Based on collaboration with **Massimo Taronna** [arXiv:1311.0242]

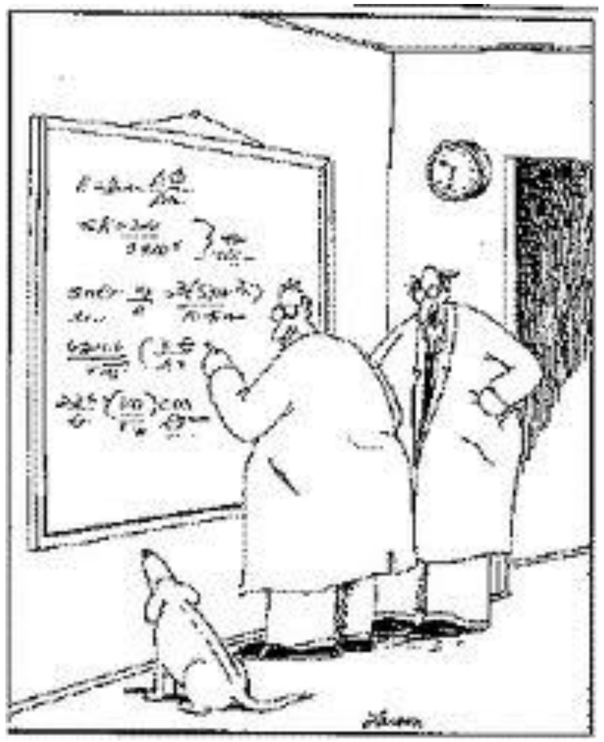
CUBIC-INTERACTION INDUCED DEFORMATIONS HIGHER-SPIN SYMMETRY

Euihun JOUNG

Laboratory APC, Univ. Paris 7

Field theories describing massless HS ?

- massless spin **1** ➜ **Gauge theory** (internal symmetry)
- massless spin **2** ➜ **Gravity** (isometry)
- massless spin **s** ➜ ?? **Unbroken symmetry of ST ?**



Recent Intro. / Review :

[0503128] (Vasiliev eq.)

[1007.0435] (General review)

[1112.4285] (ST aspect)

AdS/CFT

<u>Review :</u> [1208.4036], [1208.5182]

- 3d Vector O(N)
- W_N minimal model

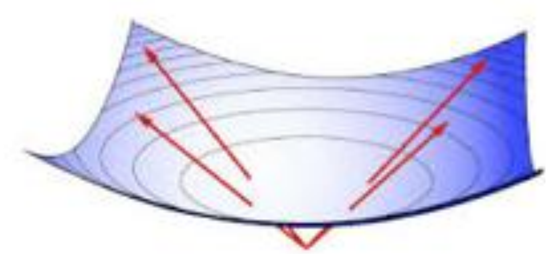
- Vasiliev eq. in AdS_4
- PV eq. in AdS_3

Free theory: possible (up to a few subtleties)

But, HS interactions do not work, ~~maybe~~ in flat space

- No long-range force by HS [Weinberg '64]
- No gravitational coupling for HS [Aragone-Deser '79]

HS interactions DO work in (A)dS



- Gravitational coupling for HS (cubic) [Fradkin-Vasiliev '87]
- Equations for HS (full order) [Vasiliev '90]

Vasiliev's equations

- à la Cartan (ex. Gravity : gauge the isometry algebra)
- HS algebra : HS generalization of the isometry algebra
- "Gauge theory of HS algebra"

Constructive approach (bottom-up)

- Free theory of HS $S^{(2)}$
- Order-by-order construction of interacting vertices $S^{(3)},\ S^{(4)},\ \ldots$
- AdS/CFT and CFT bootstrap program

Constructive approach:

Cubic interactions & HS symmetries

- ✓ General procedure for interacting actions of HS

> Give me field contents,
> I will see which (interacting) theories are possible.

- ✓ Cubic interactions $S^{(3)}$ (only result)

- ✓ Deformations of HS symmetries induced by $S^{(3)}$
- ✓ HS algebras from $S^{(3)}$

- ✓ 'HS algebras' associated with classical Lie algebras

talk of K. Mkrtchyan (two weeks ago)

(also partially-massless
and massive fields
but not in this talk)

Give me field contents,

massless spin s

$$S^{(2)}[\phi_1, \phi_2, \dots] = S^{(2)}[\phi_1] + S^{(2)}[\phi_2] + \cdots$$

gauge sym. : $\delta^{(0)} S^{(2)} = 0$ under $\delta^{(0)} \phi = \partial\, \varepsilon$

I will see which (interacting) theories are possible.

