# Revisiting effective field theories


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*IPHC — U. of Strasbourg*

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# Short presentation

**Physics beyond the standard model**, theory and phenomenology.

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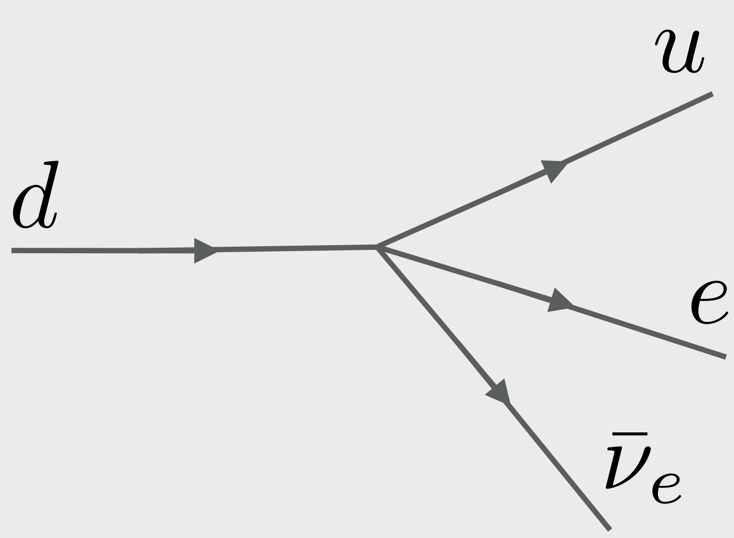
$$\mathcal{L} = \frac{G_F}{\sqrt{2}}[\bar{u}\gamma^{\mu}(1-\gamma_5)d][\bar{e}\gamma_{\mu}(1-\gamma_5)\nu_e]$$



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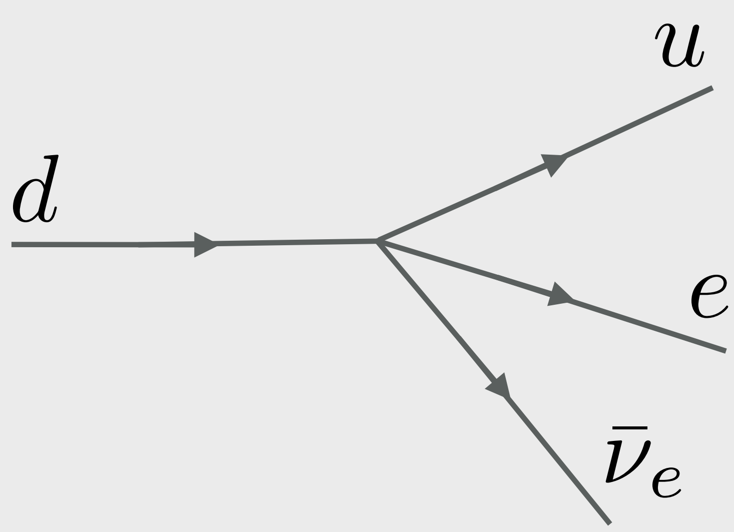

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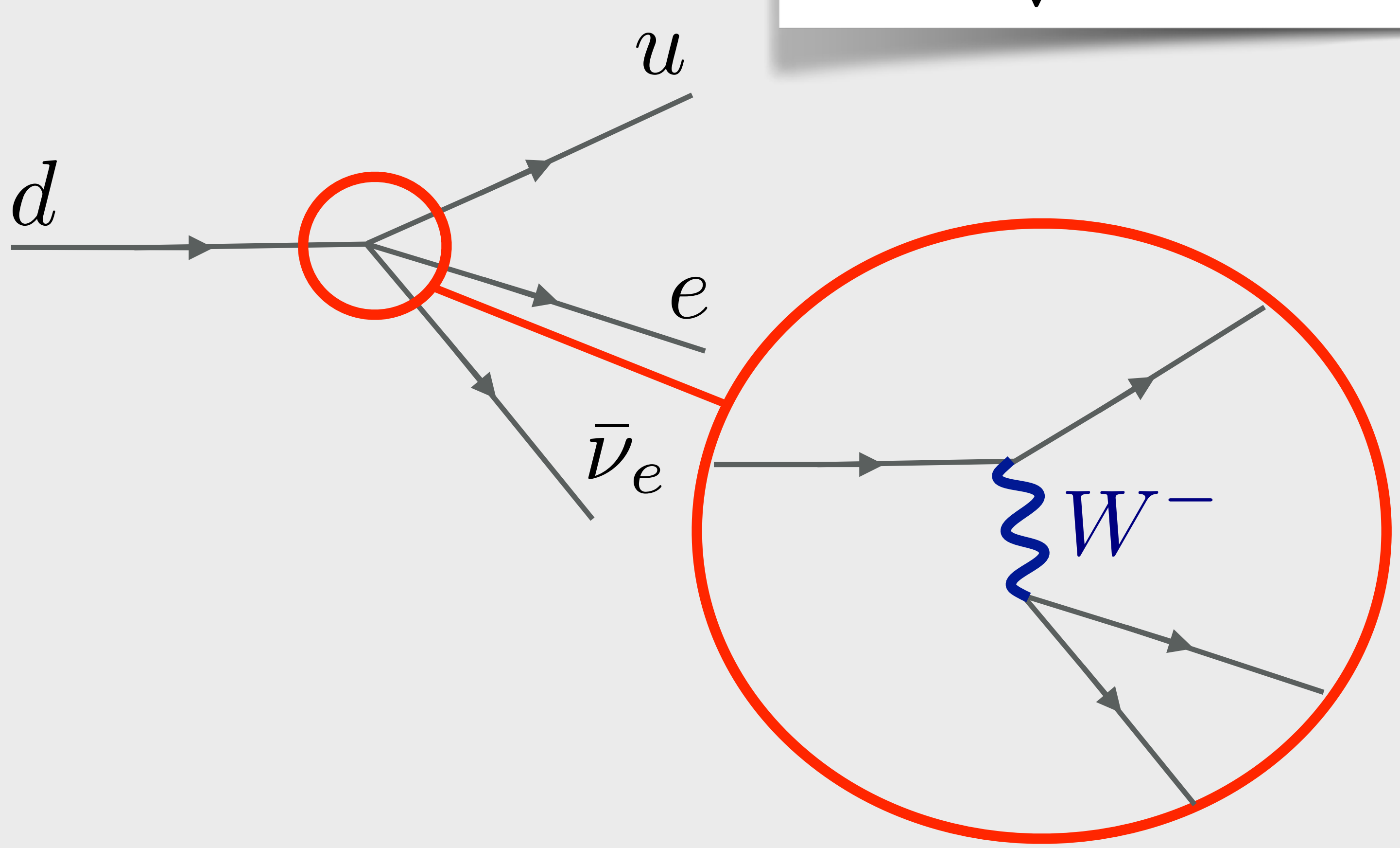

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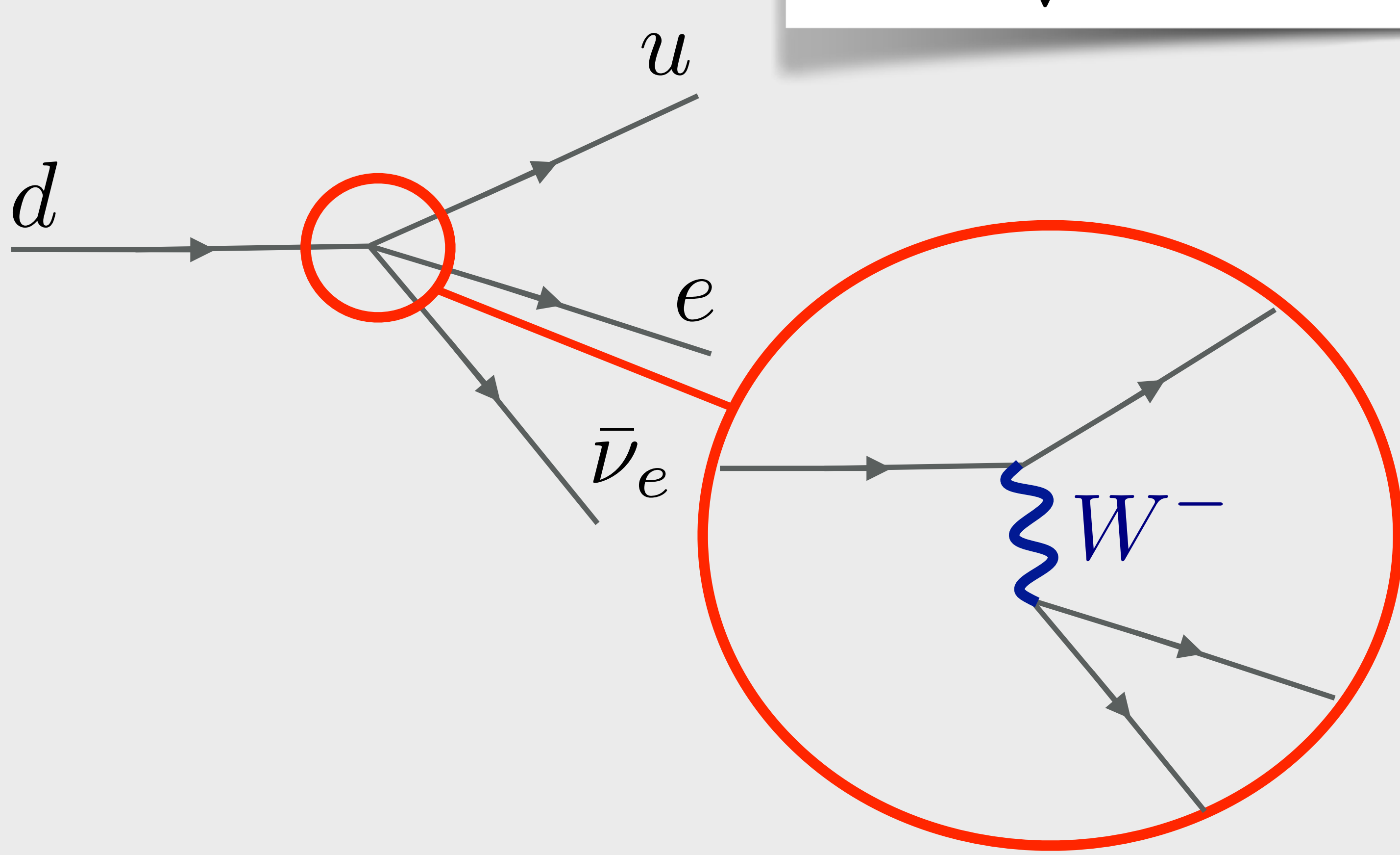


