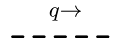
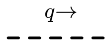
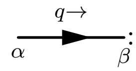
Feynman Rules of A Few Popular Interactions and Fields v1.0, Feb 2019

Propagators nonrelativistic (boson or fermion) field 

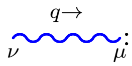
: $\mathrm{i}\Delta_{\mathrm{F}}^{\mathrm{nonrel}}(q) = \dfrac{\mathrm{i}}{q_0 - \frac{\vec{q}^{\,2}}{2m} + \mathrm{i}\epsilon}$

real/complex scalar 

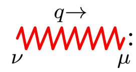
: $\mathrm{i}\Delta_{\mathrm{F}}(q) = \dfrac{\mathrm{i}}{q^2 - m^2 + \mathrm{i}\epsilon}$

fermion Dirac $\alpha\beta$ 

: $\mathrm{i}S_{\mathrm{F}}(q) = \dfrac{\mathrm{i}\,[\not{q} + m]^{\beta}{}_{\alpha}}{q^2 - m^2 + \mathrm{i}\epsilon}$

photon ($\partial \cdot A = 0$: Lorenz gauge) 

: $\mathrm{i}\Delta_{\mathrm{F}}^{\mu\nu}(q) = \dfrac{-\mathrm{i}\,g^{\mu\nu}}{q^2 + \mathrm{i}\epsilon}$

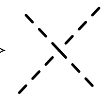
massive spin-1 

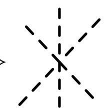
: $\mathrm{i}\Delta_{\mathrm{F}}^{\mu\nu}(q) = \dfrac{-\mathrm{i}\,(g^{\mu\nu} - \frac{q^\mu q^\nu}{m^2})}{q^2 - m^2 + \mathrm{i}\epsilon}$

Interactions and Their Lagrangeans

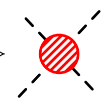
Φ^n Theories: Interactions of Scalar With Itself

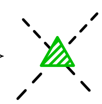
$-\dfrac{\lambda_3}{3!}\Phi^3 \Longrightarrow$  : $-\mathrm{i}\,\dfrac{\lambda_3}{3!}$

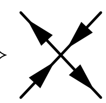
real: $-\dfrac{\lambda_4}{4!}\Phi^4$
complex: $-\dfrac{\lambda_4}{2!^2 = 4}(\Phi^\dagger\Phi)^2$ $\Bigg\} \Longrightarrow$  : $-\mathrm{i}\,\dfrac{\lambda_4}{4! \text{ or } 4}$

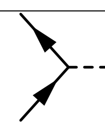
real: $-\dfrac{\lambda_6}{6!}\Phi^6$
complex: $-\dfrac{\lambda_6}{3!^2}(\Phi^\dagger\Phi)^3$ $\Bigg\} \Longrightarrow$  : $-\mathrm{i}\,\dfrac{\lambda_6}{6! \text{ or } 3!^2}$

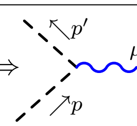
Some self-interactions with derivatives (all p incoming):

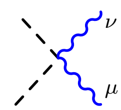
via s-wave: $-4\lambda_{\mathrm{s}}\left[\Phi^\dagger\Phi\right]\left[\Phi^\dagger(\partial^2\Phi) - (\partial^2\Phi^\dagger)\Phi\right] \Longrightarrow$  : $-\mathrm{i}\,\lambda_{\mathrm{s}}\sum_{i=1}^{4} p_i^2$

via p-wave: $-6\lambda_{\mathrm{p}}\left[(\partial_\mu\Phi)^\dagger(\partial^\mu\Phi)\right]^2 \Longrightarrow$  : $-\mathrm{i}\,\lambda_{\mathrm{p}}\sum_{i=1}^{3}\sum_{j=i+1}^{4} p_i \cdot p_j$

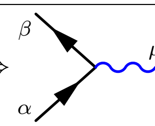
4-Fermion/Fermi-like Theory: $-\lambda_{\mathrm{F}}\left(\overline{\Psi}\Psi\right)^2 \Longrightarrow$  : $-\mathrm{i}\,\lambda_{\mathrm{F}}$

Yukawa(-like) Theory: fermion-scalar $f_0\overline{\Psi}\Phi\Psi + f_5\overline{\Psi}\gamma_5\Phi\Psi$ (+ H.c. if Φ complex) $\Longrightarrow$  : $\mathrm{i}f_0 + \mathrm{i}f_5\,\gamma_5$

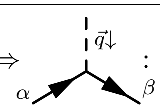
Scalar QED: $-\mathrm{i}eA^\mu\left[(\partial_\mu\Phi^\dagger)\Phi - \Phi^\dagger(\partial_\mu\Phi)\right] + e^2A^\mu A_\mu\Phi^\dagger\Phi \Longrightarrow$ 

: $-\mathrm{i}\,e(p^\mu + p'^\mu)$, 

: $\mathrm{i}\,e^2g^{\mu\nu}$

(Fermionic) QED: $-e\overline{\Psi}\not{A}\Psi \Longrightarrow$ 

: $-\mathrm{i}\,e\,(\gamma^\mu)^\beta{}_\alpha$

πN Toy-Model Pauli bi-spinor $N = \binom{\uparrow}{\downarrow}$ with spin $\vec{\sigma}$: $-\dfrac{g_A}{2f_\pi}N^\dagger\left(\vec{\sigma}\cdot(\vec{\partial}\pi)\right)N \Longrightarrow$ 

: $\dfrac{g_A}{2f_\pi}\,(\vec{\sigma})^\beta{}_\alpha \cdot \vec{q}$

Kinematics: Mandelstam variables $s = (k+p)^2$; $t = (k'-k)^2$; $u = (p'-k)^2$

Energies of massless particles for elastic $A + B \to A + B$ in lab frame: $\dfrac{E' \text{ (out)}}{E \text{ (in)}} = \dfrac{1}{1 + \frac{E}{M}(1 - \cos\theta)}$

Elastic cross section of unpolarised scattering $A + B \to A + B$:

$$\left.\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}\right|_{\mathrm{cm}} = \frac{1}{64\pi^2 s}\,\left|\overline{\mathcal{M}}\right|^2$$

massless on massive in lab: $\left.\dfrac{\mathrm{d}\sigma}{\mathrm{d}\Omega}\right|_{\mathrm{lab}} = \dfrac{1}{64\pi^2M^2}\left(\dfrac{E'}{E}\right)^2\left|\overline{\mathcal{M}}\right|^2$

$\left|\overline{\mathcal{M}}\right|^2$: squared transition amplitude, averaged over initial spins and summed over final ones.