New Physics

what it is and how we are looking for it

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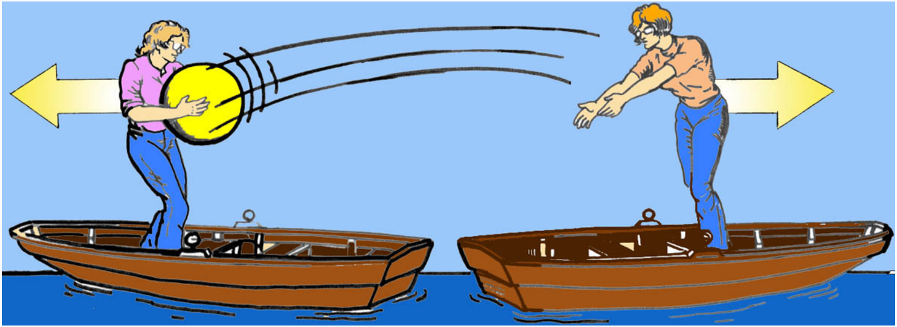
26 August 2023, Hungary

Lengyel, magyar – két jó barát,
együtt harcol s issza borát.

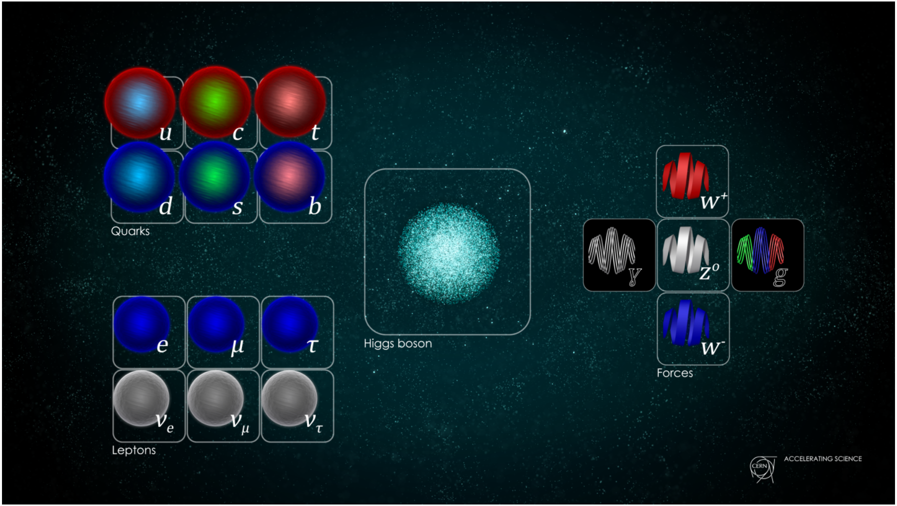
Standard Model

Quantum Field Theory



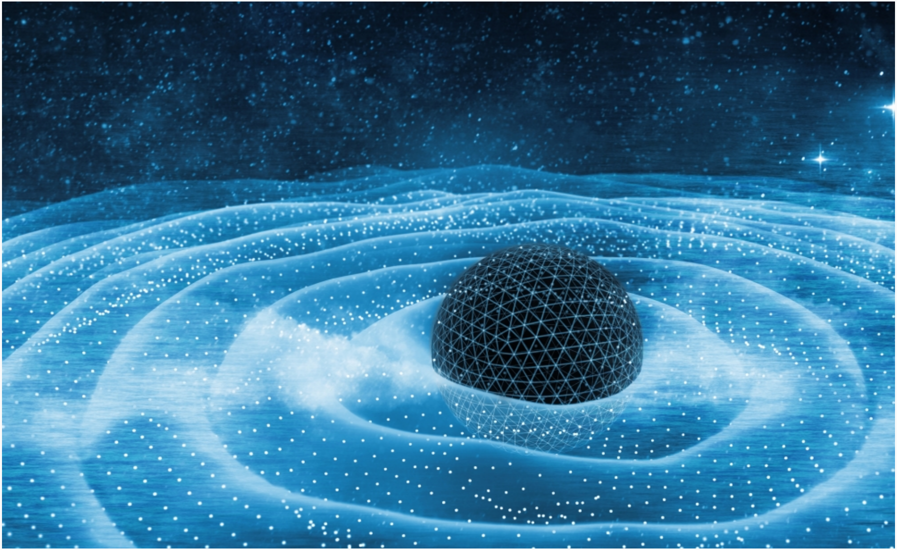
Source: Fermilab

Particles of Standard Model



Standard Model Limitations

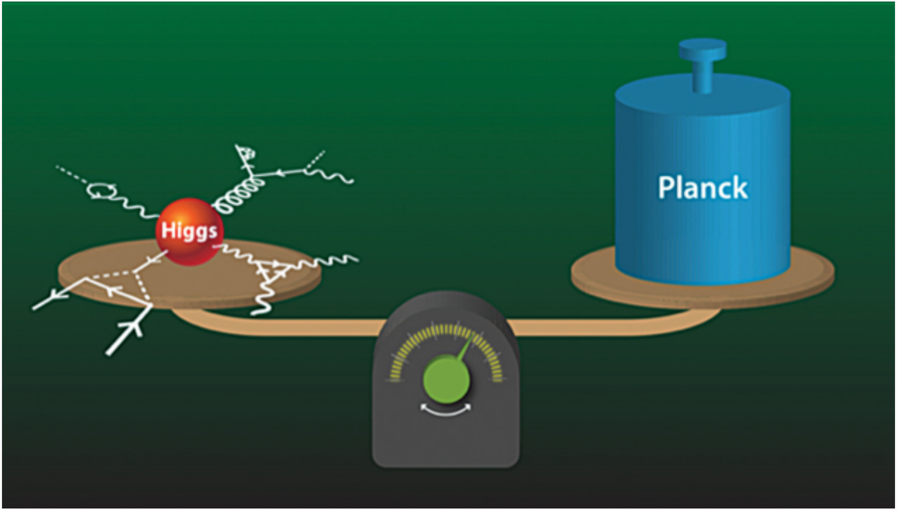
Gravity



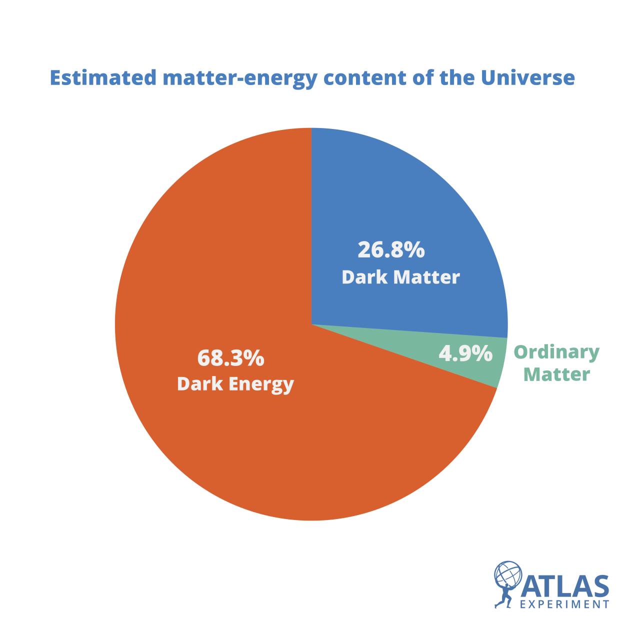
Number of free parameters

Parameters of the Standard Model			[hide]
Symbol	**Description**	**Renormalization scheme (point)**	**Value**
m_e	Electron mass		511 keV
m_μ	Muon mass		105.7 MeV
m_τ	Tau mass		1.78 GeV
m_u	Up quark mass	$\mu_{\overline{MS}}$ = 2 GeV	1.9 MeV
m_d	Down quark mass	$\mu_{\overline{MS}}$ = 2 GeV	4.4 MeV
