Introduction

This course will cover Standard Model of Particle Physics. The Standard Model comprises strong and electroweak interactions.

(i) Electroweak interactions:

leptons (spin ½ particles)

e μ τ ~ electron, muon, tau

ν_e ν_μ ν_τ ~ -"- - neutrinos

interactions between them is mediated by gauge bosons:

W^+, W^-, Z ~ massive spin-1 particles

γ ~ photon ~ massless -"-

(ii) Strong interactions:

quarks (spin ½) have 6 flavors:

u c t u-up, d-down, s-strange,

d s b c-charm, b-bottom, t-top

quarks also have 3 colors, such that each quark of a given flavor comes in in 3 diff. colors.

Quarks interact by exchanging gluons:

g ~ gluon ~ spin-1 massless particle.

there are 8 gluon colors

Quarks & gluons combine into bound states like mesons ($q\bar{q}$) & baryons (qqq)

↓ mesons: $\pi^{\pm}, \pi^0, K, \rho, \omega, \ldots$

↓ baryons: $p, n, \Omega, \Sigma^{\pm}, \Sigma^0, \Lambda^0, \Xi, \ldots$

(+) Higgs boson (spin-0)

The Standard Model does not include gravity: the "fundamental" interactions:

strong electric weak gravity

(strong, electric, weak: Standard Model)

Standard Model depends on ~18 (!) external parameters (quark masses^{6}, lepton masses^{3}, couplings^{3}, CKM matrix^{4}, Higgs mass^{1} + VEV^{1})

=> however SM is surprisingly robust:
it had described everything we know about strong & electroweak interactions up until 2003, when neutrino masses were discovered, indicating that there is physics beyond SM.

=> theories beyond SM have been proposed ever since the construction of SM, and include technicolor, supersymmetry, etc. (no exp. evidence yet)
=> a complete "theory of everything" should probably incorporate (quantum) gravity ~ string theory is a possibility

} not covered in this class

=> Nowdays a lot of SM physics is considered "nuclear physics", while beyond SM physics is labelled "particle physics".

$\Rightarrow$ Theoretical language of SM is Quantum Field Theory (QM + special relativity).

Hence knowledge of QFT is needed for the course. We will start by reviewing some QFT material.