

May 13, 2016

Convert $\square \phi$ to normal kinetic term

(1)

$$G_{\mu\nu} \frac{(iD)^2}{\phi^4} (\partial_\mu \phi)^2 +$$

$$+ G_{\mu\nu} iD \cdot \int \left(\frac{2(\partial_\mu \phi)^2}{\phi^3} - \frac{\square \phi}{\phi^2} \right) -$$

$$- G_{\mu\nu} \frac{(iD)^2}{\phi^2} \square \ln \phi$$

$$\mathcal{L}_{\text{eff}} \supset - \frac{(\partial_\mu \phi)^2}{\phi^2} x^2 \left\{ 3 G_{\mu\nu} + (G_{\mu\nu\rho} + G_{\mu\rho\nu}) x \right\}$$

(2)

$$G_{\mu} \left(-\frac{\partial \phi}{\phi^2} \right) = \partial_{\mu} \phi \cdot \partial_{\mu} \left(\frac{G_{\mu}}{\phi^2} \right) =$$

$$\Rightarrow \partial_{\mu} \phi \left(-\frac{2 \partial_{\mu} \phi}{\phi^3} \right) G_{\mu} +$$

$$+ \frac{\partial_{\mu} \phi}{\phi^2} \int \left(G_{\mu\mu} \frac{iD}{(-\phi^2)} \partial_{\mu} \phi + G_{\mu\nu} \frac{iD}{(-\phi^2)} \partial_{\mu} \phi \right) =$$

$$= -(\partial_{\mu} \phi)^2 \int \left(\frac{2 G_{\mu}}{\phi^3} + (G_{\mu\mu} + G_{\mu\nu}) \frac{iD}{\phi^4} \right) =$$

$$= -\frac{(\partial_{\mu} \phi)^2}{\phi^3} \int \left(2 G_{\mu} + (G_{\mu\mu} + G_{\mu\nu}) \frac{iD}{\phi} \right) \quad \leftarrow \text{multiply by } iD \text{ now}$$

$$\Rightarrow G_{\mu} iD \int \left(\frac{2(\partial_{\mu} \phi)^2}{\phi^3} - \frac{\partial_{\mu} \phi}{\phi^2} \right) =$$

$$\Rightarrow -\frac{(\partial_{\mu} \phi)^2}{\phi^4} (iD)^2 (G_{\mu\mu} + G_{\mu\nu})$$

(3)

$$\cdot - G_{\mu\nu} \frac{(iD)^2}{\phi^2} \eta \ln \phi =$$

$$= G_{\mu\nu} \frac{(\partial_\mu \phi)^2 (iD)^2}{\phi^4} - G_{\mu\nu} \frac{(iD)^2}{\phi^3} \partial \phi =$$

$$= G_{\mu\nu} (iD)^2 \left(\frac{(\partial_\mu \phi)^2}{\phi^4} - \frac{\eta \phi}{\phi^3} \right) =$$

$$\cdot - G_{\mu\nu} (iD)^2 \frac{\eta \phi}{\phi^3} = \partial_\mu \phi (iD)^2 \partial_\nu \left(\frac{G_{\mu\nu}}{\phi^3} \right) \Rightarrow$$

$$\Rightarrow \partial_\mu \phi (iD)^2 \left(-3 \frac{\partial_\mu \phi \cdot G_{\mu\nu}}{\phi^4} + \frac{G_{\mu\nu}}{\phi^3} \frac{iD \phi}{(-\phi^2)} \frac{G_{\mu\nu}}{\phi^3} \frac{iD \phi}{(-\phi^2)} \right)$$

$$= (\partial_\mu \phi)^2 (iD)^2 \left(-3 \frac{G_{\mu\nu}}{\phi^4} - (G_{\mu\nu} + G_{\mu\nu}) \frac{iD}{\phi^5} \right)$$

$$= - (\partial_\mu \phi)^2 (iD)^2 \left(2 \frac{G_{\mu\nu}}{\phi^4} + (G_{\mu\nu} + G_{\mu\nu}) \frac{iD}{\phi^5} \right) =$$

$$= - \frac{(\partial_\mu \phi)^2}{\phi^4} (iD)^2 \left(2 G_{\mu\nu} + (G_{\mu\nu} + G_{\mu\nu}) \frac{iD}{\phi} \right)$$

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Altogether, the effective action contains,

$$\begin{aligned}
 & G_{\mu\nu} \frac{(iD)^2}{\phi^4} \cancel{(\partial_\mu \phi)^2} - \frac{(\partial_\mu \phi)^2}{\phi^4} (iD)^2 (\cancel{G_{\mu\nu}} + G_{\mu\nu}) - \\
 & - \frac{(\partial_\mu \phi)^2}{\phi^4} (iD)^2 \left[2 G_{\mu\nu} + (G_{\mu\nu\rho} + G_{\rho\nu\mu}) \frac{iD}{\phi} \right] = \\
 & = - \frac{(\partial_\mu \phi)^2}{\phi^4} (iD)^2 \left[3 G_{\mu\nu} + (G_{\mu\nu\rho} + G_{\rho\nu\mu}) \frac{iD}{\phi} \right] \\
 \\
 & \mathcal{L}_{\text{eff}} = - \frac{(\partial_\mu \phi)^2}{\phi^2} x^2 \left[3 G_{\mu\nu} + (G_{\mu\nu\rho} + G_{\rho\nu\mu}) x \right]
 \end{aligned}$$