PERTURBATIVE EXPANSION

$$S = S^{(2)} + S^{(3)} + S^{(4)} + \cdots$$

$$\delta\, S = 0 \quad \text{under} \quad \delta\phi = \delta^{(0)}\phi + \delta^{(1)}\phi + \delta^{(2)}\phi + \cdots$$

$$\boxed{\delta^{(0)} S^{(n)} + \cdots + \delta^{(n-1)} S^{(2)} = 0}$$

solve one by one from n=3

More precisely, CUBIC interactions:

$$\delta^{(0)} S^{(3)} \approx 0$$

$$S^{(3)} \quad \Rightarrow \quad \delta^{(1)}_{\varepsilon} \phi \quad \Rightarrow \quad [\![\varepsilon_1 , \varepsilon_2]\!]^{(0)}$$

cubic interactions → deformation of gauge transformation → deformation of gauge algebra

Gauge Algebra

$$\delta_{[\varepsilon_1} \delta_{\varepsilon_2]} \phi = \delta_{[\![\varepsilon_1 , \varepsilon_2]\!]} \phi \text{ + (trivial sym.)}$$

field-dependent bracket !

$$[\![\, , \,]\!] = [\![\, , \,]\!]^{(0)} + [\![\, , \,]\!]^{(1)} + [\![\, , \,]\!]^{(2)} + \cdots$$

$$\boxed{\delta^{(0)}_{[\varepsilon_1} \delta^{(1)}_{\varepsilon_2]} \phi = \delta^{(0)}_{[\![\varepsilon_1 , \varepsilon_2]\!]^{(0)}} \phi}$$

To Do List

massless fields of arbi. spin

✓ For given ϕ_1, ϕ_2, ϕ_3 in (A)dS,
find all possible $S^{(3)}[\phi_1, \phi_2, \phi_3]$

To determine $S^{(3)}$,
we don't need the entire field content,
but only the three fields

✓ For each of $S^{(3)}[\phi_1, \phi_2, \phi_3]$
find the corresponding **deformation** of

- gauge transformation $\delta^{(1)}_{\varepsilon_i} \phi_j$
- gauge algebra $[\![\, \varepsilon_i \,,\, \varepsilon_j \,]\!]^{(0)}$

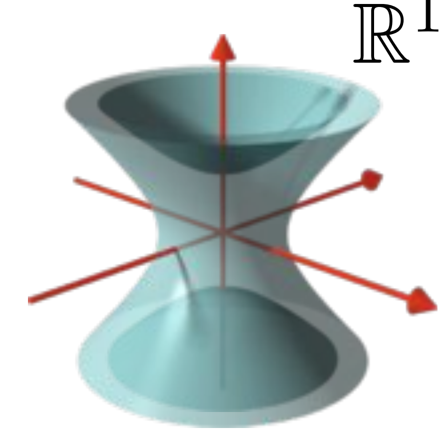
$i, j = 1, 2, 3$

✓ Explore their consequences (ex. global symmetry)

Technical Difficulties

- Handle arbitrary number of indices
- (A)dS covariant derivatives

Key Ideas/Technics



- Proper adaptation of ambient-space (or embedding) approach

$$\varphi_{\mu_1\cdots\mu_s}(x) \quad \Longleftrightarrow \quad \Phi_{M_1\cdots M_s}(X)$$

- Auxiliary variables: similar to string oscillators

$$\Phi(X,U)$$

interactions: operators ∝ $\partial_{X_i}, \partial_{U_i}$

- **Step-by-step** construction

1) Transverse and Traceless part

~~2) The rest (unphysical part)~~

(Old and New)

RESULTS

What was known before (incomplete list):

Flat, Metric-like

- All 4d vertices in light-cone [Brink, 2xBengtsson]
- All any d vertices in light-cone [Metsaev]
- Identification of gauge-algebra deformation [Bekaert, Boulanger, Lerclerq]
- All vertices in covariant form [Manvelyan, Mkrtchyan, Ruehl; Sagnotti, Taronna]
- All vertices in BRST form [Fotopoulos, Tsulaia; Metsaev]

Strict (A)dS, Frame-like

- All 4d vertices [Fradkin, Vasiliev]
- All any d non-Abelian vertices [Vasiliev]

