# The Quest for Unification

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# Questions

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- Why $SU(3) \times SU(2) \times U(1)$?
- Why 3 families of quarks and leptons?
- How to explain the specific structure of a family?

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Experimental findings suggest the existence of two new scales of physics beyond the standard model

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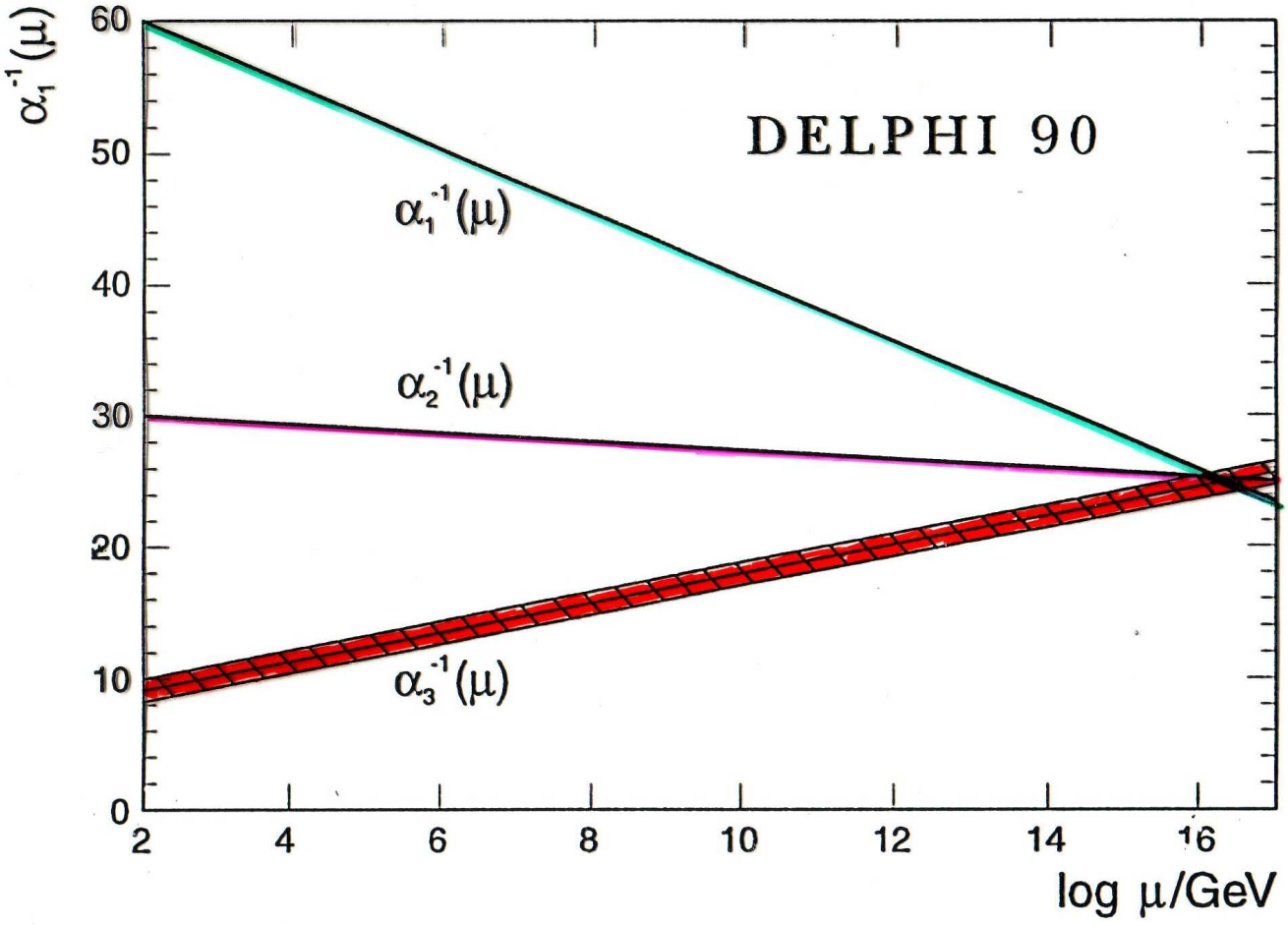
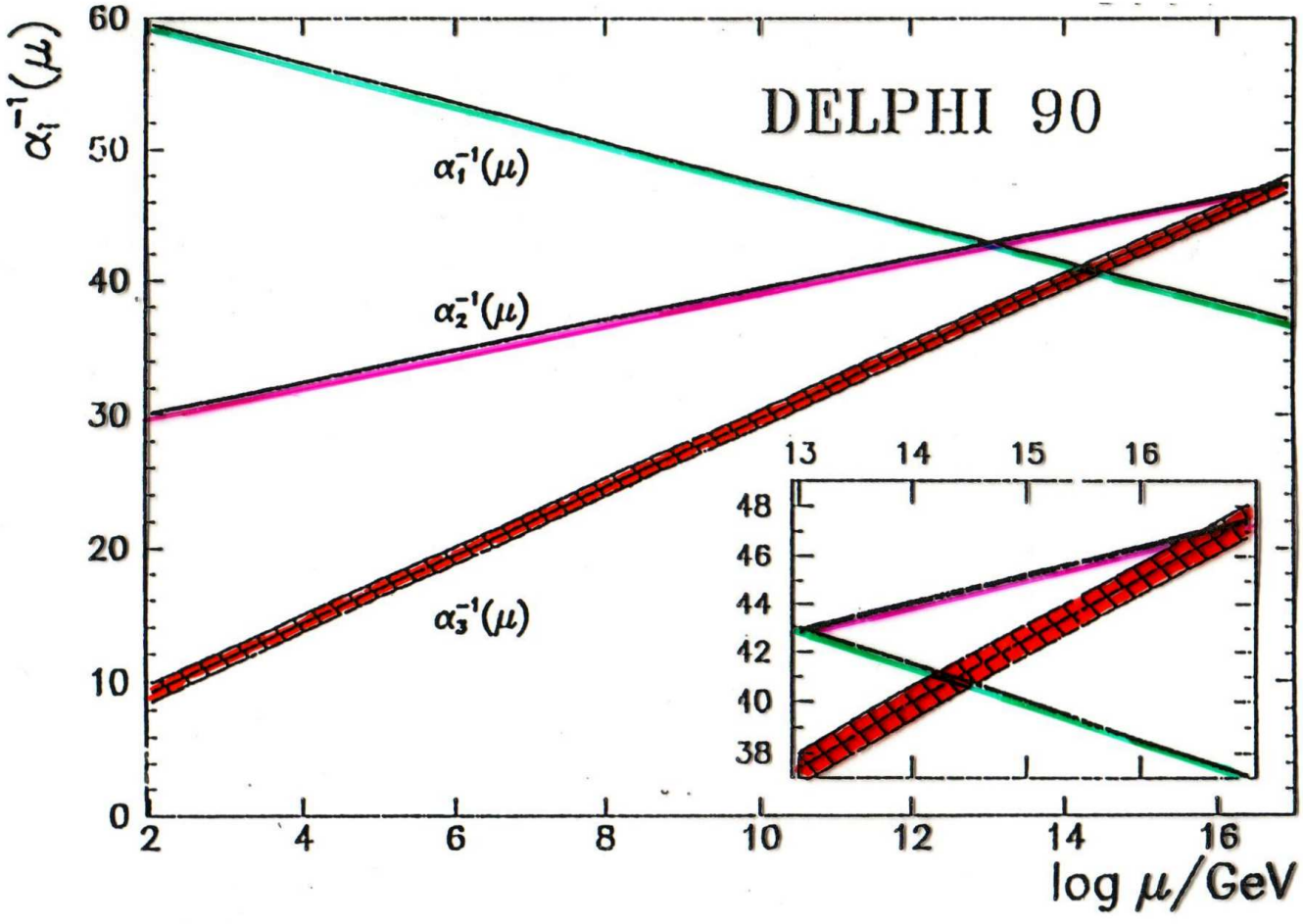
- Evolution of couplings constants of the standard model towards higher energies.

