
The case of the (still) mysterious Universe
CERN
70
YEARS / ANS CERN

Interplay between String Theory, Particle Physics and Cosmology

Irene Valenzula
Theoretical physicist, Theory Department, CERN

Cumrun Vafa
Hollis Professor of Mathematics and Natural Philosophy and Chair of the Physics Department, Harvard University

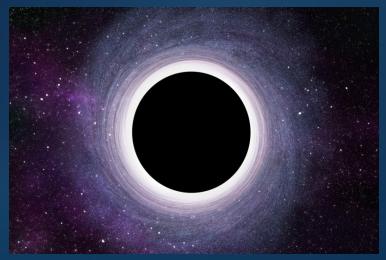
Mixing of Scales by Gravity

mixed by gravity

Small distance
(high energy densities)

Large distance
(small energy densities)

Particles colliding
at high energies probe
smaller distances



But if energies are above $M_p=10^{19}$ GeV,
they yield large black holes

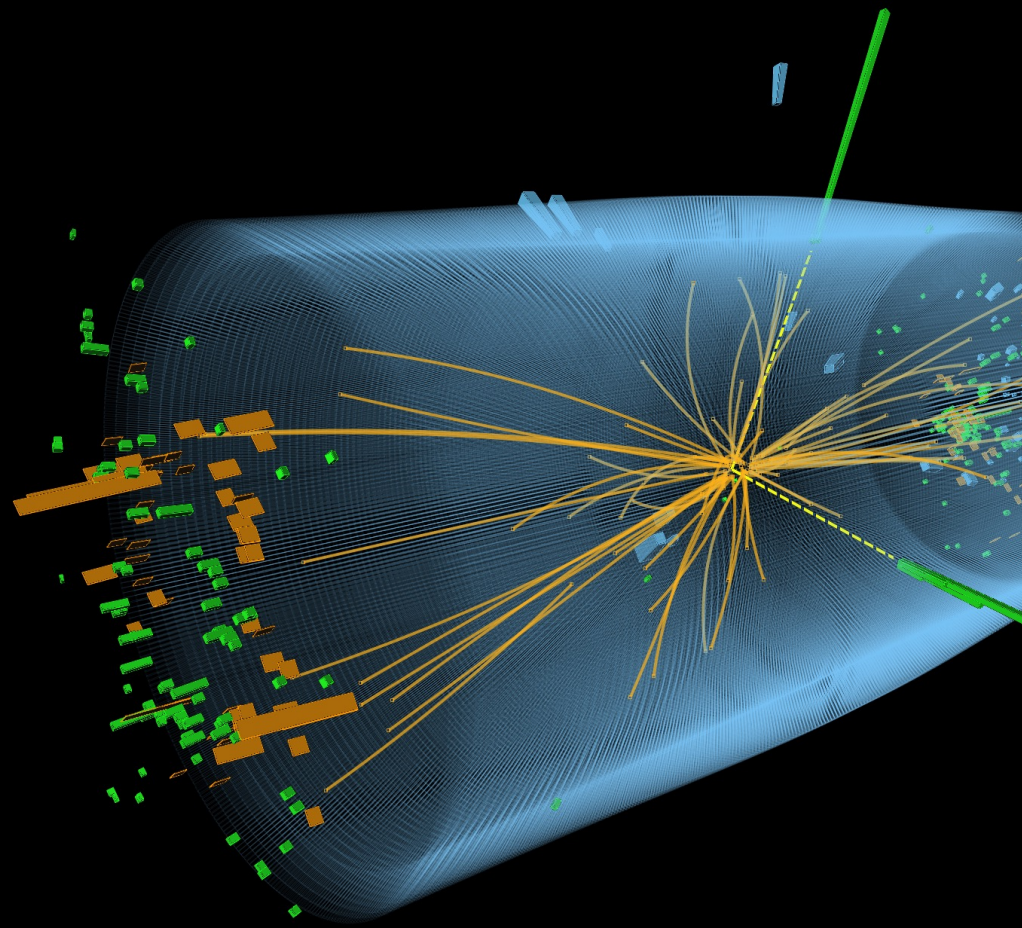
Unification of physics

Quantum Gravity can have implications at low energies
and may provide explanation for some of the puzzles in Particle Physics and Cosmology

