

Title: Leaving Behind N=4 SYM: Why are Three Loops Interesting?

Date: Aug 08, 2011 11:00 AM

URL: <http://pirsa.org/11080026>

Abstract:

Leaving behind N=4 SYM: why are three loops interesting?

Christoph Sieg

Humboldt University of Berlin


08.08.11, Exact Results in Gauge/Gravity Dualities, Pl

C.S.: 1008.3351

E. Pomoni, C.S.: 1105.3487

- ① motivation
- ② short review of the formalism in Nelson
- ③ the interpolations theory : three traps results

Why are there three loops in M^4 ?

$N=1$ Superspace : $N=4$ Sym, β -deformation

Why are three loops interesting?

$N=1$ Superpace : $M=4$ Sym, β -deformation, ...

composite operators : $\text{tr} (Z \cdot \bar{z} \cdot \phi \cdot d Z \cdots) \rightarrow$ closed
superfields
one - and two - loop.

Why are three loops interesting?

$N=1$ Superpace : $N=4$ Sym, β -deformation, ...

composite operators. to $(\bar{z} \cdot \bar{z} \cdot \bar{\phi} \cdot \bar{d} z \cdots) \rightarrow$ closed
superfields
one- and two-loops.

Why are three loops interesting?

$N=1$ Superpace : $N=4$ Sym, β -deformation, ...

composite operators : $\psi_1 \bar{\psi}_2 \psi_3 \bar{\psi}_4 \dots \rightarrow$ closed
superfields

one- and two-loops.

- flavor manipulations (closed functions)

associated with Majoron dispersion relation

2 ways: $\hat{w}_2 = \Delta \rightarrow \text{For } (-\frac{1}{2}, \frac{1}{2})$



Open ^

$$2 \text{ days: } \pi_2 \sim \Delta \rightarrow \text{Four} \left(-\frac{1}{2}\epsilon + \frac{1}{2}\epsilon \right)$$



$$\text{Over}^a = 2^a, 0^b$$

$$2^a: \text{All} - \sum \text{UV paths}$$

different operators:

$$\text{2nd eqn: } \partial_x - \Delta \rightarrow \frac{1}{4\pi i} \left(-\frac{\partial}{\partial z} + \frac{\partial}{\partial \bar{z}} \right)$$



$$\text{Over}^a = 2^a, 0^b$$

$\mathcal{L}^a = \mathcal{L} - \sum \text{UV terms}$

$$\text{dilatation operator: } D = \mu \frac{\partial}{\partial \mu} \ln Z(g\mu^c)$$

$$2 \text{ steps: } \mathcal{D}_2 \sim \Delta \rightarrow \text{min} \left(-\frac{\partial}{\partial \epsilon} + \frac{\partial^2}{\partial \epsilon^2} \right)$$



$$\text{Over}^a = 2^a, 0^b \quad \text{2nd, L} = \sum \text{UV parts}$$

$$\text{dilution operator: } \mathcal{D} = \mu \frac{\partial}{\partial \mu} \ln \mathcal{Z}(\mu)$$

$\ln \mathcal{Z}$ is free of higher order poles: $\mathcal{Z} \frac{1}{\epsilon^n}, n \geq 2$



$$2 \text{ loops: } \text{Tr}_2 - \Delta \rightarrow \frac{1}{(4\pi)^2} \left(-\frac{g^2}{24} + \frac{g^2}{24} \right)$$



$$\text{Term}^2 = 2^4, 0^6$$

Σ : AL = \sum UV terms

$$\text{dilatation operator: } D = \mu \frac{\partial}{\partial \mu} \ln Z(g\mu^c)$$

$\ln Z$ is free of higher order poles: $\Gamma \frac{1}{\epsilon^n}, n \geq 2$

$$D_n \stackrel{\downarrow}{\Rightarrow} D_n \quad \text{in} \quad D = \bigcup_{n=1}^{\infty} D_n$$

$$2 \text{ loops: } D_2 \sim \Delta \rightarrow \frac{1}{(4\pi)^2} \left(-\frac{1}{2\varepsilon} + \frac{\alpha}{2\varepsilon^2} \right)$$



$$\text{Order } \epsilon = 2^4, O_{\text{base}}^6 \quad Z^2 = 1L \cdot \sum \text{UV poles}$$

dilatation operator: $D = \mu \frac{\partial}{\partial \mu} \ln Z(g\mu^c)$

$\ln Z$ is free of higher order poles: $\mathcal{O} \frac{1}{\epsilon^n}, n \geq 2$

$$D_n \stackrel{\downarrow}{\Rightarrow} D_n \quad \text{in} \quad D = \underbrace{g^2 D_1 + g^2 D_2 + \dots}_{\text{"unrenormalized"}}$$

$$2 \text{ ways: } D_2 - \Delta \rightarrow \frac{1}{4\pi r} \left(-\frac{\partial}{\partial r} + \frac{\partial}{\partial t} \right)$$



$$\text{Over}^A = 2^A, O_{\text{base}}$$

$\Sigma^A, A = \sum \text{UV parts}$

$$\text{dilatation operator: } D = \mu \frac{\partial}{\partial \mu} \ln Z(g\mu^c)$$

$\ln Z$ is free of higher order poles. $\prod \frac{1}{\epsilon_n}, n=2$

$$\uparrow \\ \rightarrow D_n \quad \text{in} \quad D = \underbrace{\delta^i D_1 + \delta^i D_2 + \dots}_{\text{"unwanted"}}$$

(three loops)

- Major manipulations that suddenly contribute to scattering of impurities
- extended interval bnn.



Use loops:

- Many manipulations that selectively contribute to scattering of impurities
- extended interval loops: $\triangleleft, \triangleright, \square, \triangleright\triangleright$



Three loops:

- Major manipulations that selectively contribute to scattering of impurities
- extended interval loops.



⑦ Short summary of $N=4$ case

Superalgebra



$$d_1 = (2, 4, \infty)$$

⑦ Short summary of N=4 case

Superalgebra



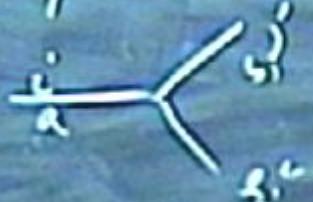
\rightarrow integrable in $T^*(\mathbb{R}^n)$

$$d_i = (2, 4, \infty)$$



⑦ Short summary of $N=4$ case

Superpotential



$i \otimes j \otimes k \in T^{\{1\}}$

$$d_0 = (2, 4, \infty)$$



$$\sim \varepsilon^{ijk} \varepsilon_{l \tau j}$$



⑦ Short summary of $N=4$ case

Superalgebra



$i g_{YM} \epsilon_{ijk} t_i T^k$

$$d_0 = (2, 4, \infty)$$



$$\sim \epsilon^{ijk} \epsilon_{\lambda\tau j} = \cancel{\delta^i_\tau} \cancel{\delta^j_\lambda} \cdot \cancel{\delta^i_\tau} \cancel{\delta^j_\lambda}$$

$$= P_1 - 1$$

|| |

⑦ Short summary of $N=4$ case

Superalgebra



$i g_m \epsilon_{ijk} t_i T^a T^b$

$$d_1 = (2, 4, \infty)$$

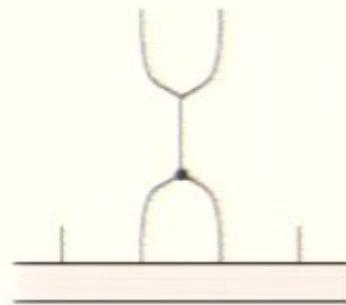


$$\sim \epsilon^{ijk} \epsilon_{abc} = \delta^i_a \delta^j_b \delta^k_c - \delta^i_b \delta^j_c \delta^k_a$$

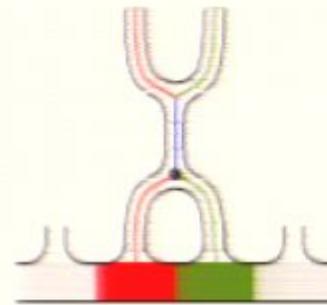


One loop

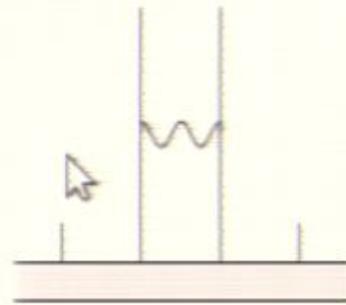
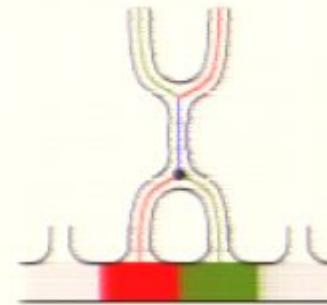
$$\text{tr}(\psi[Z, \phi]) = i \left(\begin{array}{c} \text{Diagram 1} \\ \text{Diagram 2} \end{array} - \begin{array}{c} \text{Diagram 3} \\ \text{Diagram 4} \end{array} \right), \quad -i \text{tr}(\bar{\psi}[\bar{\phi}, \bar{Z}]) = -i \left(\begin{array}{c} \text{Diagram 5} \\ \text{Diagram 6} \end{array} - \begin{array}{c} \text{Diagram 7} \\ \text{Diagram 8} \end{array} \right)$$