# MSSM (supersymmetric)



# Standard Model



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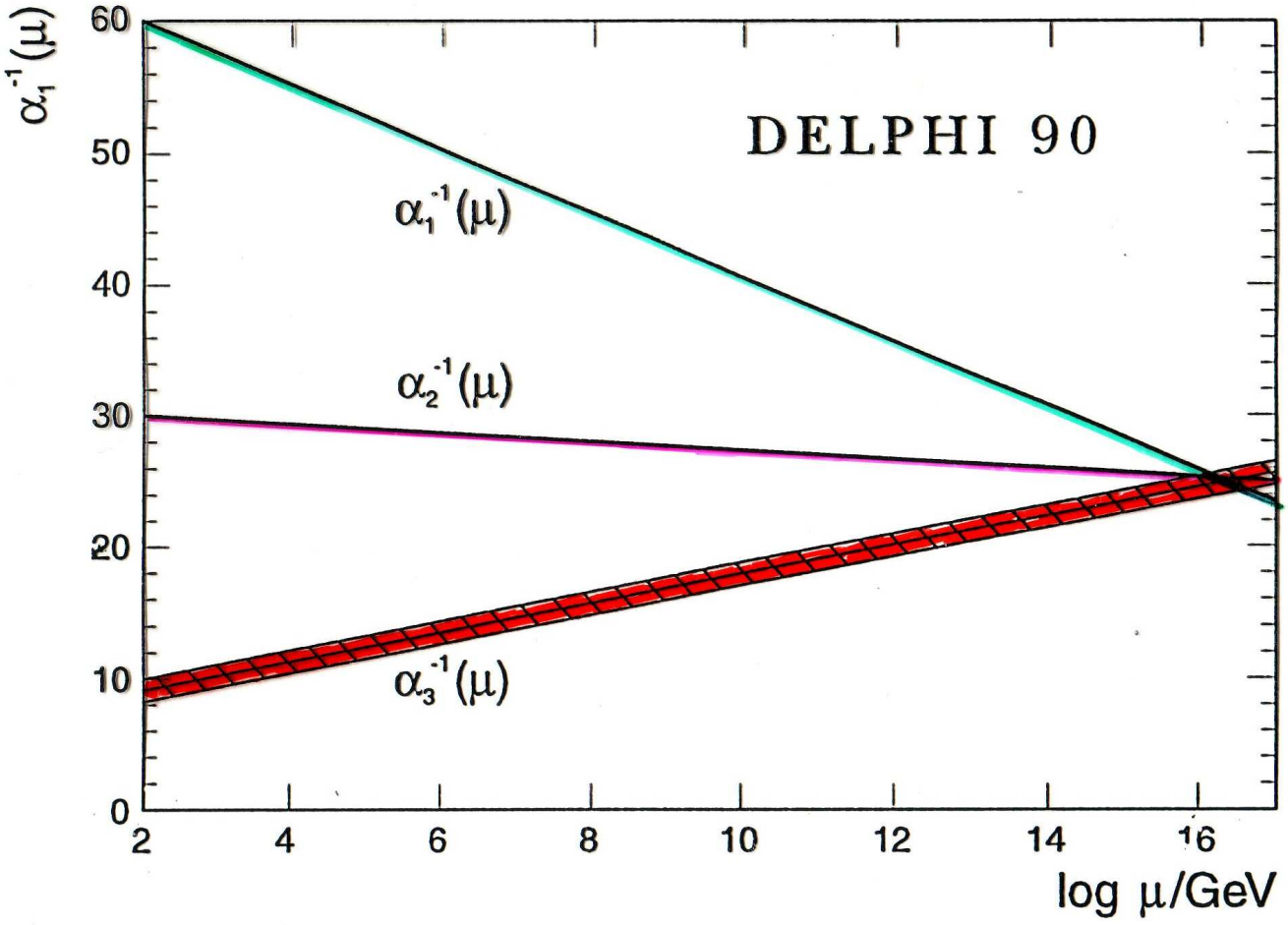