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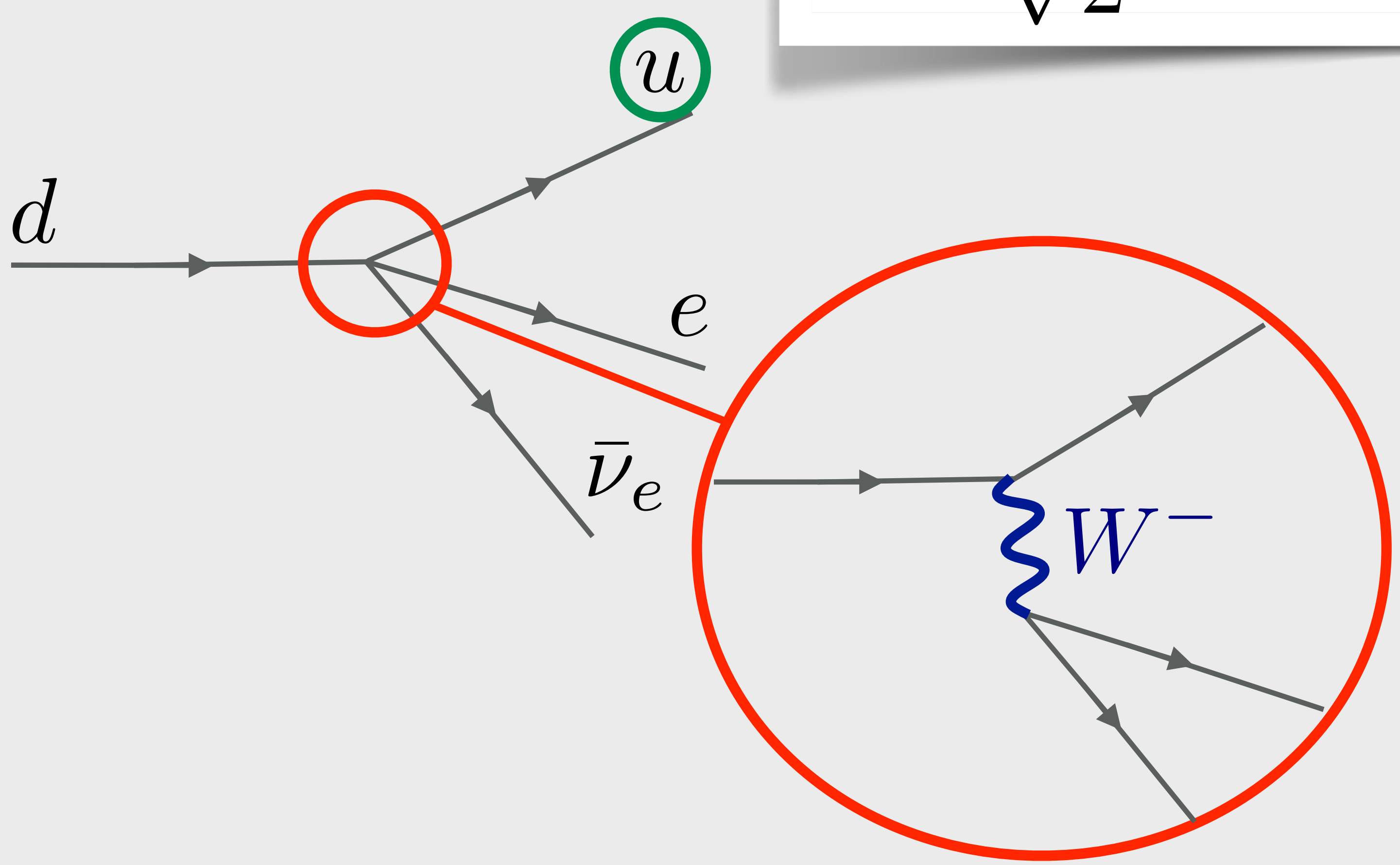


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Weakly coupled UV theory, fundamental d.o.f.s

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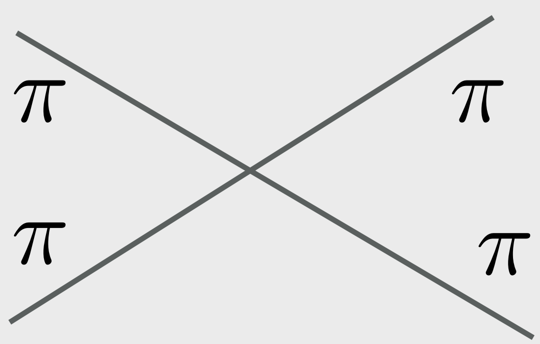

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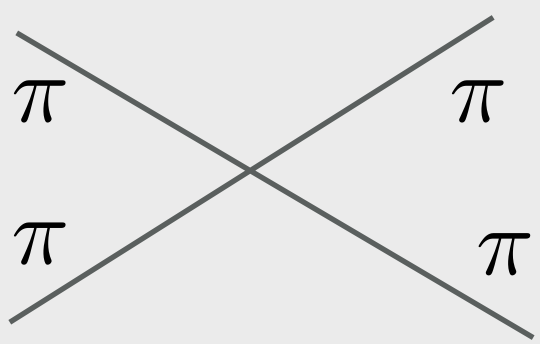

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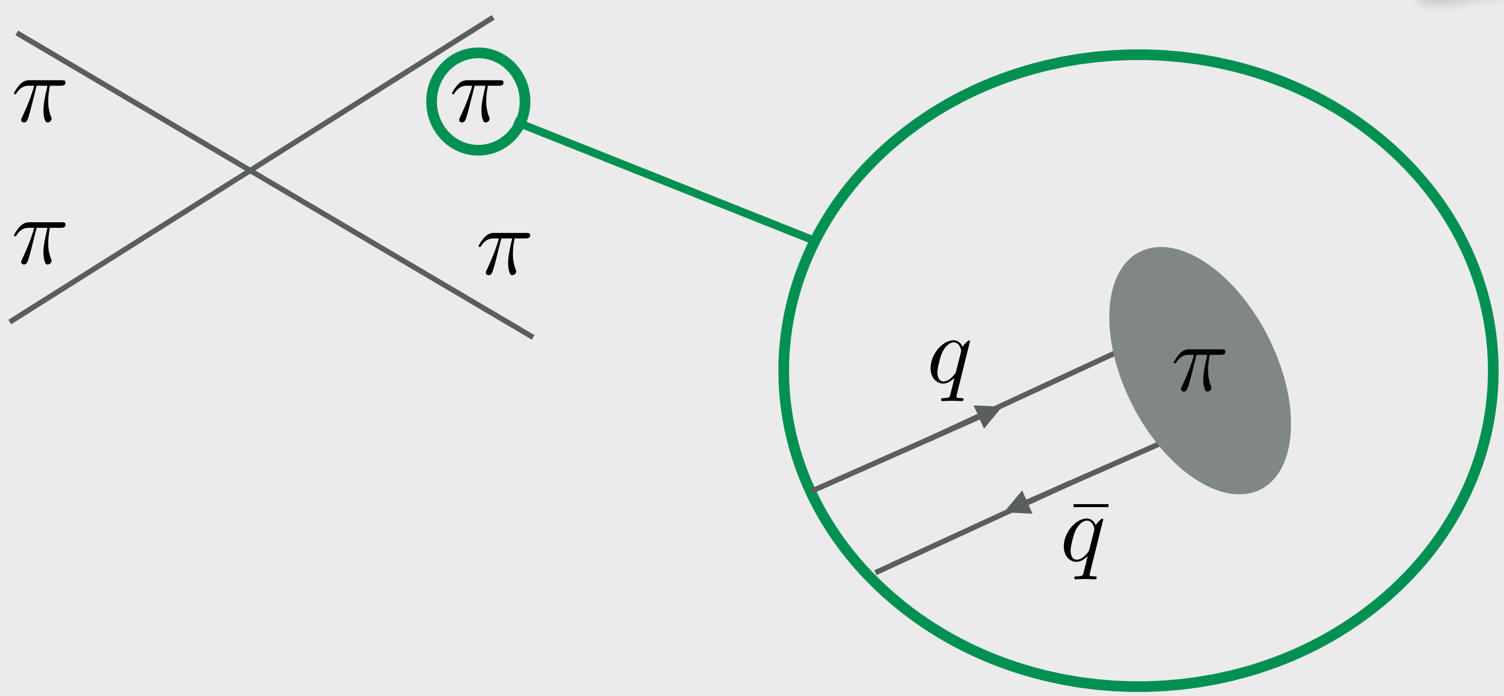