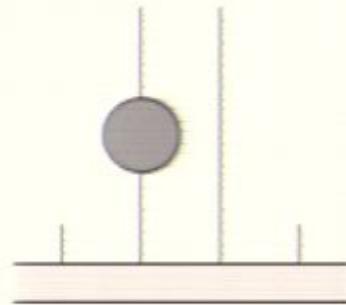
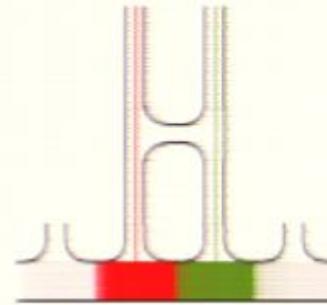
=



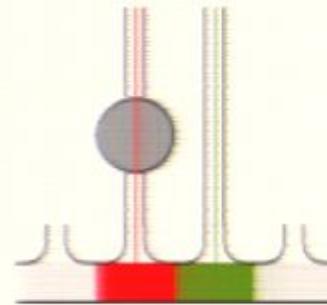
-



=

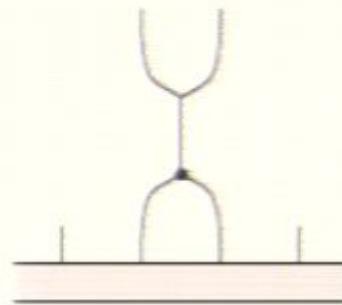


=

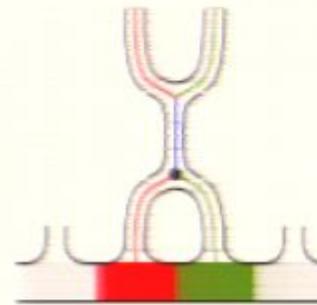


One loop

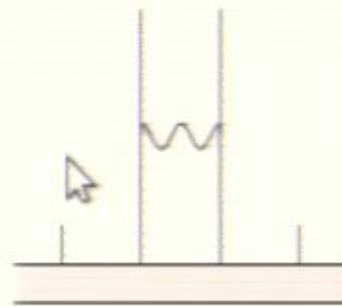
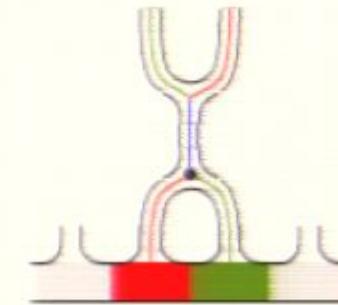
$$\text{tr}(\psi[Z, \phi]) = i \left(\text{Diagram A} - \text{Diagram B} \right), \quad -i \text{tr}(\bar{\psi}[\bar{\phi}, \bar{Z}]) = -i \left(\text{Diagram C} - \text{Diagram D} \right)$$



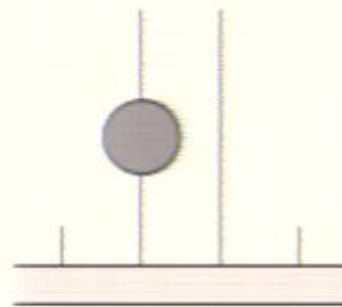
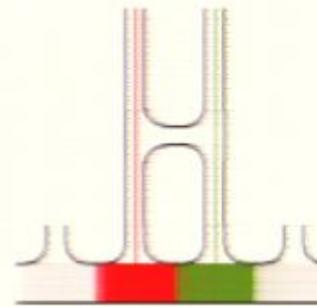
=



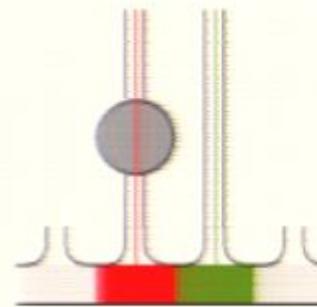
-



=



=



Chiral functions

$$\chi(1) = - \frac{\text{Diagram with red and green vertical lines}}{\{\}} + \frac{\text{Diagram with red and yellow vertical lines}}{\{1\}}$$

→ - +

$$\chi(1,2) = \frac{\text{Diagram with red, green, and pink vertical lines}}{\{\}} - \frac{\text{Diagram with red, green, and yellow vertical lines}}{\{1\}} - \frac{\text{Diagram with red, yellow, and pink vertical lines}}{\{1\}} + \frac{\text{Diagram with red, yellow, and green vertical lines}}{\{1,2\}}$$

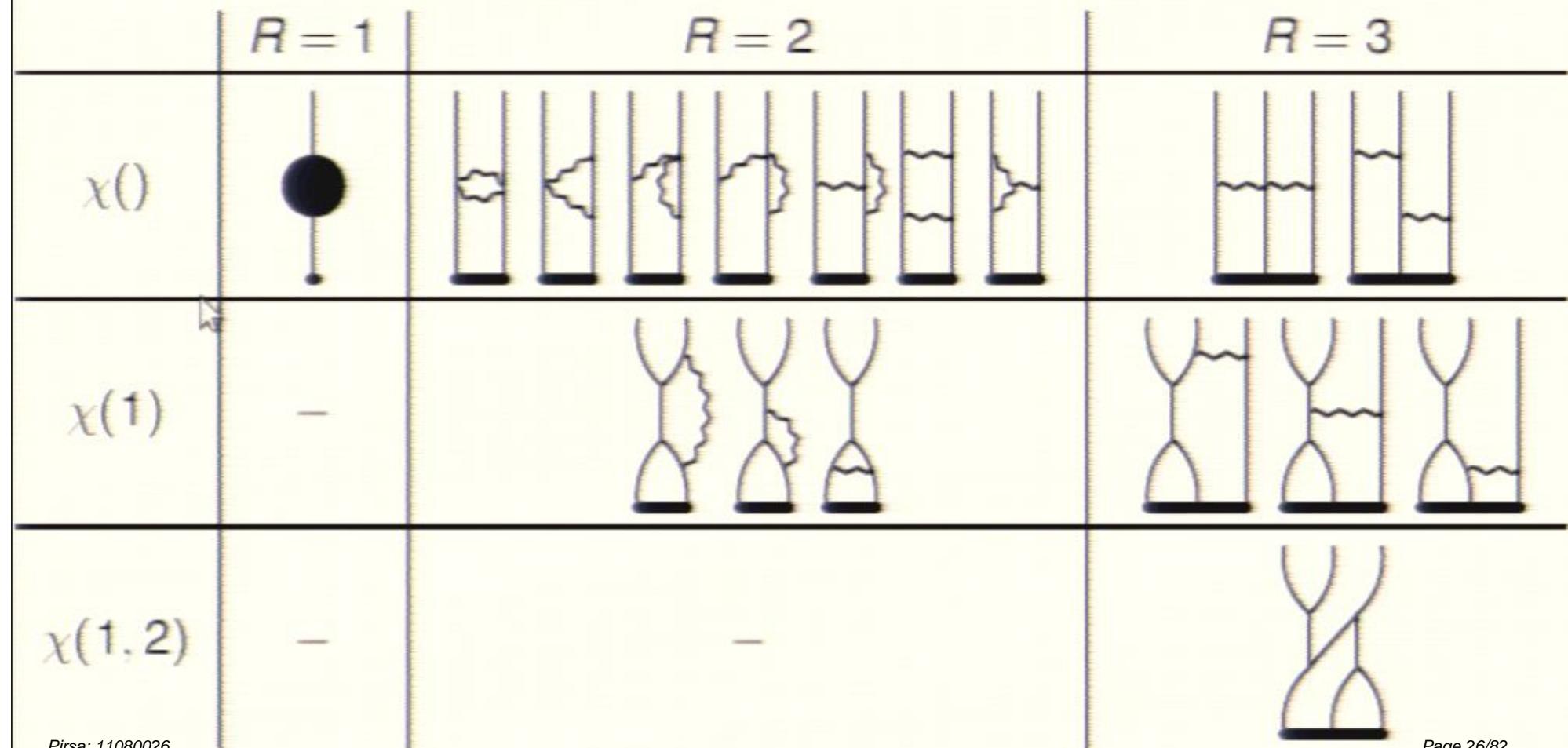
→ - - +

$$\{a_1, \dots, a_n\} = \sum_{i=1}^L P_{i+a_1, i+a_1+1} \dots P_{i+a_n, i+a_n+1}$$