# Grand Unification

This leads to SUSY-GUTs with nice things like

- unified multiplets (e.g. spinors of SO(10))
- gauge coupling unification
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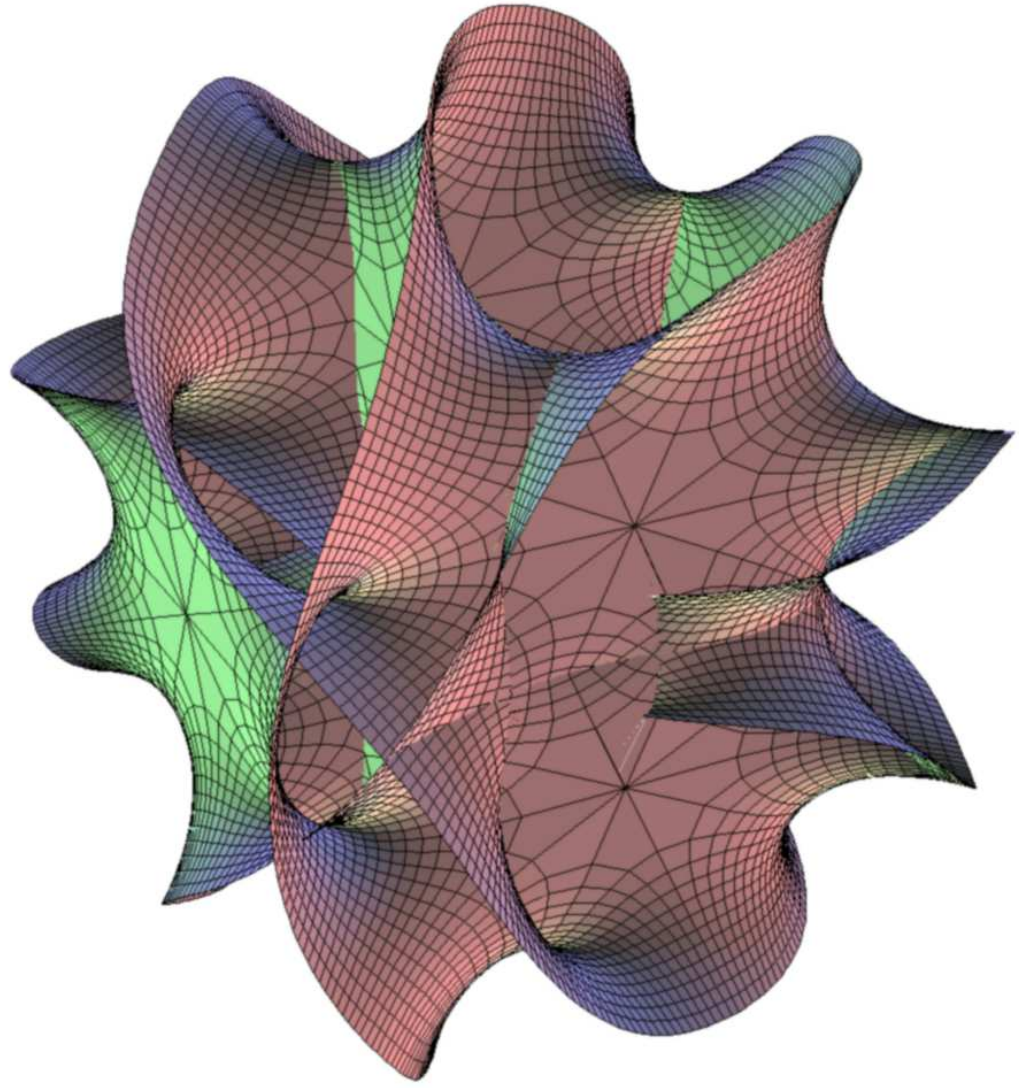
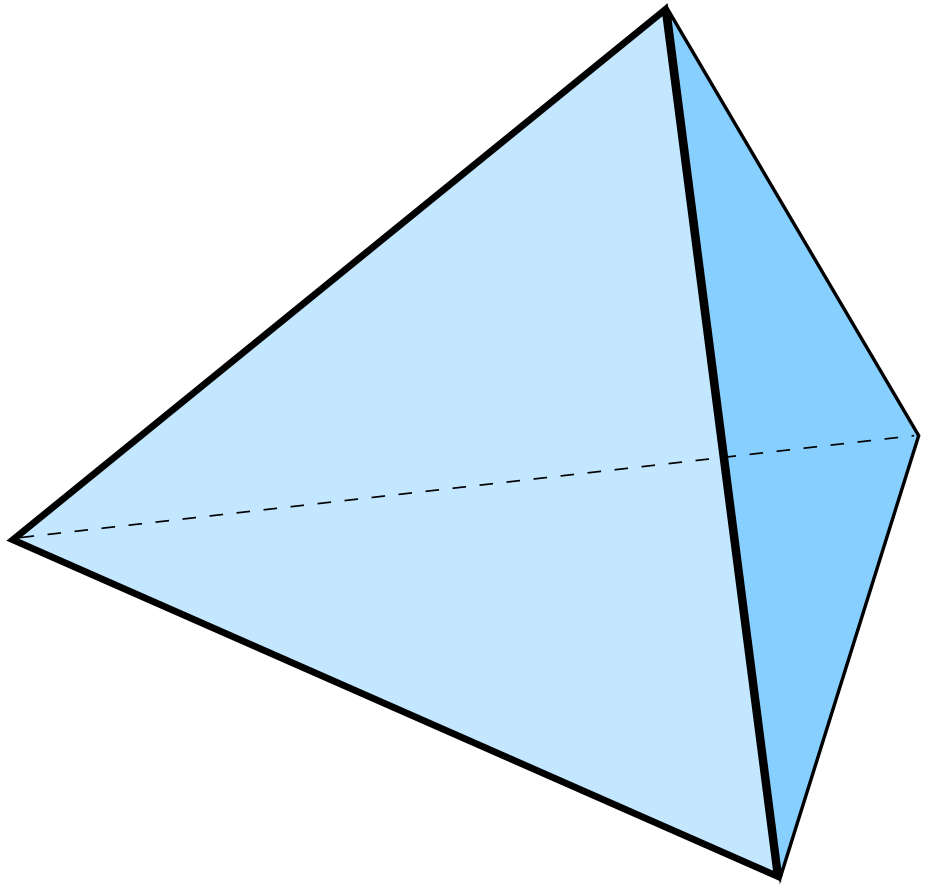
But there remain a few difficulties:

