THE HIGGS CONNECTION

to Unparticles [a]

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[a] A. Delgado, J.R. Espinosa and M.Q., arXiv:0707.4309

Introduction

- We will use the Higgs portal to unparticles [a]

$$\mathcal{L} = -\kappa_U |H|^2 \mathcal{O}_U$$

- When H acquires a VEV v it gives: $\langle \mathcal{O}_U \rangle =$

$$\int_0^\infty dM^2 F(M^2) u(M^2) = -\frac{\kappa_U v^2}{2} \int_0^\infty \frac{F^2(M^2)}{M^2} dM^2$$

$$F^2(M^2) = \frac{A_{d_U}}{2\pi} (M^2)^{d_U - 2}$$

which has an IR divergence

[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

$$\langle \mathcal{O}_U \rangle = -\frac{\kappa_U v^2}{2} \int_0^\infty \frac{F^2(M^2)}{M^2 + \zeta v^2}\, dM^2$$

- In the absence of κ_U the unparticle VEV would be zero and

$$P_U(p^2) = \frac{A_{d_U}}{2\sin(\pi d_U)} \frac{i}{(-p^2 + \zeta v^2 - i\epsilon)^{2-d_U}}$$

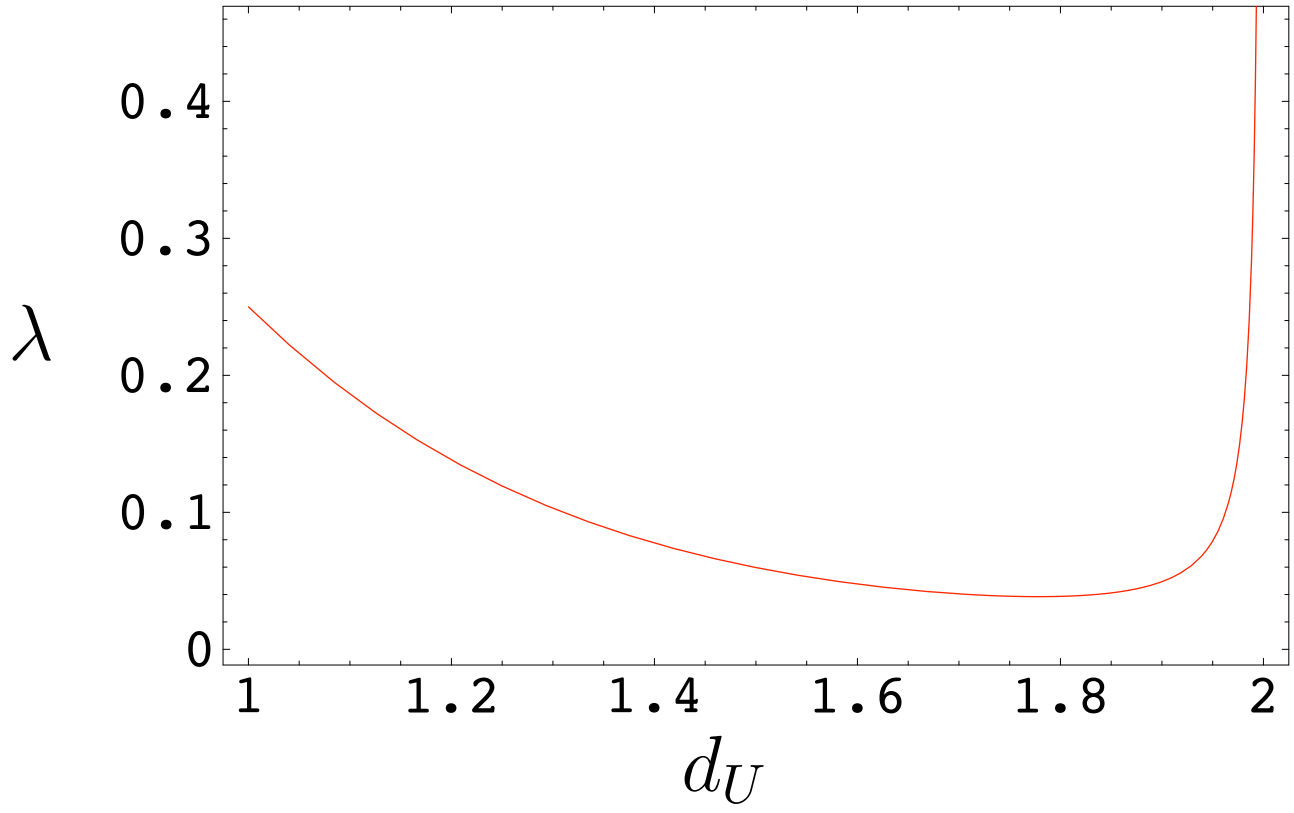
Electroweak breaking

- In the presence of κ_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

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

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

$$(\mu_U^2)^{2-d_U} \equiv \kappa_U^2 \frac{A_{d_U}}{2\pi}$$



Minimization condition for the case $m = 0$, $\zeta = 1$, $\kappa_U = v^{2-d_U}$

Pole Higgs mass and width

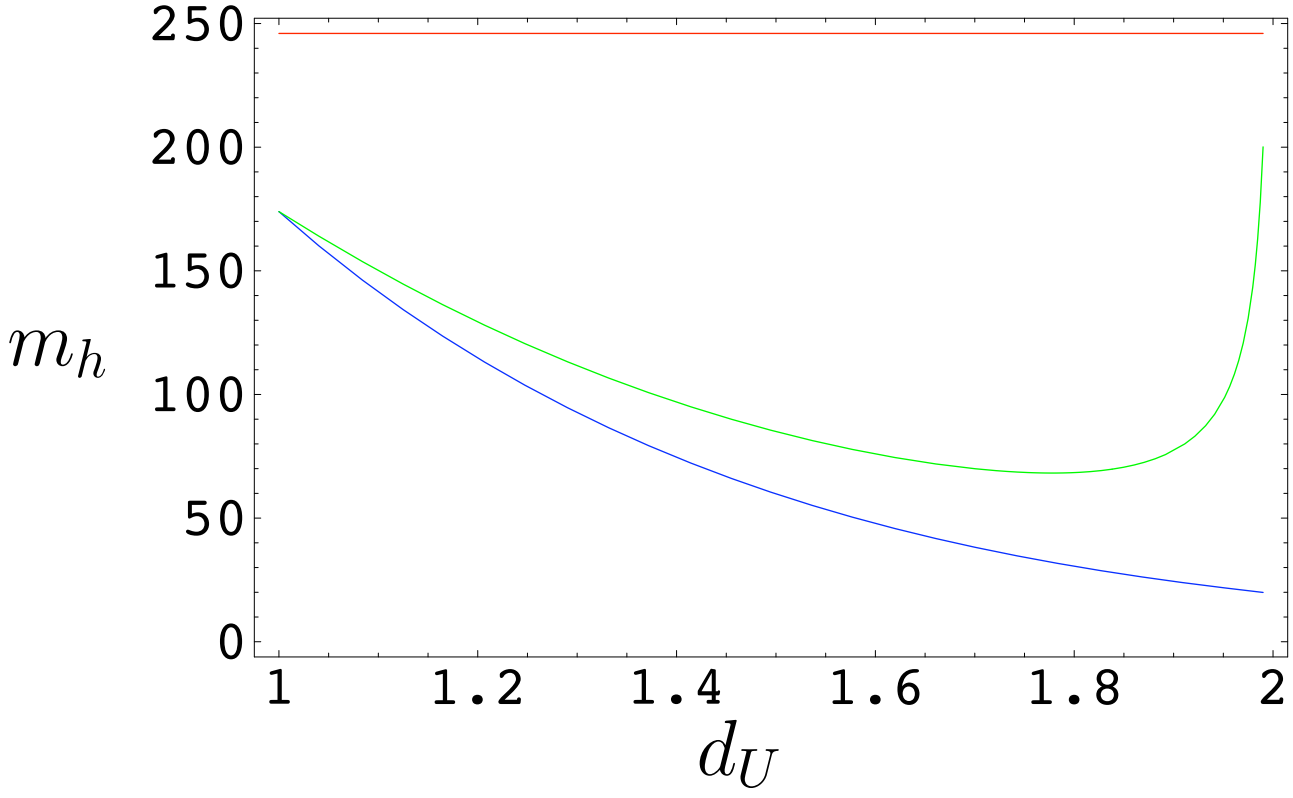
- In the presence of κ_U the neutral component of the Higgs, h^0, mixes with the $u(M^2)$ fields in an infinite scalar mass matrix. One obtains the corresponding propagator for the coupled Higgs-unparticle system

