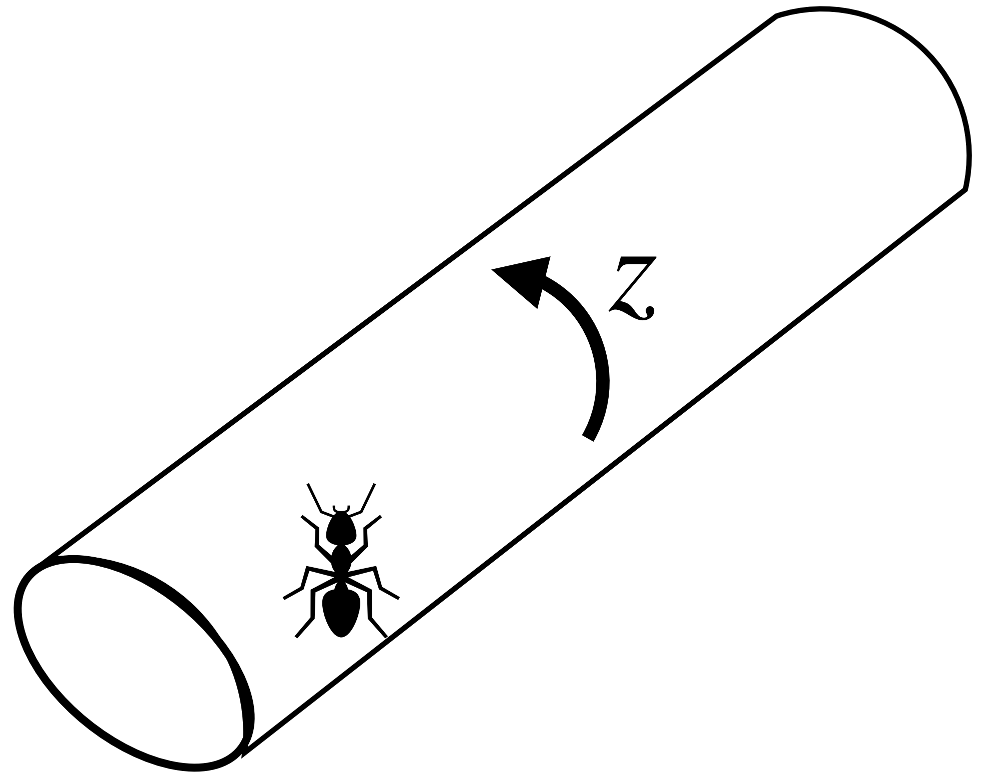

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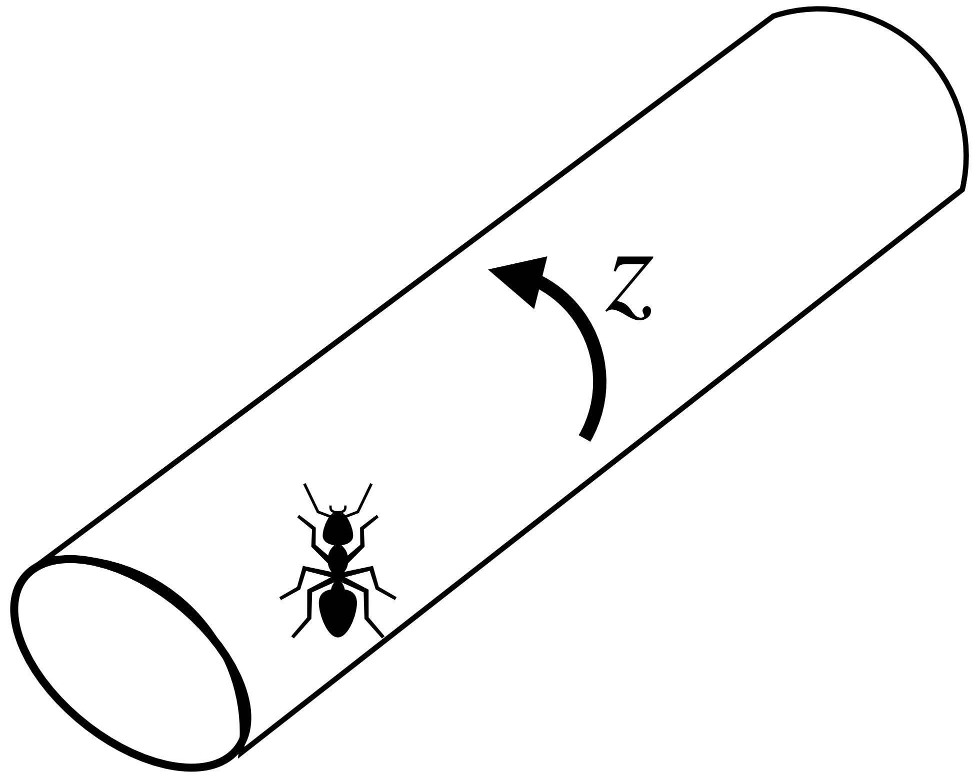

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Lesson: extra-dimensional gauge fields integrated over loops are axions.

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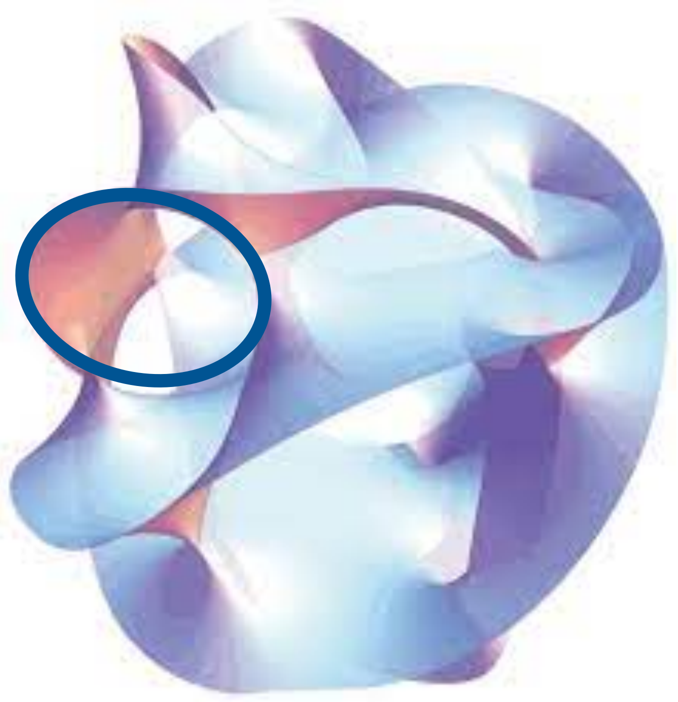

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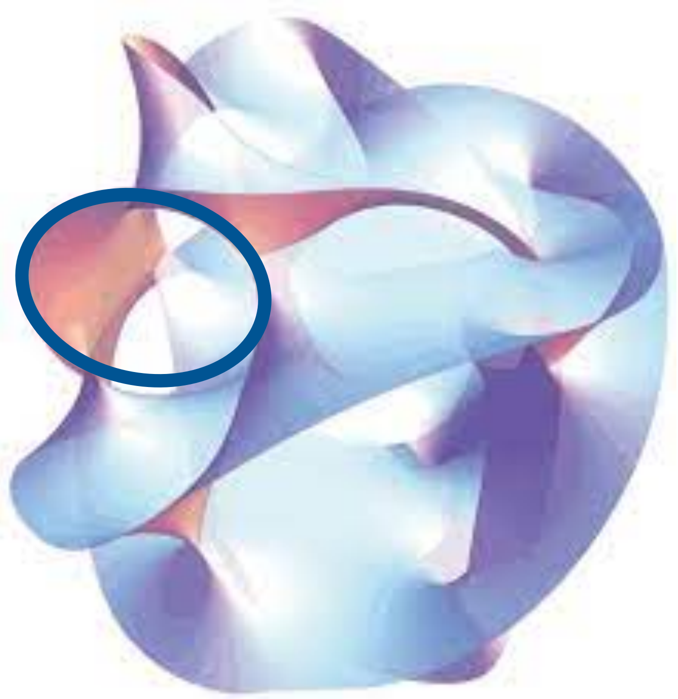

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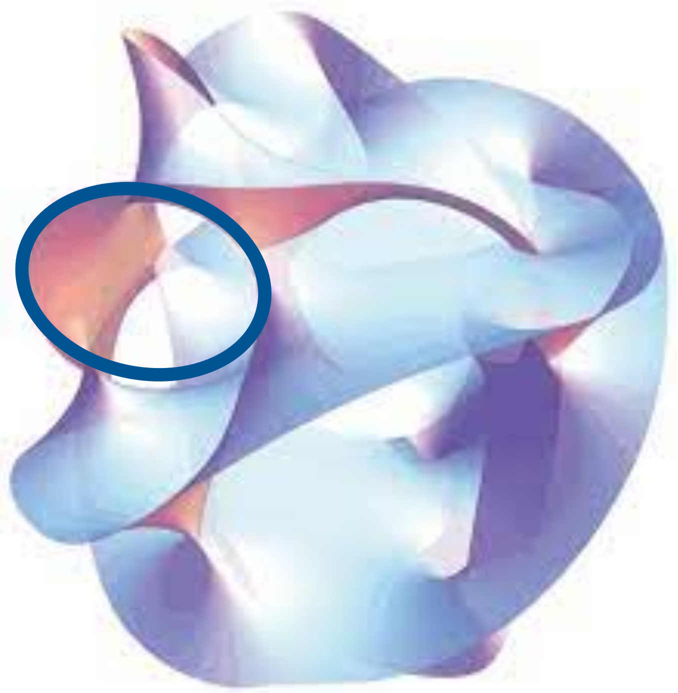

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These manifolds can have hundreds of "loops" → hundreds of axions!

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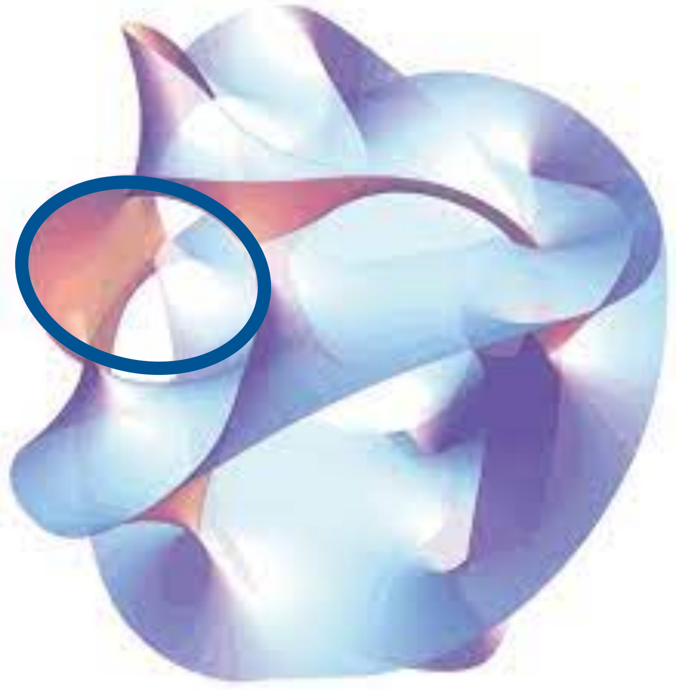

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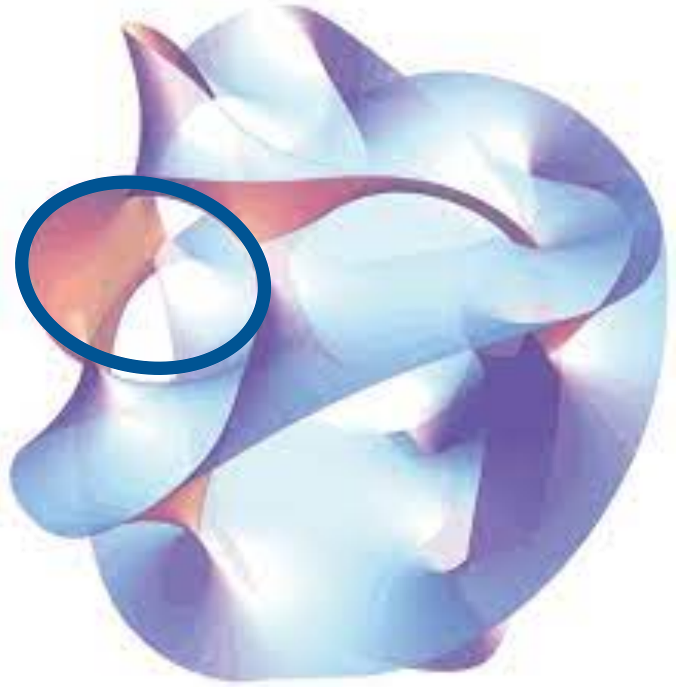

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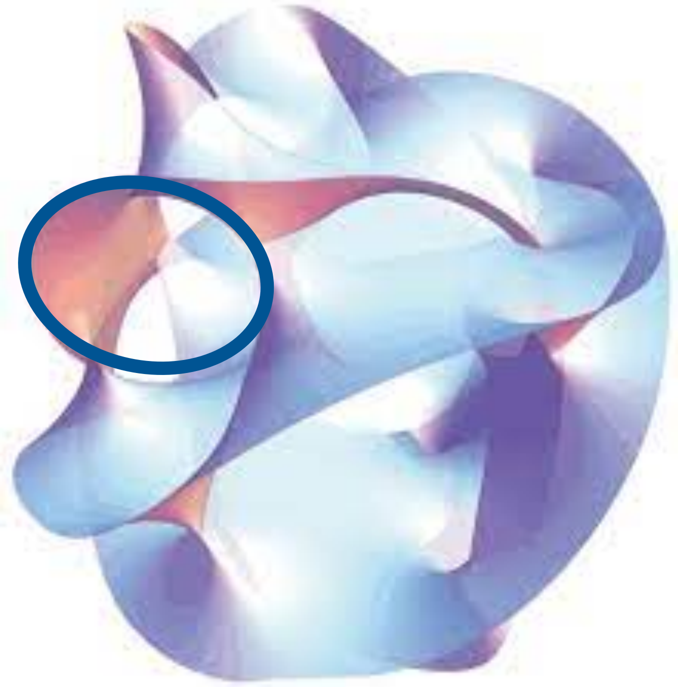

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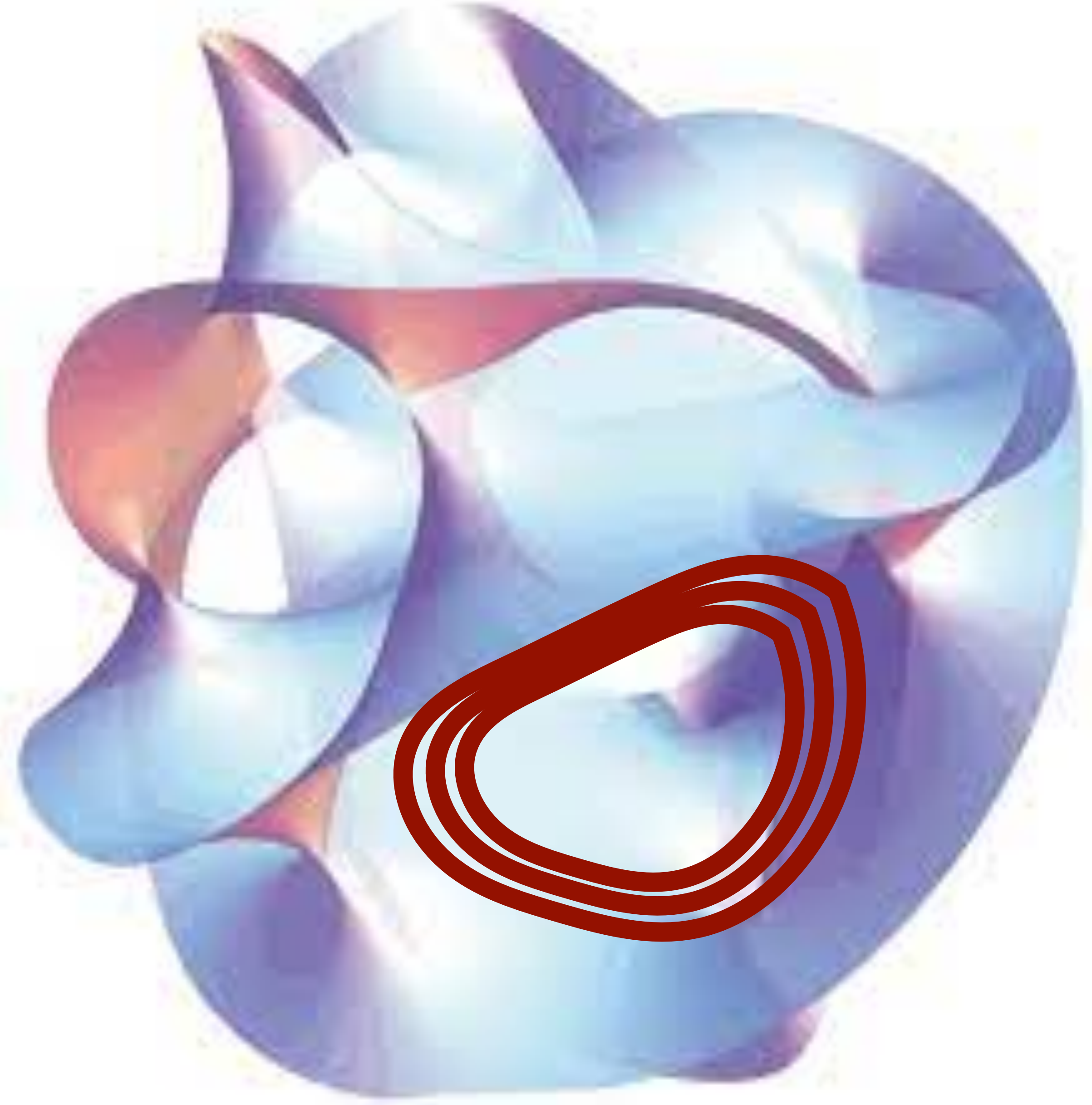