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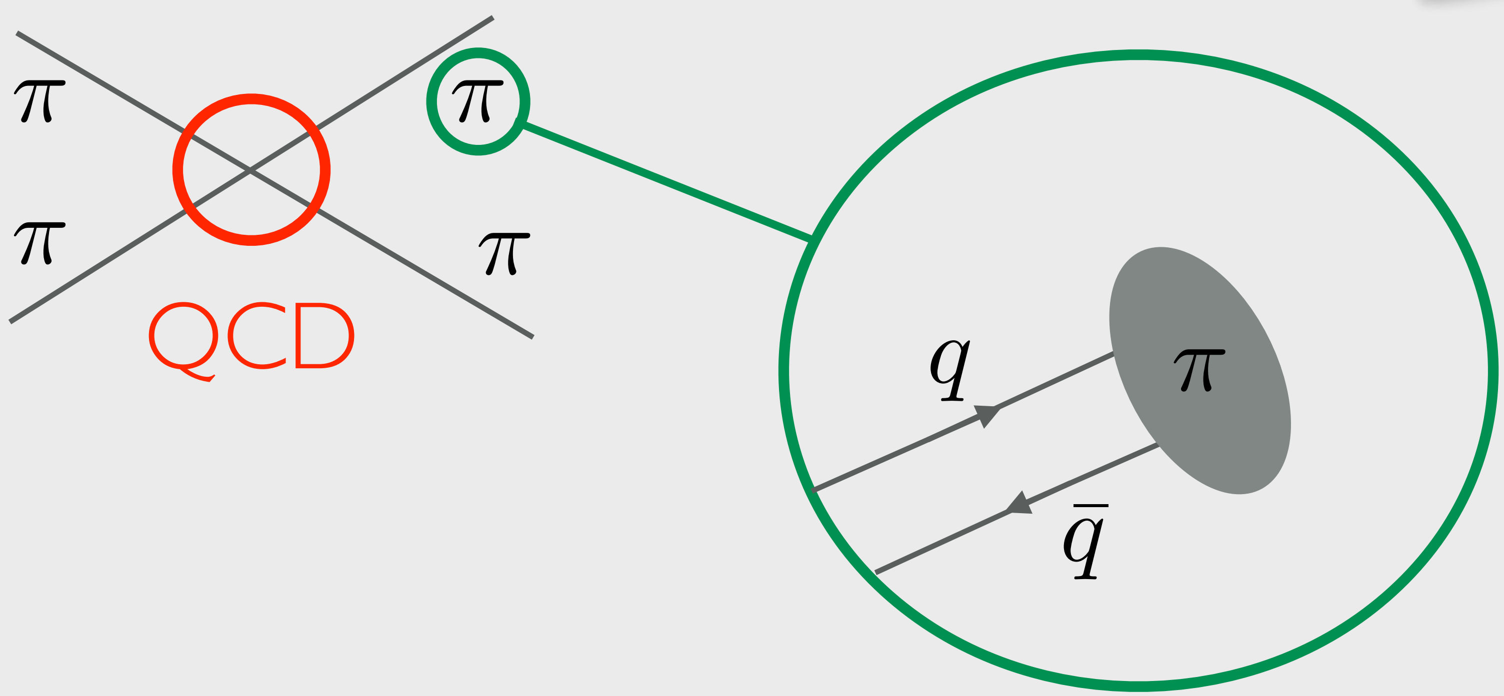


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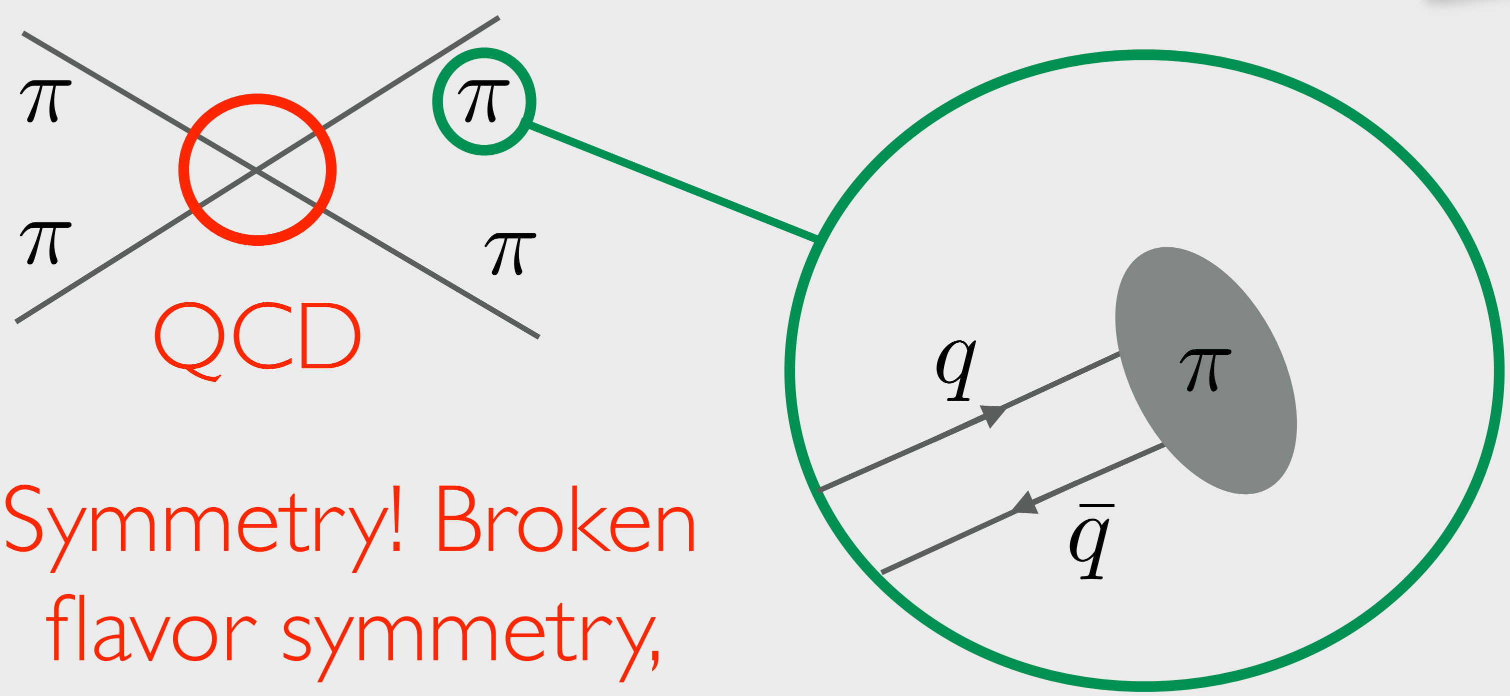


Symmetry! Broken flavor symmetry, spurions, anomalies, …

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**I. Fermi theory**
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…
Appropriate description at the appropriate scale !

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- $SU(3) \times SU(2) \times U(1)$
- $\mathcal{L} = \mathcal{L}_{\rm SM} + \sum_i \frac{c_i}{\Lambda^{d_i-4}} \mathcal{O}_i$

$$\mathcal{O}_i = C^{(1)}_{H\psi_L,ij} \overline{\psi}^i_L \gamma^\mu \psi^j_L \left( H^\dagger \overleftrightarrow{D}_\mu H \right)$$

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Ex : (classical or quantum) symmetry breaking in EFTs

**[QB/Di Luzio/Grojean/Paul/Rossia '20, '20, QB/Gendy/Grojean/Ruderman '21, '23, QB/Grojean/Kley '22]**

# Effective field theories

**Today** : two examples of recent developments in our understanding of EFTs.

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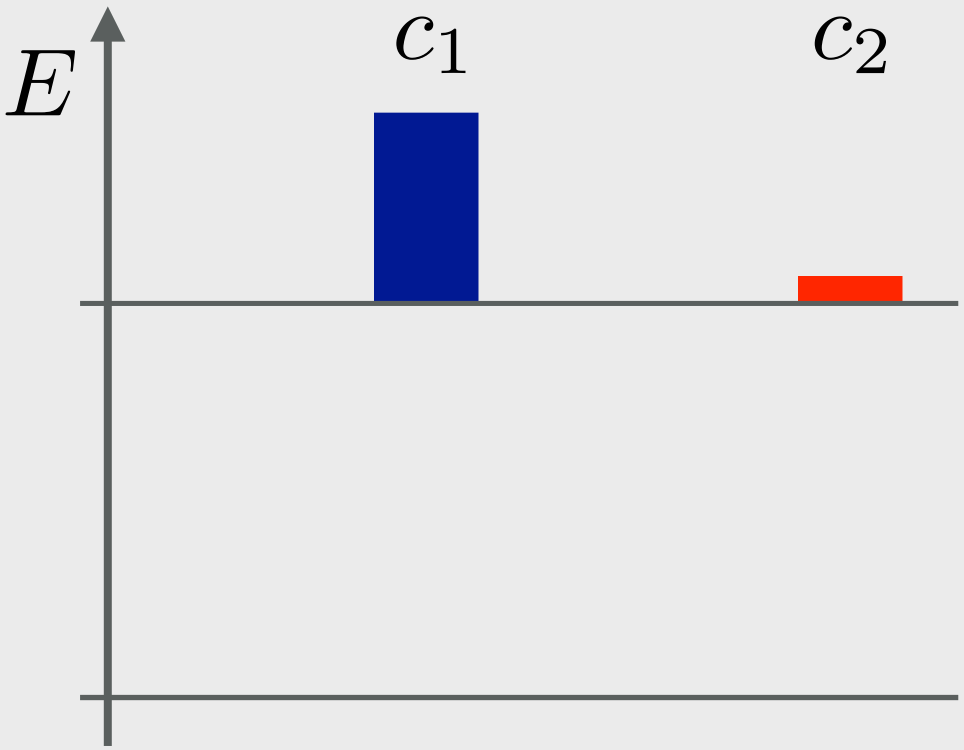