$$\chi(1,2,3) = -\{\} + 3\{1\} - 2\{1,2\} - \{1,3\} + \{1,2,3\}$$

Two loops

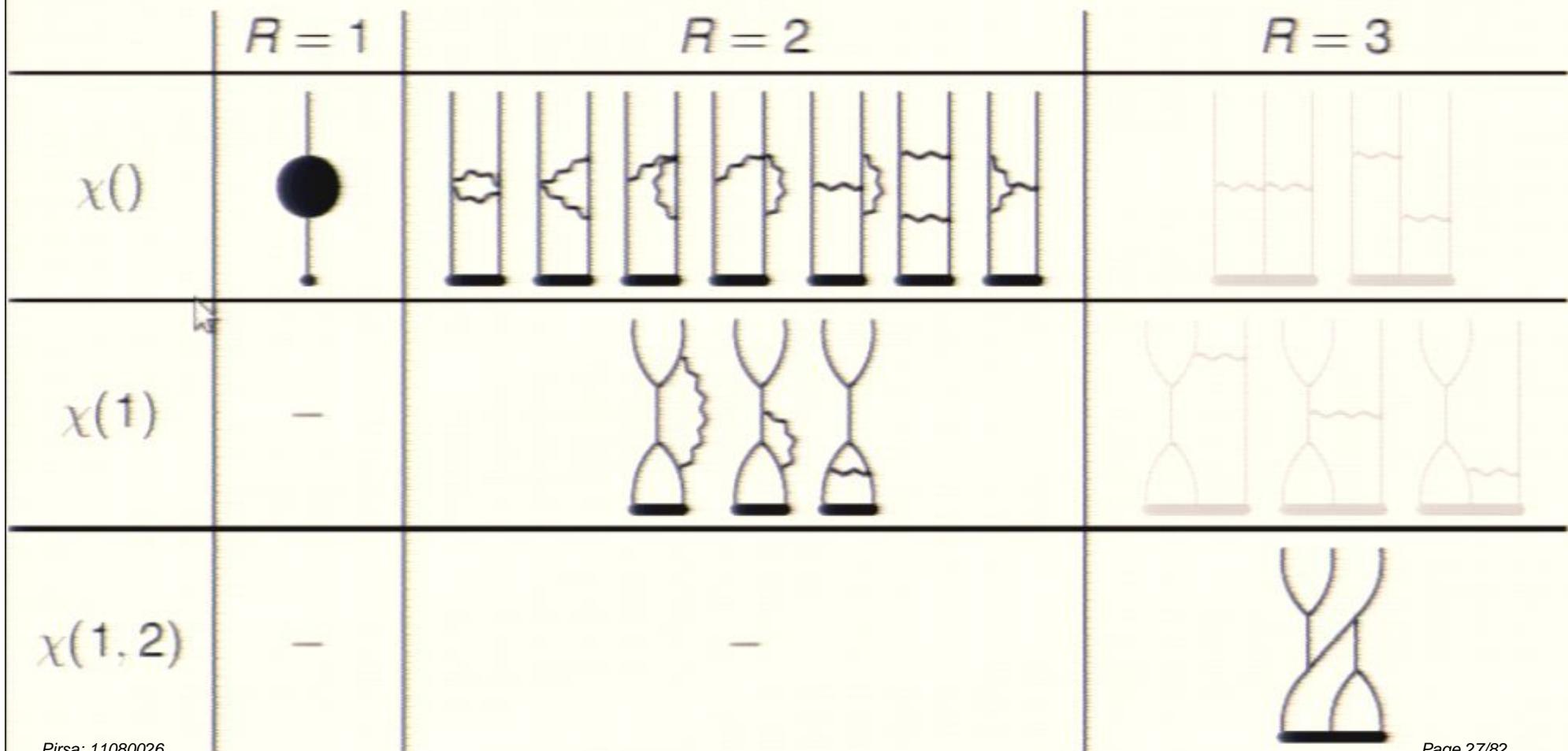
- ▶ all diagrams (apart from reflections, one-loop wave function ren.)



Two loops

- constraints on D-algebra

[Fiamberti, Santambrogio, C.S., Zanon]



Two loops

- finiteness conditions and finite 2-loop self energy
 \Rightarrow absence of $\chi(0)$

[C.S.]

	$R = 1$	$R = 2$	$R = 3$
$\chi(0)$			
$\chi(1)$	-		
$\chi(1, 2)$	-	-	

$$\mathcal{D}_2 = 4\chi(1) - 2[\chi(1, 2) + \chi(2, 1)]$$

$$\tilde{Z} = 1 - \lambda I_1 \times 4) - \lambda^2 I_2 \left[\underbrace{\times (1, 2) + \times (2, 1) - 2 \times 6)}_{\text{in brackets}} \right]$$

$$\vec{z} = \mathbf{1} - \lambda \mathbf{T}_1 \times \mathbf{u} - \lambda^2 \mathbf{T}_2 \left[\mathbf{x}(1,2) + \mathbf{x}(2,1) - 2 \mathbf{x}(\mathbf{u}) \right]$$

$\mathbf{x}(\mathbf{u})^2$ - disconnected.

$$\ln \vec{z} = -\lambda \mathbf{T}_1 \times \mathbf{u} - \left(\mathbf{T}_2 + \frac{1}{2} \mathbf{T}_1^2 \right) (\mathbf{x}(\mathbf{u})^2 - \text{discon.}) -$$

$\overbrace{\qquad\qquad\qquad}^{1/2}$ $(\xi)^2$

$$\tilde{Z} = 1 - \lambda T_1 \times b - \lambda^2 T_2 \left[\underbrace{x(1,2) + x(2,1) - 2 \times b}_\text{$x(b)^2$ - disconnected} \right]$$

$$\ln \tilde{Z} = - \lambda T_1 \times b - \underbrace{\left(T_2 + \frac{1}{2} T_1^2 \right)}_\text{$-\frac{1}{2} \epsilon^2$} (k b)^2 - \text{discon.} - \frac{1}{2} \epsilon^2$$

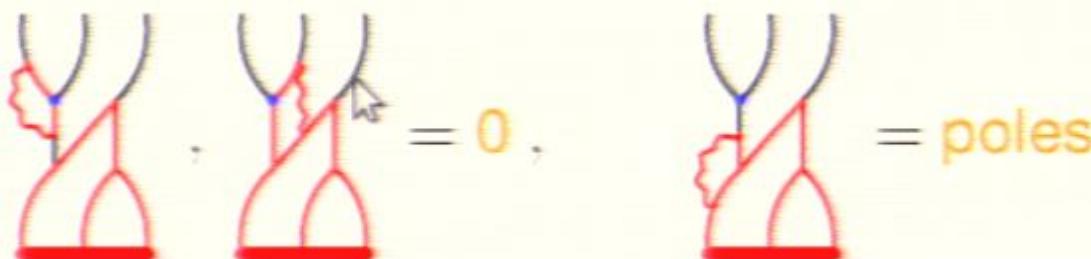
One loop, feasible thanks to finiteness condition

Finiteness conditions

for all $R \geq 2$ diagrams with O_L of the $SU(2)$ sector (also beyond?),

o overall UV divergence if at least one of the conditions holds:

- all chiral vertices take part in loops, e.g.:



- one of its spinor derivatives D_α is brought outside loops
- for v_0 chiral vertices outside loops:
more than $2(v_0 - 1)$ spinor derivatives $\bar{D}_{\dot{\alpha}}$ are brought outside loops

all $R \geq 2$ diagrams with $\chi()$ finite

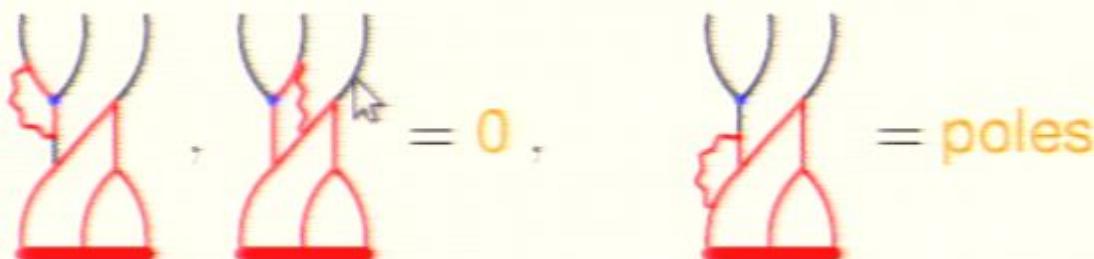
cancellations between certain diagrams involving vector fields

Finiteness conditions

for all $R \geq 2$ diagrams with \mathcal{O}_L of the $SU(2)$ sector (also beyond?),

o overall UV divergence if at least one of the conditions holds:

- . all chiral vertices take part in loops, e.g.:



- . one of its spinor derivatives D_α is brought outside loops

- . for v_0 chiral vertices outside loops:

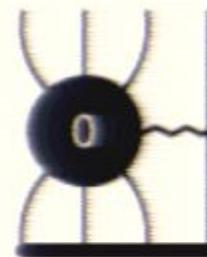
more than $2(v_0 - 1)$ spinor derivatives $\bar{D}_{\dot{\alpha}}$ are brought outside loops

all $R \geq 2$ diagrams with $\chi()$ finite

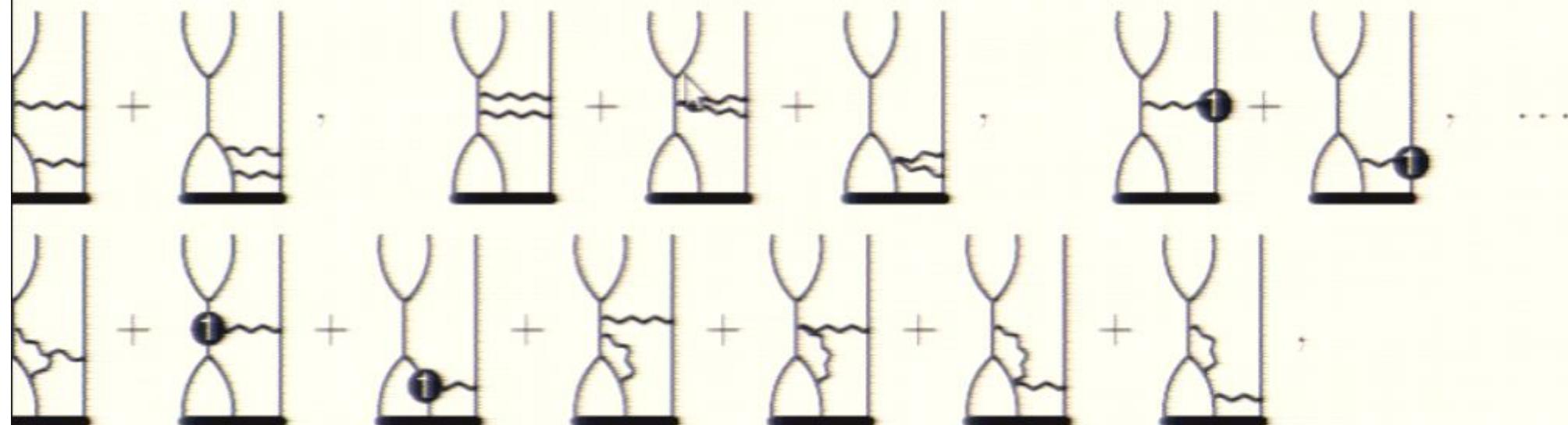
cancellations between certain diagrams involving vector fields

Cancellations

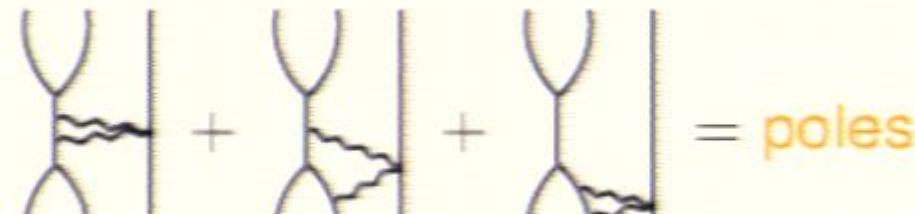
maximum range $R = 4$ diagrams if χ is not of maximum range irrelevant



cancellations for next-to-maximum range $R = 3$ diagrams



but cancellations not complete



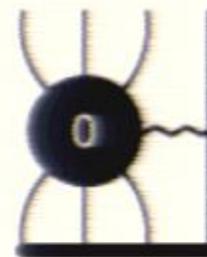
The interpolating theory: field content

[Gadde, Pomoni, Rastelli]

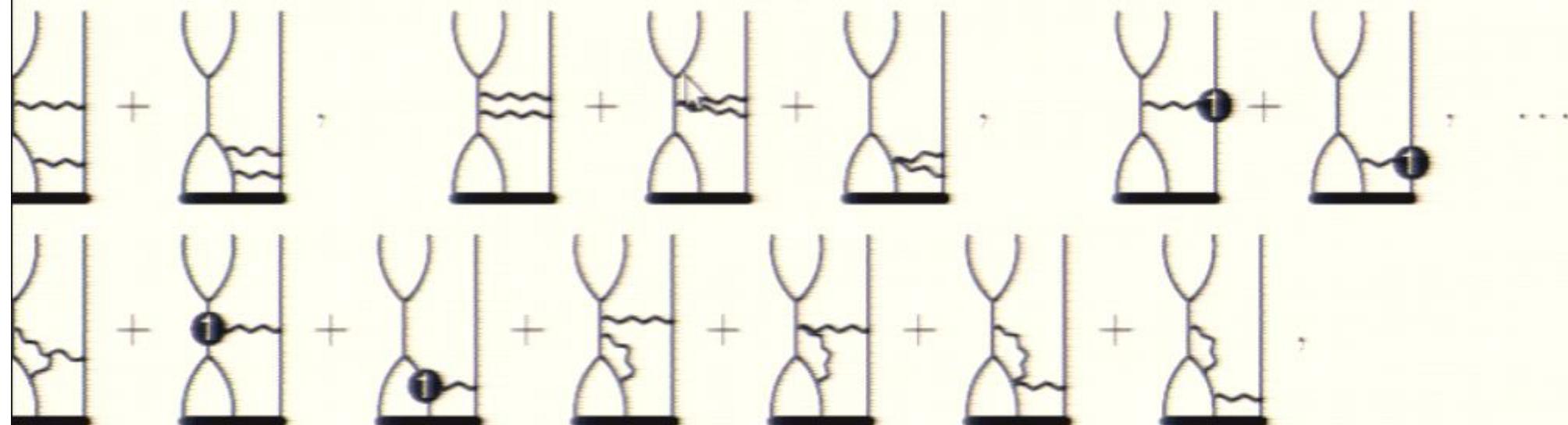
field	$SU(N) \times SU(N)$	$SU(2)_L$	$SU(2)_R$	$U(1)$
V	(adj., 1)	1	1	0
ϕ	(adj., 1)	1	1	1
$\bar{\phi}$	(adj., 1)	1	1	-1
\hat{V}	(1, adj.)	1	1	0
$\hat{\phi}$	(1, adj.)	1	1	1
$\hat{\bar{\phi}}$	(1, adj.)	1	1	-1
Q_i	(□, □)	□	□	0
\tilde{Q}_i	(□, □)	□	□	0
\bar{Q}^i	(□, □)	□	□	0
\tilde{Q}^i	(□, □)	□	□	0

Cancellations

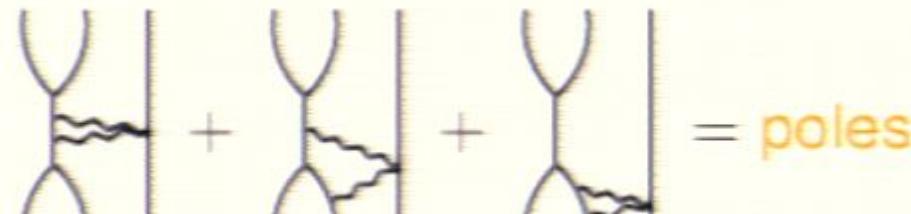
maximum range $R = 4$ diagrams if χ is not of maximum range irrelevant