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

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

- $P(m_h^2)^{-1} \equiv 0$

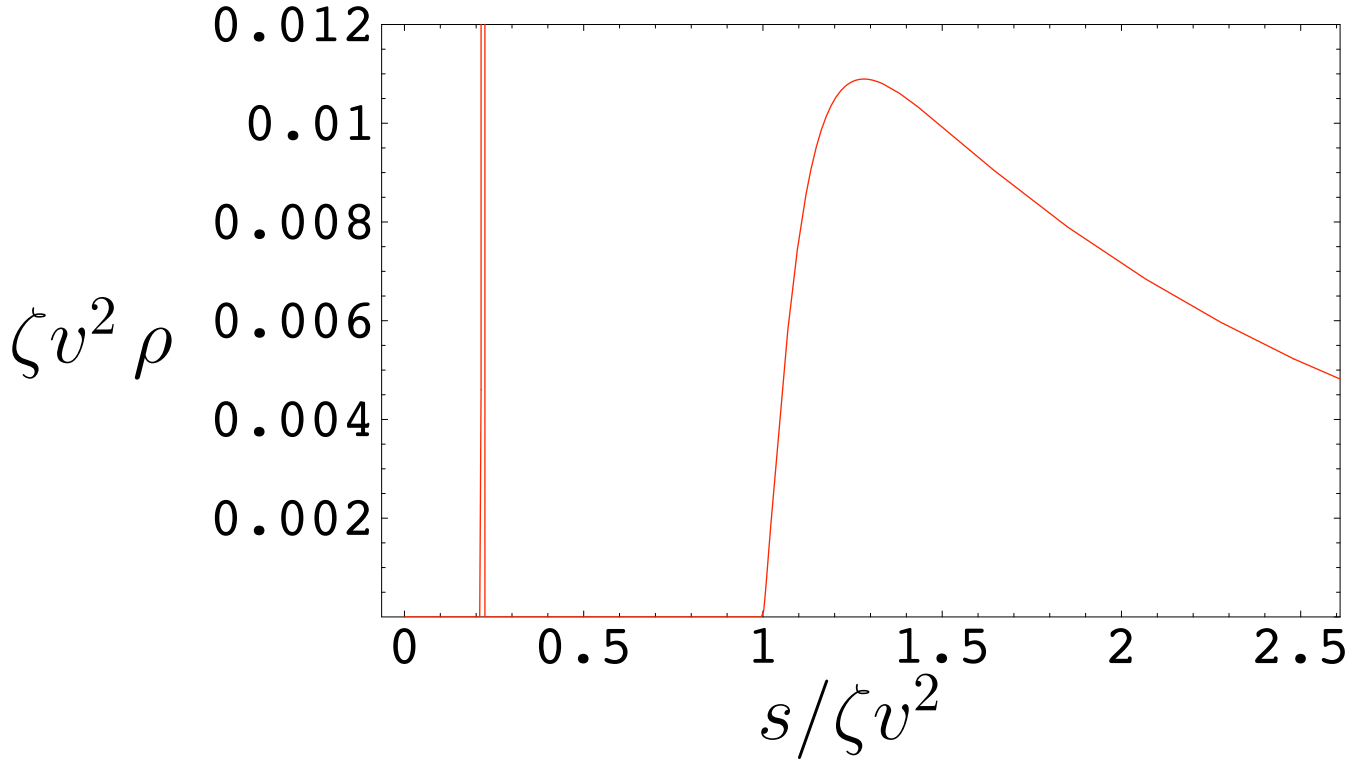
Case $m_h^2 < \zeta v^2$



Pole mass and unresummed Higgs mass for $\zeta = 1$.