- breakdown of GUT group (large representations)
- doublet-triplet splitting problem (incomplete multiplets)
- proton stability (need for R-parity)

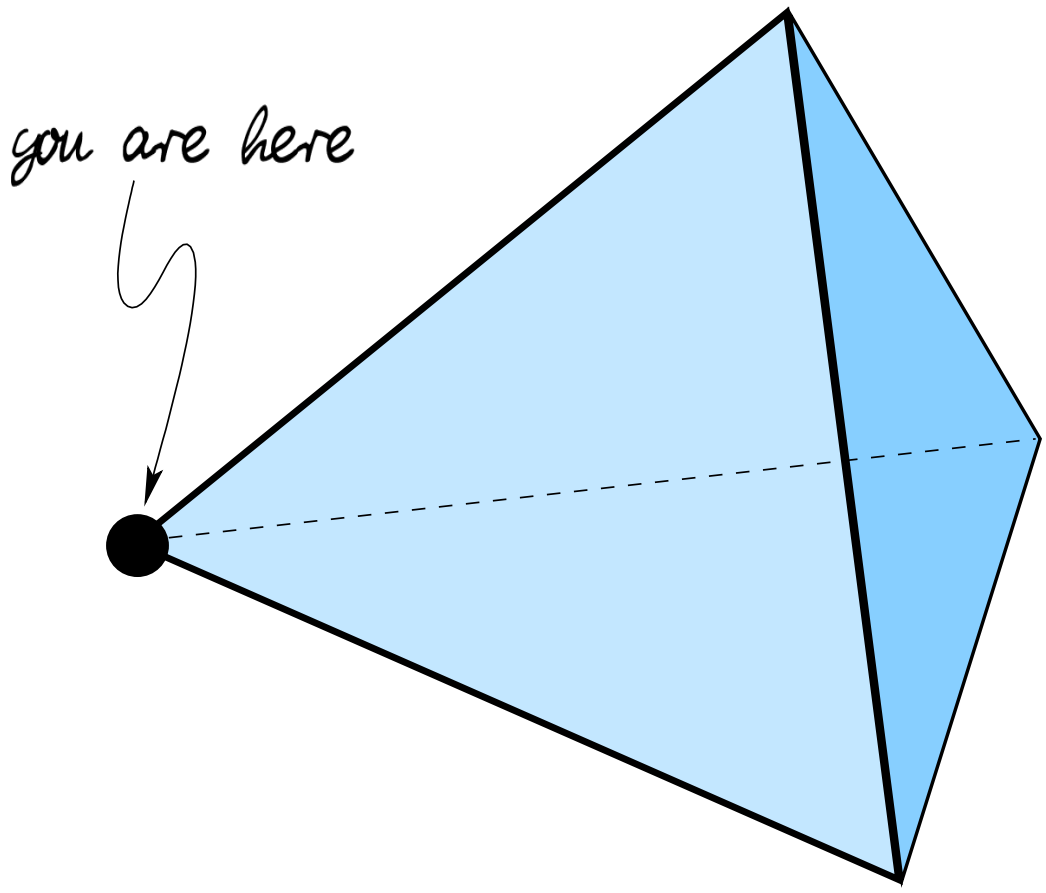
# Calabi Yau Manifold



# Orbifold



# Where do we live?



# Possible answers

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- Why $SU(3) \times SU(2) \times U(1)$?
  - From $E_8$ in $D = 10$.
- Why 3 families of quarks and leptons?
  - From topological properties of compactified space.
- How to explain the specific structure of a family?
  - Spinor representation of $SO(10)$.