SKIP TECHNICAL DETAILS

CUBIC INTERACTIONS

the most general form up to integration by part and field redefinition

$$S^{(3)}[\Phi_1,\Phi_2,\Phi_3] \overset{\rm TT}{=} \int_{\rm (A)dS} C(Y,Z)\,\Phi_1(X_1,U_1)\;\Phi_2(X_2,U_2)\;\Phi_3(X_3,U_3)\,\Big|_{\substack{X_i=X\\U_i=0}}$$

$$Y_i := \partial_{U_i}\cdot\partial_{X_{i+1}}\,,\qquad Z_i := \partial_{U_{i+1}}\cdot\partial_{U_{i-1}}\qquad [i\simeq i+3]$$

general solution to the condition $\delta^{(0)}S^{(3)}\approx 0$

$$C(Y,Z) = \boxed{e^{\lambda\left(Z_1\partial_{Y_2}\partial_{Y_3}+Z_1Z_2\partial_{Y_3}\partial_G+\text{cyc.}+Z_1Z_2Z_3\partial_G^2\right)}}\,K(Y,G)\,\Big|_{G=Y_iZ_i}$$

$$c_{\Delta,n} = (d+\Delta-1)(d+\Delta-3)\cdots(d+\Delta-2n+1)$$

- (A)dS effect. $\int_{\rm (A)dS}\boldsymbol{\lambda^n}\,I_\Delta = \boldsymbol{c_{\Delta,n}\,\Lambda^n}\int_{\rm (A)dS} I_\Delta$

- Coupling Fn. $K(Y,G) = \sum_{n=0}^{s_{\min}} k_n\,\underbrace{Y_1^{s_1-n}\,Y_2^{s_2-n}\,Y_3^{s_3-n}\,G^n}_{\#\text{ of derivatives : } s_1+s_2+s_3-2n}$

coupling cnst.

Examples

$\boxed{2-2-2}$

$$K = k_0 \underbrace{Y_1^2\, Y_2^2\, Y_3^2}_{R^{\mu\nu}{}_{\rho\sigma}\, R^{\rho\sigma}{}_{\lambda\kappa}\, R^{\lambda\kappa}{}_{\mu\nu}} + k_1 \underbrace{Y_1\, Y_2\, Y_3\, G}_{R^{\mu\nu}{}_{\rho\sigma}\, R^{\rho\sigma}{}_{\mu\nu}} + k_2 \underbrace{G^2}_{R}$$

GR

$\boxed{1-1-1}$

$$K = k_0 \underbrace{Y_1\, Y_2\, Y_3}_{\mathrm{tr}[F^{\mu}{}_{\nu}\, F^{\nu}{}_{\rho}\, F^{\rho}{}_{\mu}]} + k_1 \underbrace{G}_{\mathrm{tr}[F^{\mu}{}_{\nu}\, F^{\nu}{}_{\mu}]}$$

YM

$\boxed{2-1-1}$

$$K = k_0 \underbrace{Y_1^2\, Y_2\, Y_3}_{R^{\mu\nu\rho\sigma}\, F_{\mu\nu}\, F_{\rho\sigma}} + k_1 \underbrace{Y_1\, G}_{g^{\mu\nu}\, g^{\rho\sigma}\, F_{\mu\rho}\, F_{\nu\sigma}}$$

Gravitational interaction

CUBIC INTERACTIONS

the most general form up to integration by part and field redefinition

$$S^{(3)}[\Phi_1,\Phi_2,\Phi_3] \overset{\mathrm{TT}}{=} \int_{\mathrm{(A)dS}} C(Y,Z)\,\Phi_1(X_1,U_1)\ \Phi_2(X_2,U_2)\ \Phi_3(X_3,U_3)\,\Big|_{\substack{X_i=X\\ U_i=0}}$$

$$Y_i := \partial_{U_i}\cdot\partial_{X_{i+1}}\,, \qquad Z_i := \partial_{U_{i+1}}\cdot\partial_{U_{i-1}} \qquad [i\simeq i+3]$$

general solution to the condition $\delta^{(0)}S^{(3)}\approx 0$

$$C(Y,Z) = e^{\lambda\left(Z_1\partial_{Y_2}\partial_{Y_3}+Z_1Z_2\partial_{Y_3}\partial_G+\mathrm{cyc.}+Z_1Z_2Z_3\partial_G^2\right)}K(Y,G)\,\Big|_{G=Y_iZ_i}$$