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(same symmetries)

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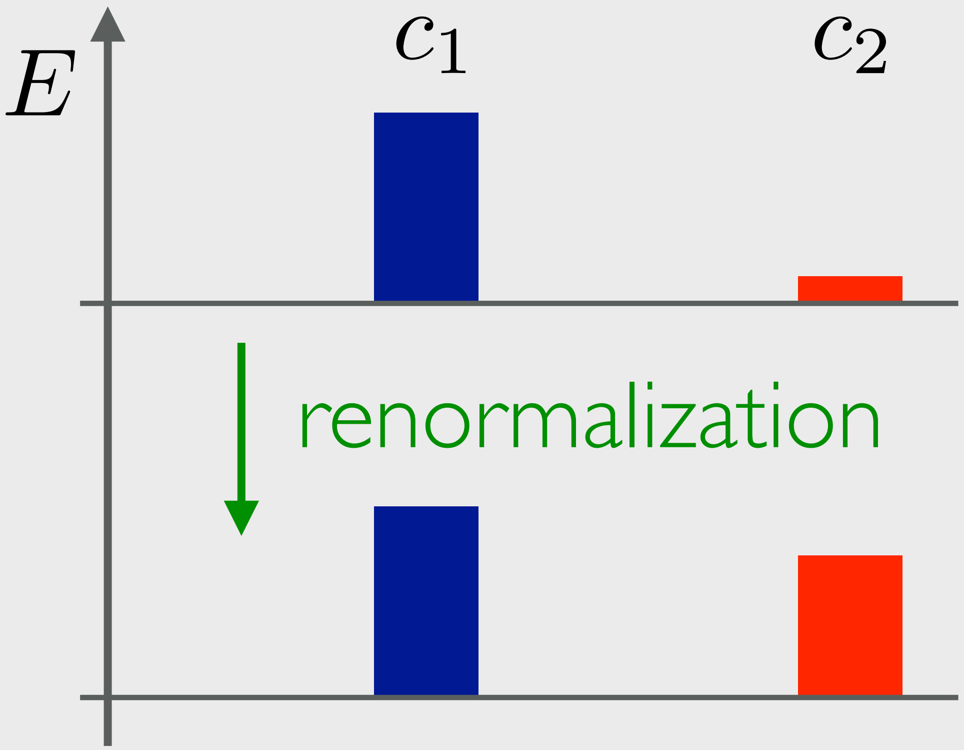


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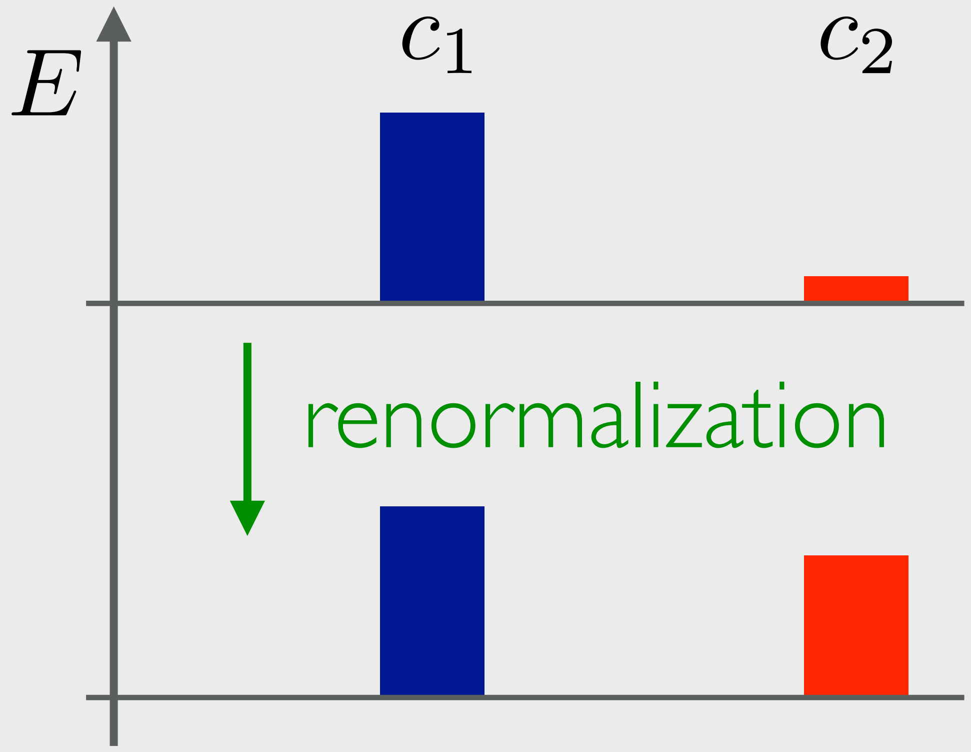


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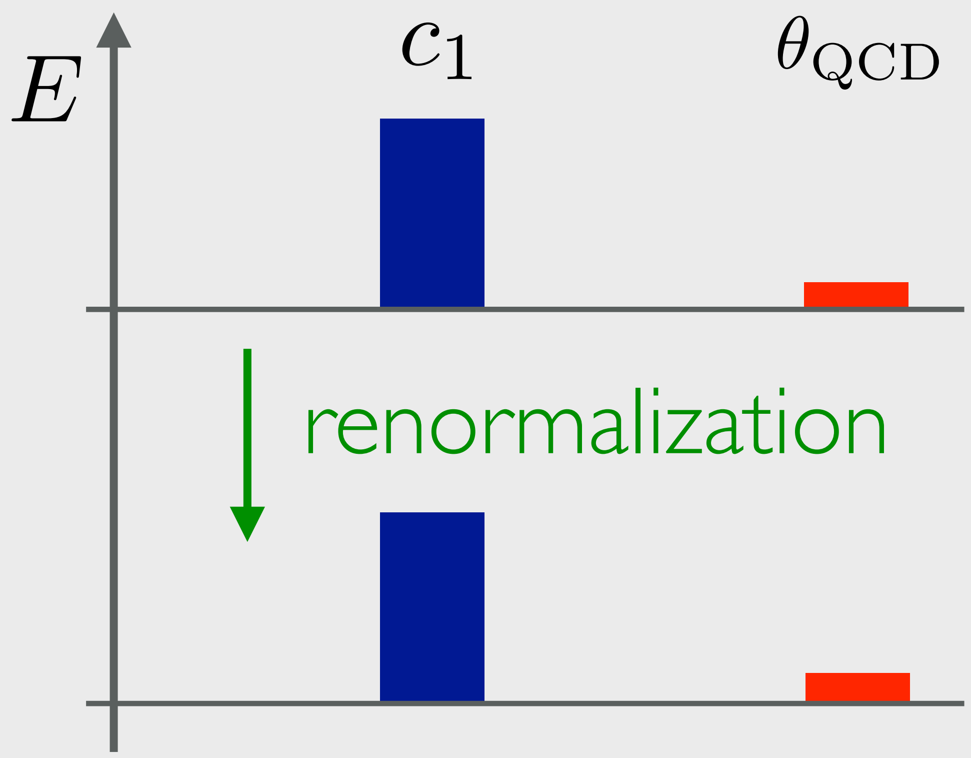


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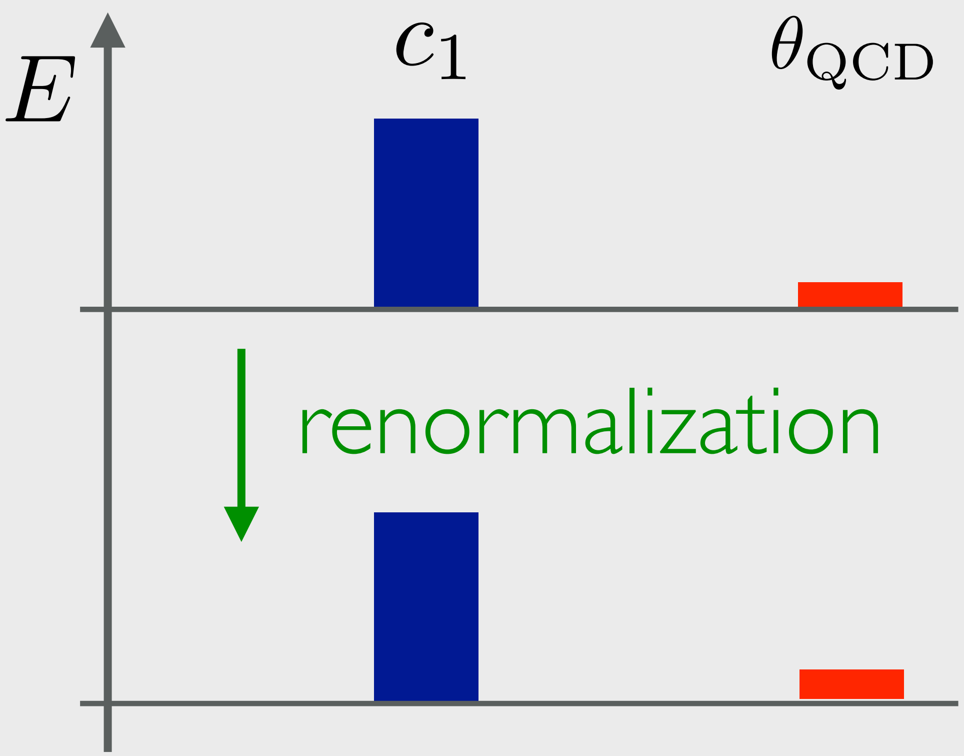