cancellations for next-to-maximum range $R = 3$ diagrams



but cancellations not complete



= poles



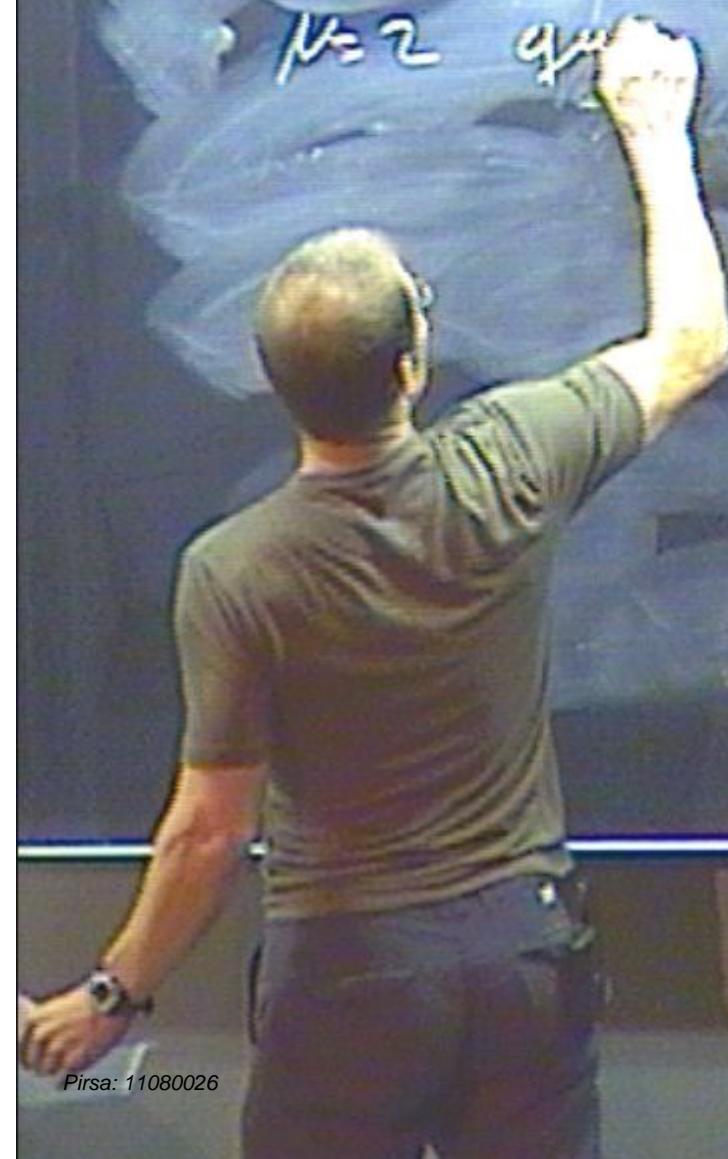
Inhalation Theory





Interpretation, Heavy : Gaddy Powai, Rastelli

$\mu = 2.44$



③

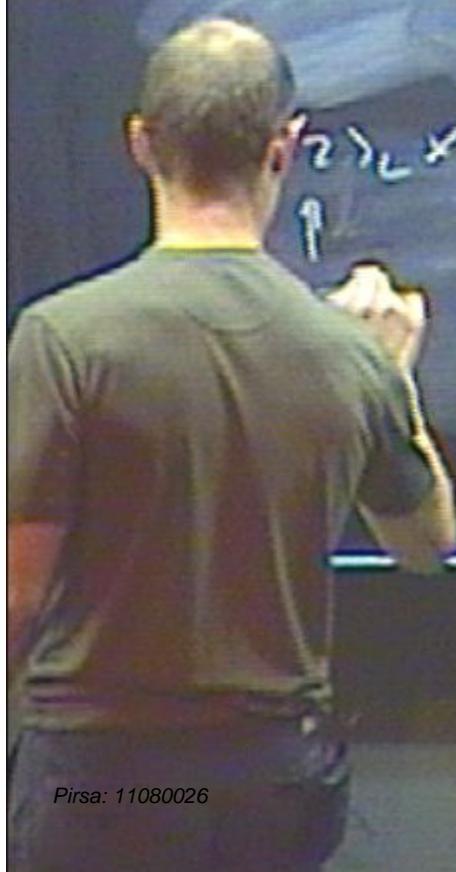
Integrating Berry : Gaudin-Panini, Rasetti

$\mu=2$ quiver Yang-Baxter : $SU(2) \times SU(2)$



$$(2)_L \times \text{SU}(2)_R \times U(1)$$

$R\text{-symm.}$



③

Molecular orbiting theory : Gardner, Pauwels, Rastelli

$\mu = 2$ quinque sigma theory : $Su(2) \times Su(2)$



$$S_u(2)_L \times S_u(2)_R \times U(1)$$

\rightarrow \leftarrow

$R\text{-symm}$ $J=0$ $J=0$

$N = N$

Z_2 orbital of $N=5$ sym

$\mu = 2$ SCACD

Dashed dashed Subsector:



Closed marsh Subsector:

protected sites: $w(4 \cdot 4)$, $b(8 \cdot 8)$, $t_1(8 \cdot 8)$

by reeds,
Symetria,
Sphagnum

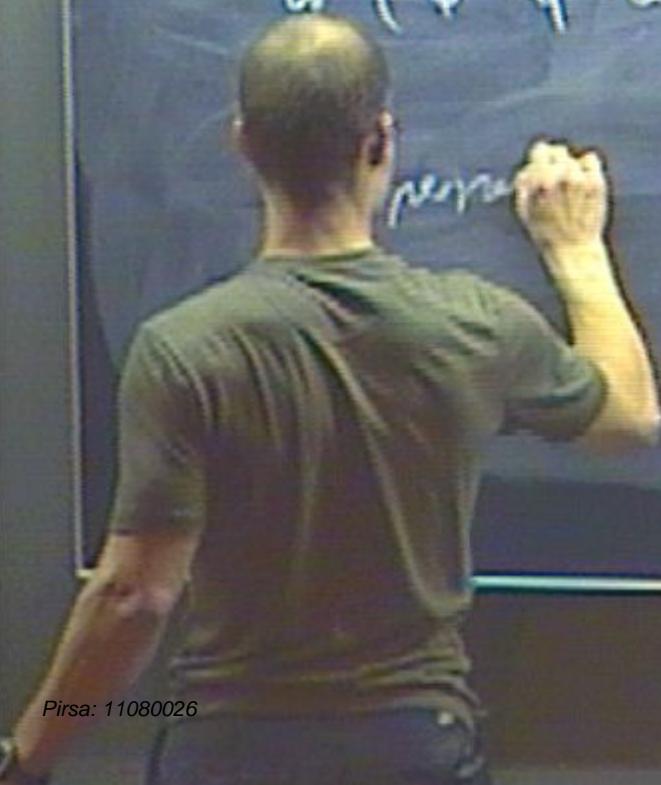


Closed chiral subsector:

protected states: $w(\phi \cdot \phi)$, $b_1(\phi \cdot \phi \Gamma)$, $b_2(\phi \bar{\phi} \Gamma)$

by accident.
Symmetry
Selectivity

$b(\phi \cdot \phi \Omega, \phi \cdot \phi Q, \dots)$



Dashed curved subsector:

protected slits: $w(\phi \cdot \delta)$, $b(\phi \cdot \delta T)$, $t_y(\phi \cdot \bar{\alpha})$

$b(\phi \cdot \{ \alpha_1 \phi \cdot \delta Q^1, \dots \})$

Supplementary: $\frac{b}{\phi} = s \delta_i$

by accident
symmetry
self-reinforcement

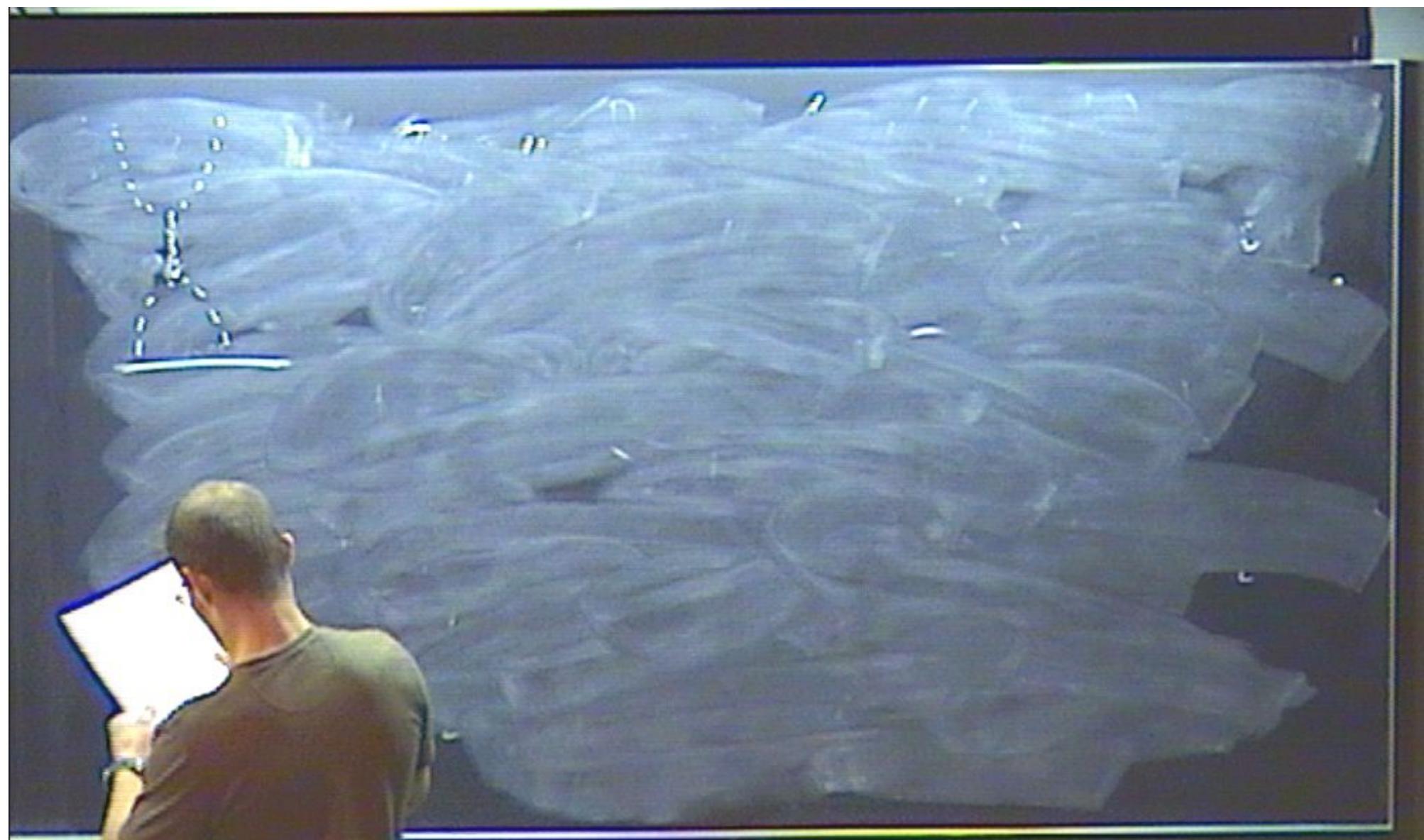
Closed chiral subsector:

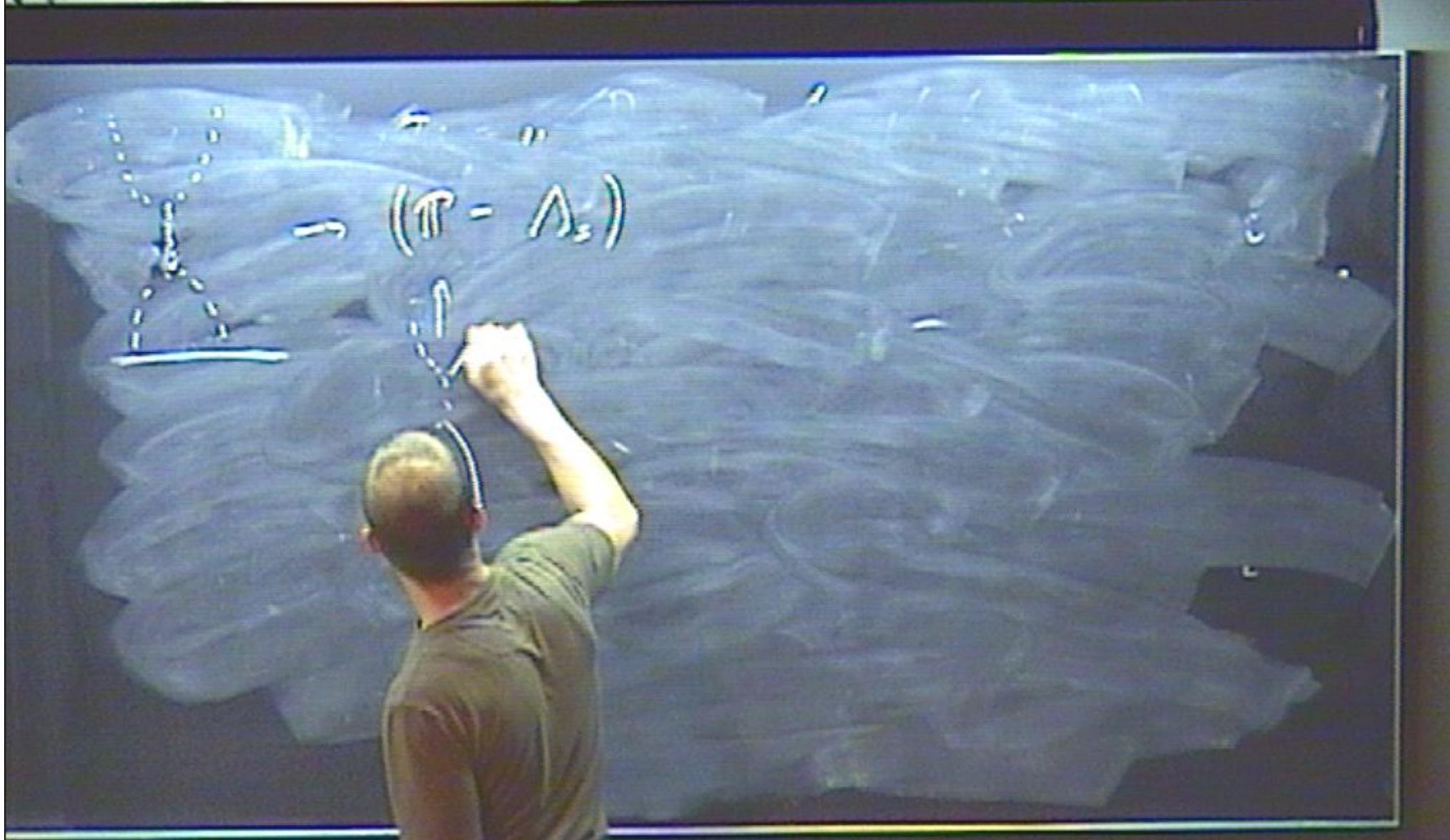
protected states: $w(\phi \cdot \phi)$, $b_1(\phi \cdot \phi \Gamma)$, $b_2(\phi \bar{\phi} \Gamma^2)$

by accident.
Symmetries
Sextic action

$b_3(\phi \cdot \{ \phi, \bar{\phi} \cdot \bar{\phi} \Gamma^3 \} \dots)$

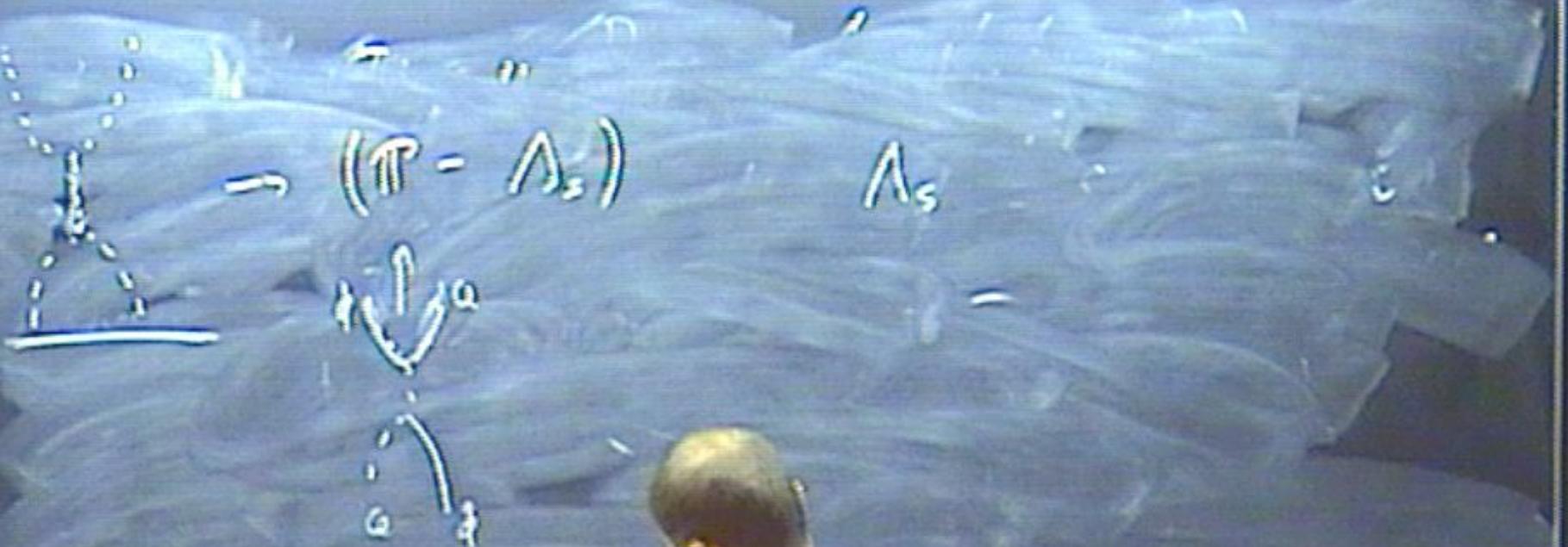
Superalgebra: $\frac{\partial}{\partial \phi_i} = s \delta_i^a, \quad \frac{\partial}{\partial \bar{\phi}_i} = s \delta_i^a$





A man with a shaved head, wearing a green t-shirt, stands in front of a chalkboard, writing with a piece of chalk. He is holding a chalk holder in his left hand. The chalkboard has a diagram of a ship on the left and the equation $\rightarrow (\bar{P} - \Delta_s)$ written in blue chalk.