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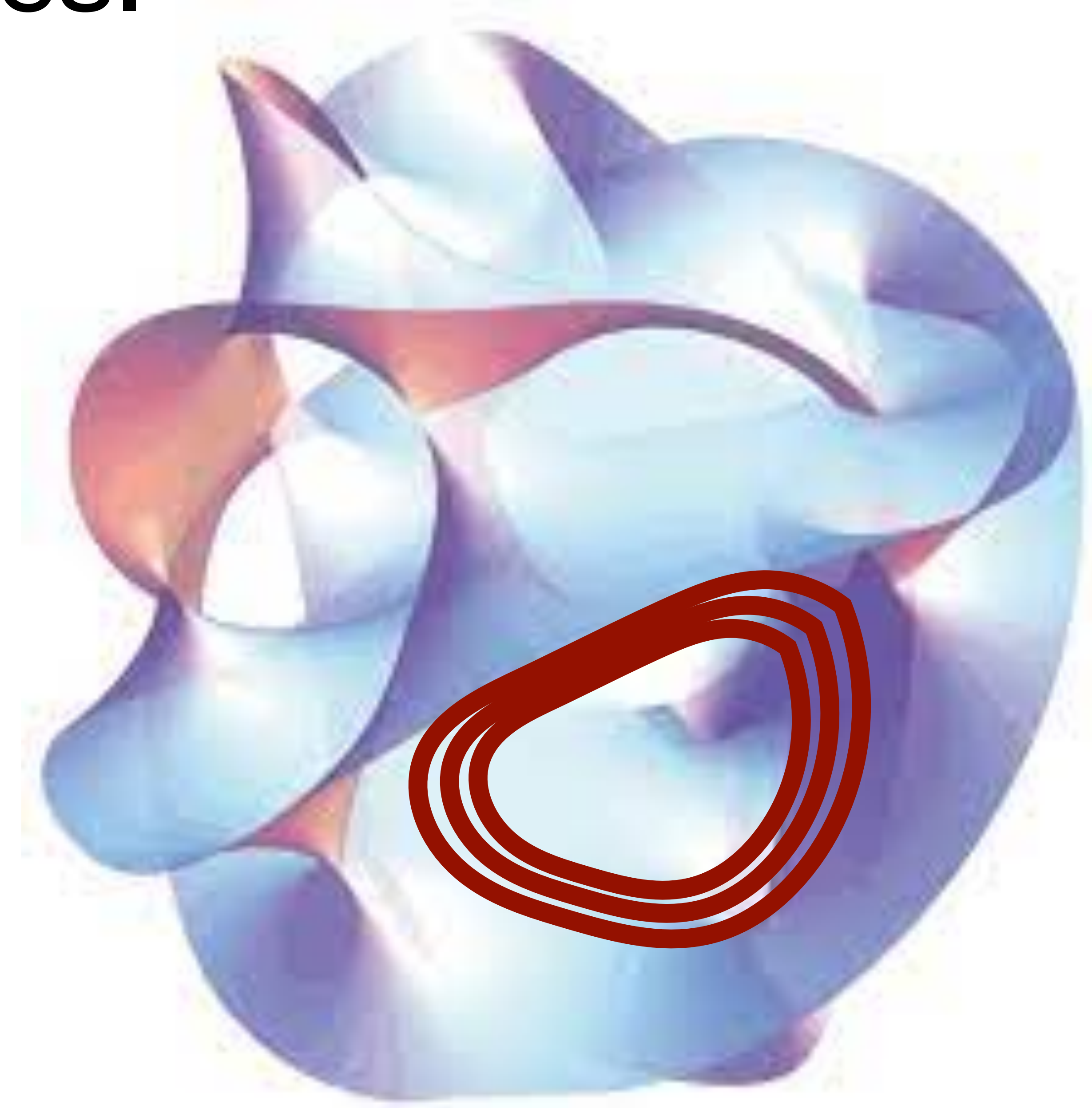

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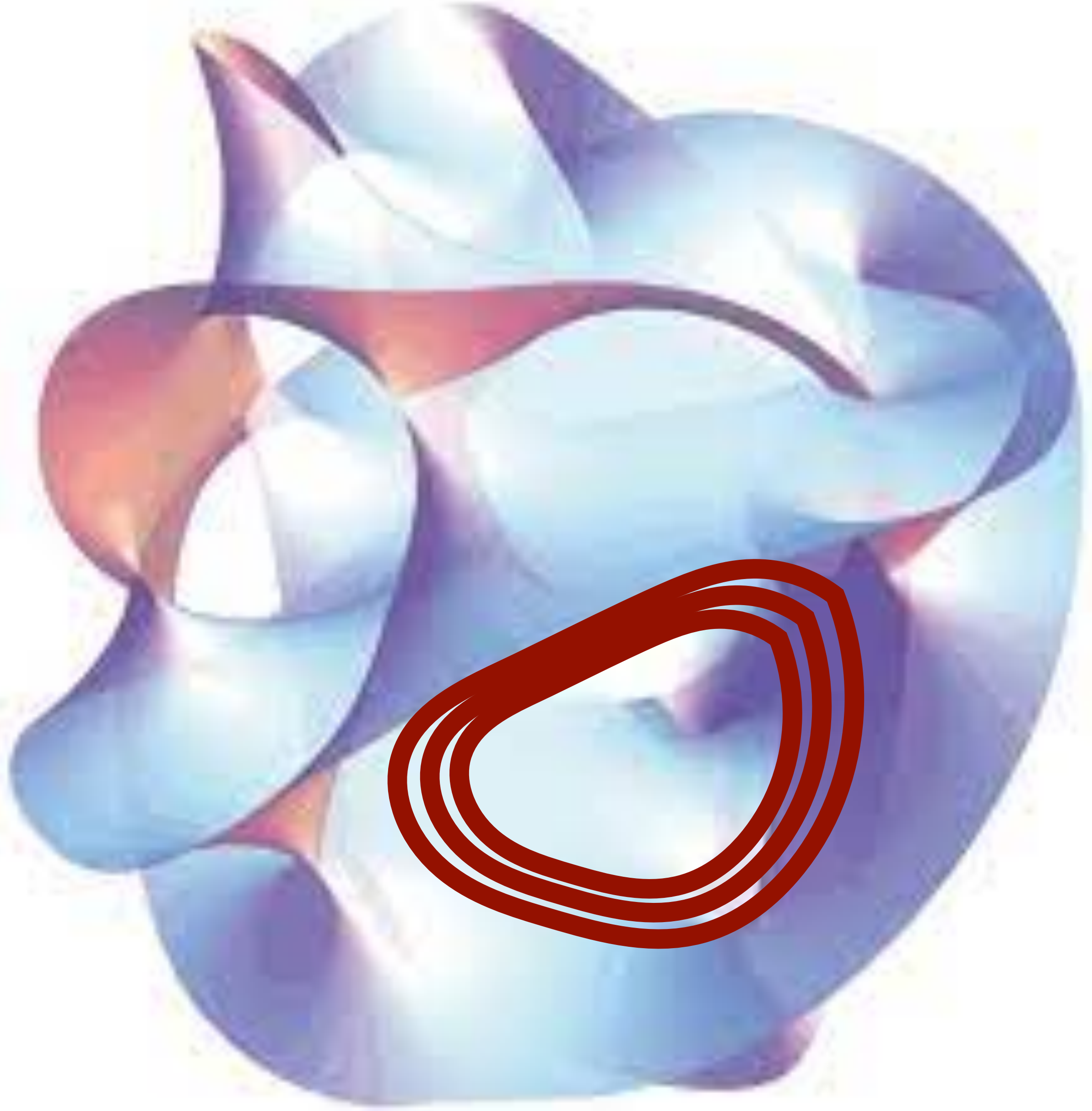

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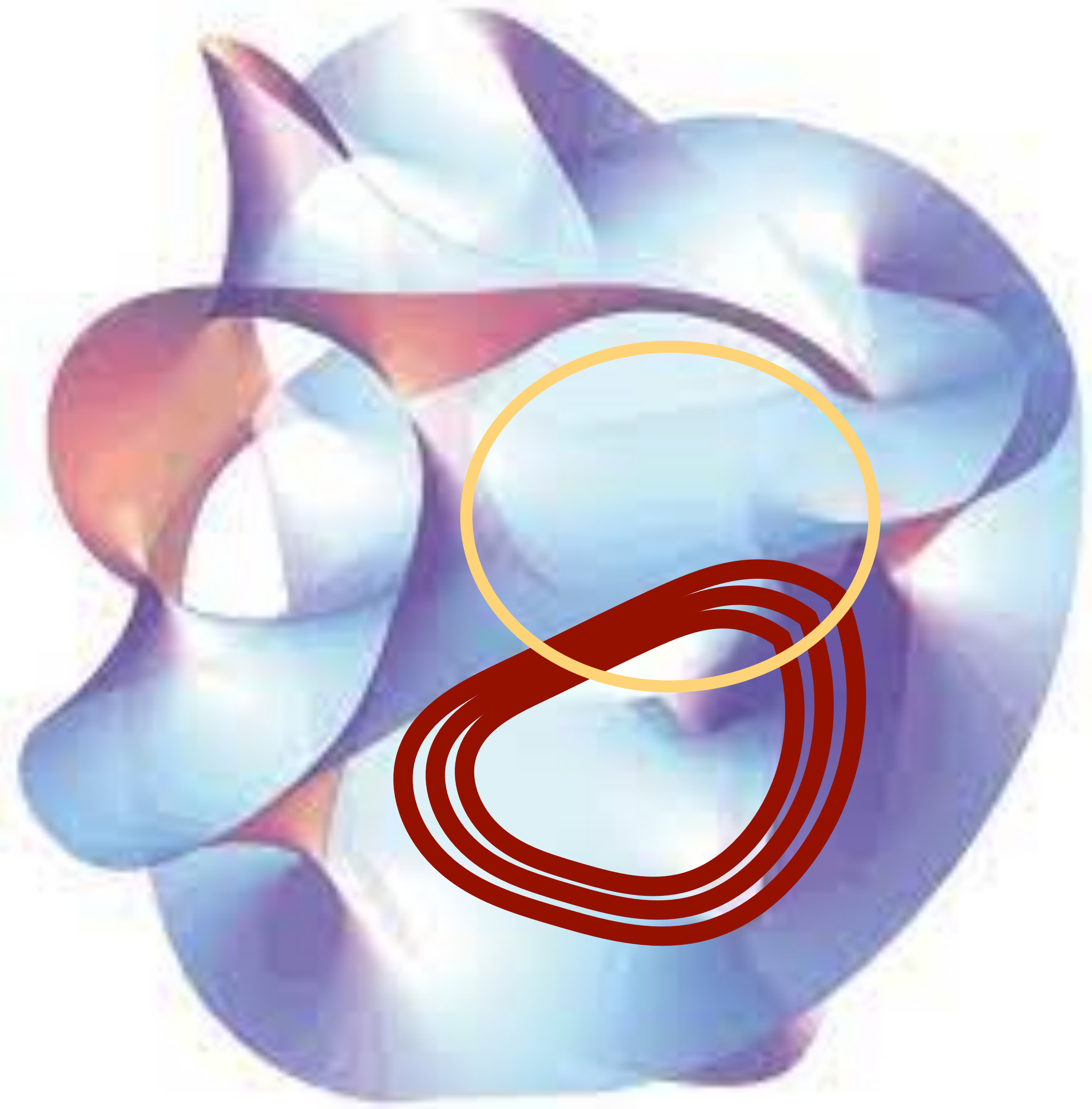

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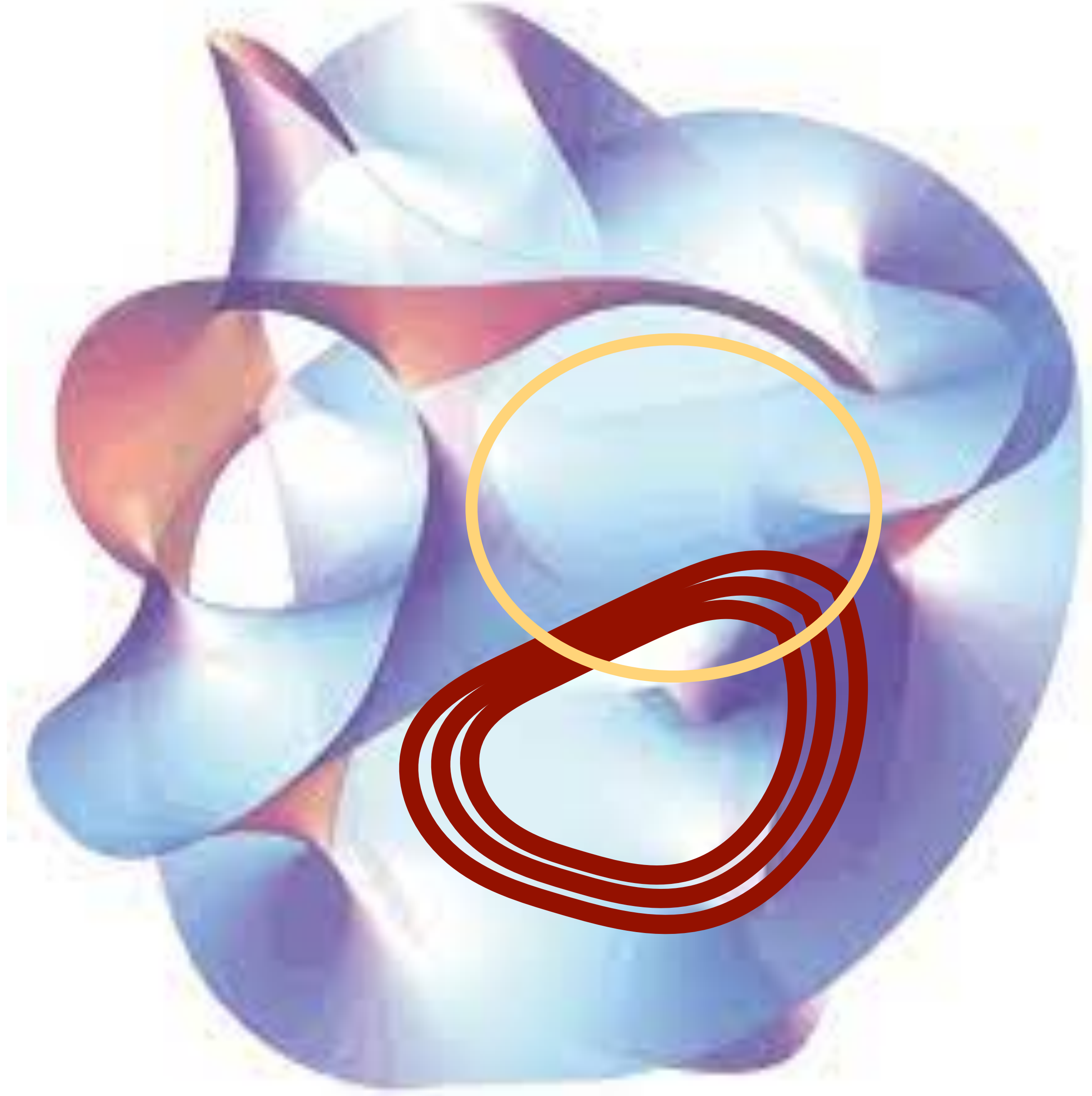