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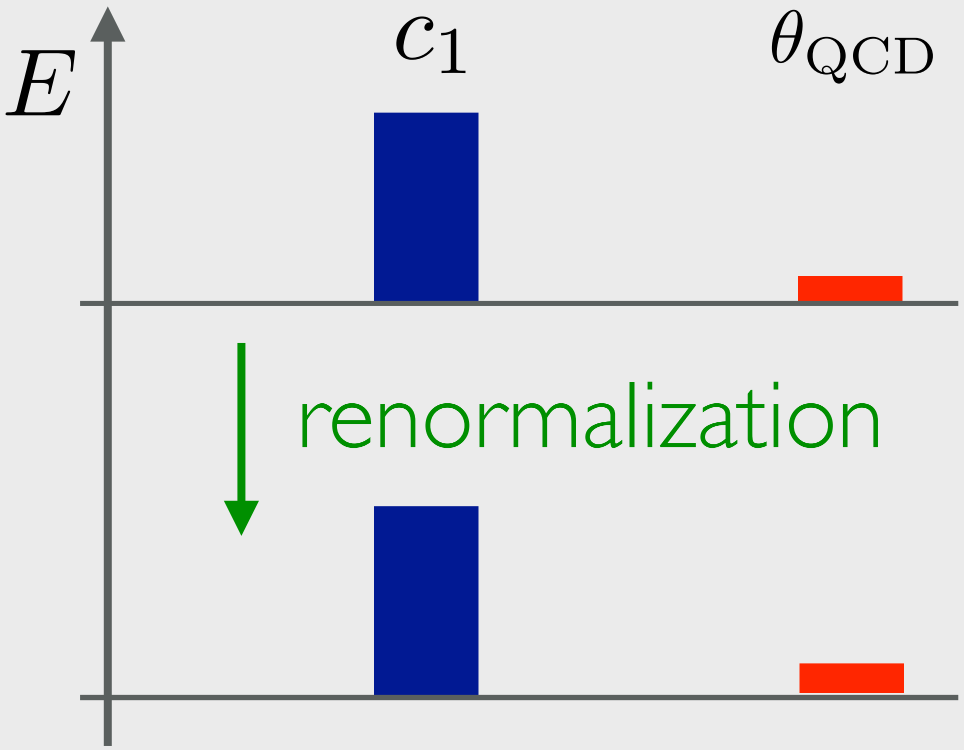


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Or **positivity bounds**.

**[QB/Hall/Manzari/Scherb '23]**

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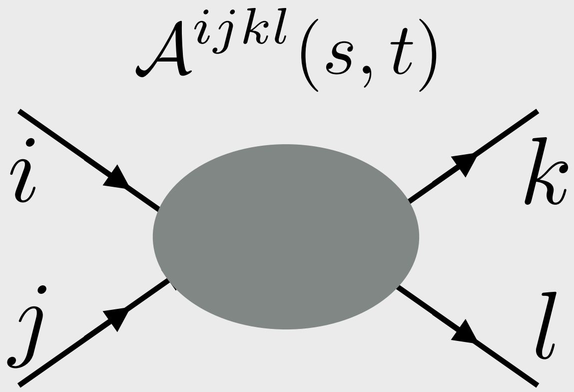

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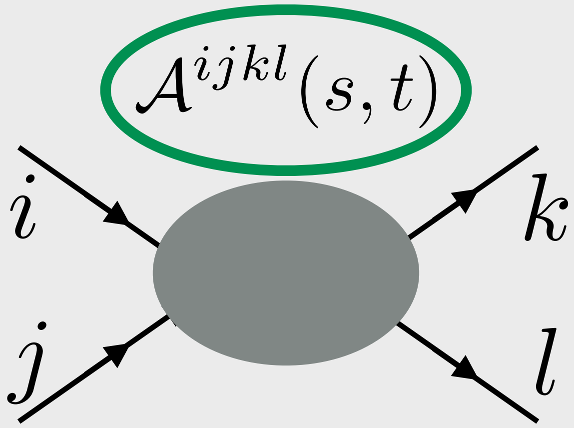


Analytic function

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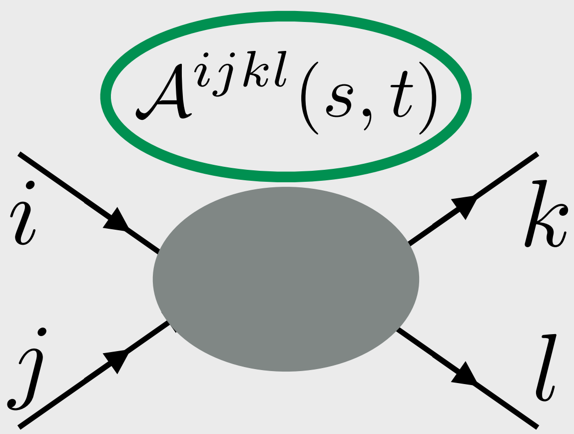


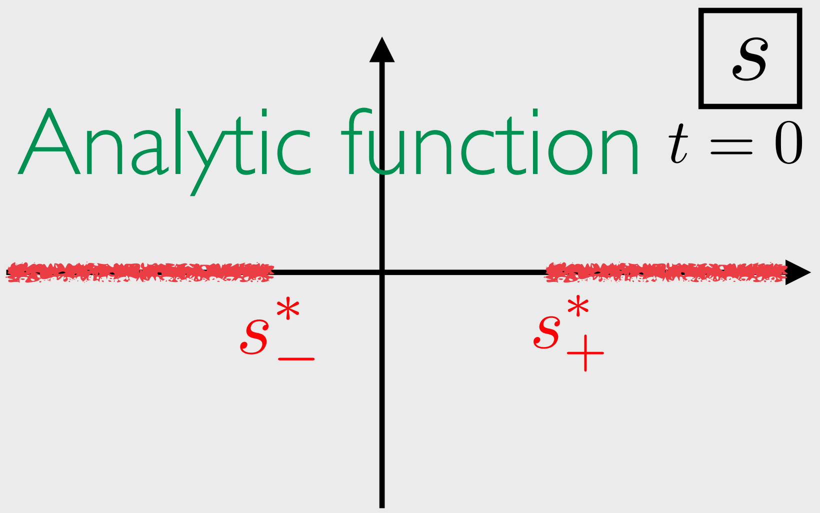

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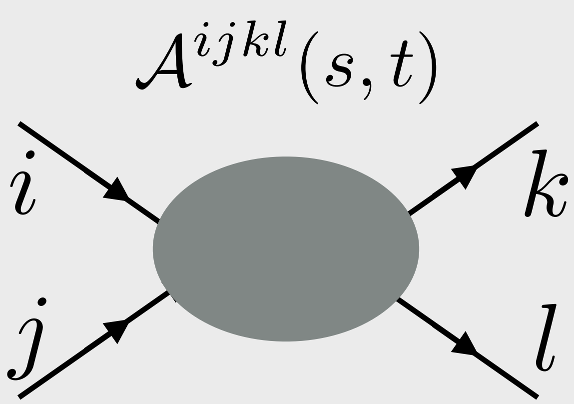


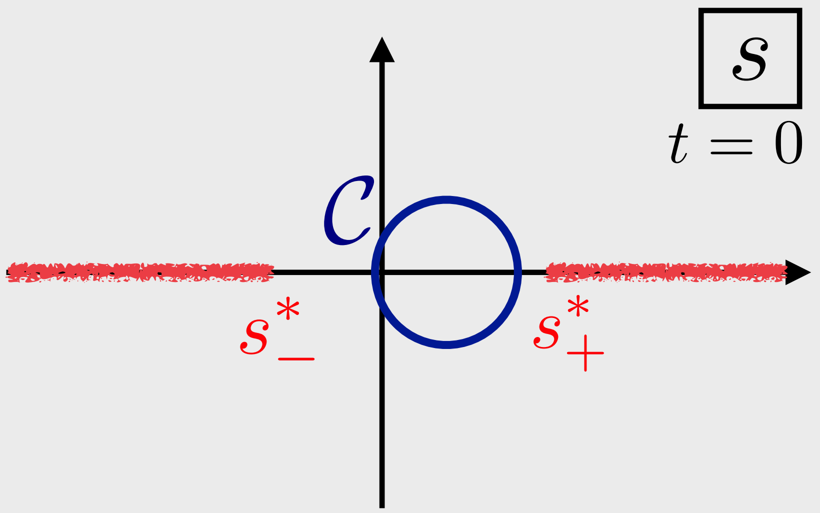

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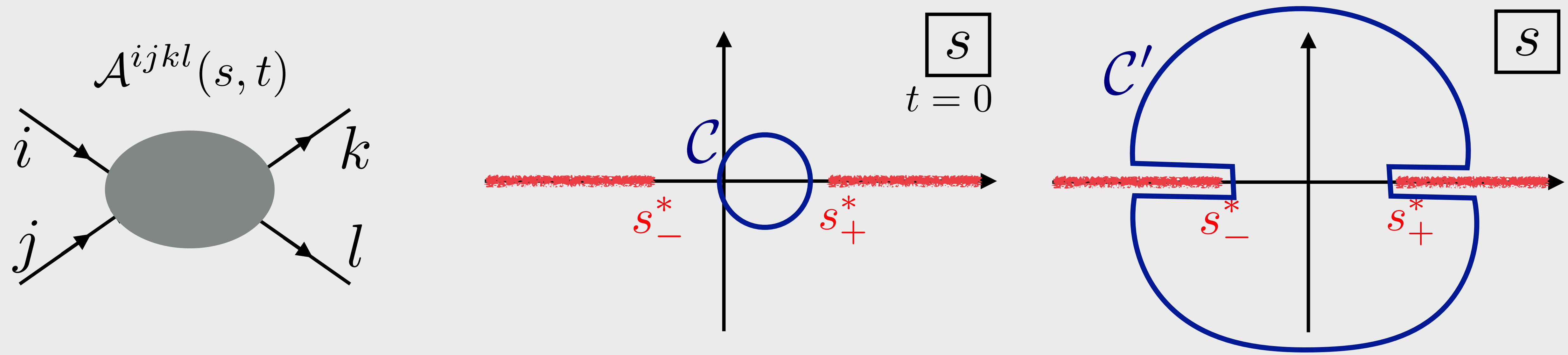

