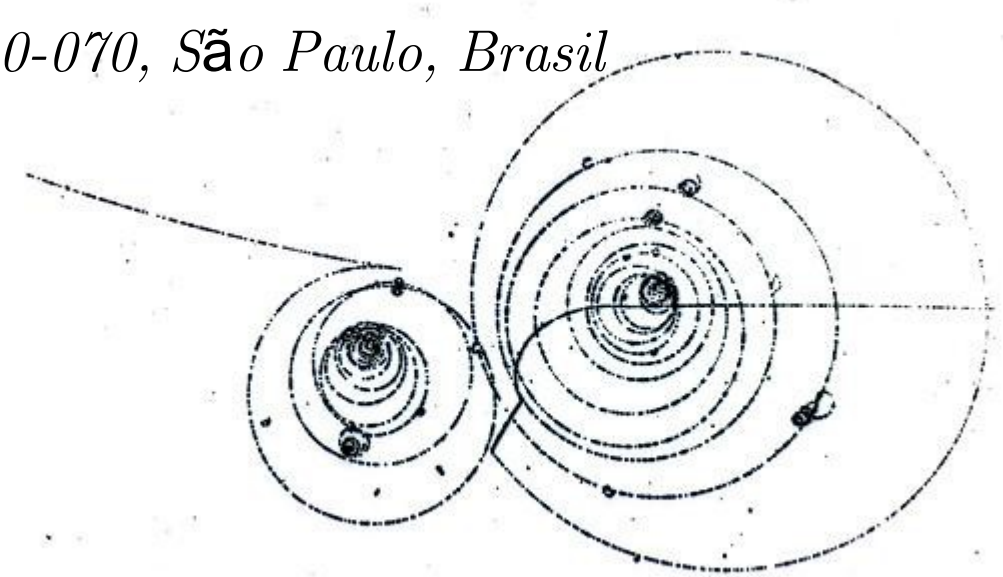
Hidden sector effects on double higgs production near threshold

A. C. A. Oliveira, R. Rosenfeld

a) Instituto de Fsica Teorica, Universidade Estadual Paulista, Rua Dr. Bento T.

Ferraz, 271, 01140-070, São Paulo, Brasil



Is still hard for me speak english, so please, be patient...

Topics

- Motivation
- Higgsinium in SM
- The formalism: Nonrelativistic reduction

  2 subtleties
- Nice results

Overview

Goal: Bound States formation is intrinsically a nonperturbative effect:

As physicists, in a very first approach, we have to find another, but as simple, way to modelate it

Motivation

- Discoveries in particles physics – Muonium, Charmonium, Bottonium
- Properties studies – Positronium, Top

B. Grinstein and M. Trott, Phys. Rev. D 76, 073002 (2007).

V. S. Fadin and V A. Khoze, JETP Lett. 46, 525 (1987);

M. J. Strassler and M. E. Peskin,Phys. Rev. D 43, 1500 (1991);

K. Hagiwara, Y. Sumino and H. Yokoya, Phys. Lett. B666, 71 (2008).

.....

Motivation

- Discoveries in particles physics – Muonium, Charmonium, Bottonium
- Properties studies – Positronium, Top

Why not for Higgs discovery?!

SM Higgs

- Short lifetime, to have a Higsinum in SM the Higgs mass would be huge

  → above unitarity limit

- In Hadron coliders only at least one loop double production is alowed

  → Very small cross section compared to background!

SM Higgs

- Short lifetime, to have a Higsinum in SM the Higgs mass would be huge

→ above unitarity limit

- In Hadron coliders only at least one loop double production is alowed

→ Very small cross section compared to background!