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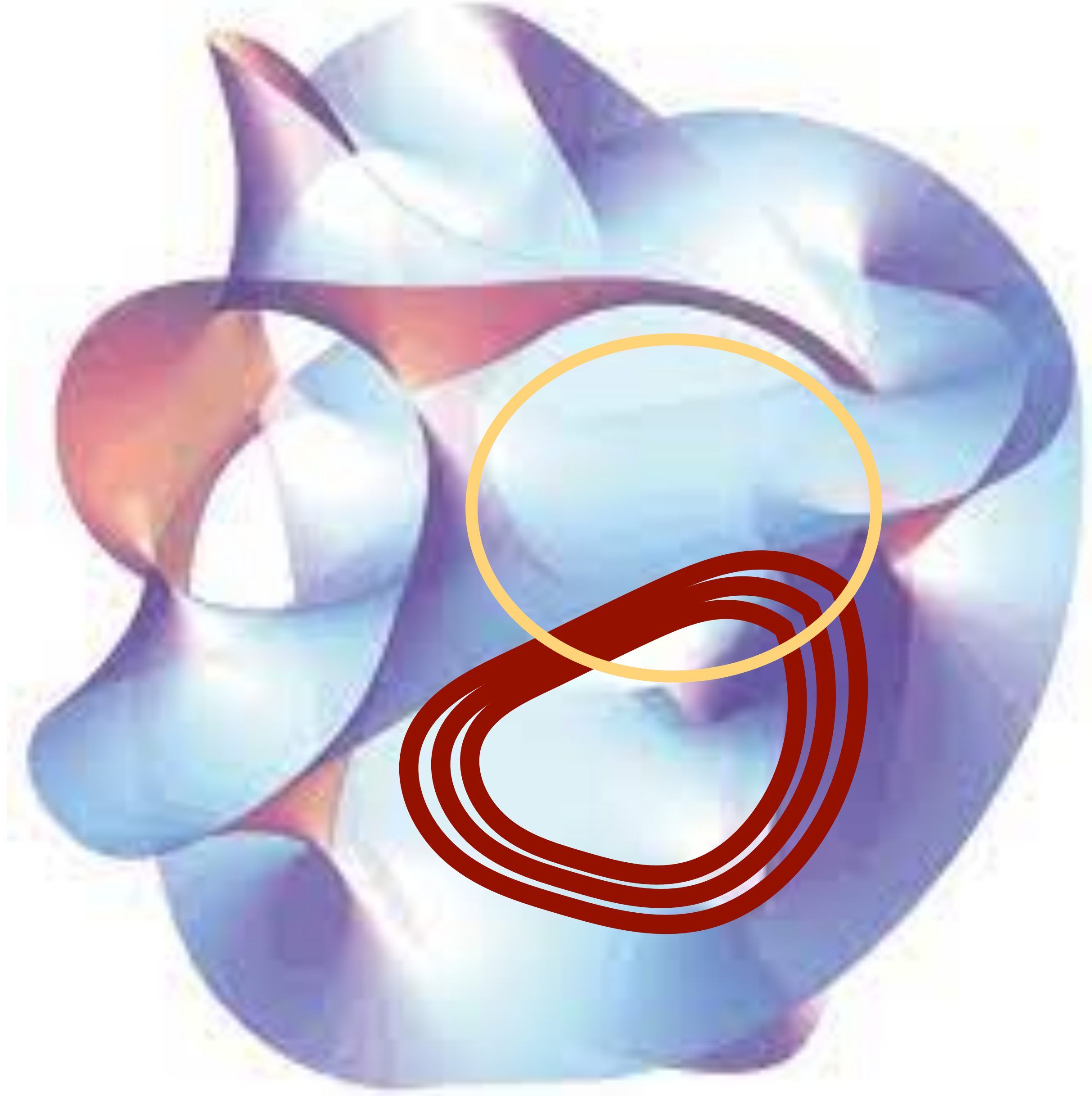

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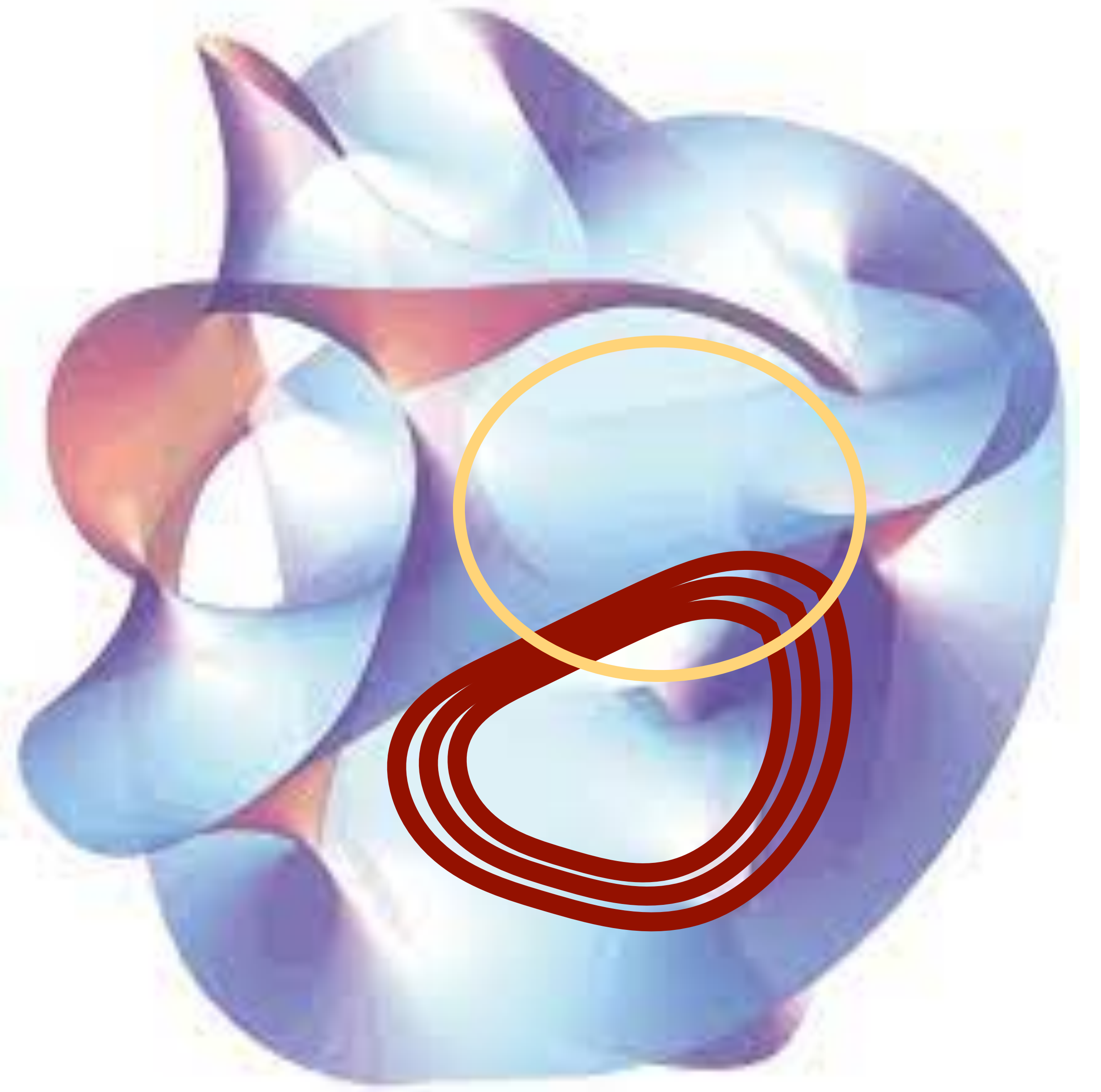

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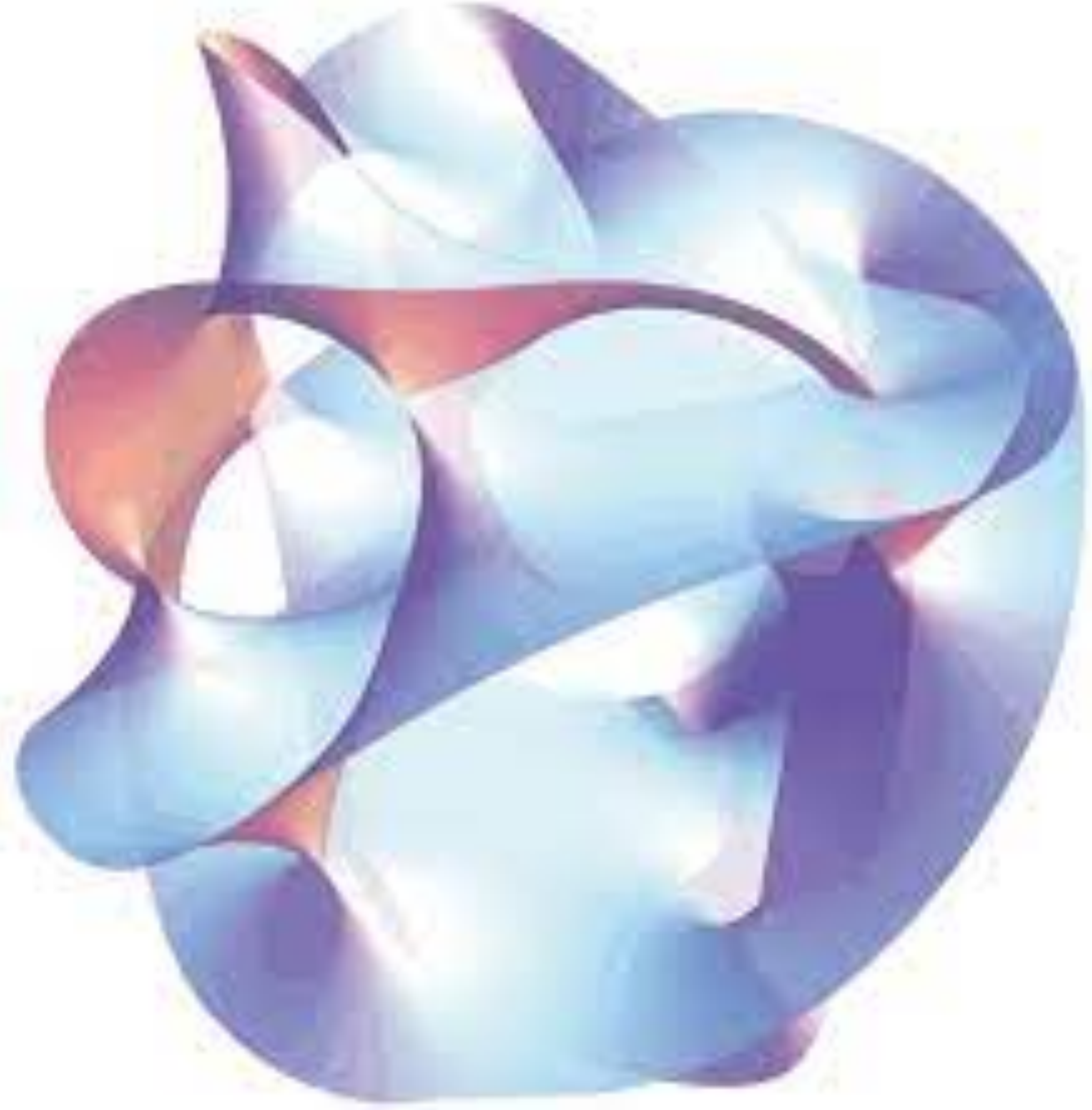
N is usually $\mathcal{O}(100\text{s})$

— are such theories ruled out?

Axion potentials in string theory



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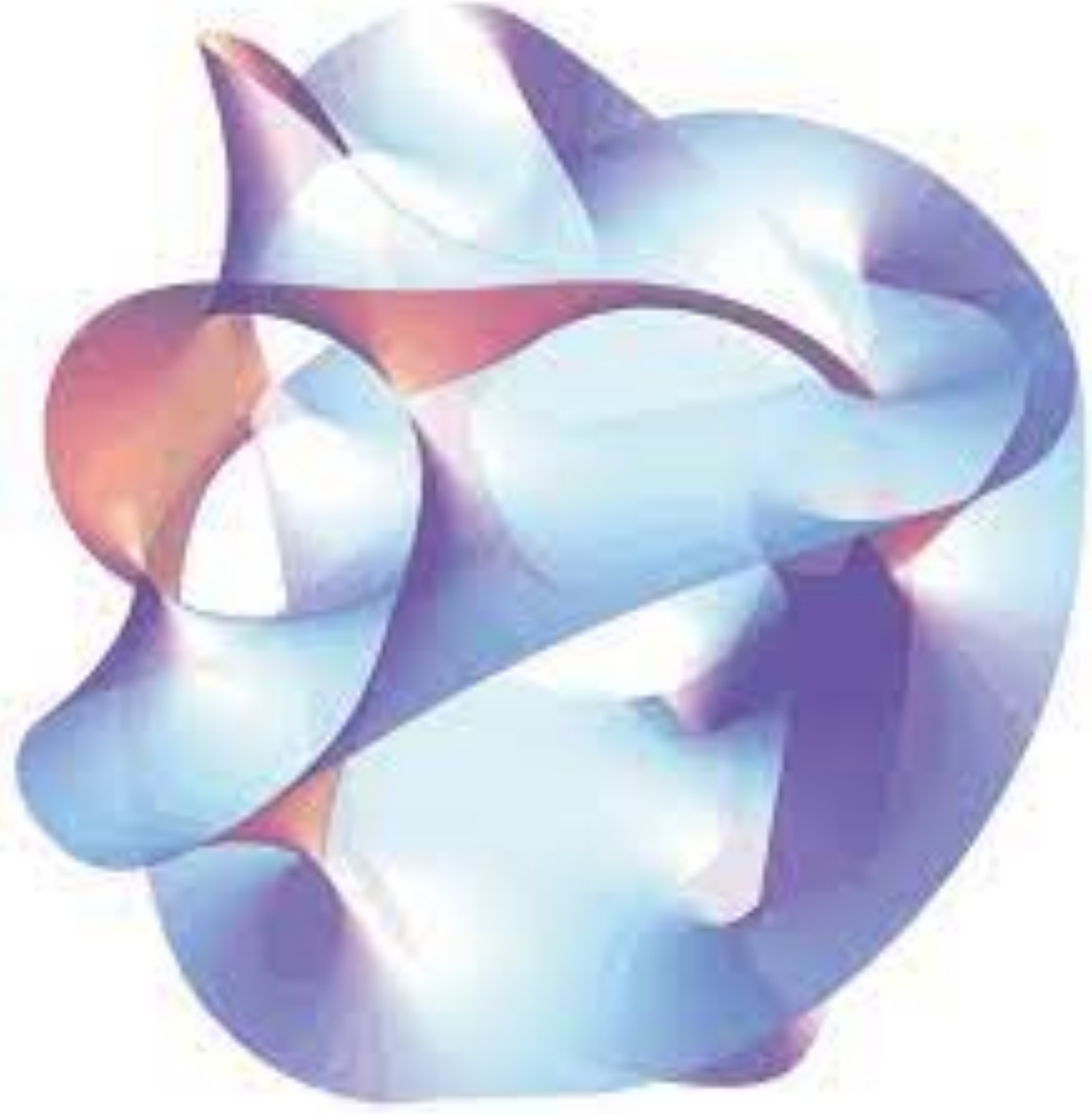