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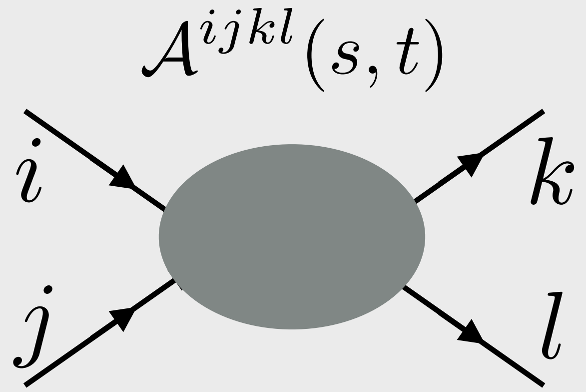


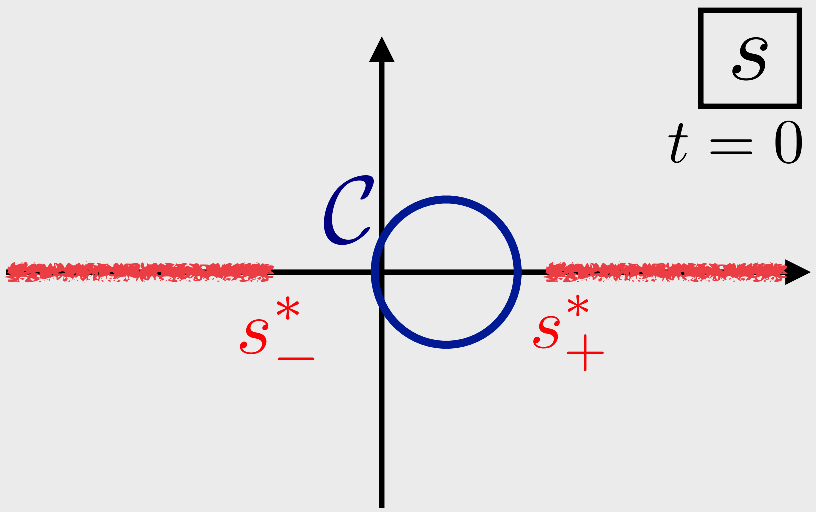


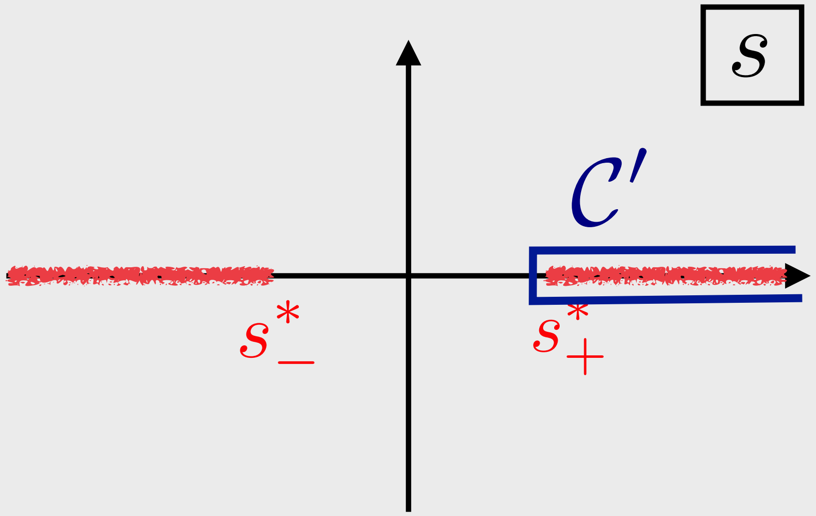

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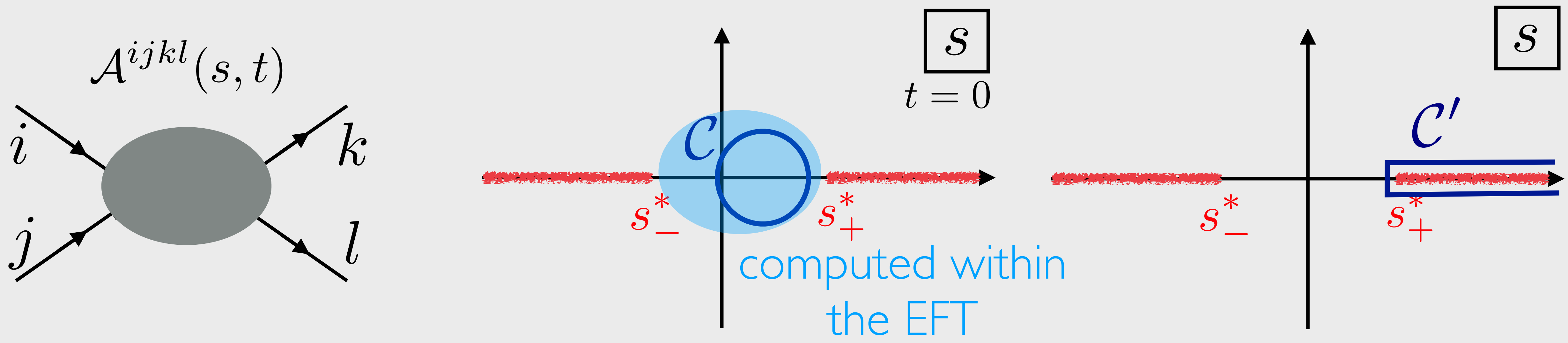

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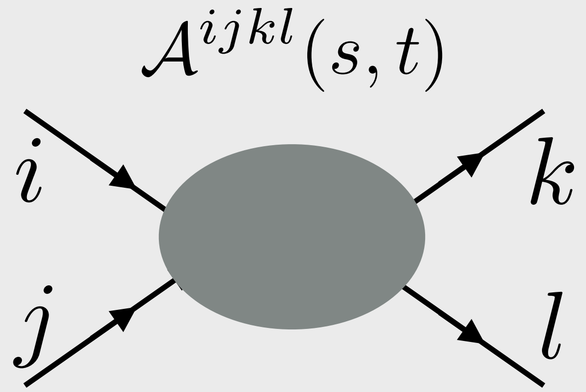


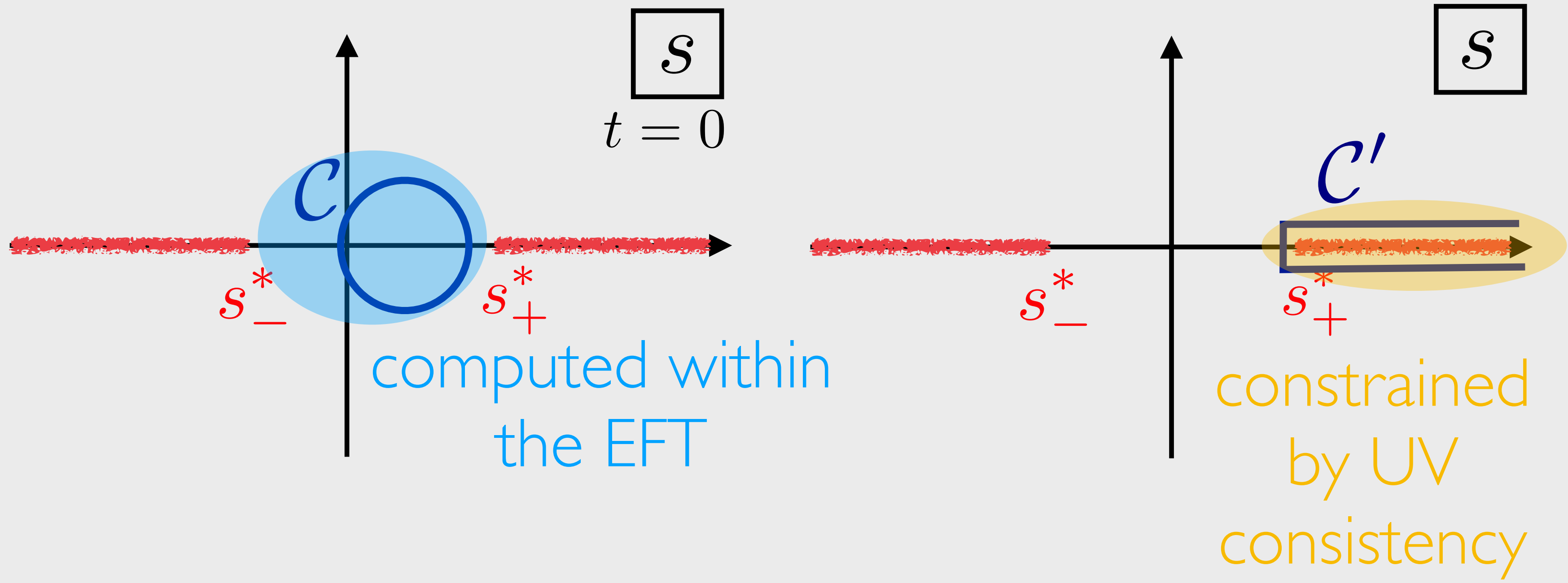

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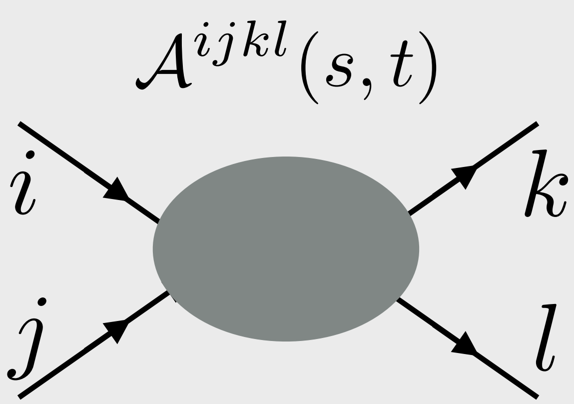