A new idea

A "new" idea

- Add a singlet scalar sector to fix the problem – produce bounding potential

$$\mathcal{L} = \mathcal{L}_{SM} + \frac{1}{2}(\partial_\mu \phi)^2 + \frac{1}{2} m_\phi^2 \phi^2 + guhh\phi$$

- Note: the coupling adds a new mass scale, but also note that is an effective Lagrangian – It don't comes from any model building
- The same tecnique is used at nowdays in direct DM detection and to probe Top physics

C. Arina, F. Josse-Michaux and N. Sahu, 1004.0645 and 1004.3953.

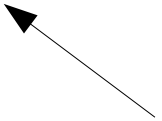
Sumino, Yukinari, Yokoya, Hiroshi 1007.0075v1

Lets Work

We will search in thresholdl limit, were for Gev Higgs mass will be avaible in LHC

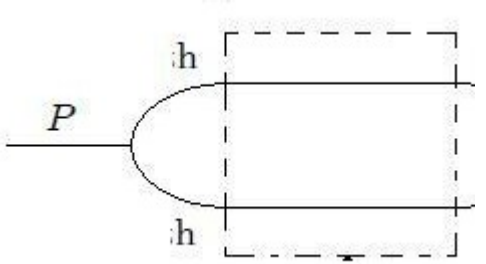
Modelate with small effect

$$\hat{\sigma}(gg \to hh) = \hat{\sigma}_{\mathbf{0}}(gg \to hh)R(E)$$



Concentrating in enhancement causes

$$\hat{\sigma}(gg \to hh) = \hat{\sigma}_0(gg \to hh)R(E)$$



- Optical Theorem

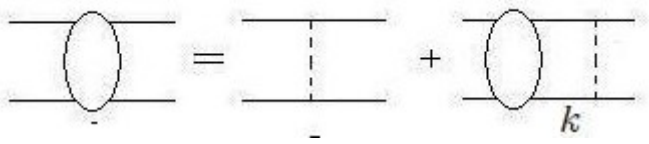
$$\sum_f \sigma\left(a, b \to f\right) = -\frac{1}{E_{cm} p_{cm}} Im\mathcal{M}\left(a, b \to a, b\right)$$

Danger!!!

Now we can work only with 4 point function...

Bethe Salpeter Equation (1951)

- 4 point Schwinger Dyson equation with ladder approach (one boson exchange)
  - Why ladders? – avoid noninstantaneus part of the new scalar potential at threshold



$$E = \sqrt{s} - 2M_h$$

(Eikonal – P. Skands) Cumbersome, but standart nonrelativistic reduction

Schroedinger!

$$\left[(E + i\Gamma_h) - \left(-\frac{\nabla^2}{m_h} + V(r)\right)\right] G(\vec{x}, E) = \delta^3(\vec{x})$$

- Important: G is not the four point function, in the approach we defined what would be the propagator of the bound state, just like a wave function

$$R(E) = \frac{ImG(\vec{0}, E)}{ImG_0(\vec{0}, E)}$$

Schroedinger!

$$\left[(E + i\Gamma_h) - \left(-\frac{\nabla^2}{m_h} + V(r)\right)\right] G(\vec{x}, E) = \delta^3(\vec{x})$$

- Atention: G here is not the four point function, in the approach we defined what would be the propagator of the bound state, just like a wave function

$$R(E) = \frac{ImG(\vec{0}, E)}{ImG_0(\vec{0}, E)}$$

So, It's just solve a diferential equation!