- **Coupling Fn.** $K(Y,G) = \sum_{n=0}^{s_{\min}} k_n\ Y_1^{s_1-n}\,Y_2^{s_2-n}\,Y_3^{s_3-n}\,G^n$

DEFORMATIONS

gauge transformation deformations $\delta^{(1)}$

$$\delta^{(1)}_{E_1}\Phi_3(X,U) \overset{\mathrm{TT}}{=} -\frac{1}{2}\,\Pi_\Phi\,\partial_{Y_1}\bar{C}(Y,Z)\,E_1(X_1,U_1)\,\Phi_2(X_2,U_2)\Big|_{\substack{X_i=X\\ U_i=0}}$$

+ field redefinition !

gauge algebra (bracket) deformations $[\![\ ,\ ]\!]^{(0)}$

$$[\![\,E_1\,,E_2\,]\!]^{(0)} \overset{\mathrm{TT}}{=} \frac{1}{4}\,\Pi_E\,(\partial_{Y_1}\partial_{Z_1}+\partial_{Y_2}\partial_{Z_2})\bar{C}(Y,Z)\,E_1\,E_2\Big|$$

+ parameter redefinition !

$$\boxed{\bar{C}(Y,Z)=e^{\lambda\left(Z_1\partial_{Y_2}+Z_2\partial_{Y_1}+Z_1Z_2\partial_G\right)\partial_{Y_3}}K(Y,G)\Big|_{G=Y_i\,Z_i}}$$

The redefintions exists such that

$$\delta^{(1)}_{E_i}=0 \quad \text{and/or} \quad [\![\,E_i\,,E_j\,]\!]^{(0)}=0\ ?$$

RESULT :

CLASSIFICATION OF CUBIC INTERACTIONS

DEFORMATIONS

- Four different classes of couplings for a given $s_1 - s_2 - s_3$ interaction
- Depending on spins, certain classes can be empty

	$\#\partial$	$\delta^{(1)}_{E_1}$	$\delta^{(1)}_{E_2}$	$\delta^{(1)}_{E_3}$
Class I	$s_1+s_2+s_3$	$=0$	$=0$	$=0$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_1$	$=0$	$\vdots$	$\vdots$
Class II	$\vdots$	$\neq 0$	$\vdots$	$\vdots$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_2$	$\vdots$	$=0$	$=0$
Class III	$\vdots$	$\vdots$	$\neq 0$	Λ
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2s_3$	$\vdots$	$\vdots$	Λ
Class IV	$\vdots$	$\vdots$	$\vdots$	$\neq 0$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$s_1+s_2-s_3$	$\neq 0$	$\neq 0$	$\neq 0$

$$s_1 \geq s_2 \geq s_3$$

CLASS I

	$\#_\partial$	$\delta^{(1)}_{E_1}$	$\delta^{(1)}_{E_2}$	$\delta^{(1)}_{E_3}$
	$s_1+s_2+s_3$	$=0$	$=0$	$=0$
Class I	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_1$	$=0$	$\vdots$	$\vdots$
	$\vdots$	$\neq 0$	$\vdots$	$\vdots$
Class II	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_2$	$\vdots$	$=0$	$=0$
	$\vdots$	$\vdots$	$\neq 0$	Λ
Class III	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2s_3$	$\vdots$	$\vdots$	Λ
	$\vdots$	$\vdots$	$\vdots$	$\neq 0$
Class IV	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$s_1+s_2-s_3$	$\neq 0$	$\neq 0$	$\neq 0$

$s_1 \geq s_2 \geq s_3$

- Non-deforming $\delta^{(1)}_{E_i} = 0$ Abelian couplings
- Expressible in terms of **any two** curvatures
  - R_1 and R_2
  - R_1 and R_3
  - R_2 and R_3

CLASS IV

	$\#_\partial$	$\delta^{(1)}_{E_1}$	$\delta^{(1)}_{E_2}$	$\delta^{(1)}_{E_3}$
	$s_1+s_2+s_3$	$=0$	$=0$	$=0$
Class I	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_1$	$=0$	$\vdots$	$\vdots$
	$\vdots$	$\neq 0$	$\vdots$	$\vdots$
Class II	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_2$	$\vdots$	$=0$	$=0$
	$\vdots$	$\vdots$	$\neq 0$	Λ
Class III	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2s_3$	$\vdots$	$\vdots$	Λ
	$\vdots$	$\vdots$	$\vdots$	$\neq 0$
Class IV	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$s_1+s_2-s_3$	$\neq 0$	$\neq 0$	$\neq 0$

