Other Spins

$$\Phi(x) \sim \int d\!\!/p \; a^{\dagger} e^{-ixp} + b\, e^{+ipx}$$

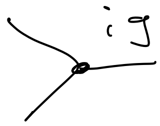
Solutions to M.E.

$$A^{\mu}(x) \sim \int d\!\!/p \; a_{\gamma}^{\dagger} \varepsilon^{\mu} e^{-ipx} + a_{\gamma} \varepsilon^{\mu} e^{+ipx}$$

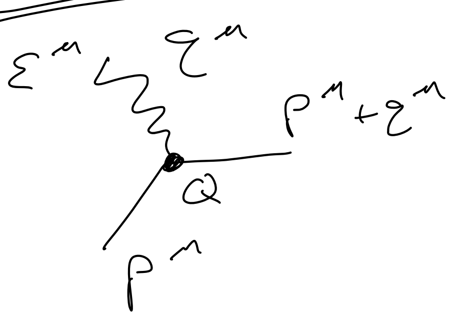
$$\psi(x) \sim \int d\!\!/p \; a^{\dagger} v\, e^{-ipx} + b\, u\, e^{+ipx}$$

Solutions to D.E.

Spin 0



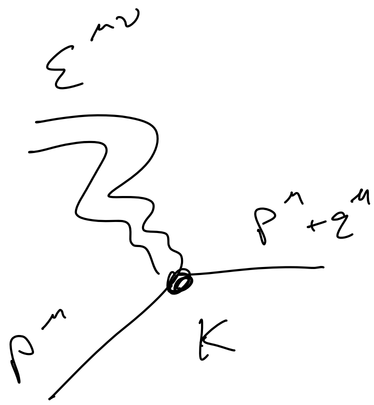
Spin 1



$$= iQ\, p^{\mu} \cdot \varepsilon_{\mu}$$

$$\boxed{\varepsilon_{\mu} \cdot q^{\mu} = 0}$$

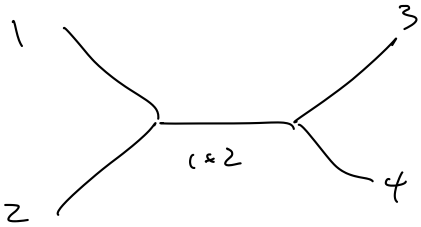
Spin 2



$$iK\, \varepsilon_{\mu\nu}\, p^{\mu} p^{\nu}$$

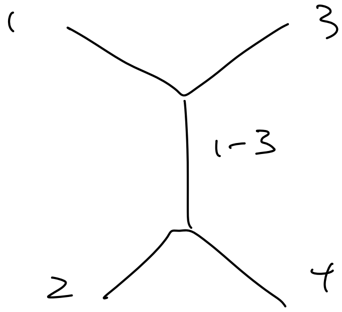
ϕ^3

"s-channel"

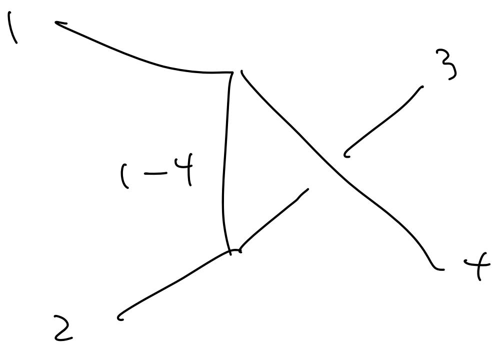


$$= (ig)\frac{i}{\underbrace{(p_1+p_2)^2}_{\equiv s}-m^2}(ig) = \frac{-ig^2}{s-m^2}$$

"t-channel"



$$= (ig)\frac{i}{\underbrace{(p_1-p_3)^2}_{\equiv t}-m^2}(ig) = \frac{-ig^2}{t-m^2}$$

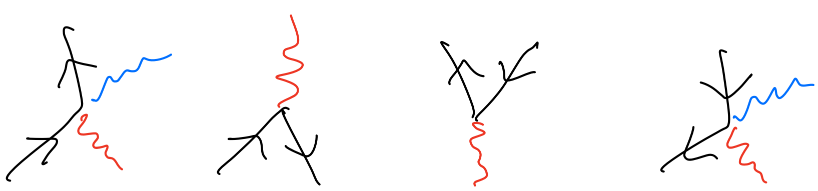


$$= (ig)\frac{i}{\underbrace{(p_1-p_4)^2}_{\equiv u}-m^2}(ig) = \frac{-ig^2}{u-m^2}$$

$$\psi^\dagger\psi\phi \sim (a+b^\dagger)(a^\dagger+b)(a_\gamma^\dagger+a_\gamma)$$

$$\sim aa^\dagger + ab + b^\dagger a^\dagger + b^\dagger b$$

"Crossing Symmetry"



Direct Approach

$$\langle e_3 e_4 | S | e_1 e_2 \rangle$$

$$= \langle e_3 e_4 | T\left(e^{i\int d^4x\, V_I}\right) | e_1 e_2 \rangle$$

D.C. ① ② ③

$$= \langle e_3 e_4 | \left(\cancel{I} + i \int d^4x\, V_I(x) + \frac{i^2}{2!}\int d^4x\, d^4y\, T(V(x)V(y)) + \ldots \right) | e_1 e_2 \rangle$$

$$① \sim a_3^e a_4^e \left(c\, \psi(x)\, \psi^\dagger(x)\, \cancel{\phi(x)} \right) a_1^{\dagger e} a_2^{\dagger e}$$

0

$\phi \sim (a_\gamma^\dagger + a_\gamma)$

$[\phi\, \phi^\dagger]$

$$② \sim a_3^\dagger a_4^\dagger \left(g\, \psi(x)\, \psi^\dagger(x)\, \phi(x) \right) \left(g\, \psi(y)\, \psi^\dagger(y)\, \phi(y) \right) a_1 a_2$$

x - - - y $\sim \frac{1}{p^2 - m^2}$

$$② \sim g^2\, a_3 a_4\, \psi(x)\, \psi^\dagger(x)\, \psi(y)\, \psi^\dagger(y)\, a_1^\dagger a_2^\dagger$$

$[a_1, a_2] = 0 \qquad [a_1^\dagger, a_2^\dagger] = 0 \qquad$ (Def. of Bosons)

$[a_1, a_2^\dagger] = \delta_{12} \qquad \langle p_1 | p_2 \rangle = \delta_{12}$

$$= \langle 0 | a_1 a_2^\dagger | 0 \rangle$$

$$= \langle 0 | [a_1, a_2^\dagger] - a_2^\dagger \overset{0}{\cancel{a_1 | 0 \rangle}}$$