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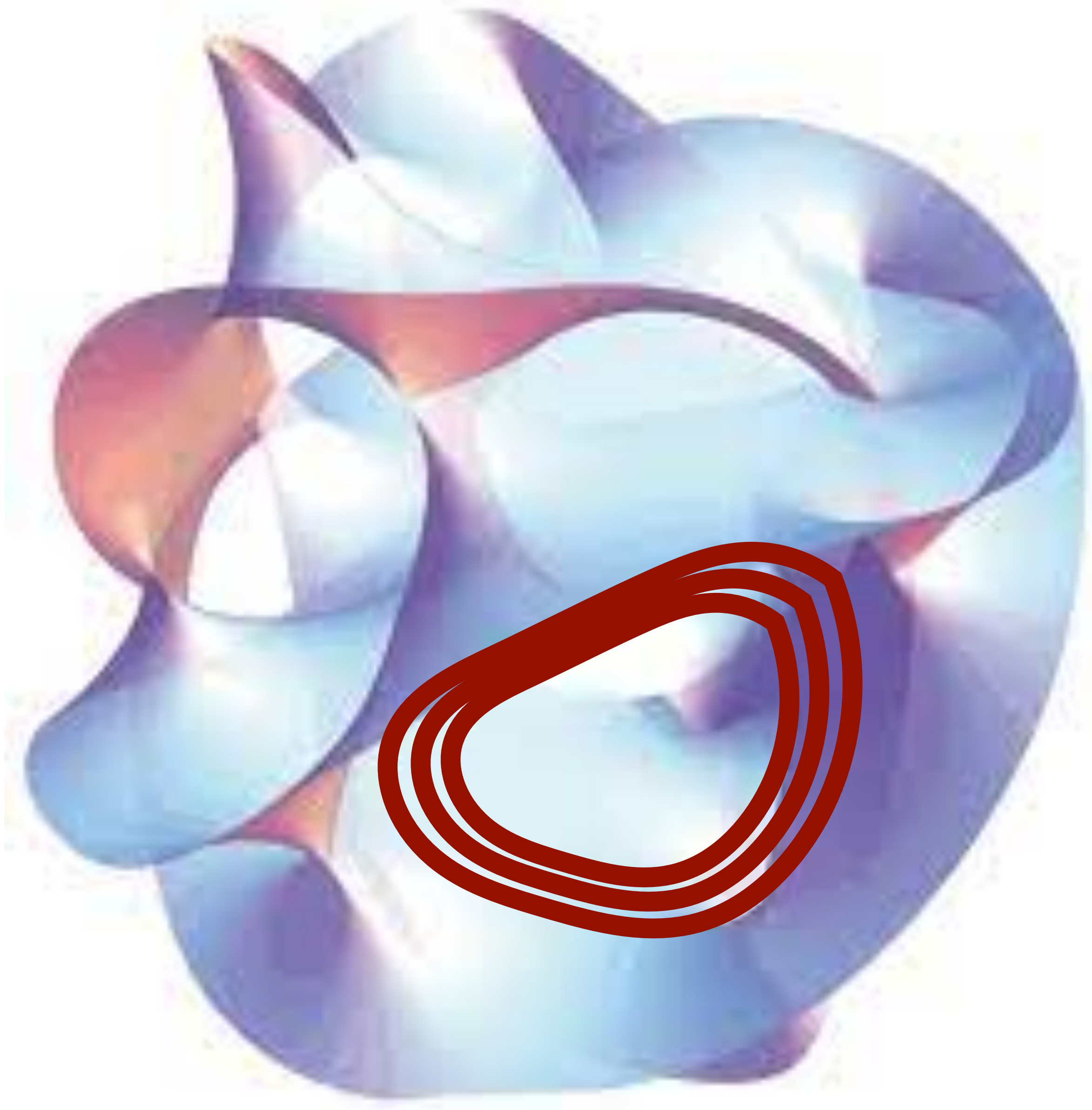

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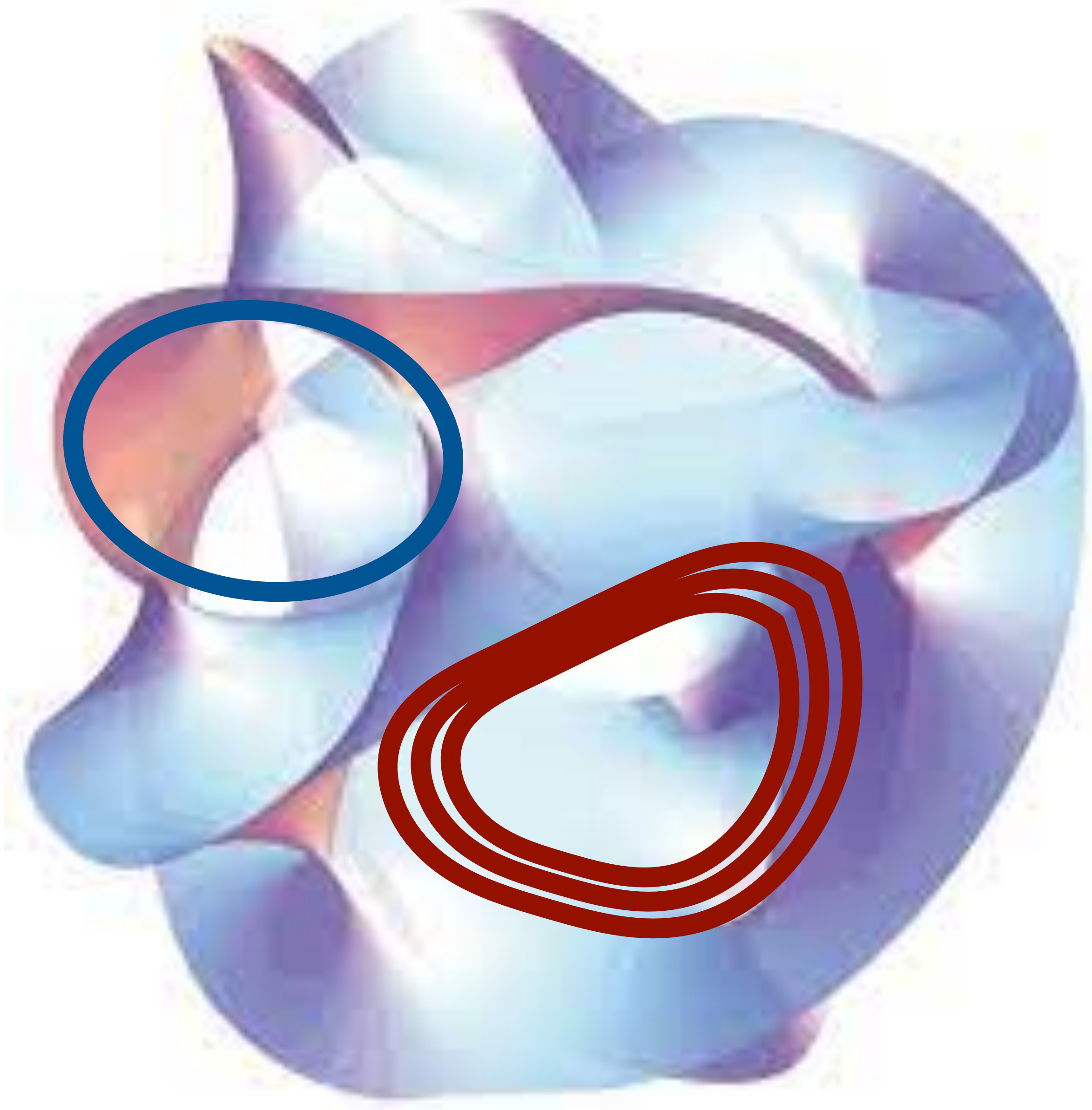

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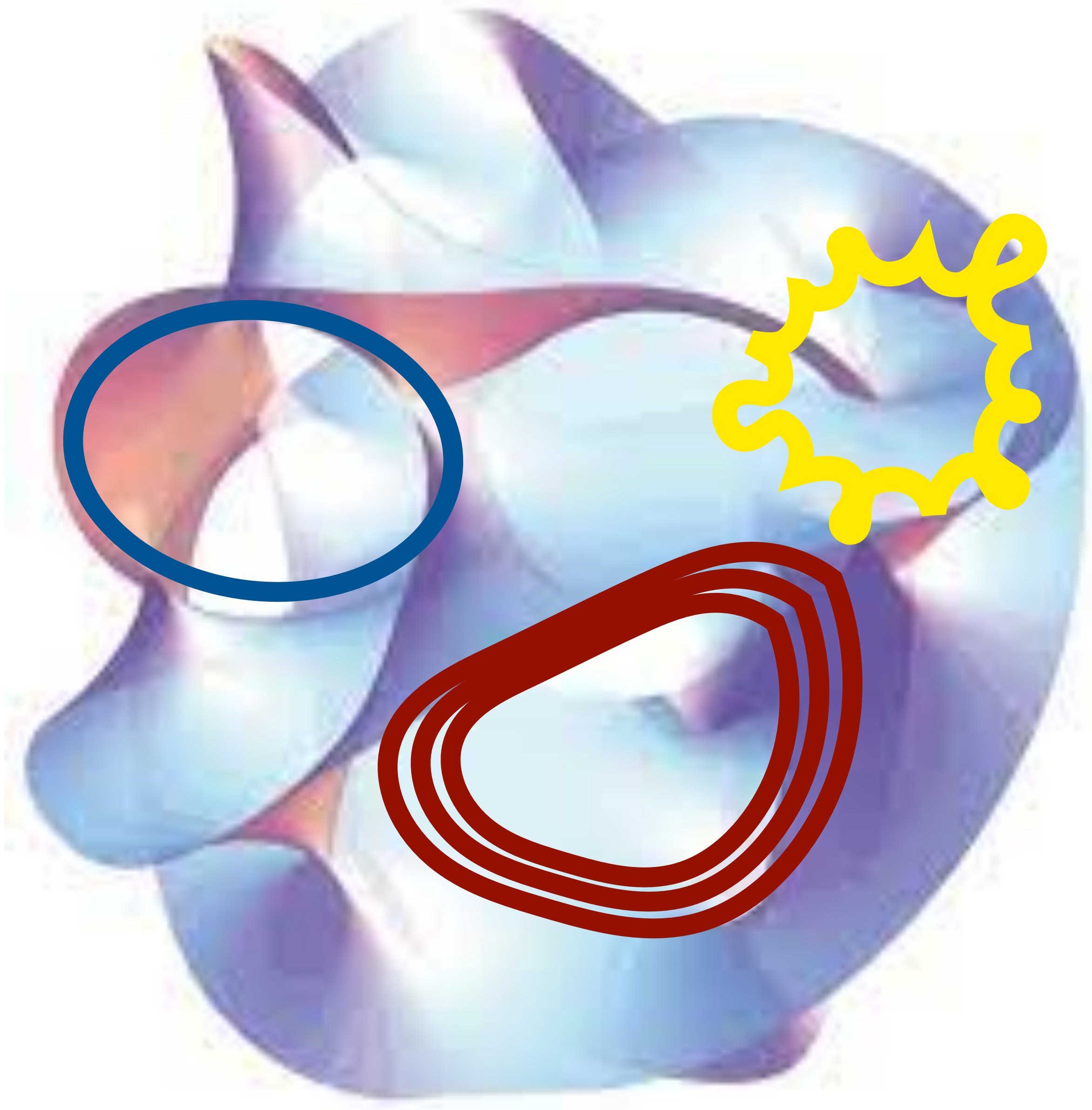

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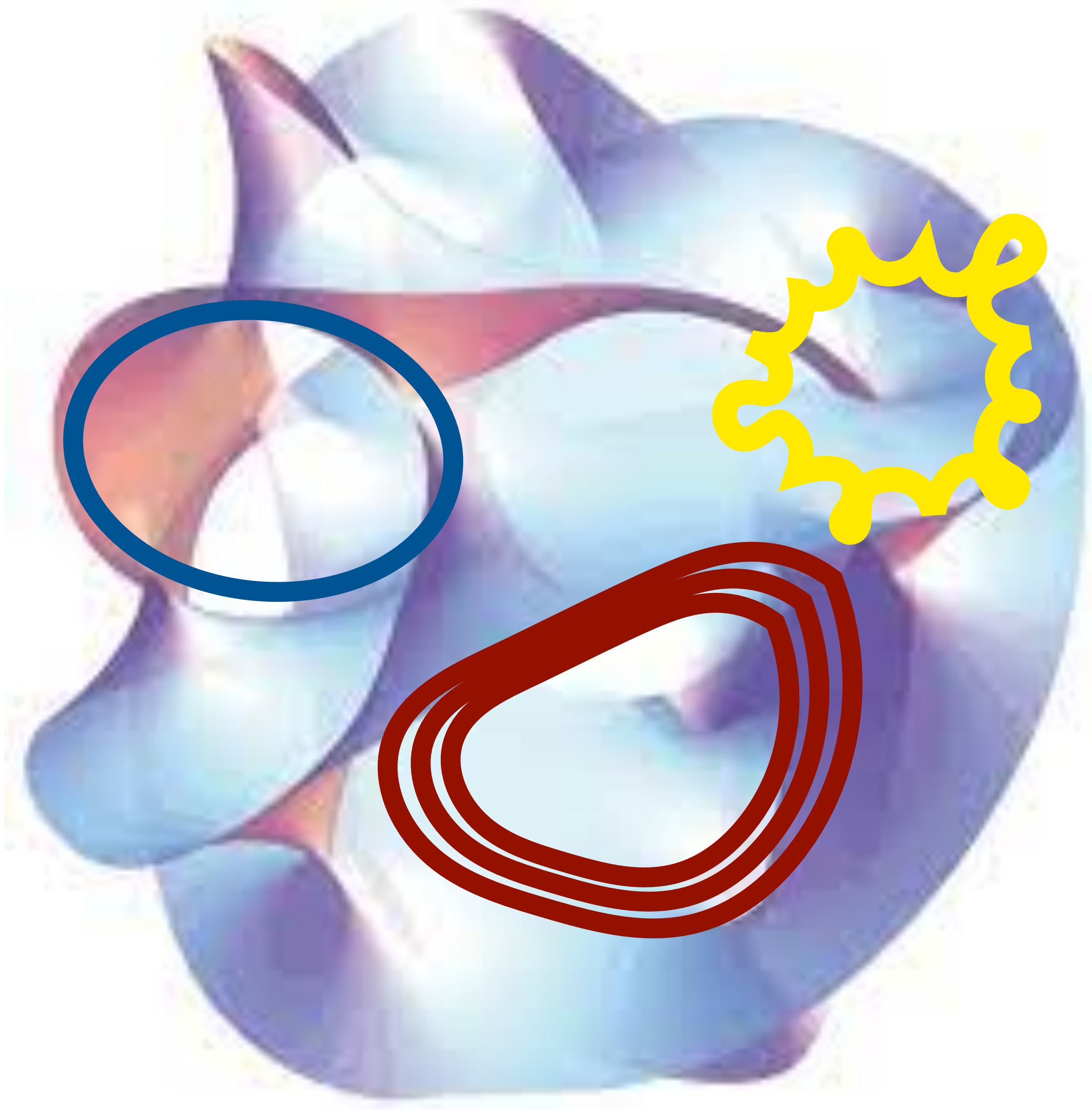
- These generate potentials for the axions



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φ_i: phases set by UV physics (generally assumed O(1))

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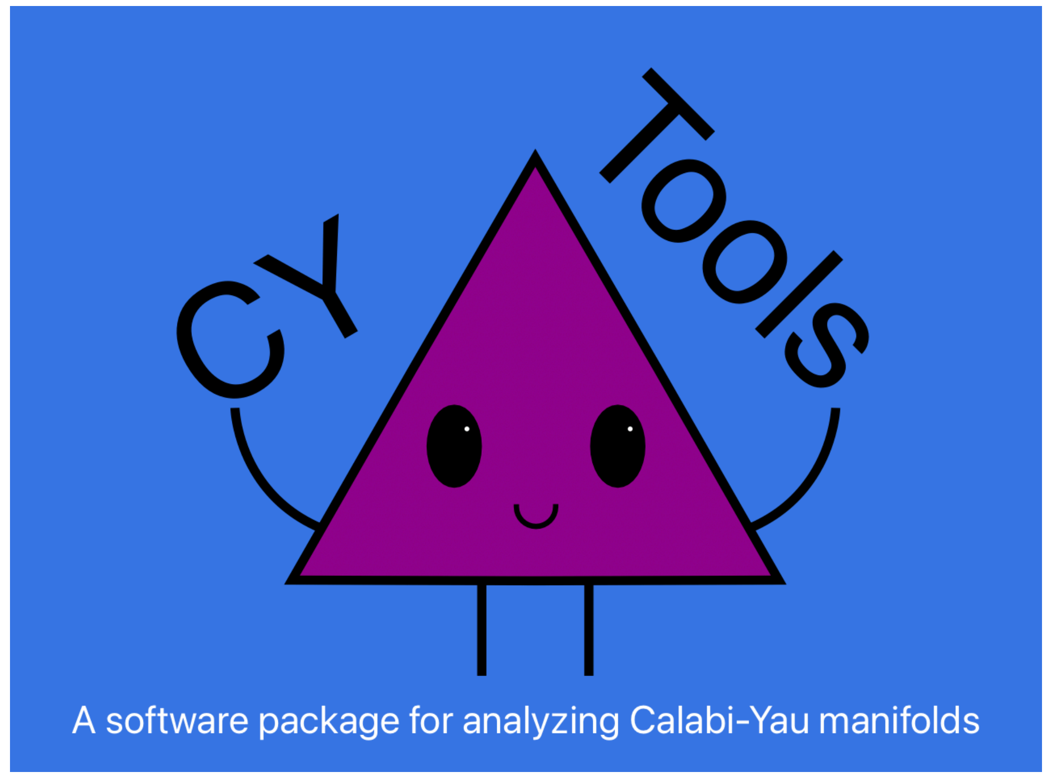