- Non-Abelian couplings $\delta^{(1)}_{E_i} \neq 0$

$$[\![\, E_i \,,\, E_j \,]\!]^{(0)} \neq 0$$

CLASS II

	$\#_\partial$	$\delta^{(1)}_{E_1}$	$\delta^{(1)}_{E_2}$	$\delta^{(1)}_{E_3}$
Class I	$s_1+s_2+s_3$	$=0$	$=0$	$=0$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_1$	$=0$	$\vdots$	$\vdots$
Class II	$\vdots$	$\neq 0$	$\vdots$	$\vdots$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_2$	$\vdots$	$=0$	$=0$
Class III	$\vdots$	$\vdots$	$\neq 0$	Λ
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2s_3$	$\vdots$	$\vdots$	Λ
Class IV	$\vdots$	$\vdots$	$\vdots$	$\neq 0$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$s_1+s_2-s_3$	$\neq 0$	$\neq 0$	$\neq 0$

$s_1 \geq s_2 \geq s_3$

- Deforming $\delta^{(1)}_{E_{\mathbf{1}}} \neq 0$, but Abelian couplings
- Expressible in terms of the curvatures R_2 and R_3
  - Generalized Bel-Robinson currents
- Fields 2 and 3 are **charged** w.r.t field 1
  - HS algebra multiplet

	$\#_\partial$	$\delta^{(1)}_{E_1}$	$\delta^{(1)}_{E_2}$	$\delta^{(1)}_{E_3}$
Class I	$s_1+s_2+s_3$	$=0$	$=0$	$=0$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_1$	$=0$	$\vdots$	$\vdots$
Class II	$\vdots$	$\neq 0$	$\vdots$	$\vdots$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2\,s_2$	$\vdots$	$=0$	$=0$
Class III	$\vdots$	$\vdots$	$\neq 0$	Λ
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$2s_3$	$\vdots$	$\vdots$	Λ
Class IV	$\vdots$	$\vdots$	$\vdots$	$\neq 0$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$s_1+s_2-s_3$	$\neq 0$	$\neq 0$	$\neq 0$

$$s_1 \geq s_2 \geq s_3$$

CLASS III

- Non-Abelian couplings with

$$\delta^{(1)}_{E_1} \neq 0 \qquad \delta^{(1)}_{E_2} \neq 0$$

$$[\![\, E_1 \,,\, E_2 \,]\!]^{(0)} \neq 0$$

$$\boxed{\begin{aligned} &\delta^{(1)}_{E_3} = \mathcal{O}(\Lambda) \\ &[\![\, E_1 \,,\, E_3 \,]\!]^{(0)} = \mathcal{O}(\Lambda) \\ &[\![\, E_2 \,,\, E_3 \,]\!]^{(0)} = \mathcal{O}(\Lambda) \end{aligned}}$$

- Qualitative difference between Flat Space & (A)dS

- **Gravitational** couplings
  - Aragone-Deser No-go
  - Fradkin-Vasiliev interactions

$s-s-2$	$\#_\partial$	$\delta^{(1)}_{E_1}$	$\delta^{(1)}_{E_2}$	$\delta^{(1)}_{E_3}$
Class I	$2s+2$	0	0	0
	$2s$	0	0	0
Class III	$2s-2$	*	*	Λ

$$\delta^{(1)}_{E_3}\Phi = \big(\underbrace{\partial^{2s-3} + \Lambda\,\partial^{2s-5} + \cdots +}_{\text{field redefinition}} \underbrace{\Lambda^{s-2}\,\partial}_{\text{General coordinate transf.}}\big)\,E_3\,\Phi$$

0 =

field redefinition

General coordinate transf.

- **YM**-like couplings
  - colored gravity in (A)dS !

