FAV Clase # 13 30/07/2025

Libro de Dirac → Topics in elementary particle physics.

FCC "The eightfold way"

México → CERN

→ supersimetría ⟶ modelo matemático

ISA → "Isolde" → Anti partículas

- Quarks (1964)
- 1964 - 1974: all mesons and baryons (hadrons) fit in one of the eightfold way "supermultiplet". why does it work?
- Gell-mann & Zweig: postulate 3 flavors of spin 1/2 quarks (u, d, s) and...

Baryons and mesons

mesons — 2q , Baryons — 3q

color charge and confinement

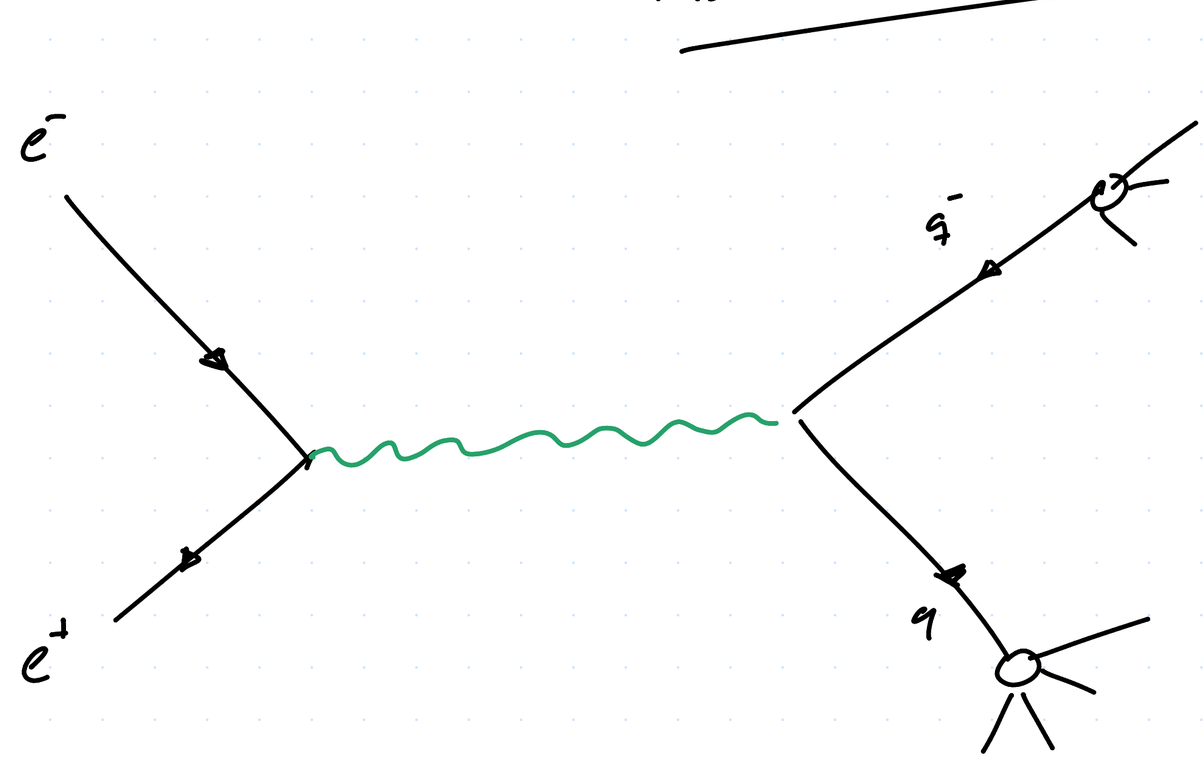
- Greenberg (1964). Postulate new quantum

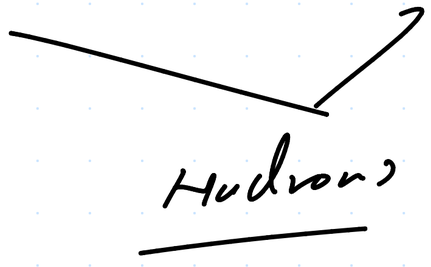
Deep inelastic scattering (DIS)

- very short-wavelength of high-energy electron (or ν or p)

must be able to probe small ..

More evidence of quarks





Theoretical progress (1961-1974)

- QFT of quarks: Quantum chromodynamics (QCD) of u, d and s

SU(3)

- Electro-weak (EW) theory = SU(2) × U(1)

breaking leads to:

- QCD and spontaneous EW symmetry
- 8 colored non-massive gluons (strong force carriers), and;
- massive $W^{\pm}$ and Z bosons (EW force carriers),
- Higgs boson, gives mass to fermions/W/Z/itself

- Decays of hadrons almost always implied charged currents, i.e. $s \to u$ or $d \to u$.

November (1974) → revolution

Burton Richter's group (SPEAR, SLAC)

N.P.P. 1976

ψ particle

J particle

/psi

Invariant mass (squared

$$M^2 c^4 e^+ = \left(P_{e^-} + P_{e^-}\right)^2$$

New neutral heavy meson, J/ψ ($\to l^+ l^-$ hadrons)

Nobel lecture: "8. THE DISCOVERY OF CHARM"

A third family of fermions

• M.L. Perl (N.P.P. 1995) et al., SLAC-LBNL group, at

DOEAR e^+e^- collider 1974-1976.

$e^+ + e^- \longrightarrow e^\pm + \mu^\mp +$ at least two undetected particles

measurement of the τ-lepton mass with the

Belle II experiment.