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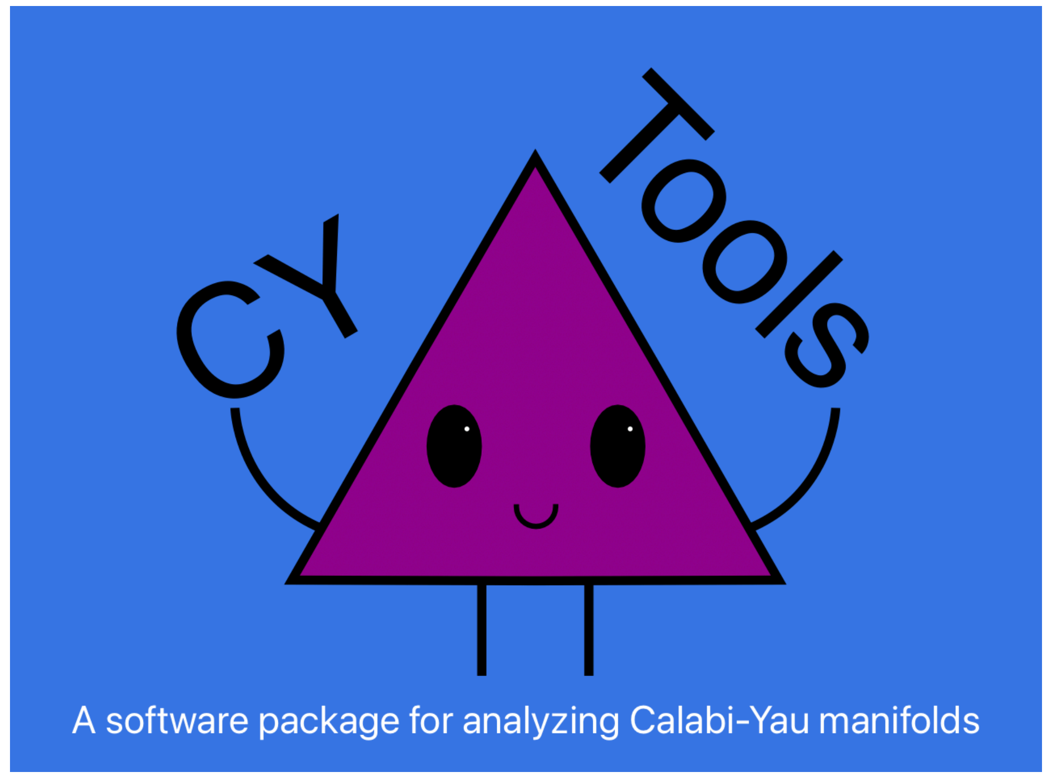

We use a publicly available package called CYTools to efficiently generate the data needed for axion effective theories.

CYTools can compute volumes of loops in Calabi-Yau geometries, so we can easily use it to calculate axion masses and decay constants.

Type IIB explicit axiverse

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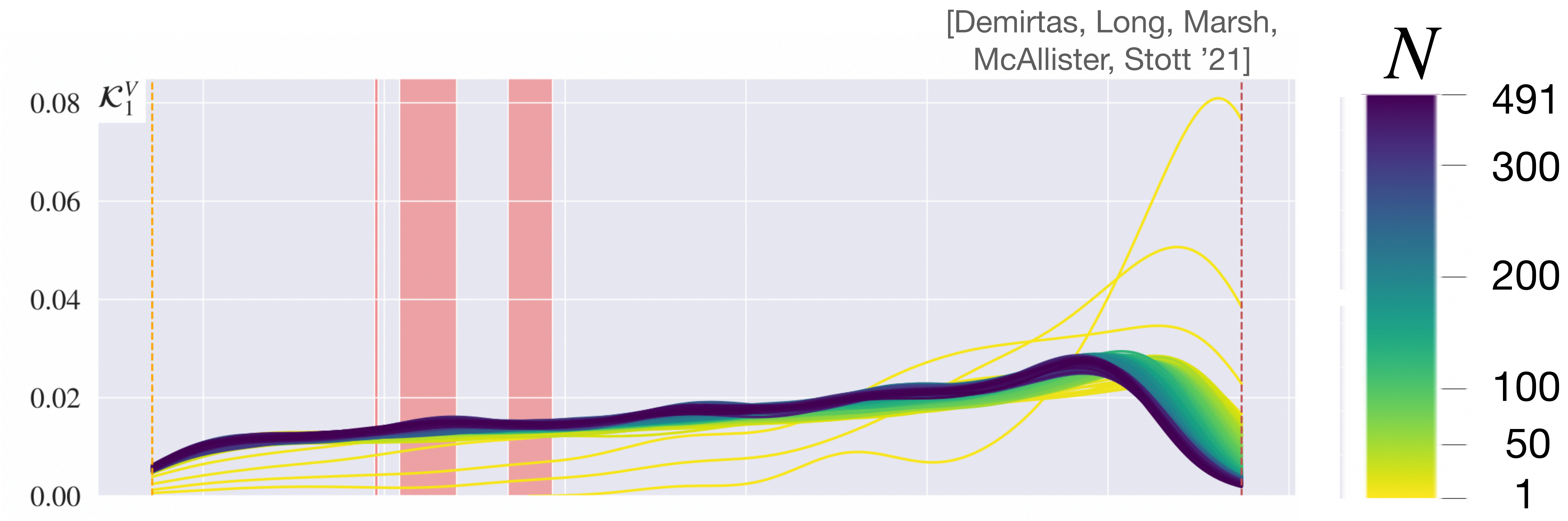
masses span
many decades



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[Demirtas, Long, Marsh, McAllister, Stott '21]

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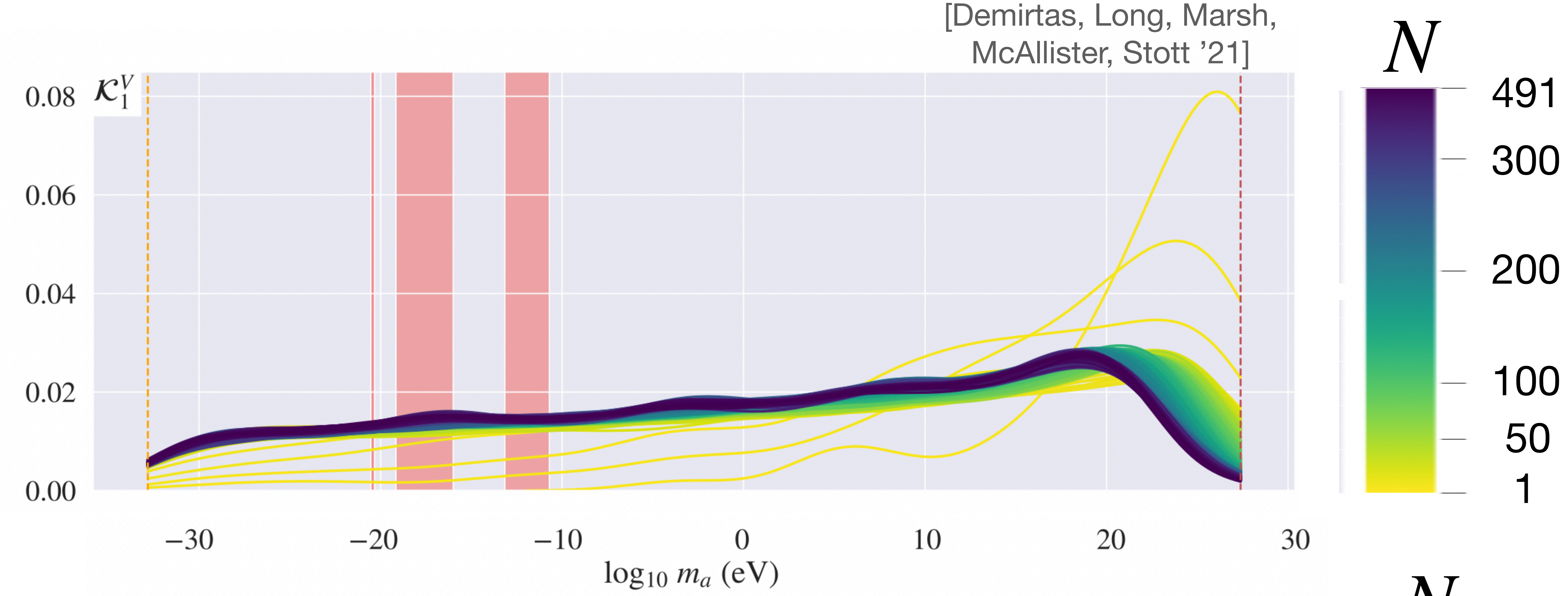
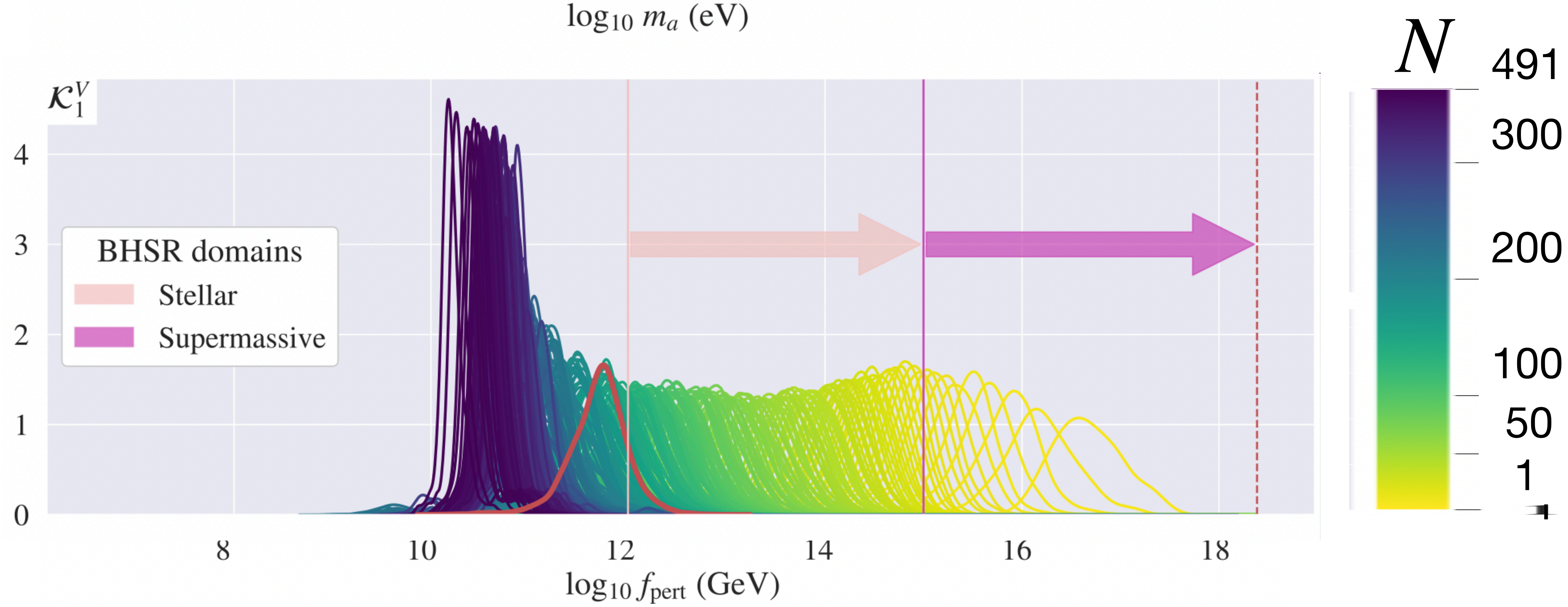


decay constants are not 10^{16} GeV



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- I will now present some results on studying **axion-photon couplings** in this axiverse.

II. Axion-photon couplings in string theory

Axion detection

- We will focus on constraints coming from the axion coupling to photons:

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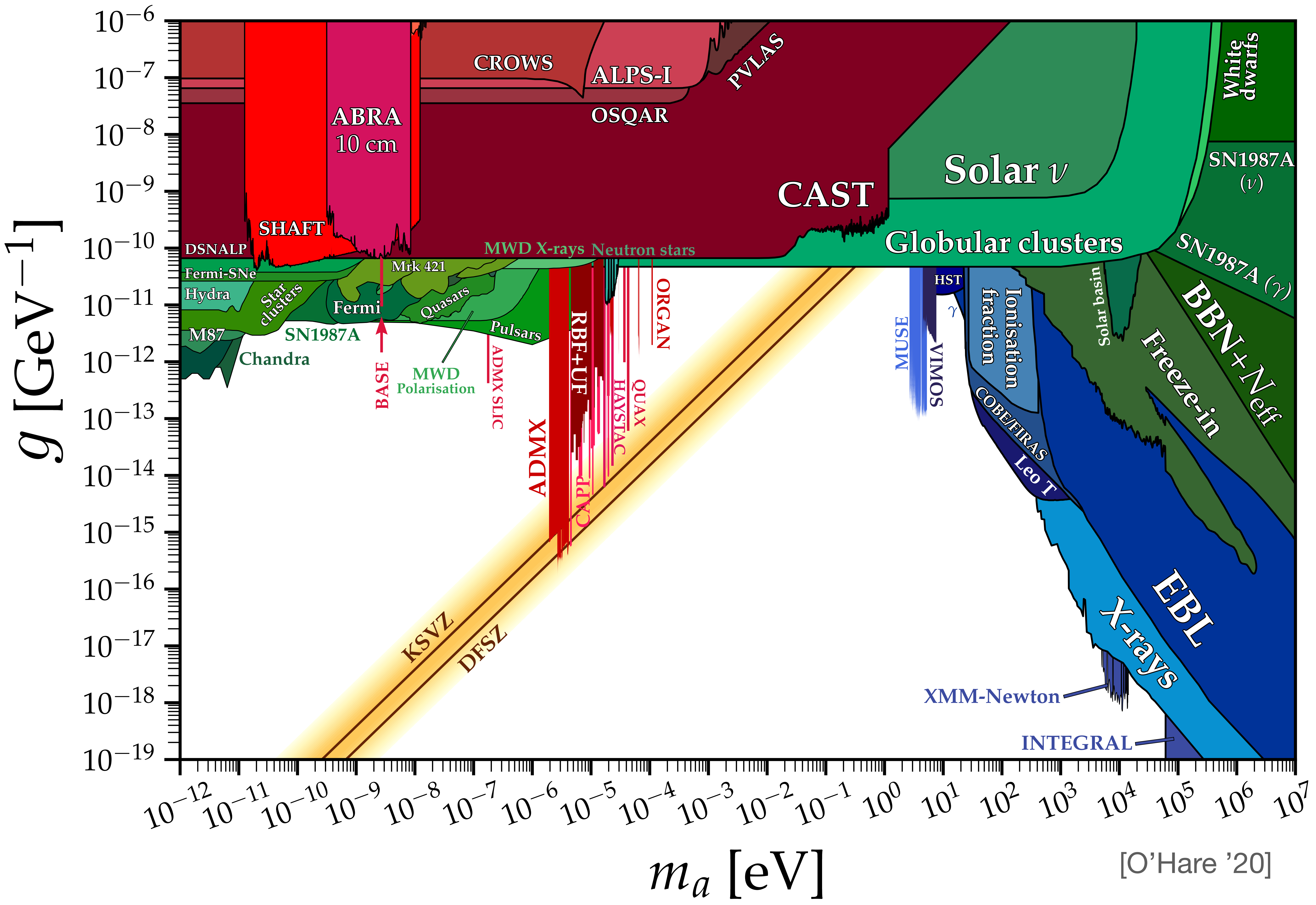

[O'Hare '20]

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Then:

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Axion-photon couplings in IIB string theory