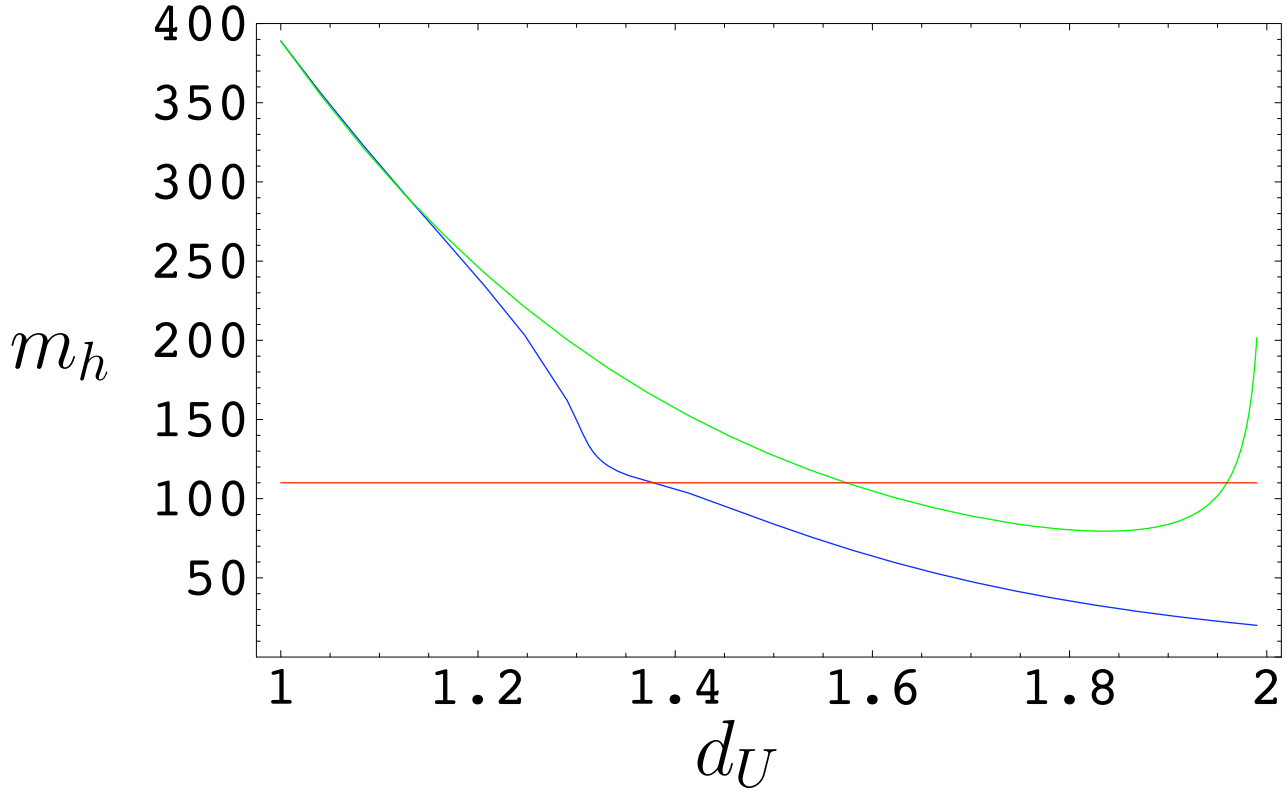
Straight line is $\sqrt{\zeta} v$

Case $m_h^2 < \zeta v^2$



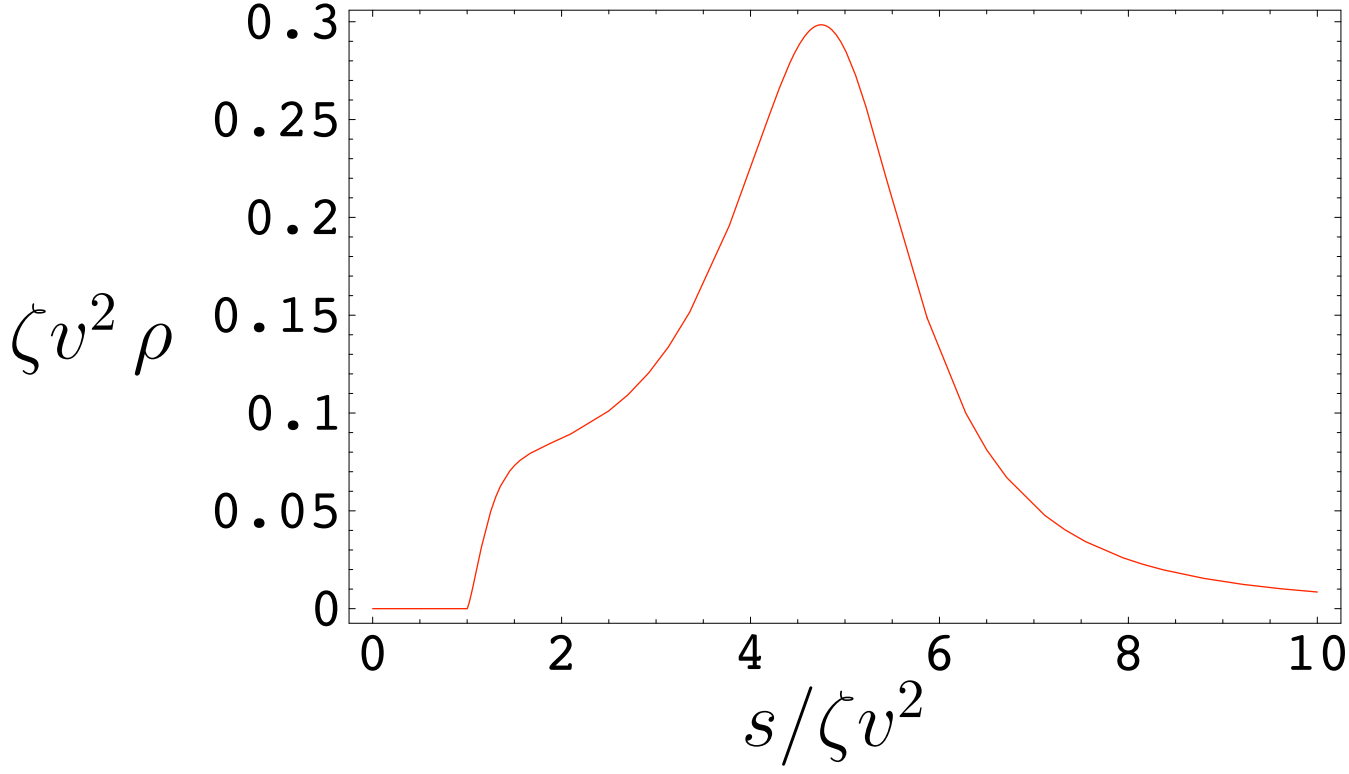
Spectral function for the Higgs (pole) and unparticles (continuous distribution) for $d_U = 1.2$