$$\rightarrow (\bar{P} - \Delta_s)$$

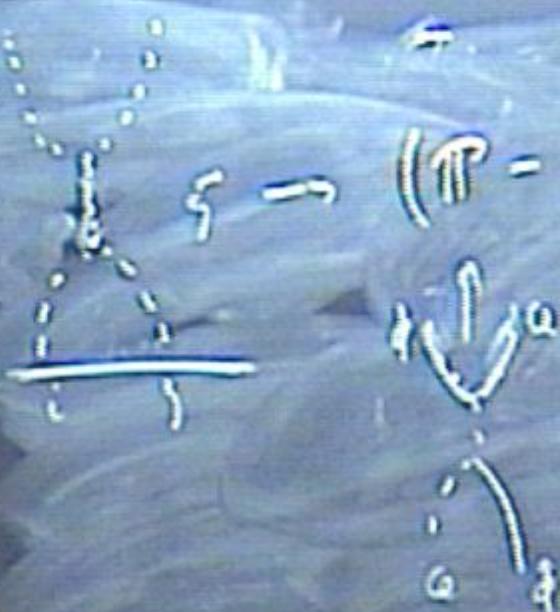


$$\rightarrow (\mathbb{P} - \Delta_s)$$

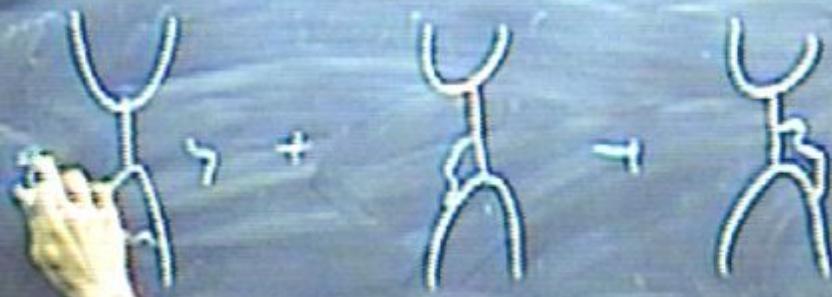

$$\Delta_s : \text{(psi)}: \alpha \alpha \rightarrow \beta \beta \alpha$$
$$\alpha \beta \rightarrow \beta \alpha \beta$$

$$\zeta \rightarrow (\bar{P} - \Lambda_s)$$

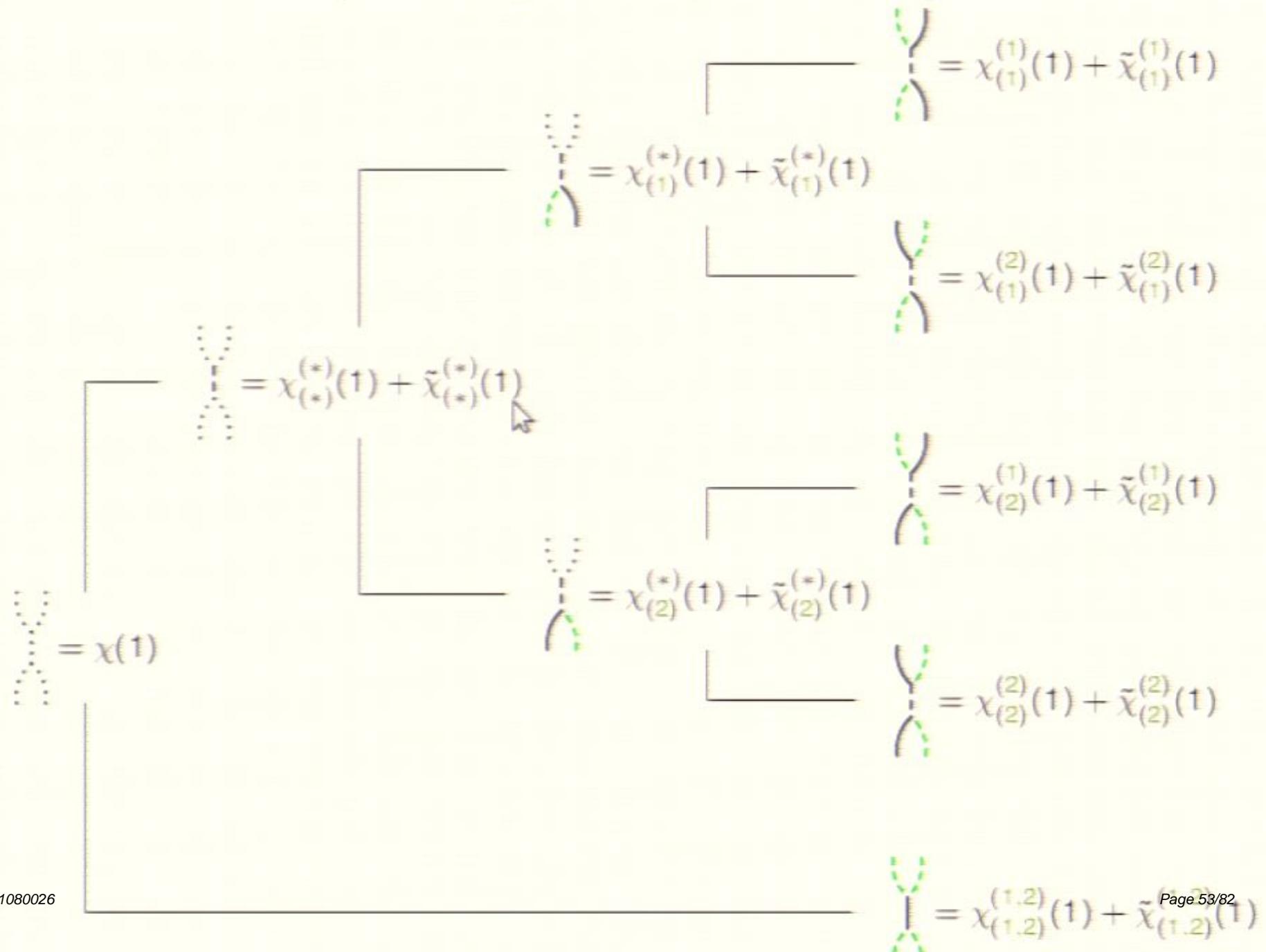
$$S = \frac{2}{3}, \beta = \frac{\pi}{3}$$
$$\Lambda_s : \begin{cases} u \mapsto e^{\frac{i\pi}{3}} u \\ v \mapsto e^{-\frac{i\pi}{3}} v \end{cases}$$

$$\zeta \rightarrow (\pi - \Lambda_s)$$


$$S = \frac{2}{3} \cdot \frac{3}{2} = \frac{1}{2}$$
$$\Lambda_s : \begin{matrix} (u,v) : du \rightarrow v \, du \\ u \, dv \rightarrow v \, du \end{matrix}$$