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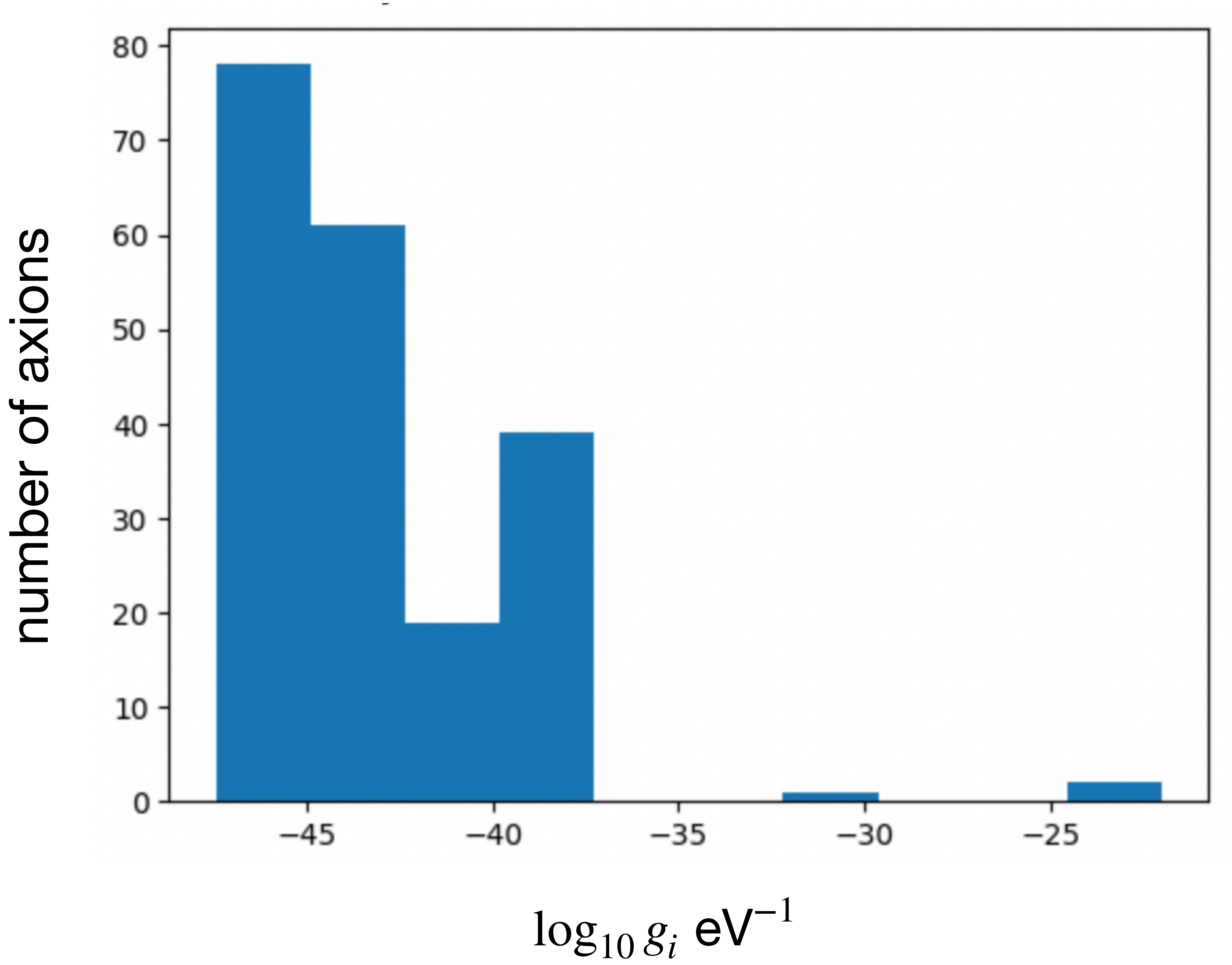

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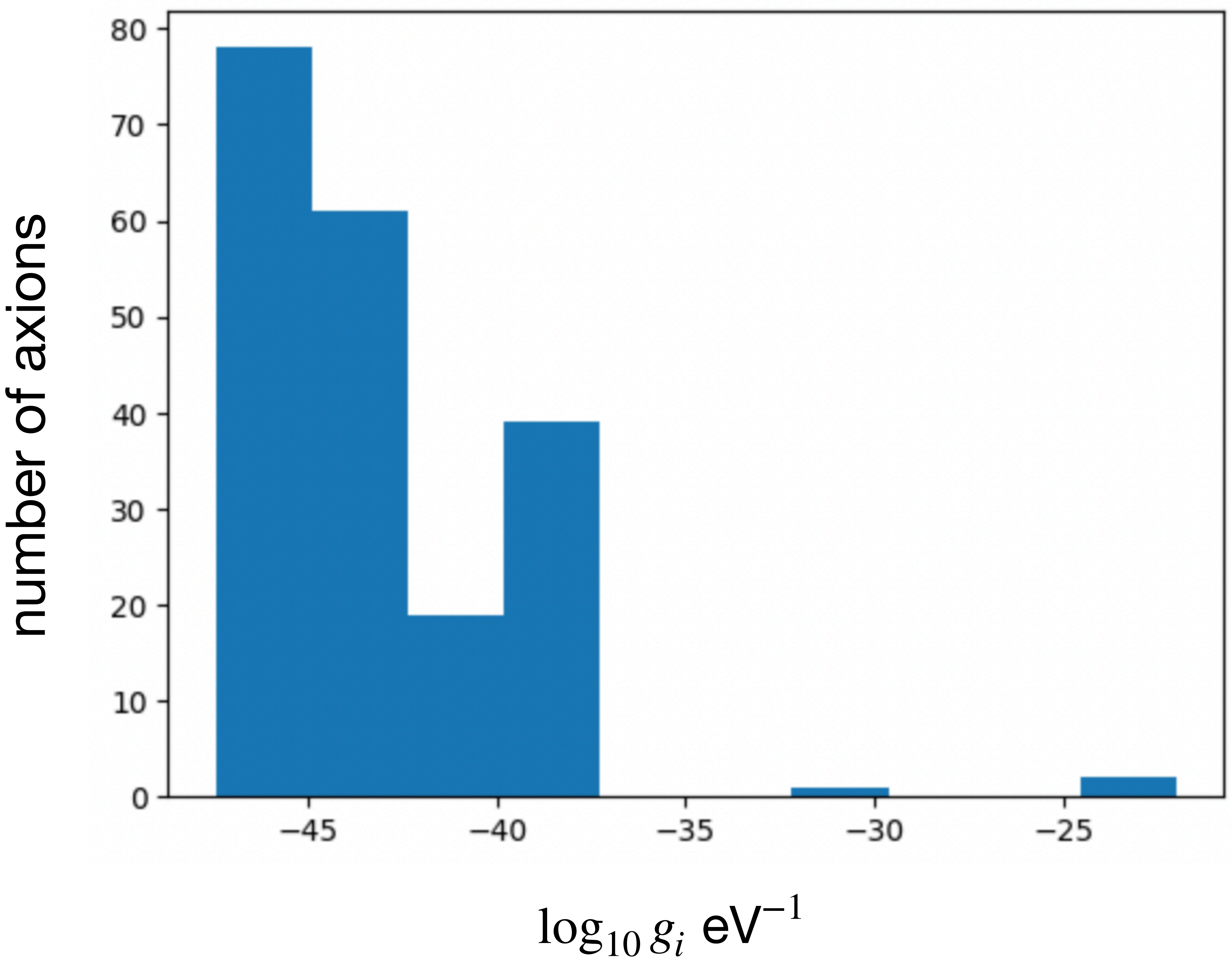

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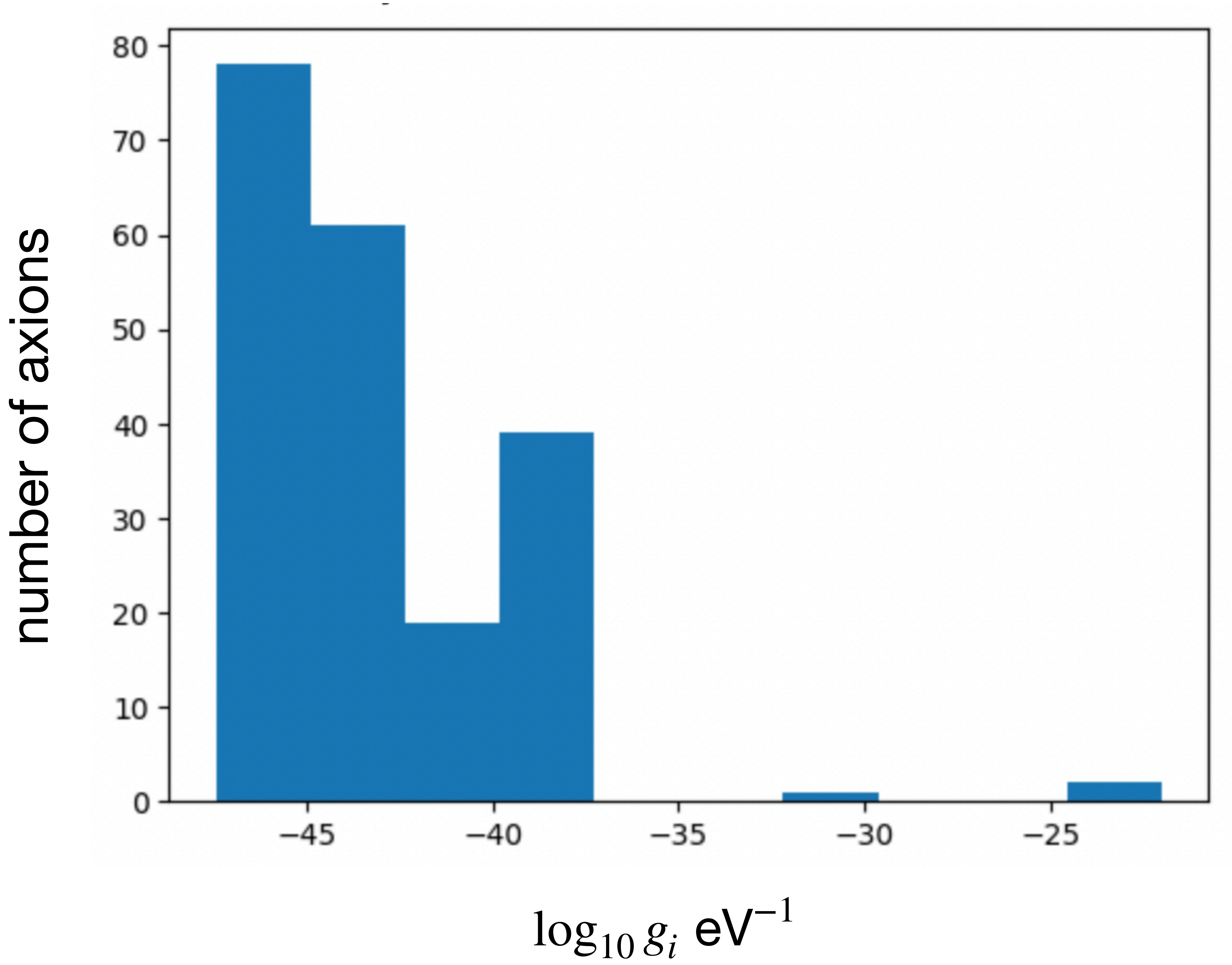

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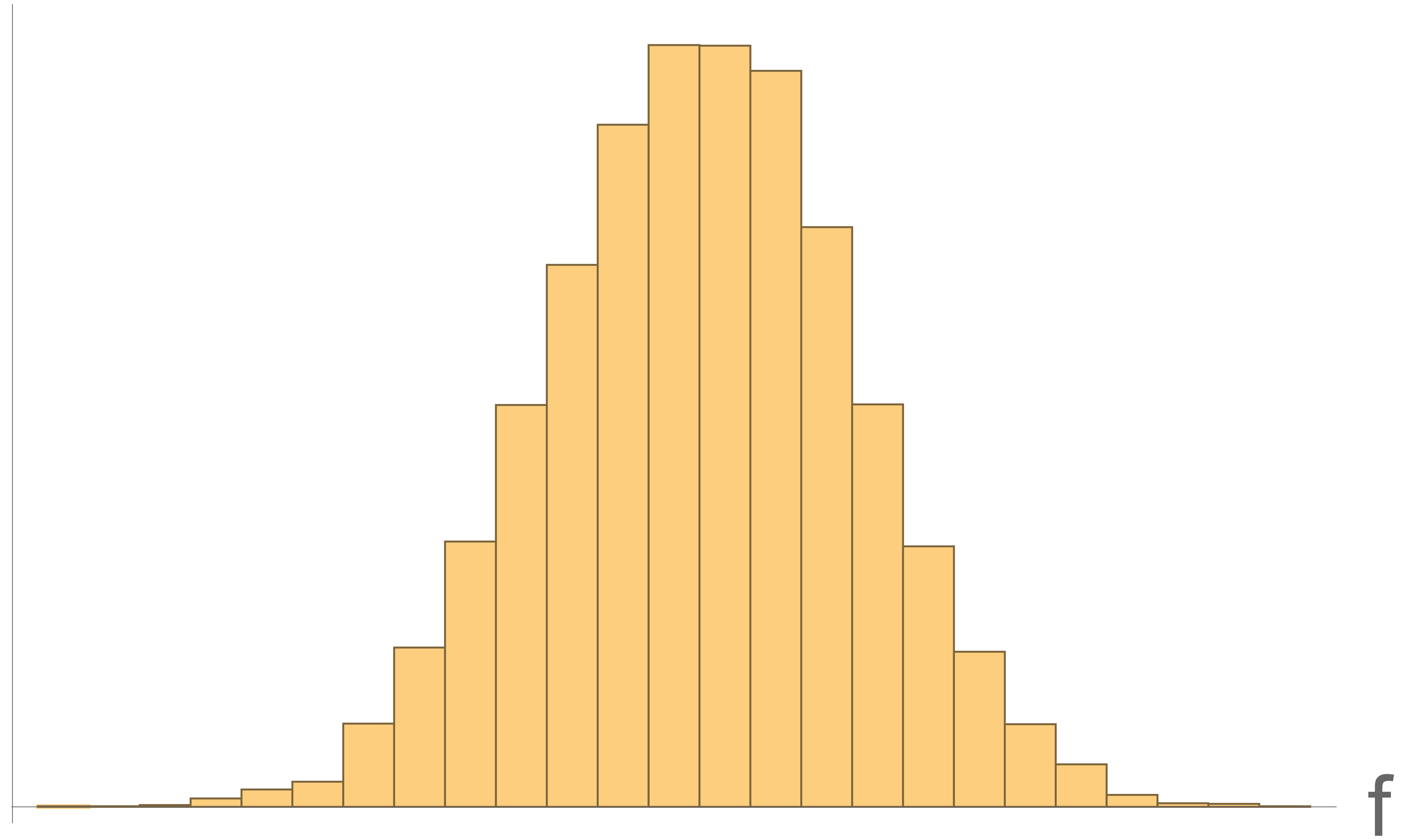

