

What is the physical world made of ?

or

“So that no more with bitter sweat  
I need to talk of what I don't know yet,  
So that I may perceive whatever holds  
The world together in its inmost folds, ...”

*Faust, Johann Wolfgang von Goethe*



---

## 0. Prelude

In particle physics, our understanding of physical phenomena is based on identifying a few fundamental constituents and a few fundamental interactions.

The forces/interactions among the constituents of matter are interpreted in terms of the exchange of gauge bosons.

**Matter particles:** quarks and leptons

**Forces:** strong, weak  $\otimes$  electromagnetic, (gravity)

**Gauge bosons:** gluons,  $W^\pm$  and Z bosons, photon, (graviton)

**The ultimate goal of elementary particle physics is to find the fundamental law(s) of nature, the final underlying theory, that determines the dynamics of matter.**

S.Weinberg: “... *to look for a simple set of physical principles, which have about them the greatest possible sense of inevitability and from which everything we know about physics can, in principle, be derived.*” Elementary Particles and the Laws of Physics, The 1986 Dirac Memorial Lectures. Steven Weinberg, Sheldon L. Glashow, Abdus Salam, won the Nobel prize in Physics in 1979 ”for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including inter alia the prediction of the weak neutral current”.

---

The Standard Model (SM) of particle physics successfully describes the strong and electroweak interactions of leptons and quarks down to distances of  $\mathcal{O}(10^{-17})$  cm.

The underlying theory is a local relativistic Quantum Field Theory (QFT), subject to symmetry principles and a principle of renormalizability.

S. Weinberg:

One could imagine “... *that specifying the symmetry group of nature may be all we need to say about the physical world, beyond the principles of Quantum Mechanics.*”

Elementary Particles and the Laws of Physics, The 1986 Dirac Memorial Lectures