Introduction

- We will use the Higgs portal to unparticles

\[ \mathcal{L} = -\kappa_U |H|^2 O_U \]

- When \( H \) acquires a VEV \( v \) it gives:

\[ \langle O_U \rangle = \int_0^\infty dM^2 F(M^2) u(M^2) = -\frac{\kappa_U v^2}{2} \int_0^\infty \frac{F^2(M^2)}{M^2} dM^2 \]

\[ F^2(M^2) = \frac{A_{dU}}{2\pi} (M^2)^{dU-2} \]

which has an IR divergence

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\(^a\)P.J. Fox, A. Rajaraman and Y. Shirman, arXiv:0705.3092
• IR regulator the conformal coupling

\[ \delta \mathcal{L} = -\zeta |H|^2 \int_0^\infty dM^2 u^2(M^2) \]

• It leads to

\[ \langle O_U \rangle = -\frac{\kappa_U v^2}{2} \int_0^\infty \frac{F^2(M^2)}{M^2 + \zeta v^2} dM^2 \]

• In the absence of \( \kappa_U \) the unparticle VEV would be zero and

\[ P_U(p^2) = \frac{A_{dU}}{2 \sin(\pi d_U)} \frac{i}{(-p^2 + \zeta v^2 - i\epsilon)^{2-d_U}} \]
Electroweak breaking

• In the presence of $\kappa_U$ Higgs and unparticle mix
• Minimization condition for Higgs changes
• Because $\langle \mathcal{O}_U \rangle < 0$ electroweak breaking can proceed even for $m^2 \geq 0$
• It becomes

$$m^2 + \lambda v^2 - \lambda_U (\mu_U^2)^{2-d_U} v^{2(d_U-1)} = 0$$

$$\lambda_U \equiv \frac{d_U}{4} \zeta^{d_U-2} \Gamma(d_U-1) \Gamma(2-d_U)$$

$$\left( \mu_U^2 \right)^{2-d_U} \equiv \kappa_U^2 \frac{A_{dU}}{2\pi}$$
Minimization condition for the case $m = 0, \zeta = 1,$

$$\kappa U = \nu^2 - dU$$
Pole Higgs mass and width

• In the presence of $\kappa_U$ the neutral component of the Higgs, $h^0$, mixes with the $u(M^2)$ fields in an infinite scalar mass matrix. One obtains the corresponding propagator for the coupled Higgs-unparticle system

$$i P(p^2)^{-1} = p^2 - 2\lambda v^2 +$$

$$v^2 (\mu_U^2)^{2-d_U} \int_0^\infty \frac{M^2 dU - 2}{M^2 + \zeta v^2 - p^2} \left( \frac{M^2}{M^2 + \zeta v^2} \right)^2 dM^2$$

• $P(m_h^2)^{-1} \equiv 0$
Case $m_h^2 < \zeta v^2$

Pole mass and unresummed Higgs mass for $\zeta = 1$. Straight line is $\sqrt{\zeta v}$
Case $m_h^2 < \zeta v^2$

Spectral function for the Higgs (pole) and unparticles (continuous distribution) for $d_U = 1.2$
Case $m_h^2 > \zeta v^2$

Pole mass and unresummed Higgs mass for $\zeta = 0.2$ Straight line is $\sqrt{\zeta v}$
Case $m_h^2 > \zeta v^2$

Spectral function for the Higgs-unparticle system (continuous distribution) for $d_U = 1.2$
Case $m_h^2 > \zeta v^2$

Width of the Higgs boson from unparticle merging for $\zeta = 0.2$