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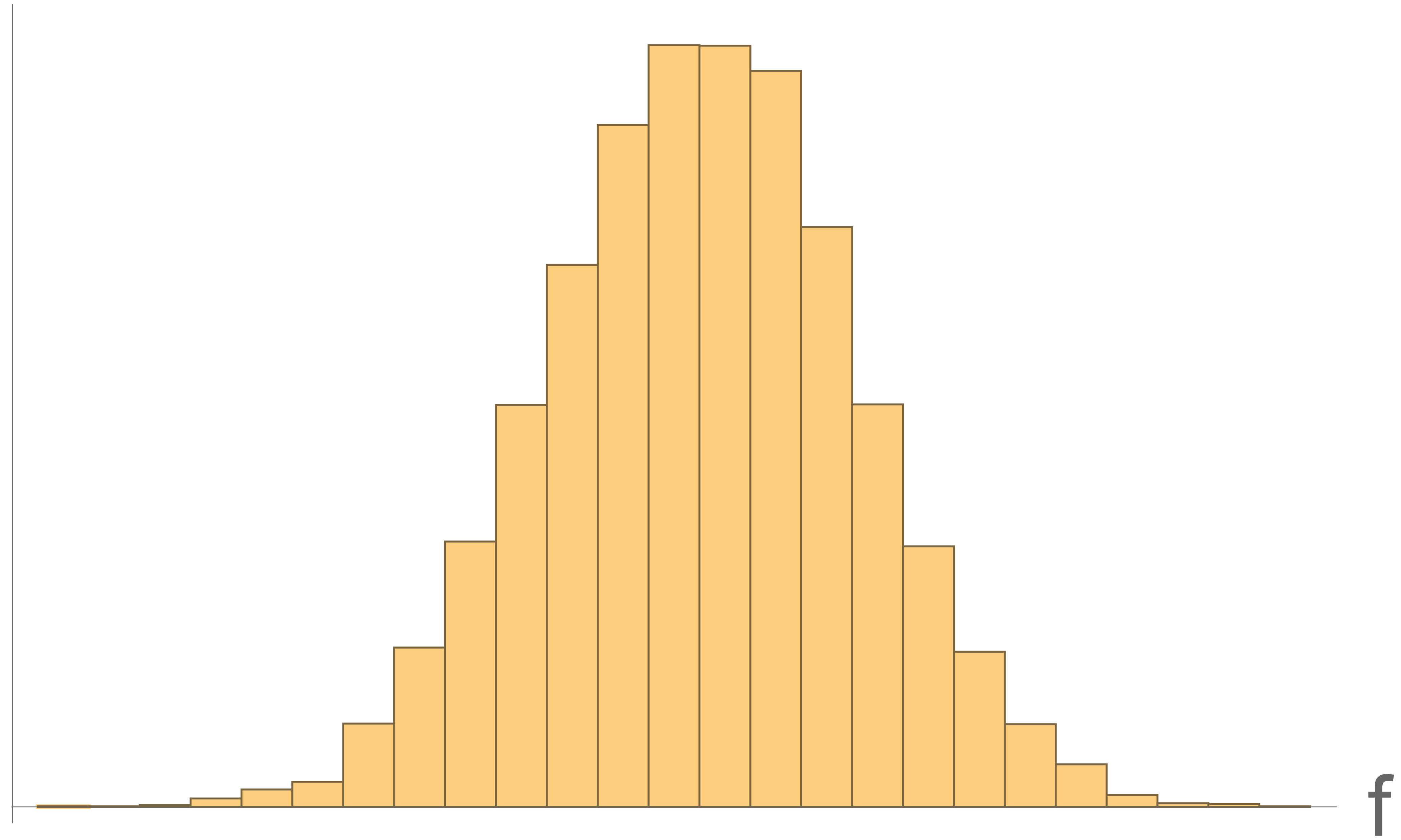

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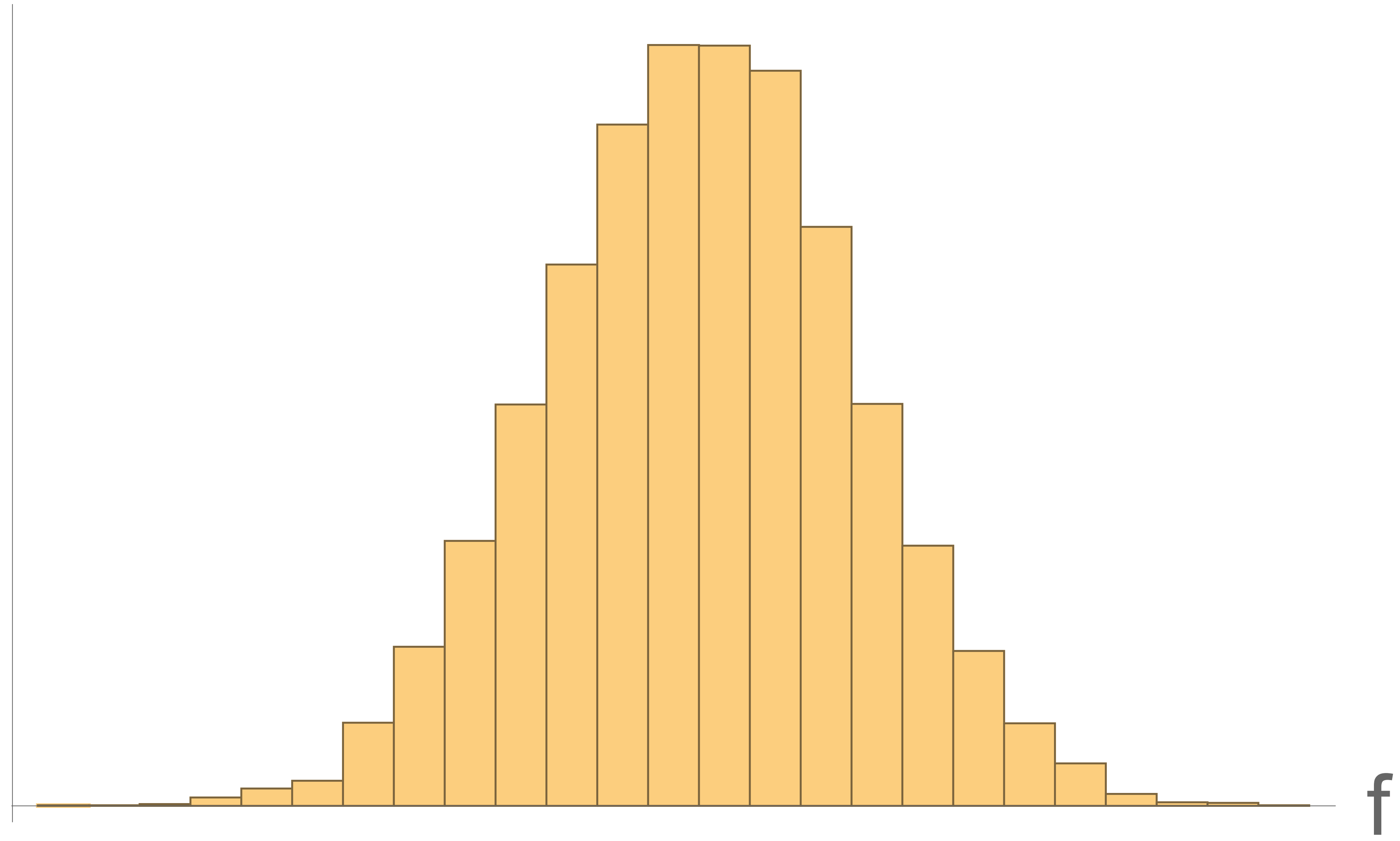

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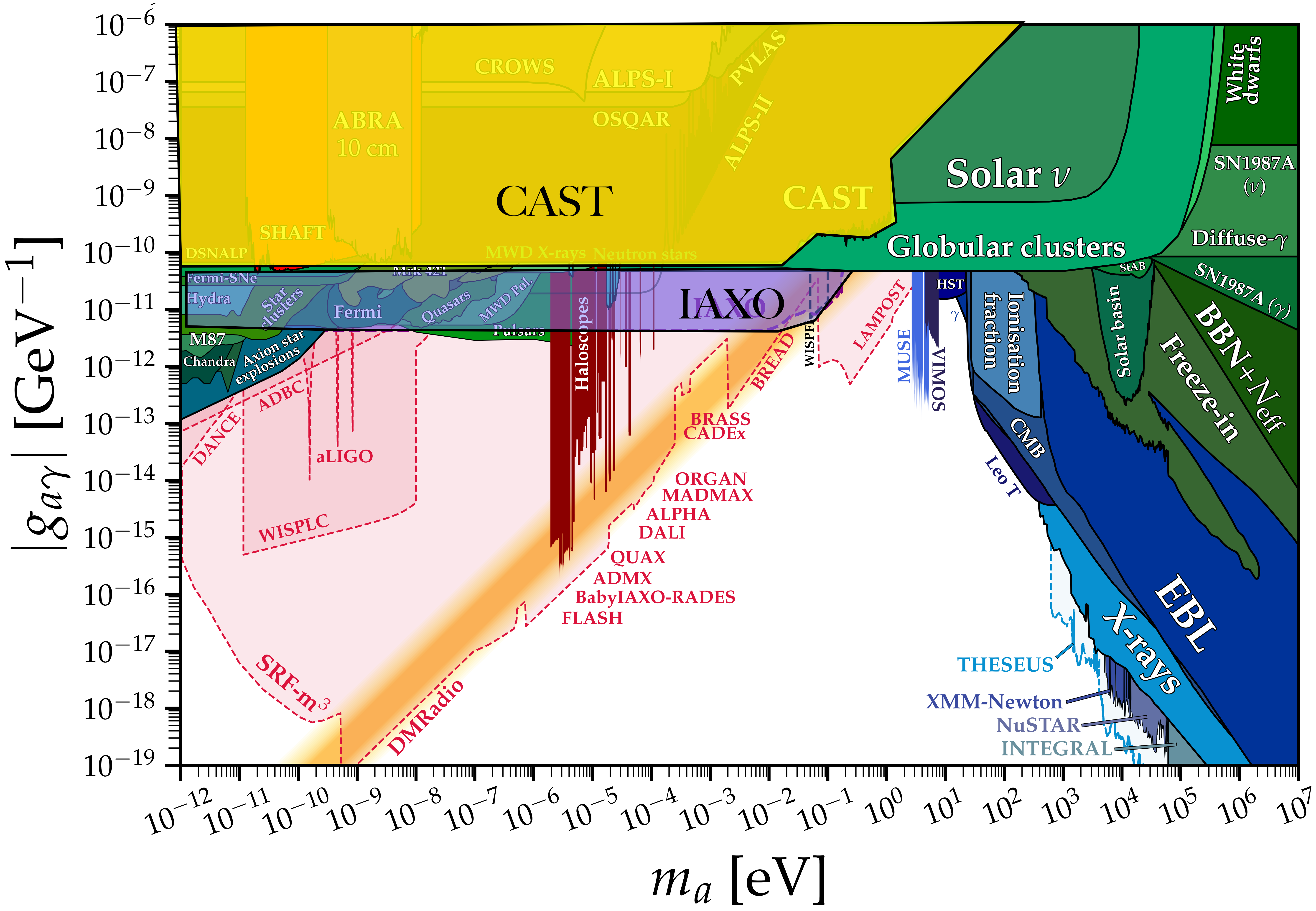

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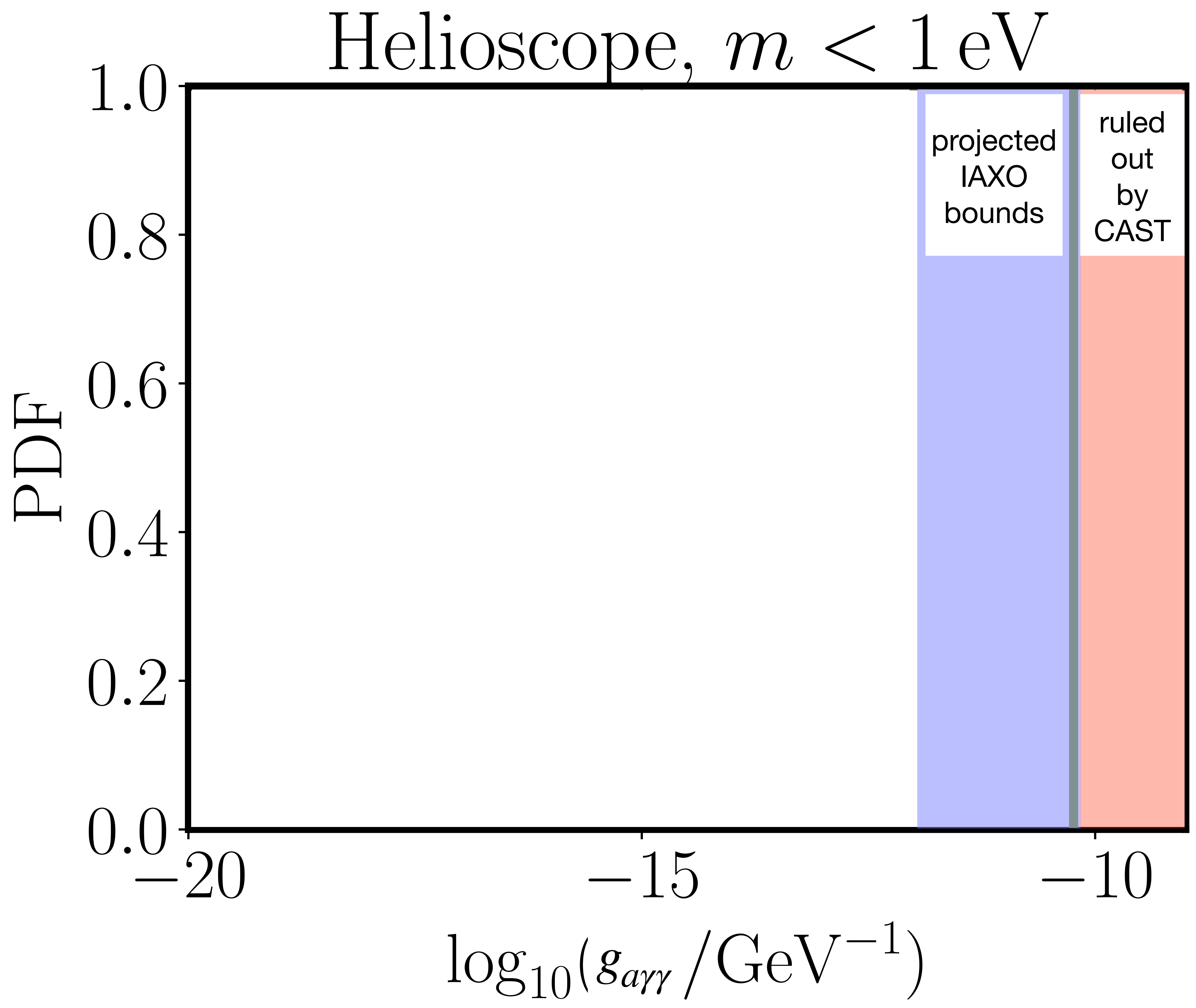

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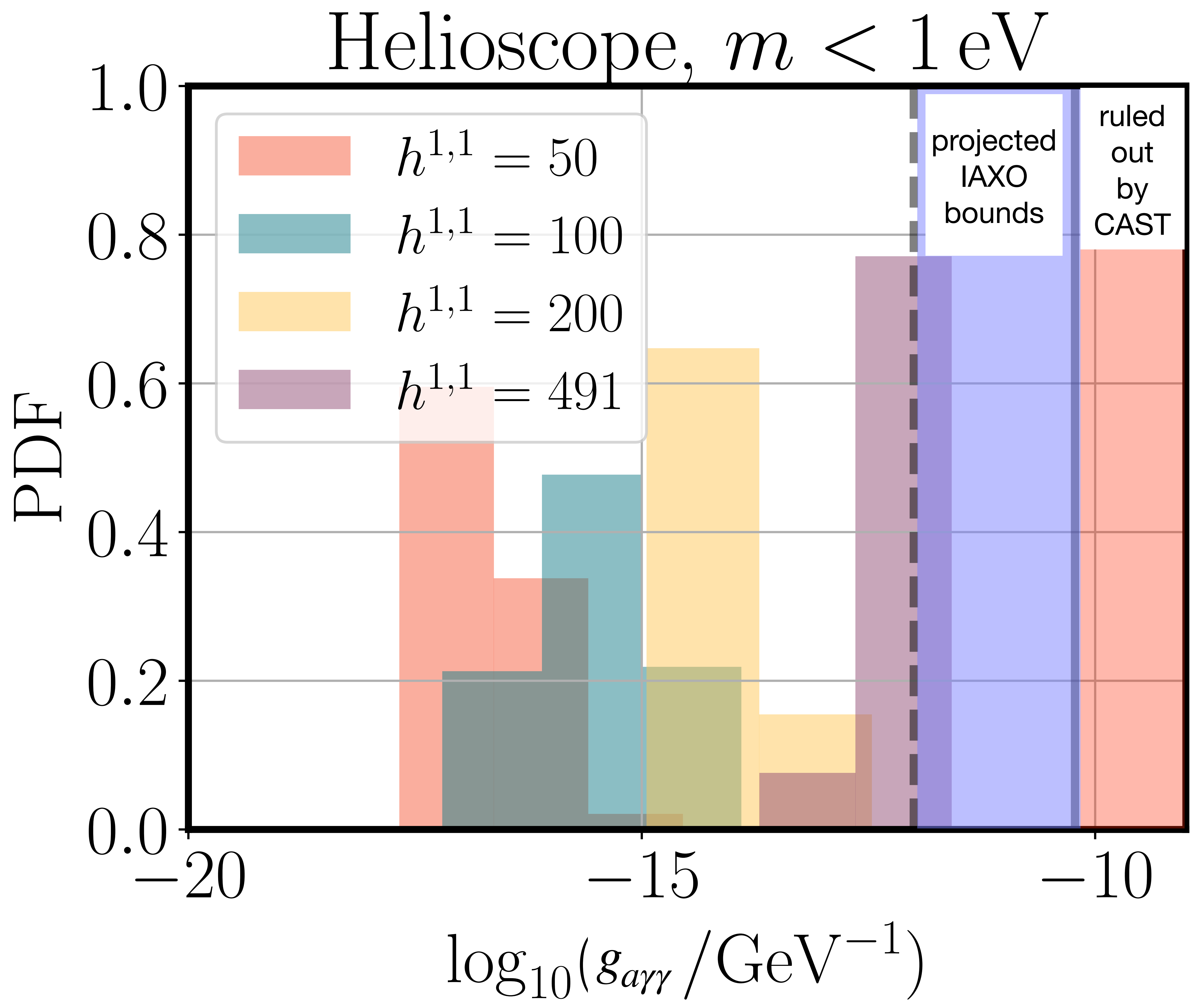

