The Standard Model

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Overview of the Standard Model

Matter made of **quarks** and **leptons** (spin 1//2)

lepton	mass	charge	quark	mass	charge
e^-	0.511 MeV	-1	d	$\sim 2\,\mathrm{MeV}$	$-1/3$
ν_e	?	0	u	$\sim 4\,\mathrm{MeV}$	$2/3$
μ^-	105.7 MeV	-1	s	$\sim 95\,\mathrm{MeV}$	$-1/3$
ν_e	?	0	c	$\sim 1.2\,\mathrm{GeV}$	$2/3$
τ^-	1777 MeV	-1	b	$\sim 4.2\,\mathrm{GeV}$	$-1/3$
ν_τ	?	0	t	$\sim 173\,\mathrm{GeV}$	$2/3$

Interactions mediated by **gauge bosons**

interaction	gauge boson	range	spin	remarks
electromagnetic	γ	∞	1	screened
weak	$W^{\pm}, Z^0$	$\lesssim 10^{-18}$ m	1	P violation
strong	gluons	confined	1	confinement
gravity	gravitons (?)	∞	2(?)	geometry

Masses generated by the **Higgs boson** (spin 0, $m = 125.1\,\mathrm{Gev}$)

Overview of the Standard Model

Successes of the standard model

- Consistent (unitary and renormalizable) theory
- Weak neutral currents and gauge bosons
- High energy chromodynamics
- P and CP violation
- Cancellation of chiral anomalies
- Masses generated by the Higgs scalar

Challenges to the Standard model

- Derivation of confinement and hadronic physics
- Hierarchy of masses ($m_e = 0.5\mathrm{MeV}, \quad m_t = 173\mathrm{GeV}$)
- Status of massive neutrinos
- Number of free parameters ≥ 18
- Fine tuning of the Higgs mass

Presentation of the course

- **Lecture 1: relativistic quantum theory**
  Dirac equation and its symmetries
  coupling to the electromagnetic field
  introduction to QED
- **Lecture 2: electroweak theory**
  non abelian gauge theories
  spontaneous symmetry breaking
  electroweak theory
- **Lecture 3: masses and mixings**
  introduction of quarks and CKM mixing matrix
  neutrinos masses and PMNS mixing matrix
- **Lecture 4: renormalization and effective theories**
  renormalizable vs non renormalizable
  effective theories
  Majorana masses for neutrinos

More detailed slides with bibliography and homeworks
https://amubox.univ-amu.fr/s/ZjtBDrmAcAqYXA3