Pole Masses from the Effective Potential

Pole mass defined by location of pole in propagator: $\quad (\hat{\Phi} = v_0 + \hat{h})$

$$G_h^{-1}(p,-p)_{\text{conn.}} = p^2 - m_{\overline{MS}}^2 - \Sigma(p^2) \quad \equiv \langle 0|T(\hat{h}\,\hat{h})|0\rangle$$

$$0 = M_{\text{pole}}^2 - m_{\overline{MS}}^2 - \Sigma(p^2 = M_{\text{pole}}^2) \qquad (*)$$

Can define another mass from the effective potential (really, this just the curvature of V_{eff} at its minimum):

$$\underset{\uparrow \text{"potential"}}{m_V^2} = \left.\frac{\partial^2 V_{\text{eff}}}{\partial \Phi^2}\right|_{\underset{\uparrow\ \text{tree-level!}}{\Phi = v_0}} = \left.\frac{\partial^2 V_{\text{eff}}}{\partial h^2}\right|_{h=0} = -\Gamma_h^{[2]}(p=0)$$

$$\left[\text{recall } \Gamma_h^{[2]}(p=0) = G_h^{-1}(p=0)_{\text{conn.}}\right]$$

So,

$$m_V^2 = -G_h^{-1}(p=0)_{\text{conn.}} = -\left(-m_{\overline{MS}}^2 - \Sigma(p^2=0)\right) \longleftarrow$$ Ren. scale indep. (since Green functions are scale indep

$$\Longrightarrow \quad m_{\overline{MS}}^2 = m_V^2 - \Sigma(p^2=0)$$

Plug this into $(*)$, eliminating $m_{\overline{MS}}^2$:

$$\boxed{0 = M_{\text{pole}}^2 - m_V^2 - \left(\Sigma(p^2 = M_{\text{pole}}^2) - \Sigma(p^2=0)\right)}$$

The advantage of obtaining the pole masses this way is that all momentum-independent diagrams (except tadpoles) that contribute to $\Sigma(p^2)$ are included in the calculation for Veff. Only a subset of diagrams need to be calculated.

$= \Sigma(p^2)$.

included in Veff $\qquad$ Need to be calculated

$[\Delta\Sigma = \Sigma(p^2) - \Sigma(p^2=0)]$