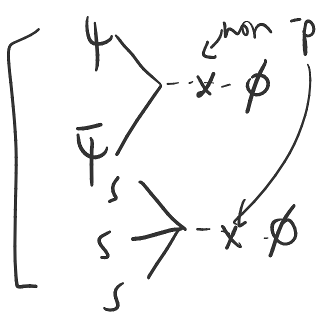
$$\mathcal{L} = \frac{1}{2}(\partial_\mu \phi)^2 + \bar{\psi}\phi\psi y + \phi s^3 + \frac{m^2}{2}\phi^2$$

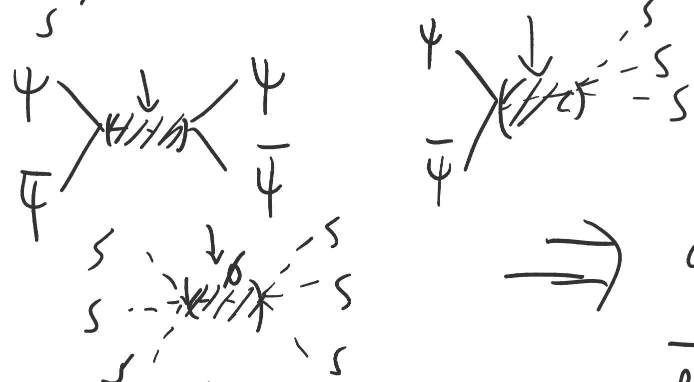
EOM of ϕ: $\dfrac{\delta\mathcal{L}}{\delta\phi}$, $\dfrac{\delta\mathcal{L}}{\delta(\partial_\mu\phi)}$

Apply Euler-Lagrange eqn. $\partial_\mu\left(\dfrac{\delta\mathcal{L}}{\delta(\partial_\mu\phi)}\right) - \dfrac{\partial\mathcal{L}}{\partial\phi} = 0$

$\mathcal{L}$ is then only fcn. of $\psi, \bar{\psi}, s$.

non-propagating = <u>req. ϕ to satisfy EOM</u>



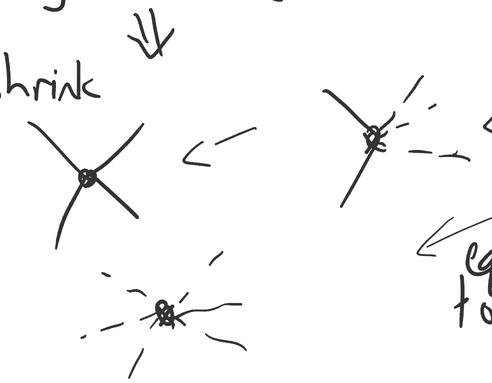


$\Rightarrow$ diagramatically,

$$\frac{1}{p^2 - m_\phi^2} \approx \frac{-1}{m_\phi^2}\left(\frac{1}{1-\frac{p^2}{m_\phi^2}}\right)$$

$$= \frac{-1}{m_\phi^2}\left(1 + \frac{p^2}{m_\phi^2} + \ldots\right)$$

shrink



equiv. to EOM

"Lagrange multiplier" treatment of heavy dof

$$\mathcal{L} = \frac{1}{2}(\partial_\mu \phi)^2 + \bar{\psi}\phi\psi y + \phi s^3 + \frac{m^2}{2}\phi^2$$

EOM of ϕ: $\delta\mathcal{L}$ $\delta\mathcal{L}$

$\mathcal{L} = \frac{1}{2}(\partial_\mu\phi)^2 \ldots \Sigma$

EOM of ϕ: $\frac{\delta \mathcal{L}}{\delta \phi}$, $\frac{\delta \mathcal{L}}{\delta(\partial_\mu \phi)}$

Apply Euler-Lagrange eqn. $\quad \partial_\mu\left(\frac{\delta \mathcal{L}}{\delta(\partial_\mu\phi)}\right) - \frac{\partial \mathcal{L}}{\partial \phi} = 0$

$$\frac{\delta \mathcal{L}}{\delta(\partial_\mu \phi)} = \partial_\mu \phi$$

$$\frac{\partial \mathcal{L}}{\partial \phi} = m^2\phi + y\bar{\Psi}\Psi + s^3$$

$$\partial^2 \phi = m^2\phi + y\bar{\Psi}\Psi + s^3$$

EOM for ϕ $\quad \left[(\partial^2 - m^2)\phi = y\bar{\Psi}\Psi + s^3 \right.$

$$\mathcal{L} = \frac{-\partial^2\phi}{2} + \frac{m^2\phi^2}{2} + y\bar{\Psi}\phi\Psi + \phi s^3$$