Quantum Gravity

Cosmology
(gravity)

Particle Physics
(quantum world of elementary particles)



Credit: ESA

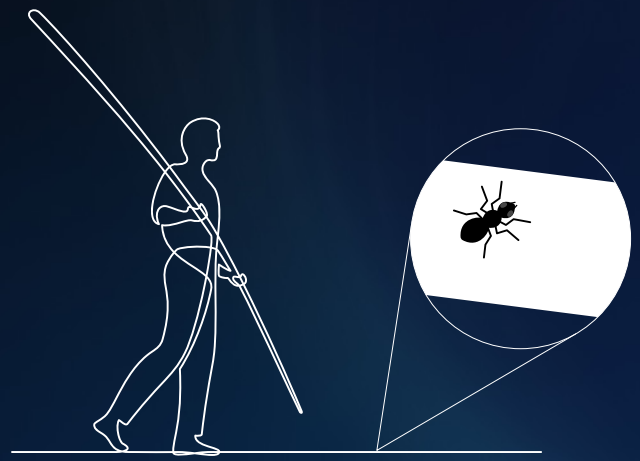
Example: Gravity as the weakest force

$F_g = m^2/r^2$ $F_e = e^2/r^2$

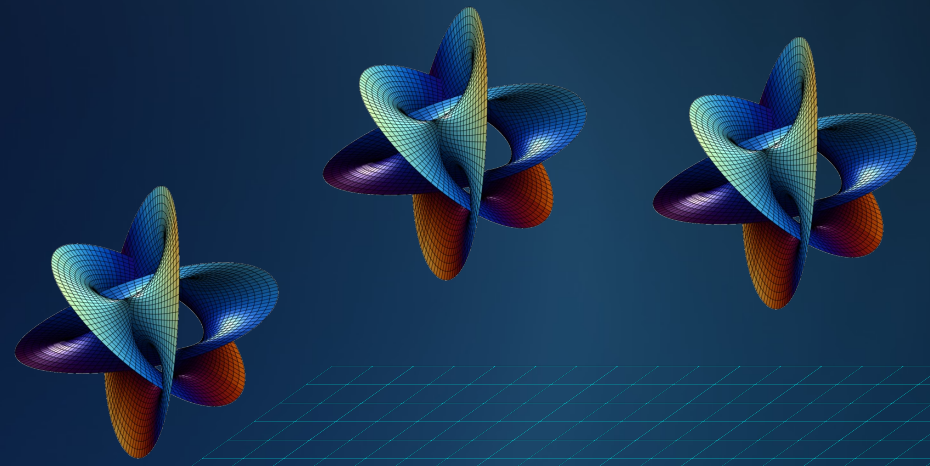
mass (m) < charge (e)