# String Theory

What do we get from string theory?

- supersymmetry
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- large unified gauge groups
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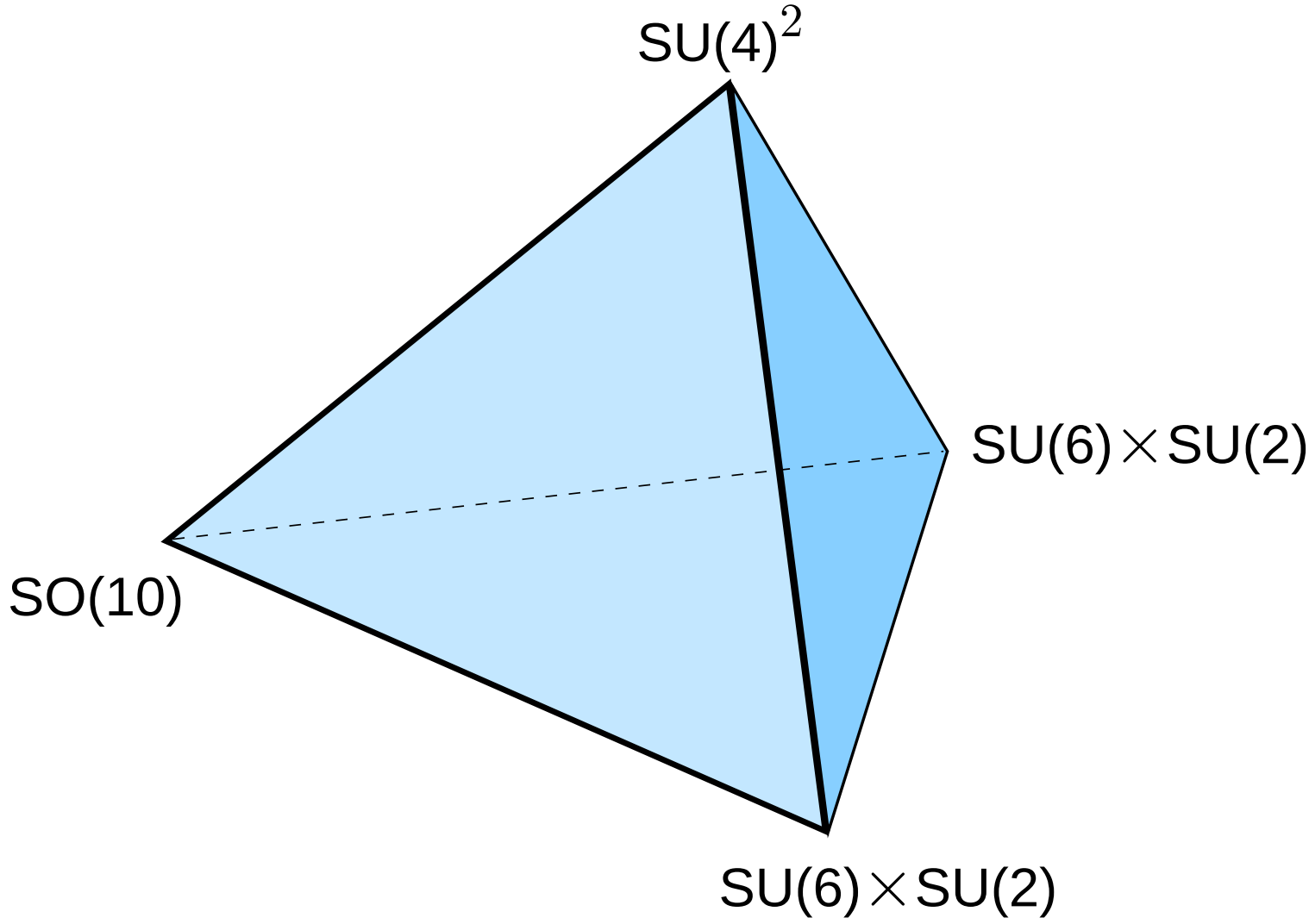
These are the building blocks for a unified theory of all the fundamental interactions.
But do they fit together, and if yes how?