$s-s-1$	$\#_\partial$	$\delta^{(1)}_{E_1}$	$\delta^{(1)}_{E_2}$	$\delta^{(1)}_{E_3}$
Class I	$2s+1$	0	0	0
Class III	$2s-1$	*	*	Λ

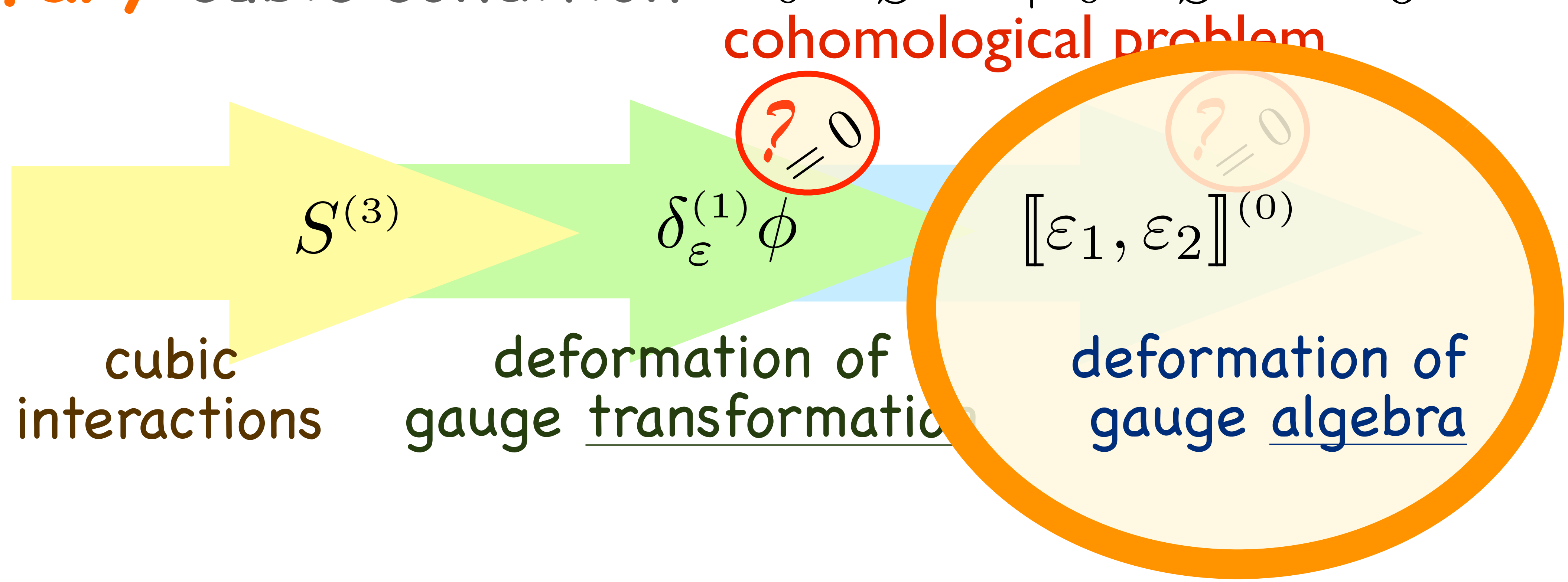
$$\delta^{(1)}_{E_3}\Phi = \big(\partial^{2s-2} + \Lambda\,\partial^{2s-4} + \cdots + \Lambda^{s-1}\big)\,E_3\,\Phi$$

0 =

field redefinition

YM gauge transf.

So far, cubic condition : $\delta^{(0)} S^{(3)} + \delta^{(1)} S^{(2)} = 0$



Next step ?

- Consistency of Algebra $\Rightarrow$ **Global symmetry**
- **Quartic** condition : $\delta^{(0)} S^{(4)} + \delta^{(1)} S^{(3)} + \delta^{(2)} S^{(2)} = 0$

(work in progress)

GLOBAL HIGHER SPIN SYMMETRIES
(HIGHER SPIN ALGEBRAS)

Killing Equations for (A)dS background

$$\partial_{(M_1} E_{M_2 \cdots M_s)} = 0$$

all bracket structures!

- ✓ Lie Algebra with bracket $[\![\ ,\ ]\!]^{(0)}$
- ✓ Bracket entirely determined by TT alone

- ✤ Must satisfy Jacobi identity
  - $\Rightarrow$ Determine **HS algebra** and **non-Abelian** cubic interactions

