Revisiting soliton contributions to perturbative processes

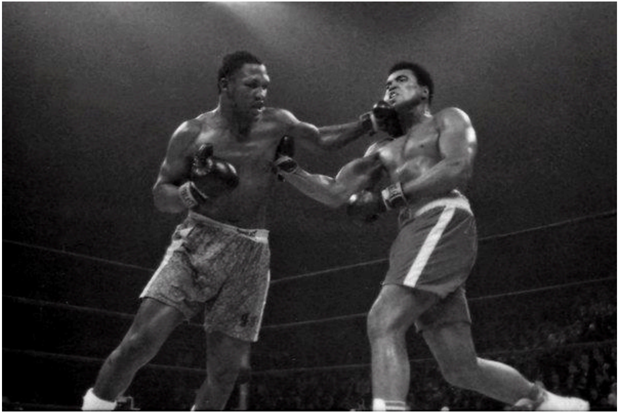
Andy Royston

Texas A&M University

Strings, Princeton, June 26, 2014

Based on 1403.5017 and 1404.0016 with C. Papageorgakis

Gong Show, Round 16

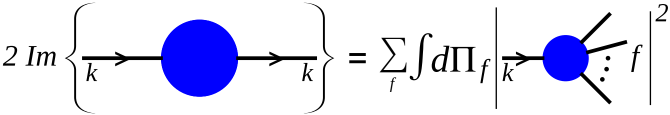


Even the "Fight of the Century" went only 15 rounds

Q & A

Q: Do solitons run in loops?

A: Yes, in the following sense:



Q:

- Can we compute their contribution to perturbative processes?
- Is this contribution "exponentially suppressed"? (in what quantity?)[1]

A:

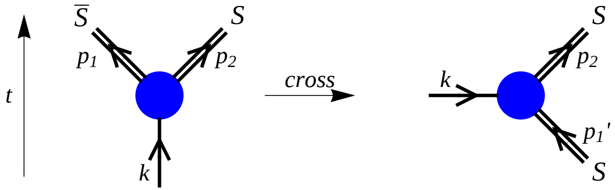
- Yes, under certain assumptions.
- Usually, but not necessarily. (in the ratio R_c/R_S.)

---

[1] Drukier and Nussinov (1982)..., Demidov and Levkov (2011), Banks (2012)

How do we compute?

Use analyticity and crossing symmetry:



$$\mathcal{A}_{\text{pair-prod}}(k^2) \quad = \quad \mathcal{A}_{\text{scat}}(k^2)\Big|_{p_1'=-p_1}$$

compute $\mathcal{A}_{\text{scat}}$ perturbatively in soliton sector:

$$\delta(k + p_1' - p_2)\mathcal{A}_{\text{scat}}(k^2) = \langle S(\mathbf{p}_2)|\, T\{e^{-i\int dtH_I}\}|\mathbf{k}, S(\mathbf{p}_1')\rangle$$

Exhibiting suppression

- consider class of scalar models $\phi(x) = \phi_S\left(\frac{\mathbf{x}-\mathbf{x}_0}{R_S}; \ldots\right)$

Exhibiting suppression

- consider class of scalar models $\phi(x) = \phi_S\left(\frac{\mathbf{x}-\mathbf{x}_0}{R_S}; \ldots\right)$

- find $\mathcal{A}_{\mathrm{pair-prod}}(k^2)$ vanishes *faster than any power* in the ratio R_c/R_S for k^2 above† threshold $(2M_S)^2$

†need to understand threshold effects better

Exhibiting suppression

- consider class of scalar models $\phi(x) = \phi_S\left(\frac{\mathbf{x}-\mathbf{x}_0}{R_S}; \ldots\right)$

- find $\mathcal{A}_{\mathrm{pair-prod}}(k^2)$ "exponentially suppressed" in the ratio R_c/R_S for k^2 above† threshold $(2M_S)^2$

$$\mathcal{A}_{\mathrm{pair-prod}}(k^2) \lesssim e^{-2R_S/R_c} \qquad \ldots$$

† need to understand threshold effects better

Exhibiting suppression

- consider class of scalar models $\phi(x) = \phi_S\left(\frac{\mathbf{x}-\mathbf{x}_0}{R_S}; \ldots\right)$

- find $\mathcal{A}_{\mathrm{pair-prod}}(k^2)$ "exponentially suppressed" in the ratio R_c/R_S for k^2 above† threshold $(2M_S)^2$

$$\mathcal{A}_{\mathrm{pair-prod}}(k^2) \lesssim e^{-2R_S/R_c} \qquad \ldots$$

- *provided* R_S bounded away from zero (as a function on the moduli space of soliton solutions)

†need to understand threshold effects better

Possible lessons for 5D MSYM

- first take off the EFT glasses and suppose that 5D MSYM is a microscopic theory
- $\Rightarrow$ integrate over all loop momenta (*i.e.* $\Lambda_{UV} \to \infty$)
- but then, for $k^2 > (2M_S)^2$, will produce S-$\overline{S}$ pairs
- $R_S = \rho \to 0$ so argument for exponential suppression breaks down, suggesting soliton contributions may compete
- unfortunately approx. scheme also breaks down...need new methods

Possible lessons for 5D MSYM

- first take off the EFT glasses and suppose that 5D MSYM is a microscopic theory
- $\Rightarrow$ integrate over all loop momenta (*i.e.* $\Lambda_{UV} \to \infty$)
- but then, for $k^2 > (2M_S)^2$, will produce S-$\overline{S}$ pairs
- $R_S = \rho \to 0$ so argument for exponential suppression breaks down, suggesting soliton contributions may compete
- unfortunately approx. scheme also breaks down...need new methods

Thank you!

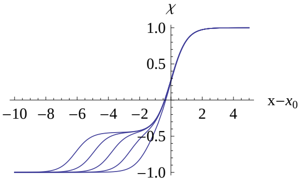
example with internal modulus[3]

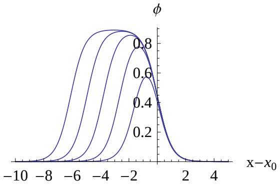
$$\mathcal{L} = \frac{1}{2}(\partial_\mu \phi \partial^\mu \phi + \partial_\mu \chi \partial^\mu \chi) - \frac{1}{2}(W_\phi^2 + W_\chi^2)$$

$$W = \chi - \frac{1}{3}\chi^3 - \chi\phi^2 - \frac{\beta}{3}\phi^3$$

$$\Rightarrow \phi(\chi) = \frac{\beta\chi + b\sqrt{\beta^2+4} - \sqrt{(\chi\sqrt{\beta^2+4} + \beta b)^2 + 4(b^2-1)}}{2},$$

$$\chi(x) = \sqrt{\frac{b^2-1}{\beta^2+4}}\left[\frac{2\tanh(x-x_0)+2b}{\sqrt{b^2-1}(\sqrt{\beta^2+4}-\beta)} - \frac{\sqrt{b^2-1}(\sqrt{\beta^2+4}-\beta)}{2\tanh(x-x_0)+2b} - \frac{\beta b}{\sqrt{b^2-1}}\right]$$





[3] BNRT (1997); Brito and de Souza Dutra (2014)