Soft Limits of Amplitudes and Supersymmetry

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by H. Elvang, M. Hadjiantonis, C. R. T. Jones, SP

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Broad Idea

Goal: Properties of EFTs with

- Supersymmetry
- Low-energy Theorems

Example: $\mathcal{N} = 2$ $\mathbb{C}\mathrm{P}^1$ Non-Linear Sigma Model

Method: Soft subtracted recursion relations [1]

Results:

- All n-point amplitudes are construtcible at leading order
- Symmetries emerge

[1] arXiv:1509.03309, C. Cheung, K. Kampf, J. Novotny, C. Shen, J. Trnka

Construction of $\mathcal{N} = 2$ $\mathbb{C}\mathrm{P}^1$ NLSM

The most general 4-point input superamplitude at leading order in the EFT is

$$\mathcal{A}_4(1_{\Phi^+}2_{\Phi^-}3_{\Phi^+}4_{\Phi^-}) = \frac{1}{\Lambda^2}\frac{[13]}{\langle 13\rangle}\delta^{(4)}(\tilde{Q}) = \frac{1}{4\Lambda^2}\frac{[13]}{\langle 13\rangle}\prod_{a=1}^{2}\sum_{i,j=1}^{4}\langle ij\rangle\eta_{ia}\eta_{ja}.$$

$1/\langle 13\rangle \Rightarrow$ some of the component amplitudes have poles
$\Rightarrow$ non-zero 3-point interactions.

$$4 + 3\text{-point input} \xrightarrow{\text{Recursion}} \text{all } n\text{-point amplitudes}$$

Preservation of Symmetries by Recursion

- Supersymmetry
- $SU(2)_R$
- Additive conserved charges

	$U(1)_R$	$SU(2)_R$
Z	-4	$\mathbf{1}$
$\bar{Z}$	4	$\mathbf{1}$
ψ^{a+}	-1	$\mathbf{2}$
ψ_a^-	1	$\mathbf{2}$
γ^+	2	$\mathbf{1}$
γ^-	-2	$\mathbf{1}$
η_a	3	$\mathbf{2}$
Φ^+	2	$\mathbf{1}$
Φ^-	4	$\mathbf{1}$

Maximal R-symmetry group realized.

Emergent Symmetries

Use Ward identities of symmetry group A as on-shell input

$$\Downarrow$$

Find that amplitudes satisfy A and B Ward identities

$$\Downarrow$$

B is an emergent symmetry

Emergent symmetries in $\mathcal{N} = 2$ $\mathbb{C}\mathrm{P}^1$ NLSM:

- $SU(2)_R$
- Electric-Magnetic duality, i.e. vectors have chiral charge