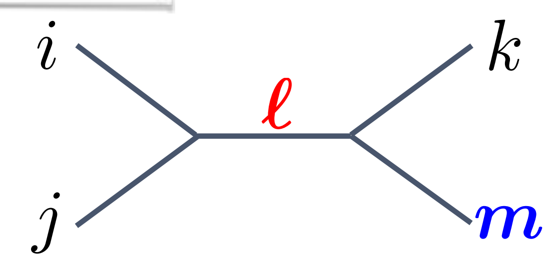
- ✤ Must be consistent with $\delta^{(1)}_{[E_1}\, \delta^{(1)}_{E_2]} = \delta^{(1)}_{[\![E_1 , E_2]\!]}$
  - $\Rightarrow$ Determine **representation** and **Abelian** (class II) cubic interactions

Jacobi identity

- ✓ Lie Algebra Bracket $[\![E_i, E_j]\!]_k$ from $S^{(3)}[\Phi_i, \Phi_j, \Phi_k]$
  - Independent of spectrum (the entire field contents)
- ✓ Jacobi identity

$$\sum_{\ell} [\![\, [\![\, E_{[i}\,,\, E_j \,]\!]_{\ell}\,,\, E_{k]}\,]\!]_{m} = 0$$

  - Spectrum matters



- ✓ Vasiliev spectrum: single field for each spin
  - Uniqueness (Vasiliev algebra)

    [Boulanger, Ponomarev, Skvortsov, Taronna]
  - Explicit structures [EJ and K. Mkrtchyan]
- ✓ Two more examples of Jacobi

ex. 1 HS algebra in flat-space ?

- Consider spin 2 interacting with HS particles

  From our analysis, $[\,T_2\,,\,T_s\,]=0$

  "spin 2 cannot be graviton"

- Is it possible that **spin 2** interacts with **HS** through **non-Abelian** interactions ?

  ❖ Jacobi imposes $[\,T_2\,,\,T_2\,]=0$

No "HS algebra" containing Poincaré as sub-algebra

This is **Coleman-Mandula** thm.
but **without** any assumption on the **spectrum** !

ex.2 Tensionless limit of ST around (A)dS ?

- Cubic interactions of **massive HS** fields
  in 1st Regge traj. open bosonic **string theory**

$$C \sim \frac{1}{g_o}\, e^{Y_1+Y_2+Y_3+\frac{1}{\alpha'}\,(Z_1+Z_2+Z_3)}$$

- Cubic interactions of **massless HS** fields in **(A)dS**
  with the **choice** of coupling fn $K(Y,G) = \frac{1}{g}\, e^{Y_1+Y_2+Y_3}$

$$C = \frac{1}{g}\, e^{Y_1+Y_2+Y_3+\lambda(Z_1+Z_2+Z_3)}$$

Gauge inv. cubic interactions

$$C(Y,Z) = e^{\lambda\left(Z_1\partial_{Y_2}\partial_{Y_3}+Z_1Z_2\partial_{Y_3}\partial_G+\text{cyc.}+Z_1Z_2Z_3\partial_G^2\right)} K(Y,G)\,\Big|_{G=Y_iZ_i}$$

Generic cubic interactions

$$S^{(3)}[\Phi_1,\Phi_2,\Phi_3] \overset{\text{TT}}{=} \int_{\text{(A)dS}} C(Y,Z)\,\Phi_1(X_1,U_1)\;\Phi_2(X_2,U_2)\;\Phi_3(X_3,U_3)\,\Big|_{\substack{X_i=X\\U_i=0}}$$

$$Y_i := \partial_{U_i}\cdot\partial_{X_{i+1}}\,, \qquad Z_i := \partial_{U_{i+1}}\cdot\partial_{U_{i-1}} \qquad [i \simeq i+3]$$

ex.2 Tensionless limit of ST around (A)dS ?

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  in 1st Regge traj. open bosonic **string theory**

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- Cubic interactions of **massless HS** fields in **(A)dS**
  with the **choice** of coupling fn $K(Y,G) = \frac{1}{g}\, e^{Y_1+Y_2+Y_3}$

$$C = \frac{1}{g}\, e^{Y_1+Y_2+Y_3+\lambda(Z_1+Z_2+Z_3)}$$

  - gives **HS algebra** given by **Moyal** product (so satisfy Jacobi)
  - in the condition that the HS fields are **reducible** !

✻ Reducible HS spectrum do appear in the BRST formulation of a tensionless limit of ST

Summary

- All cubic interactions of
  massive and (partially-)massless HS fields
- Full classification of massless interactions
- All bracket structures of HS algebra

Outlook

- Higher order interactions (work in progress)
- AdS/CFT computations, CFT bootstrap program
- Generalization to fermions and mixed-sym. fields

THANK YOU