m_s	Strange quark mass	$\mu_{\overline{MS}}$ = 2 GeV	87 MeV
m_c	Charm quark mass	$\mu_{\overline{MS}} = m_c$	1.32 GeV
m_b	Bottom quark mass	$\mu_{\overline{MS}} = m_b$	4.24 GeV
m_t	Top quark mass	On-shell scheme	172.7 GeV
θ_{12}	CKM 12-mixing angle		13.1°
θ_{23}	CKM 23-mixing angle		2.4°
θ_{13}	CKM 13-mixing angle		0.2°
δ	CKM CP-violating Phase		0.995
g_1 or g'	U(1) gauge coupling	$\mu_{\overline{MS}} = m_Z$	0.357
g_2 or g	SU(2) gauge coupling	$\mu_{\overline{MS}} = m_Z$	0.652
g_3 or g_s	SU(3) gauge coupling	$\mu_{\overline{MS}} = m_Z$	1.221
θ_{QCD}	QCD vacuum angle		~0
v	Higgs vacuum expectation value		246 GeV
m_H	Higgs mass		~ 125 GeV (tentative)

Hierarchy problem



Dark matter


Estimated matter-energy content of the Universe
26.8%
Dark Matter
68.3%
Dark Energy
4.9%
Ordinary
Matter
ATLAS
EXPERIMENT

New Physics

Beyond Standard Model:

Supersymmetry?