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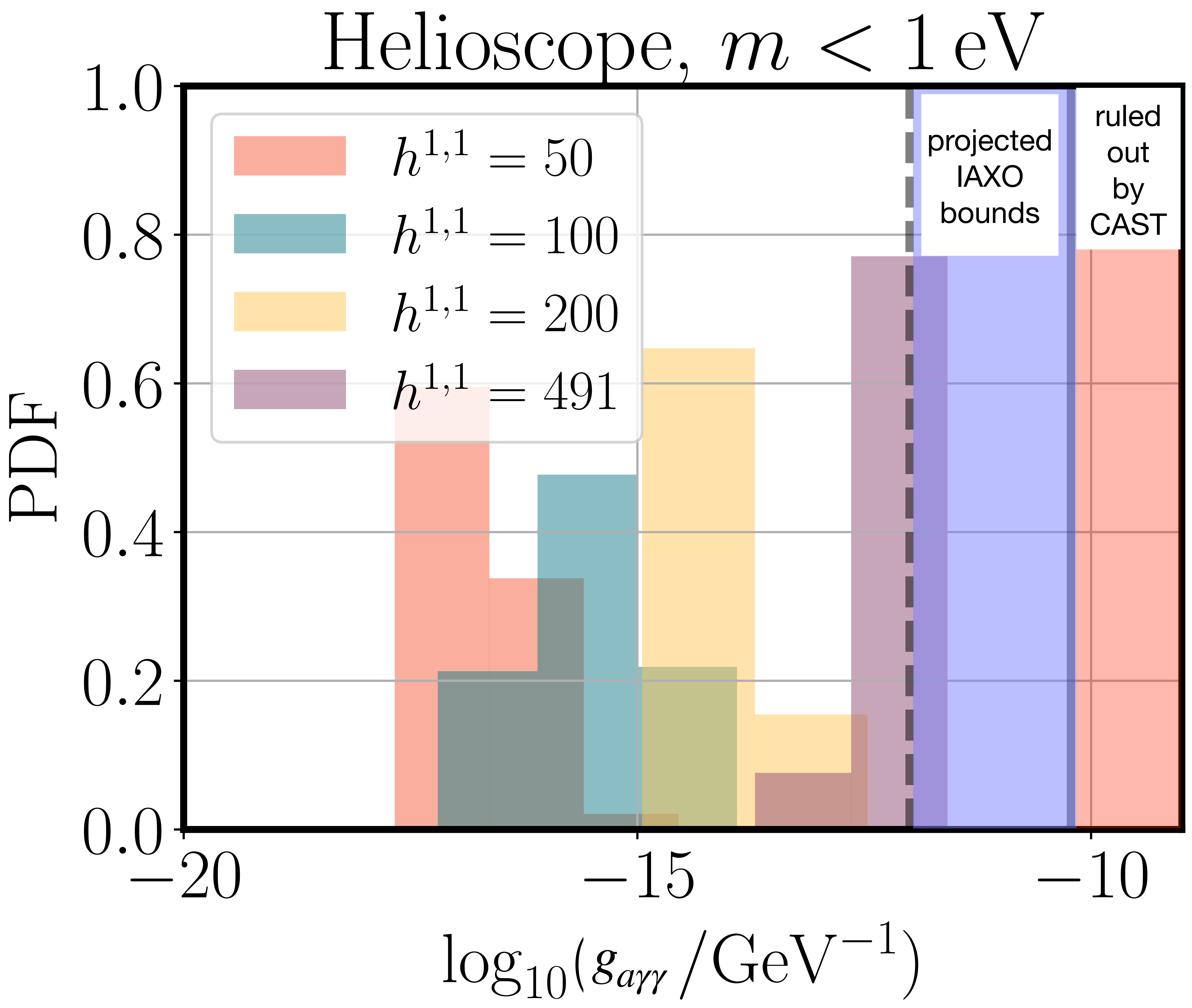

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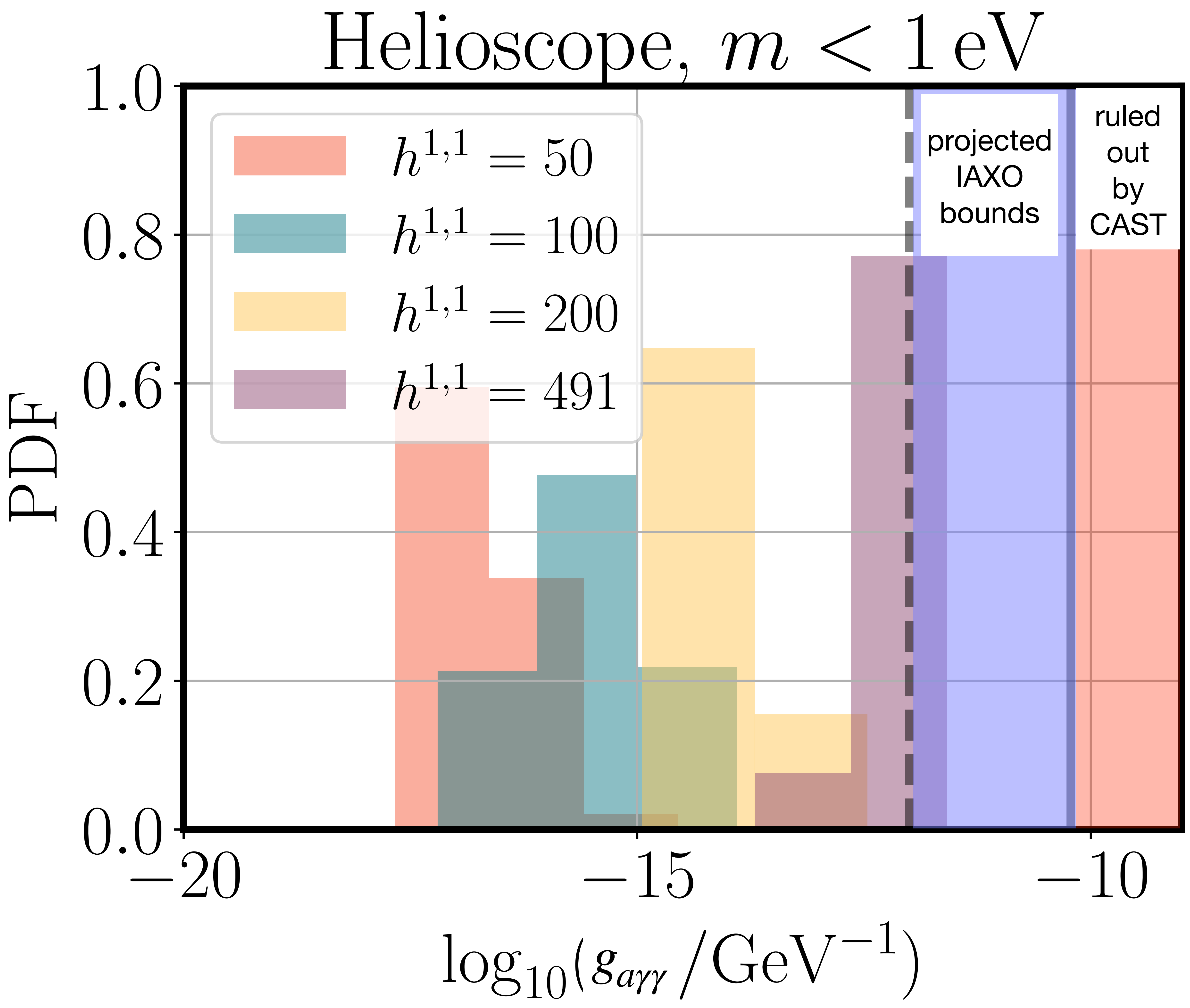

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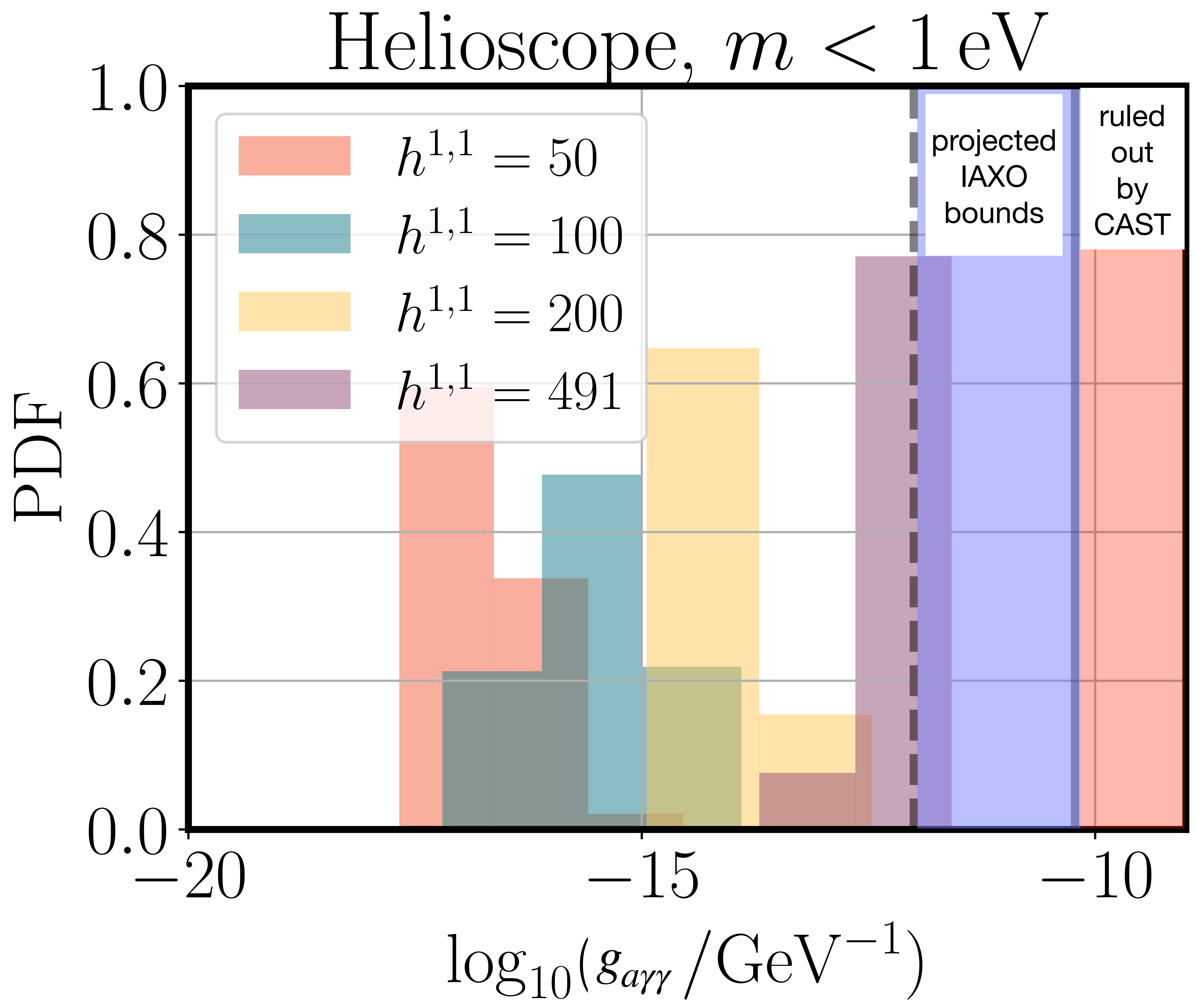

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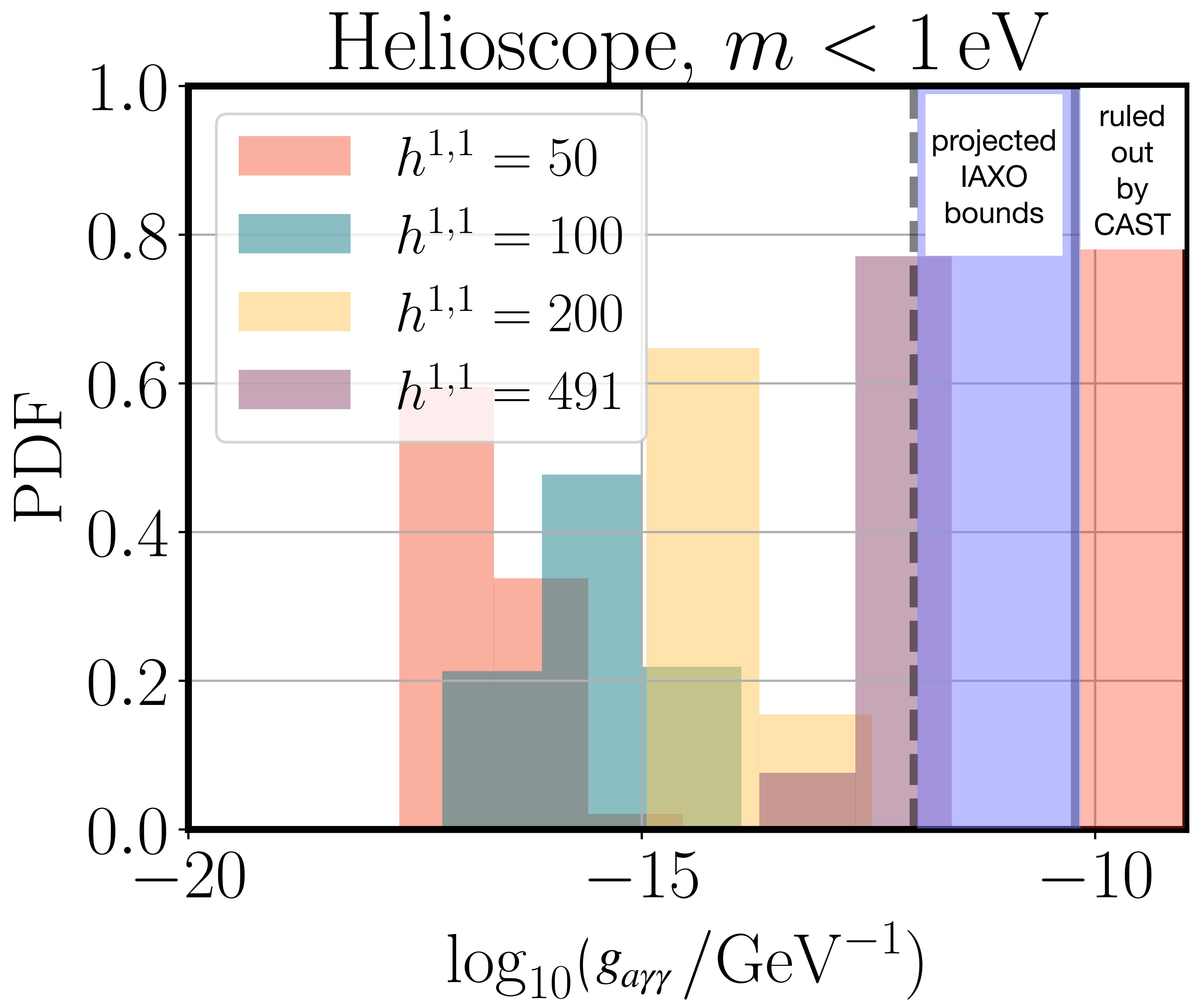

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III. Universality in the string axiverse

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All of these behaviors are a consequence of one underlying fact:

As N increases, hierarchies in instanton scales increase.

Stringy axions vs. field theory expectations

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String theory can teach us lessons about axions that we wouldn't see from a model-building perspective.

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Question: is this behavior unique to Calabi-Yau toric hypersurfaces?
Or is it a more universal feature, possibly driven by principles of quantum gravity?

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- We found a mechanism that generically suppresses axion-photon couplings.
- Even string theory models with hundreds of axions are not ruled out by axion-photon coupling experiments.

Thank you!