Case $m_h^2 > \zeta v^2$



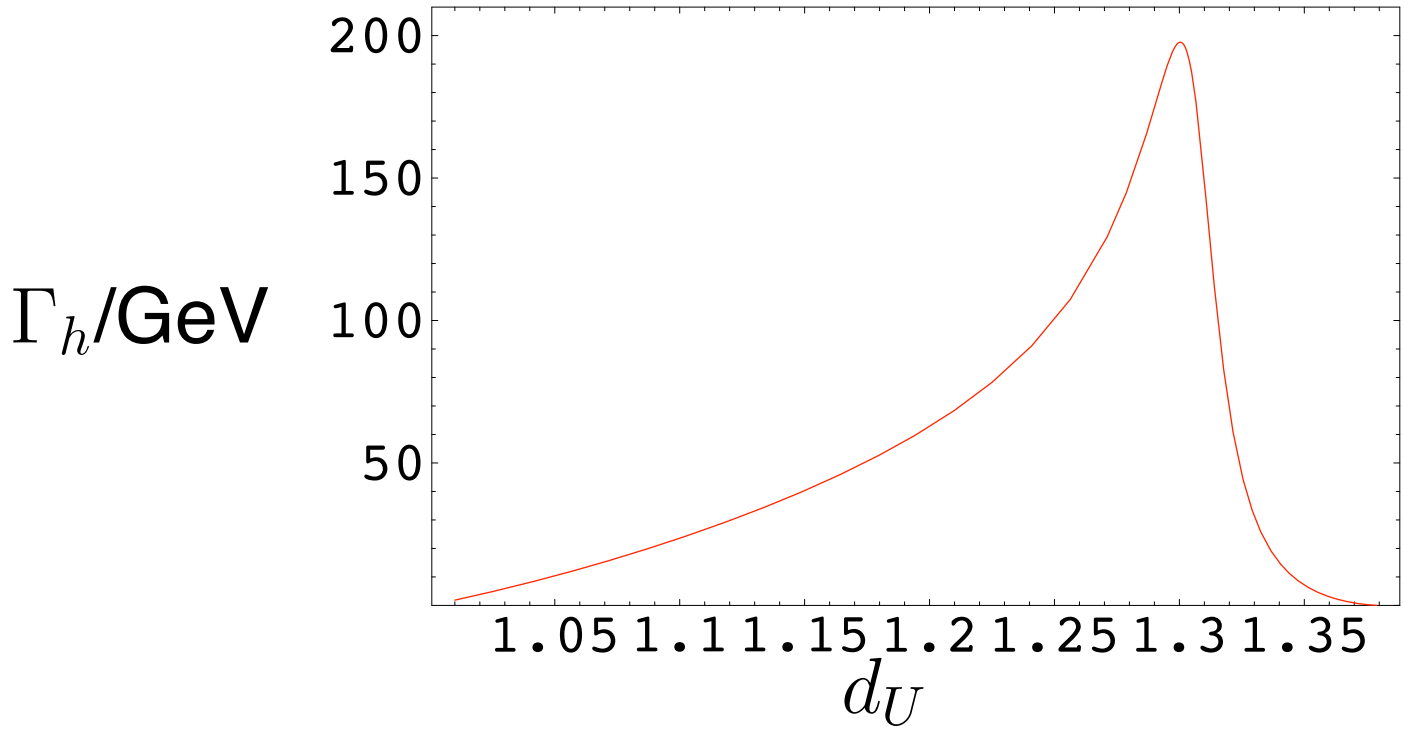
Pole mass and unresummed Higgs mass for $\zeta = 0.2$ Straight line is $\sqrt{\zeta} v$

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 $\zeta = 0.2$