Symmetry

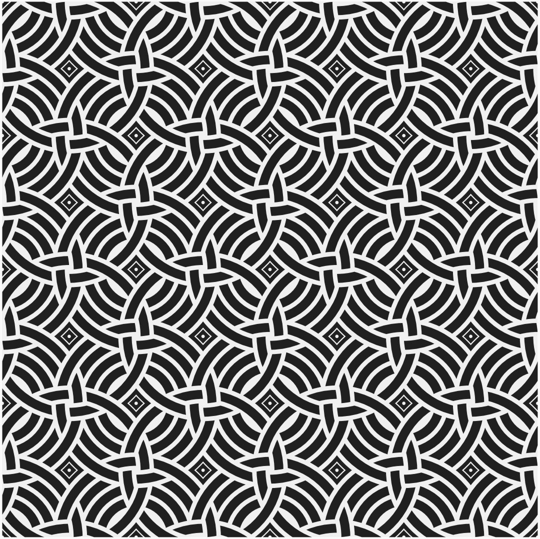
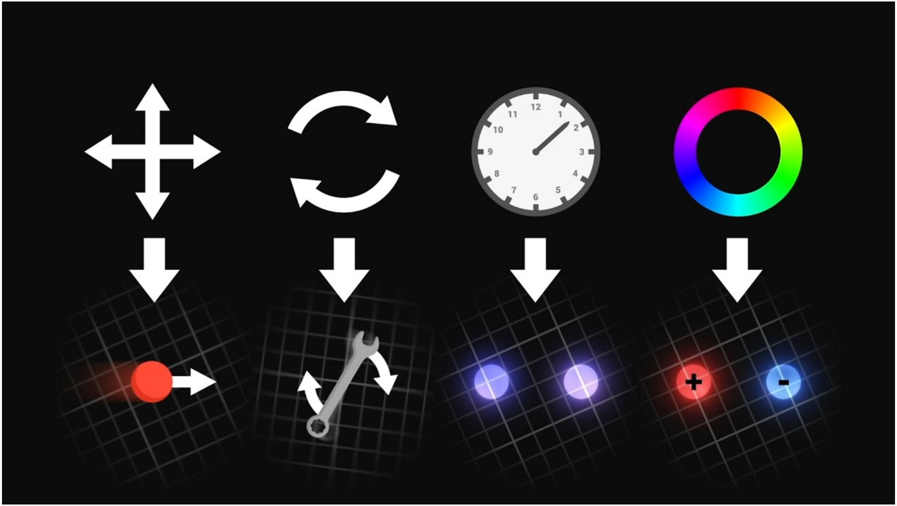