Weak interaction → Light particles

String Theory implies Extra Dimensions

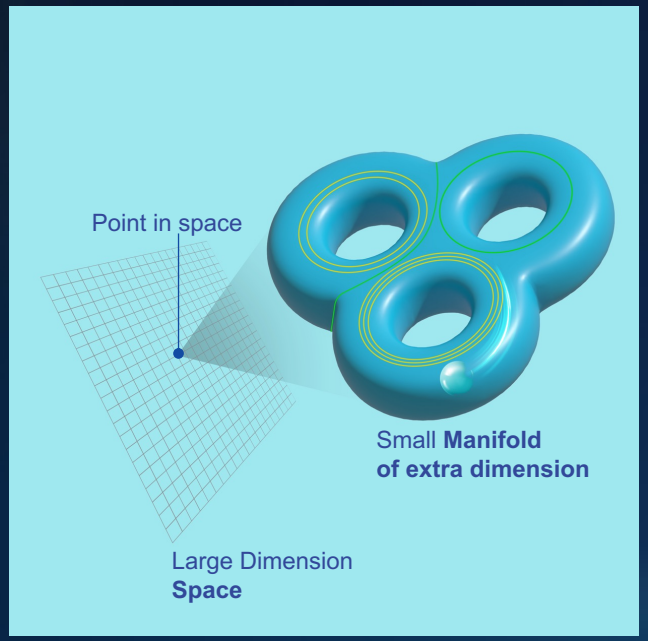


The shape and the size
of the extra dimensions define
a physical theory

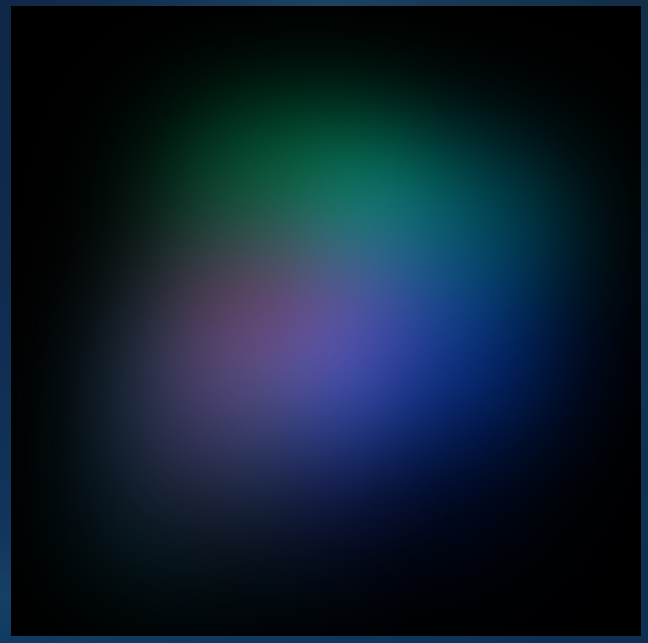


Origin of Dark Matter and Dark Energy

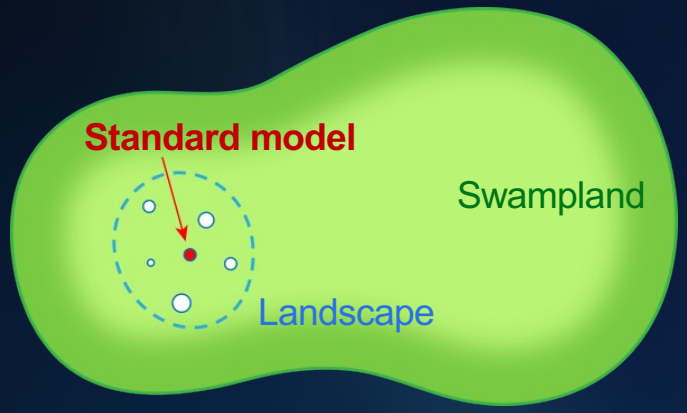
Dark Matter?