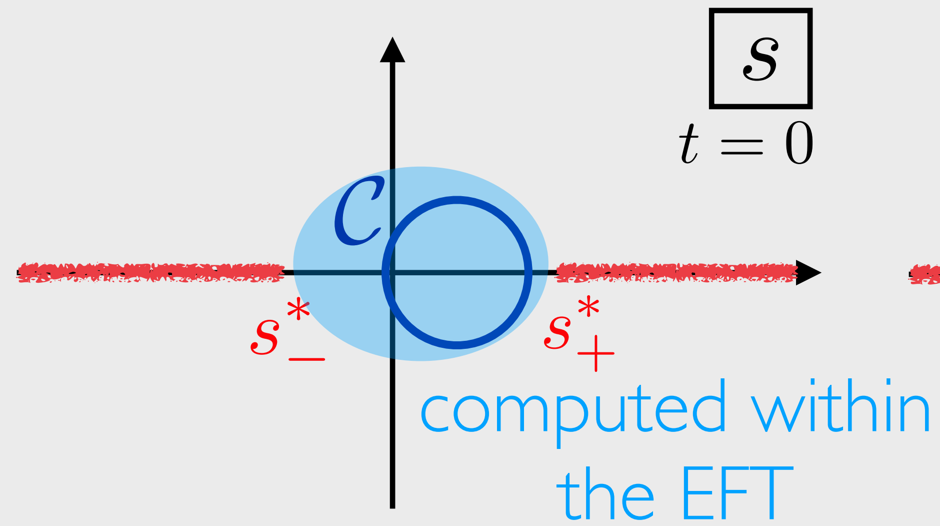


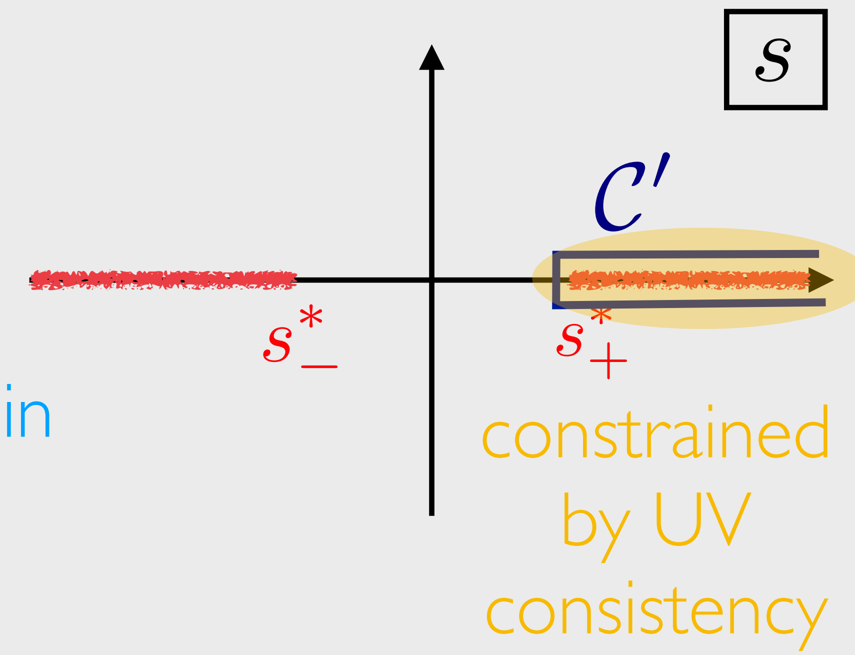


Canonical example : $\mathcal{L} \supset \frac{c}{\Lambda^4}(\partial^\mu\varphi\partial_\mu\varphi)^2$ with $c > 0$

**[Adams/Arkani-Hamed/Dubovsky/Nicolis/Rattazzi '06]**

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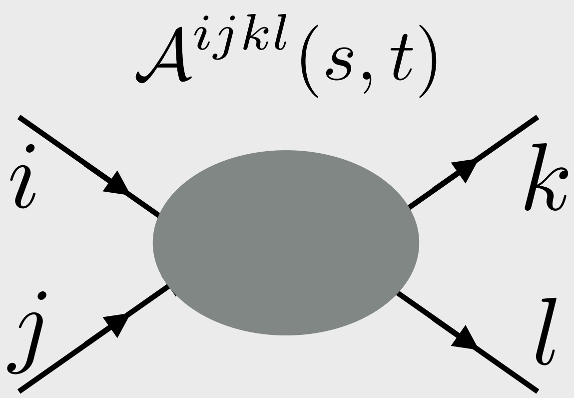


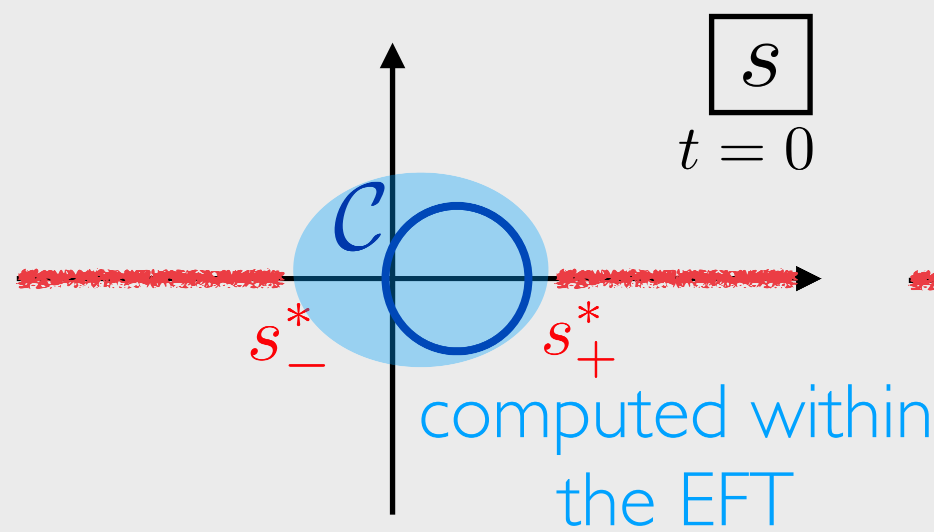


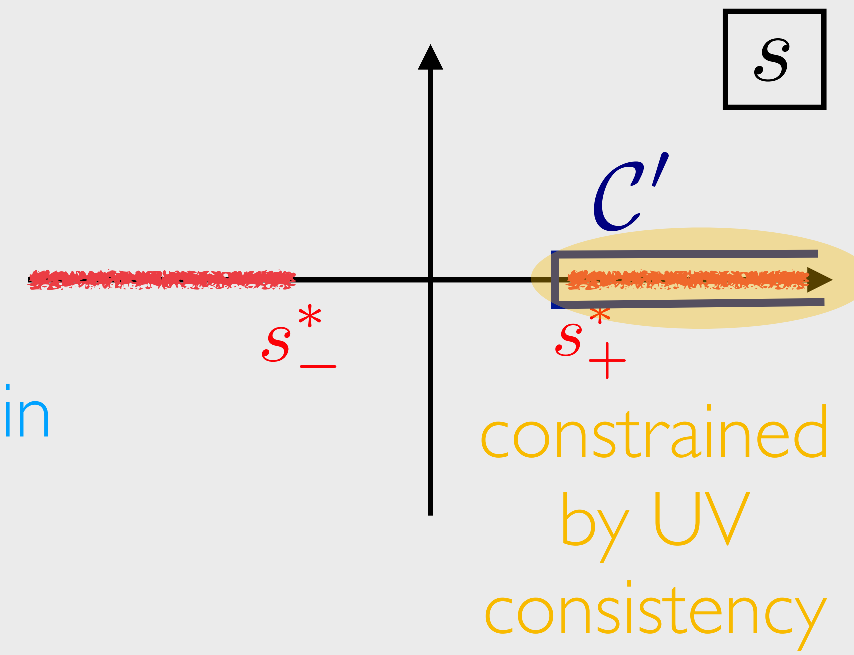


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Many more ! (at dimension 8)

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Or **non-linear supersymmetry** (SUSY).

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At low energies, full and partial multiplets, coupled to the gravitino. Use **SUSY actions with constrained superfields** !

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Reason : **positivity bounds**. For a real scalar + Goldstino, constraint $\Longrightarrow$

$$\mathcal{L} \supset f(\varphi)\partial^\mu \bar{G}\gamma^\nu G \partial_\mu\varphi\partial_\nu\varphi$$

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# Constraints from the UV : non-linear SUSY

Supersymmetry (which assembles bosons and fermions in multiplets) may be relevant somewhere at high energies… and spontaneously broken ! One prediction : a **massless Goldstino/massive gravitino**.

At low energies, full and partial multiplets, coupled to the gravitino. Use **SUSY actions with constrained superfields** !