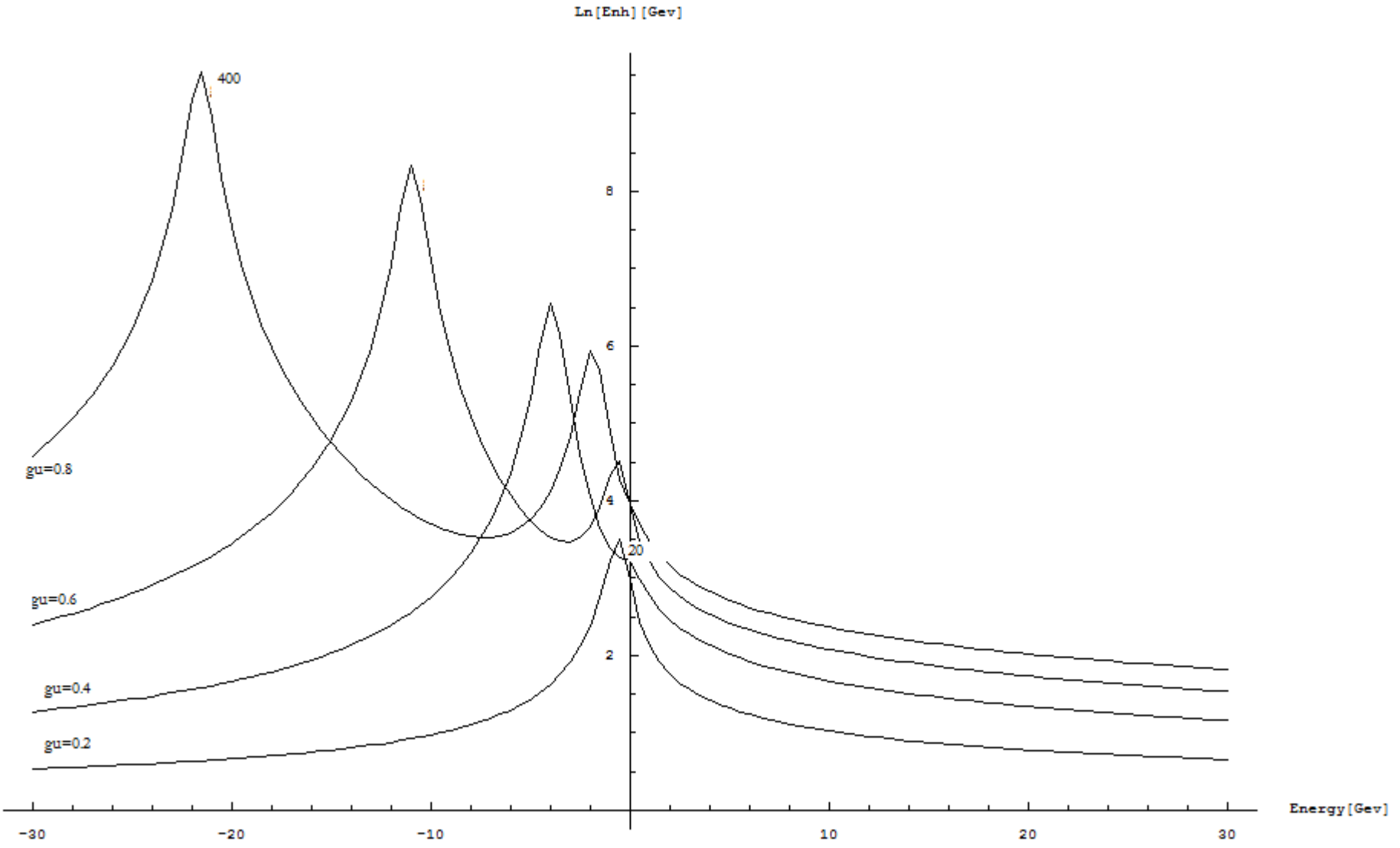
Play with parameters

SM Higgs mass = 180 Gev

SM Higgs Width = 0,63 Gev (M. Spira/1998 at Tevatron)

Mass of new scalar = 10 Gev

$$V(r) = \frac{g^2}{8m_h^2}\frac{e^{-m_\phi r}}{r}$$



Only above threshold

Comments

- Bound States fomation and Sommerfeld enhancement (Weiner lecture) are different effects – here it appears together for the enhancement

- For a small cross section even a small enhancement have some significance

- We used a effective Lagrangian – so you can fell free to apply this formalism to your favorite model!

- DM (?) - T Parity (Weiner lecture)

- Thanks for the patience!!!