$\tau^- \longrightarrow \pi^-\pi^+\pi^-\nu_\tau$

$$m_{min} = \sqrt{m_{3\pi}^2 + 2\left(\sqrt{s}/2 - E^*_{3\pi}\right)\left(E^*_{3\pi} - p^*_{3\pi}\right)} \leq m_\tau$$

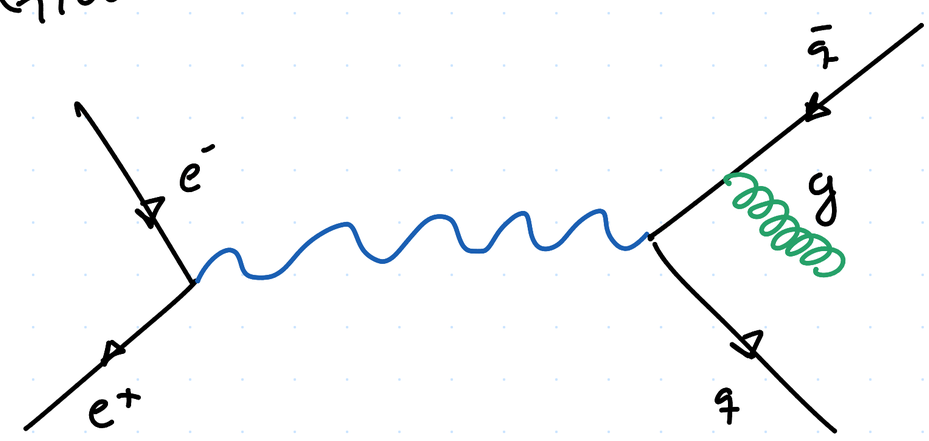
Beautiful quark

Leon Lederman's group (Fermilab), E288. Platinum fixed target

experiment, Proton.

Gluon

~ Gluon Bremsstrahlung



- Hadronics showers / calorimeters

- Electromagnetic showers / calorimeters.

PbOW4 scintillating crystals

(CMS)

2 boson

1983 at CERN $S\bar{p}S$ accelerator, $\sqrt{s} \approx 540$ GeV, UA-1/2 experiments.

$W^{\pm}$ boson

(1983 at CERN $S\bar{p}S$ accelerator, $\sqrt{s} \approx 540$ GeV, UA-1/2 experiments.

$p\bar{p} \to W \to l\bar{\nu}_l + X$

(ell ↑ ell)

→ simulación montecarlo

in the W rest frame:

- $|\vec{p}_l| - |\vec{p}_\nu| = \frac{M_W}{2}$

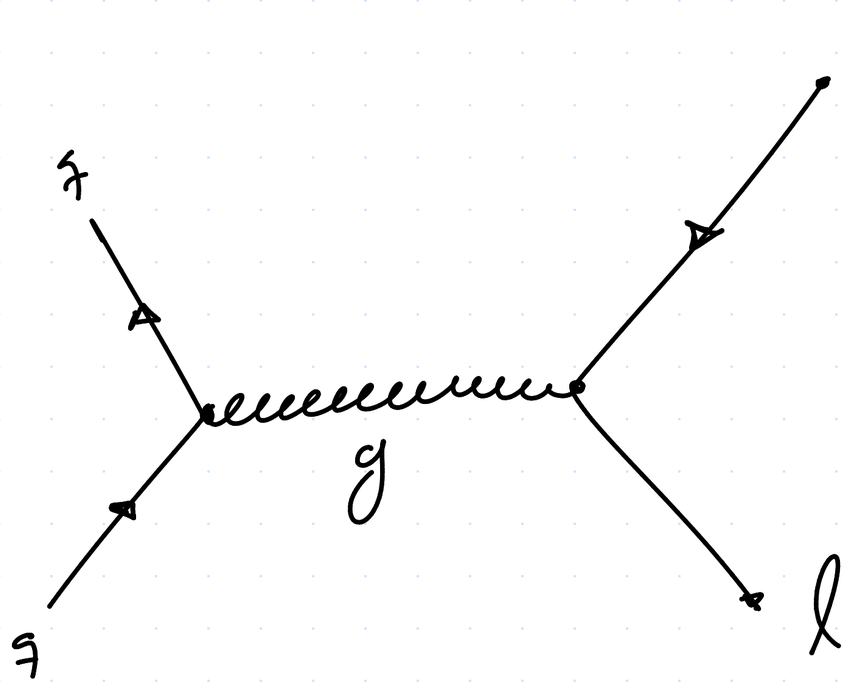
$W^{\pm}$ boson

- The Nobel Prize in Physics 1984.
  (último premio Nobel por Partículas).

Top quark

CDF and DØ Experiments (Fermilab), $p\bar{p}$

$E_{cm} = 1.8\,TeV$, ~ el mi Tevatron collider, 1994.



Standard model of Elementary Particle physics

(SM).

Lepton and quark fields interact according to the most general renormalizable Lagrangian, invariant under local $SU(3) \times SU(2) \times U(1)$ gauge symmetry + spontaneous Symmetry breaking of $SU(2) \times U(1)$.

6 L + 6 anti-L = 12 leptons

(6 Q + 6 anti-Q)* (3 colors) = 36 quarks

8 gluons + γ + Z + W^+ + W^- = 12 gauge bosons

1 Higgs boson !

- Puede haber más física más allá del modelo estándar.

↳ Dark matter

↳ Dark energy.

Algebra de Lie

- 8 gluones ↳ conj de $SU(3)$ (