[Rocek '78, Komargodski/Seiberg '09]

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**Do EFTs participate in these relations ?**

**[Broedel, Dixon '12, QB/Durieux/Grojean/Machado/ Roosmale Nepveu '20]**

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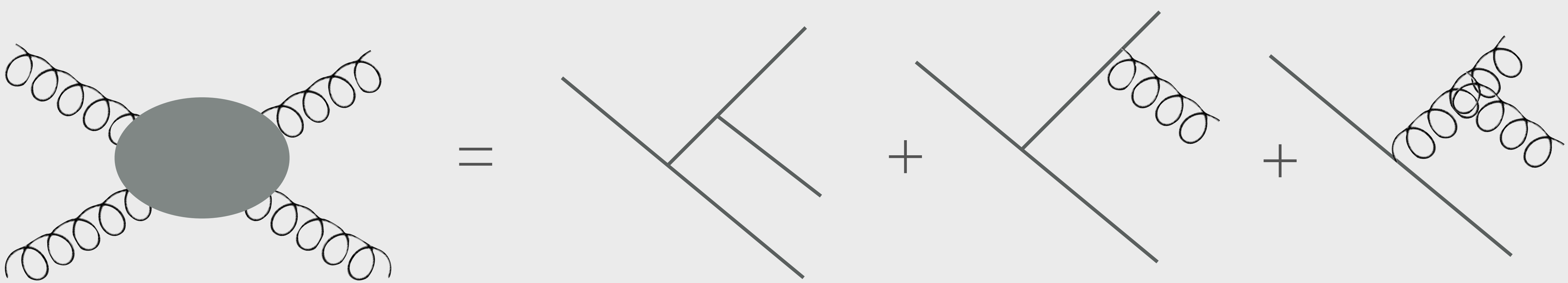

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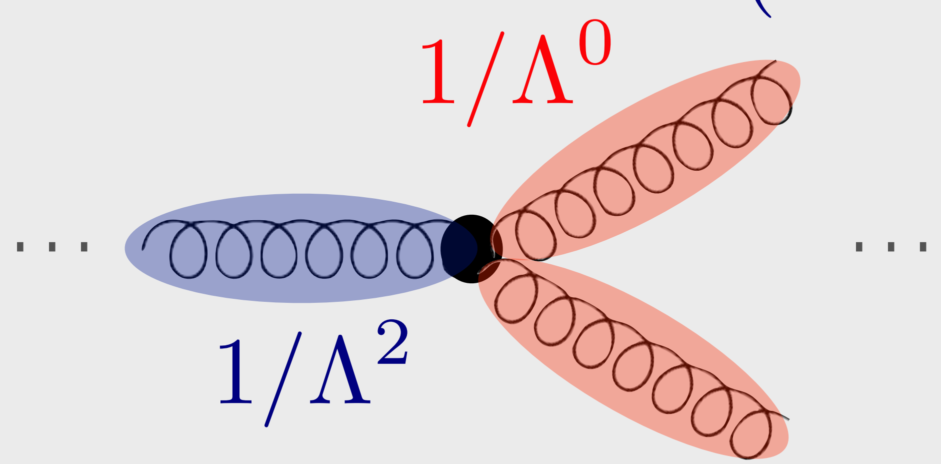

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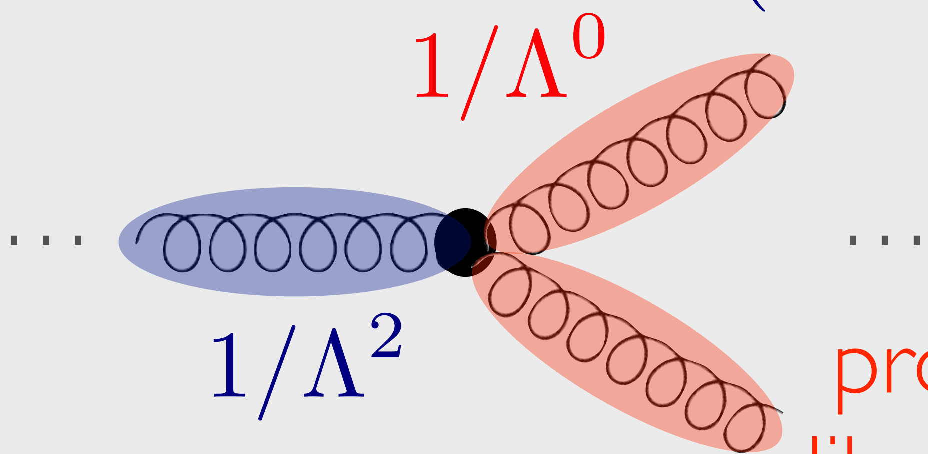


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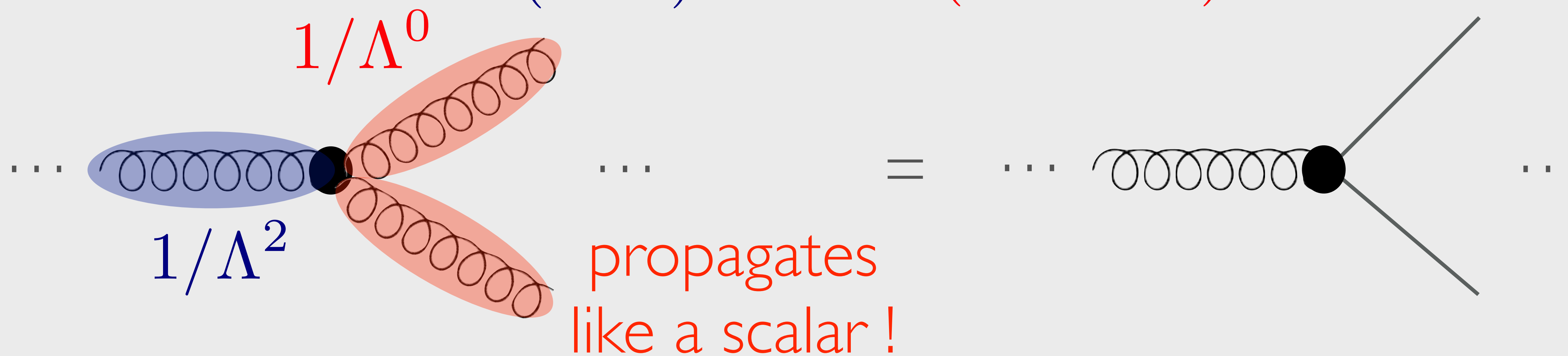

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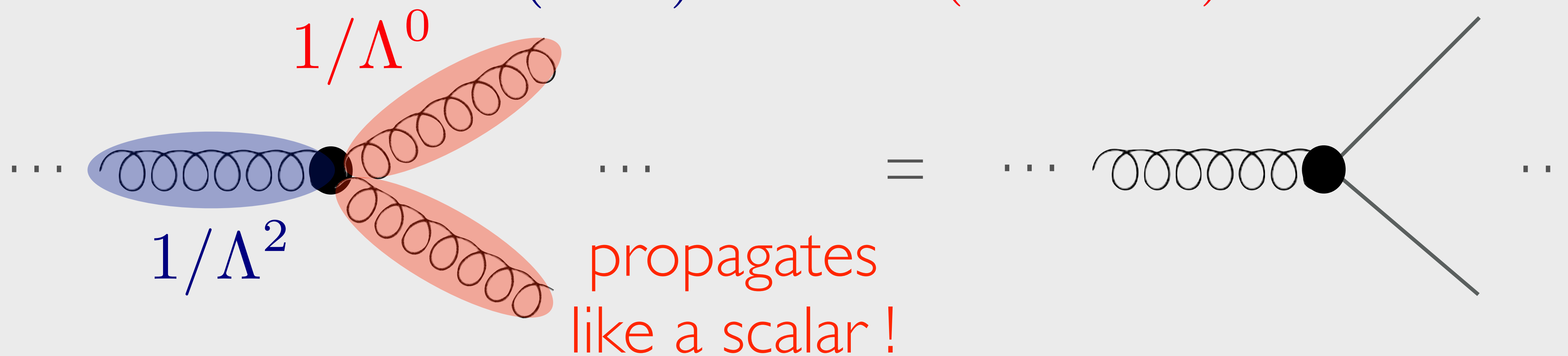


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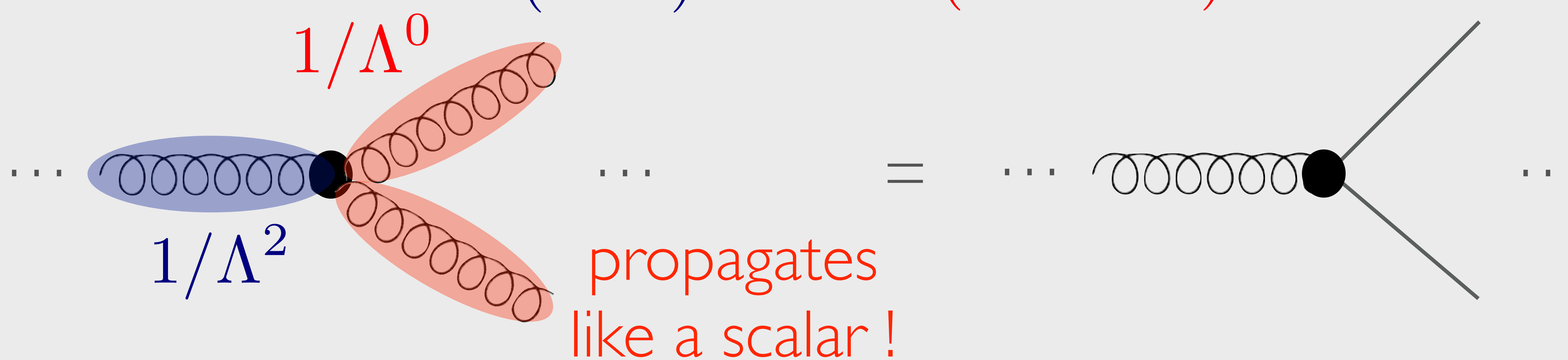


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**Gluons in EFTs behave like minimally-coupled scalars !**

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