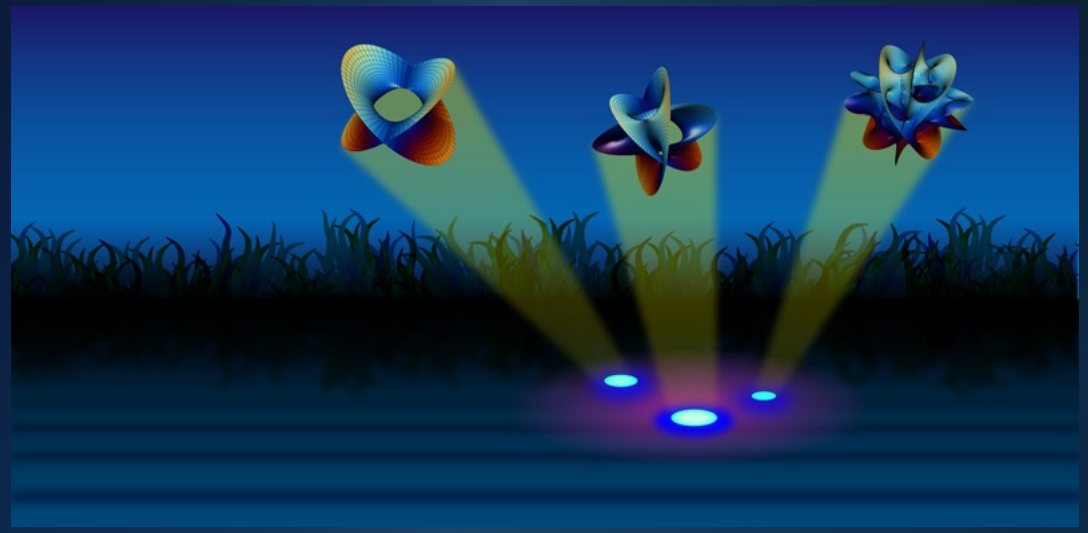


Dark Energy?



Landscape and Swampland





You cannot get everything you want → Predictions!

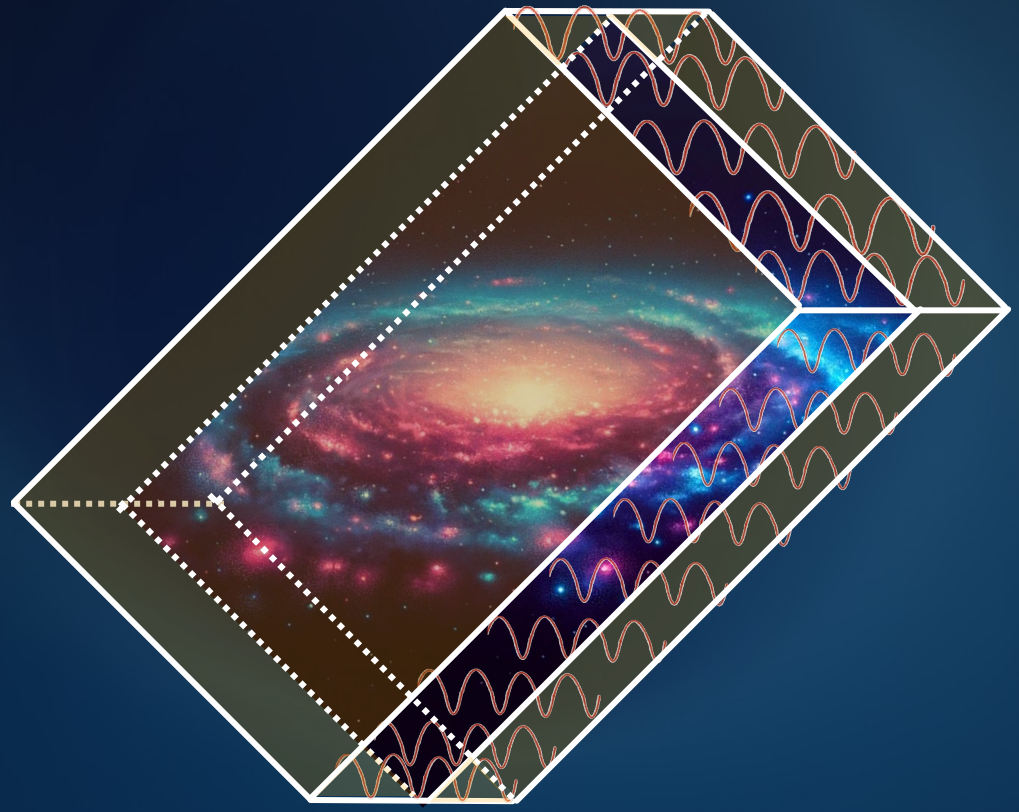
Dark Energy as an Extreme Parameter

Extremely small paramaters give rise to unexpectedly new particles

What about Dark Energy?

$\Lambda = 0.0$

Dark Dimension Scenario



one extra dimension of size $l \sim 0.1 - 10\mu m$