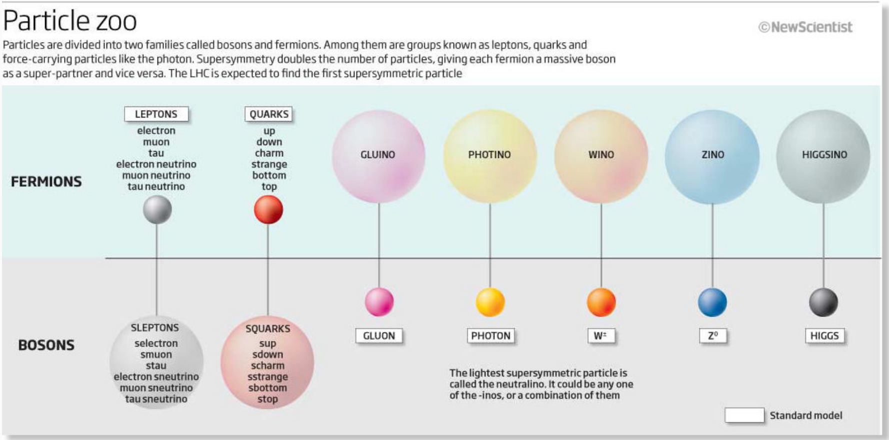
Image by zarubin-leonid on Freepik

Role of Symmetries in Physics

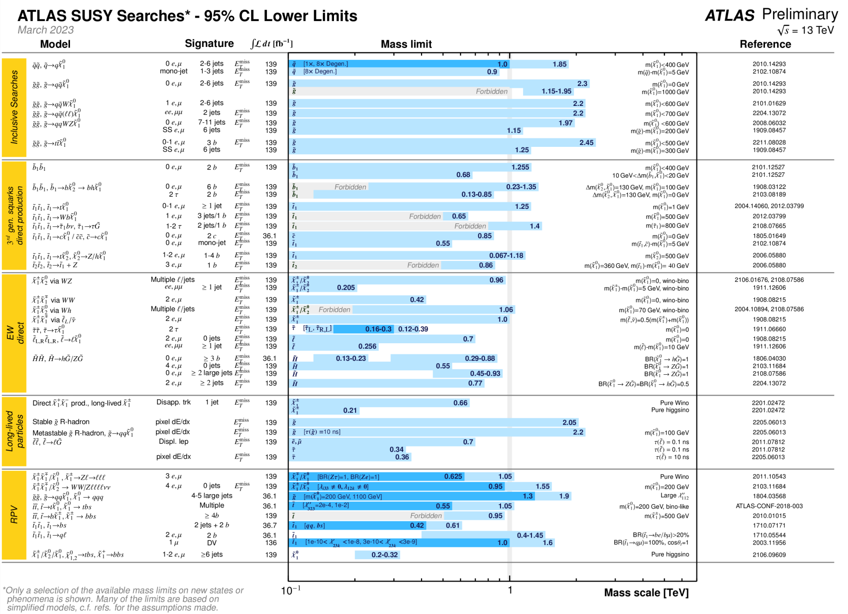


Source: youtube.com/@ScienceClicEN

Supersymmetry (SUSY)

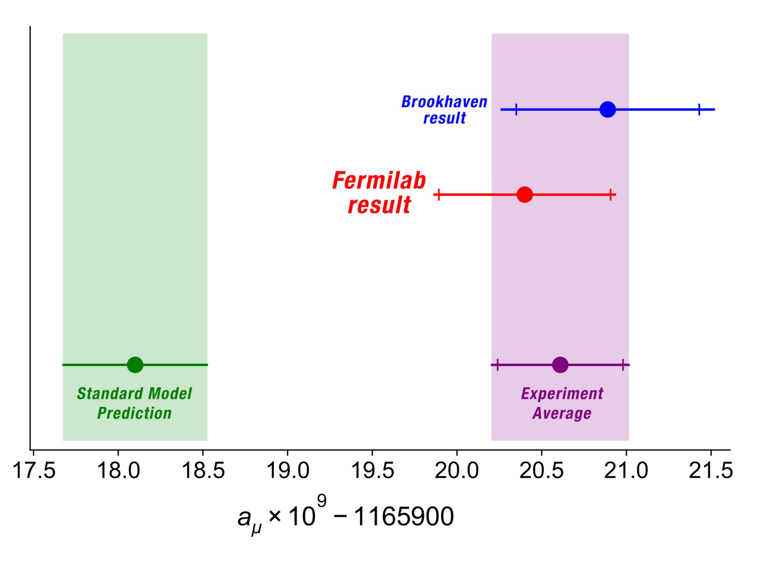


Direct searches for SUSY



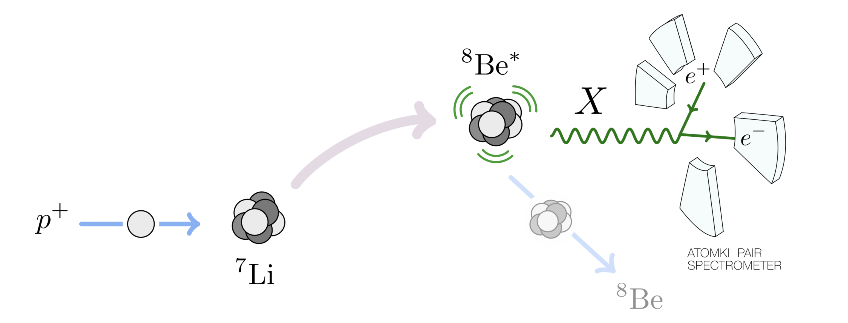
Hints of New Physics

Moun anomalous magnetic moment $(g-2)$



Source: Fermilab

ATOMKI Anomaly – X17



Source: Phys. Rev. D 95, 035017 (2017)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