ABC- of the Standard Model

These lectures are based on the lectures by:

G. Fogli (INFN- Bari) Main Source

Useful Text Books

- F. Halzen & Martin "Quarks and leptons"
- For Non- Abelian Gauge theories: Book by Cheng & Lee
- A Modern Introduction to Particle Physics by Fayyazuddin & Riazuddin

Introduction to SM :

Electromagnetic Int.

Scalar field

$(\partial^\mu \partial_\mu + m^2)\,\varphi(x) = 0$ KG equation.

This is nothing but E-momentum relation

$$E^2 - \vec{p}^2 = m^2$$

$$p^\mu = +i\hbar \frac{\partial}{\partial x^\mu}.$$

classically $p^\mu \to p^\mu + eA^\mu \xrightarrow{QM} i\partial^\mu \to i\partial^\mu + eA^\mu$

$(\partial^\mu \partial_\mu \varphi + m^2)\,\varphi(x) = -V\varphi(x)$ with

$$V = -ie(\partial_\mu A^\mu + A_\mu \partial_\mu) - e^2 A^2$$

↑ related to couplings.

In non-rel. theory (QM) the scattering amplitude for a spinless particle can be written as

$$T_{fi} = -i\int \varphi_f^*(x) V(x) \varphi_i(x)\, d^4x = i\int \varphi_f^*(x)\, ie\,(A_\mu \partial_\mu + \partial_\mu A^\mu)\,\varphi_i(x)\, d^4x \quad \text{'self'}$$

$$- e^2 \int \varphi_f^* A^2 \varphi_i(x)\, d^4x$$

Take $\int \varphi_f^*(x)\, \partial_\mu (A^\mu \varphi_i(x))\, d^4x = -\int \partial_\mu(\varphi_f^*)\, A^\mu \varphi_i(x)$

Therefore, we have obtained

$$\varphi_{fi} = -i\int J_\mu^{fi}(x)\, A^\mu(x)\, d^4x$$

$$J_\mu^{fi} = -ie\left[\varphi_f^* \partial_\mu \varphi_i - (\partial_\mu \varphi_f^*)\,\varphi_i\right)$$

This is electromagnetic current.

φ_f incoming scalar electron has mom p_i & antgoes has mom p_f.