

0.1 The Standard Model

- SM describes fundamental forces & elementary particles
- more descriptions (a bit of history + recent developments - higgs & neutrino masses) -
- limitations: gravity & general relativity

0.1.1 Elementary particles

- Bosons (Bose-Einstein statistics, integer spin) & fermions (Fermi-Dirac statistics, half-integer spin)
- Fermions - building blocks: quarks & leptons [protons/neutrons constituents?]
- Bosons - force carriers & interaction mediators (elementary bosons == gauge bosons (chart of elementary particles here))

Fermions

- elementary particles
- half-integer spin

Quarks

- building blocks for hadrons & bosons
- up down — charm strange — bottom top [by order of discovery and mass]
- charge doublets: $+2/3$ and $-1/3$ charge
- color charge & color confinement in hadrons
- interacts with all 4 fundamental forces

Leptons

- electron — muon — tau + neutrino [by order of mass]
- charge -1, neutrinos charge neutral
- interacts with all forces except strong, neutrinos only weak and gravitational

Bosons

- force mediators
- integer spin

Scalar

- spin 0 - Higgs massive, charge neutral, provides rest mass for all elementary particles,

Vector

- spin 1 - W/Z (weak), photon (QED/electrodynamic), gluons (QCD/strong) - photon/gluon massless, charge neutral, gluon carries color charge out of 8 combinations of quark colors (color octet) - W/Z massive, charged/neutral

0.1.2 Mathematical formalism

- Lagrangian: gauge QFT containing internal symmetries of $SU(3)_C \times SU(2)_L \times U(1)_Y$

0.1.3 Four-top quarks production

[observation paper results]

0.1.4 Shortcomings

0.2 Beyond the Standard Model

0.2.1 Hypothetical top-philic gauge bosons