$$= -\frac{(\partial^2 - m^2)\phi^2}{2} + y\bar{\Psi}\phi\Psi + \phi s^3$$

$$= -\frac{1}{2}\phi\,(y\bar{\Psi}\Psi + s^3) + y\bar{\Psi}\phi\Psi + \phi s^3$$

$$= \frac{\phi}{2}\left(y\bar{\Psi}\Psi + s^3\right)$$

Expand EOM in exact manner as propagator,

$$\boxed{(p^2 - m^2)}\phi = y\bar{\Psi}\Psi + s^3$$

$p^2 \ll m^2 \qquad m^2\left(\frac{p^2}{m^2} - 1\right)\phi = y\bar{\Psi}\Psi + s^3$

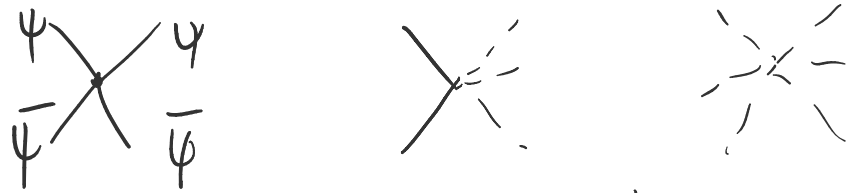
0

$$\left[-\phi = \boxed{\frac{1}{m^2}(y\bar{\Psi}\Psi + s^3)} \right.$$

$$\mathcal{L} = -\frac{1}{2m^2}\left(y\bar{\Psi}\Psi + s^3\right)^2$$

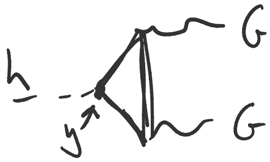
$$= -y^2\,\bar{\Psi}\Psi\bar{\Psi}\Psi - \ldots (y\bar{\Psi}\Psi s^3) - \ldots s^6$$

$$= -\frac{y^2}{2m^2}\,\bar{\Psi}\Psi\bar{\Psi}\Psi \;-\frac{1}{2m^2}\left(2y\,\bar{\Psi}\Psi\, s^3\right) \;-\frac{1}{2m^2}\, s^6$$



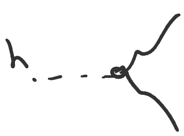
$\underbrace{(\partial_\mu \phi)^2}$ term neglected is responsible for regulating E growth of non-ren. operator

$$\mathcal{L} \supset \left(\frac{m_Z^2}{v}\right) h\, \underbrace{Z_\mu Z^\mu}$$

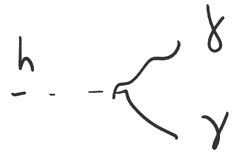


field strength ↓ mass terms ↓

$\Rightarrow$



$$\frac{y h}{m} G^a_{\mu\nu} G^{a\mu\nu} \neq h\, G_\mu G^\mu$$



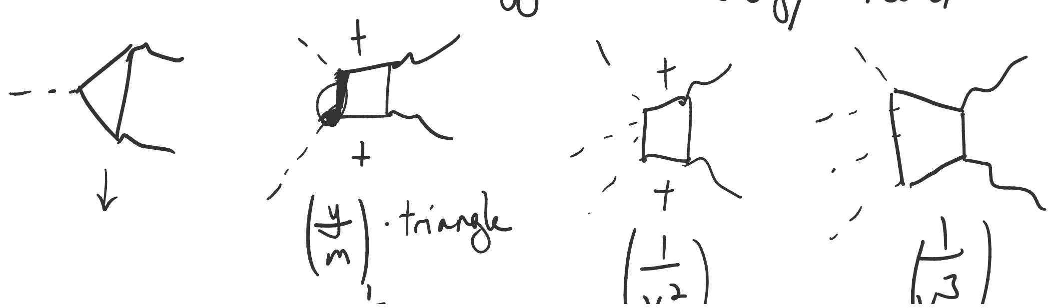
$$\frac{y h}{m} F_{\mu\nu} F^{\mu\nu} \neq h\, A_\mu A^\mu$$

This procedure of integrating out the top (or any chiral fermion).

$$\frac{y h}{m} F_{\mu\nu} F^{\mu\nu} = \left(\frac{h}{v}\right) F_{\mu\nu} F^{\mu\nu}$$

non-polynomial op.: $\log\left(1 + \frac{H^\dagger H}{v^2}\right) F_{\mu\nu} F^{\mu\nu}$

Basis of Higgs-Low Energy Theorem



$\left(\frac{y}{m}\right)$ · triangle

$= \frac{1}{V}$

$\left(\frac{1}{V^2}\right)$

$\left(\frac{1}{V^3}\right)$