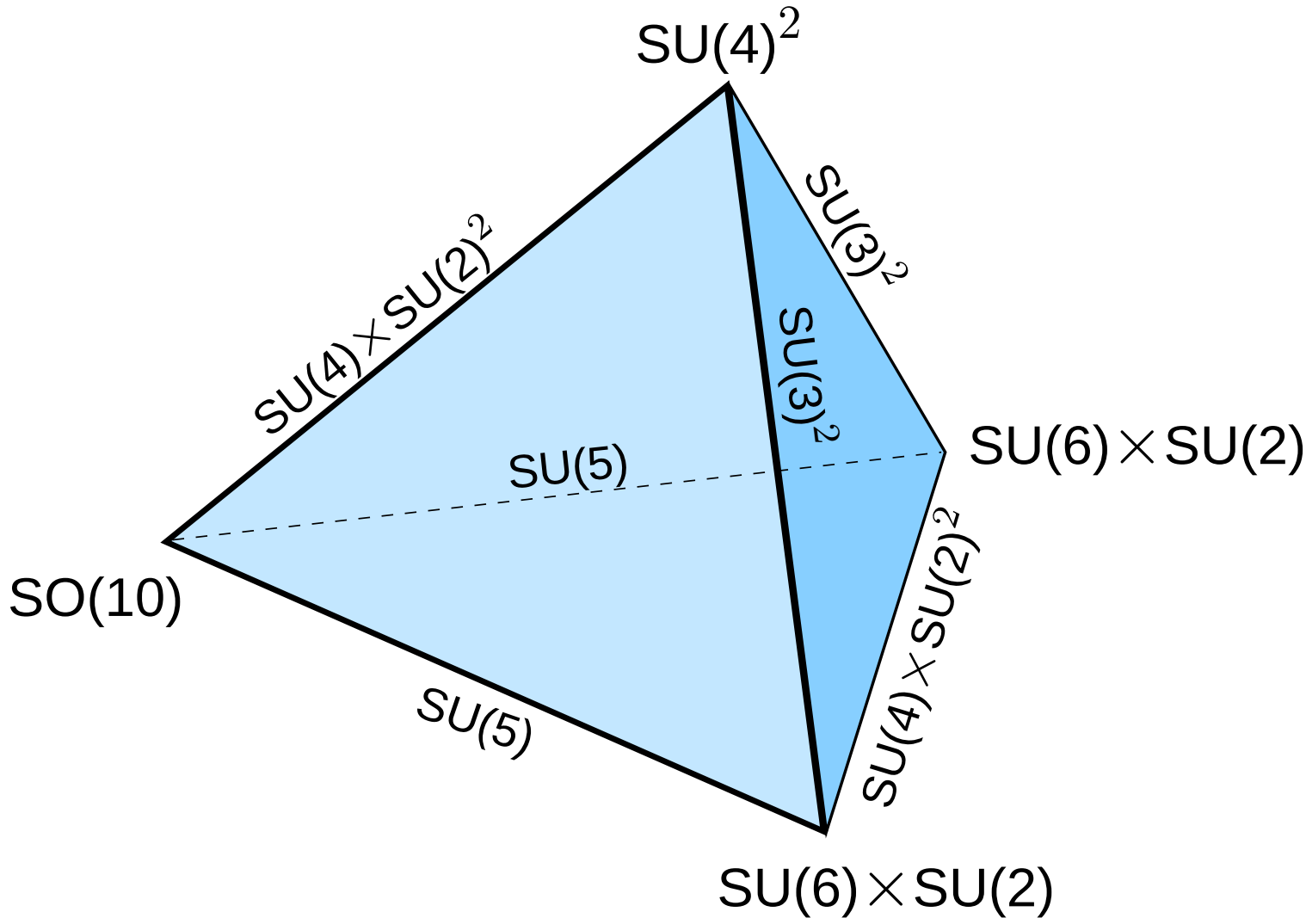
We need to understand the mechanism of compactification of the extra spatial dimensions

# Localized gauge symmetries




(Förste, HPN, Vaudrevange, Wingerter, 2004)

# Standard Model Gauge Group

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In fact string theory gives us a variant of GUTs

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Key properties of the theory depend on the geography of the fields in extra dimensions.

This geometrical set-up called local GUTs, can be realized in the framework of the “heterotic braneworld”.

(Förste, HPN, Vaudrevange, Wingerter, 2004; Buchmüller, Hamaguchi, Lebedev, Ratz, 2004)

# Where do we live?