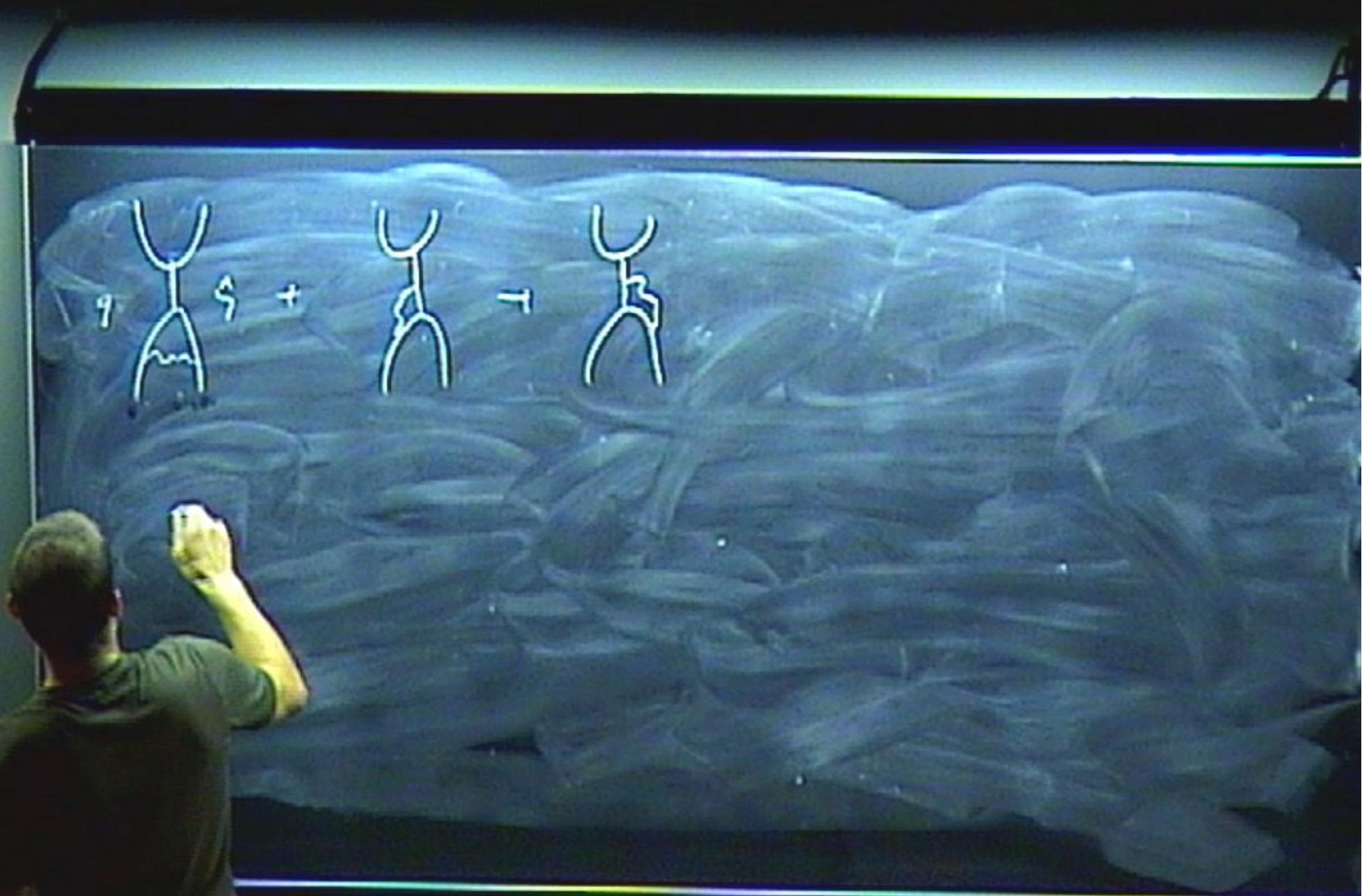


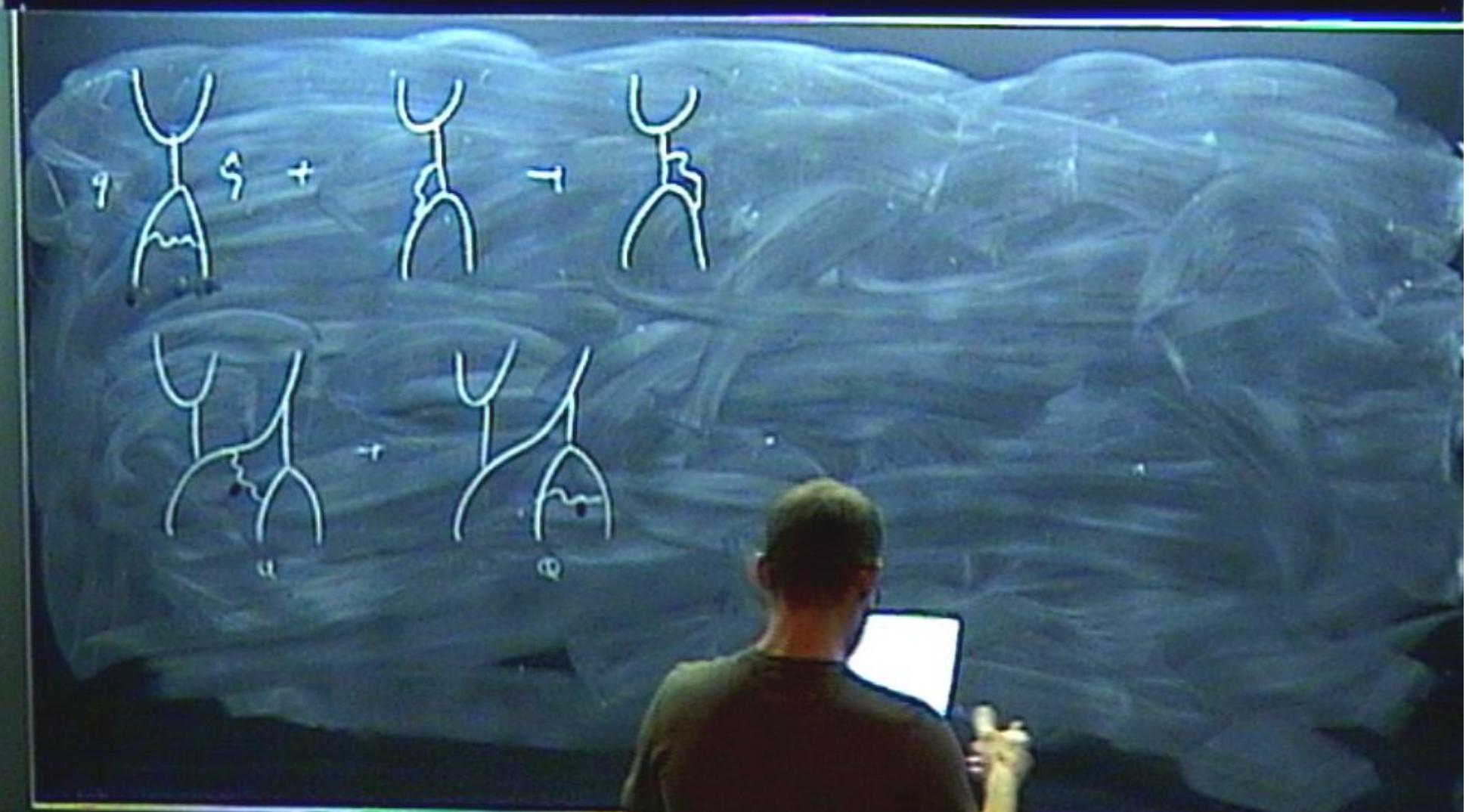
The interpolating theory: building block

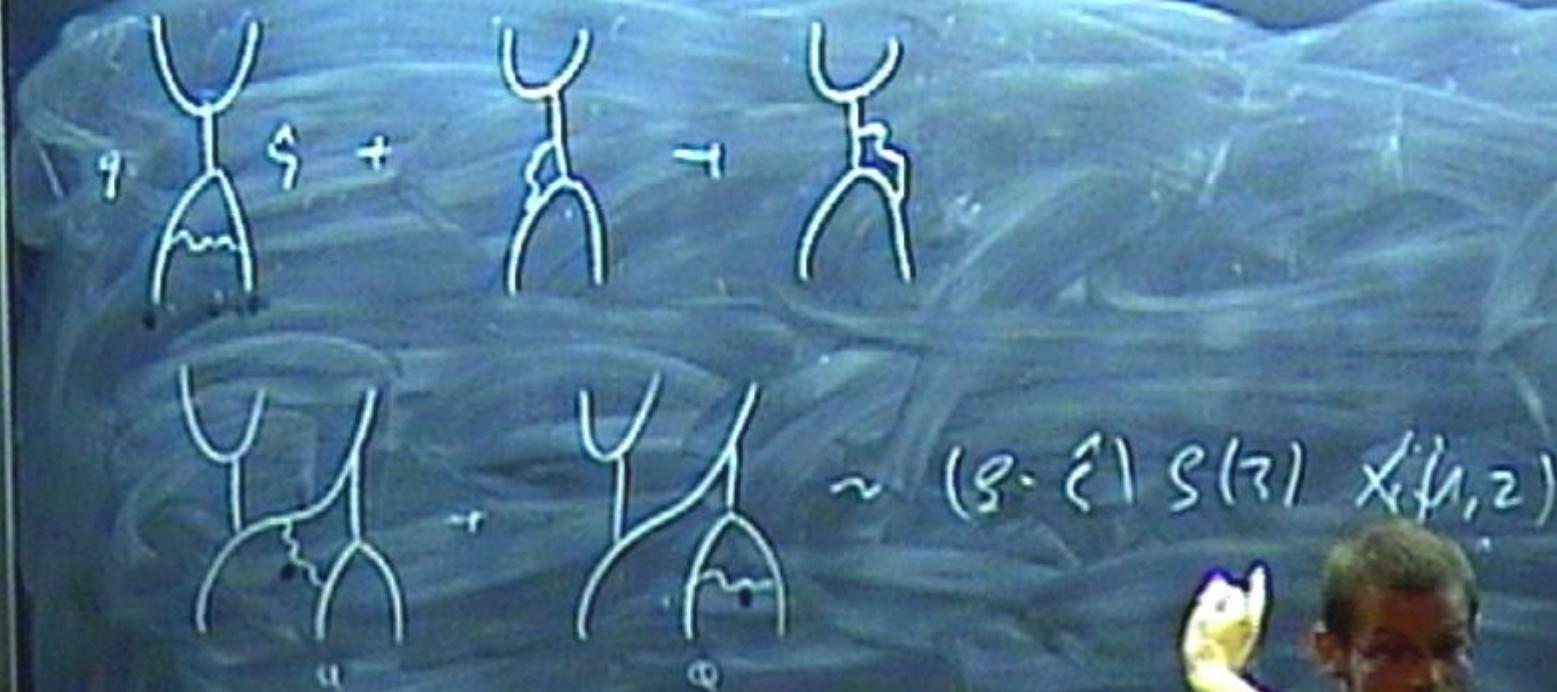


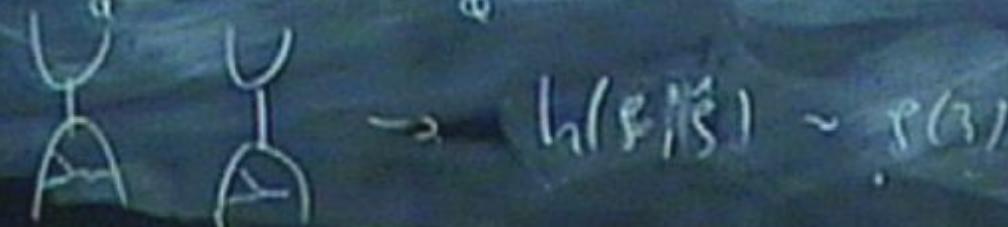
The interpolating theory: building block

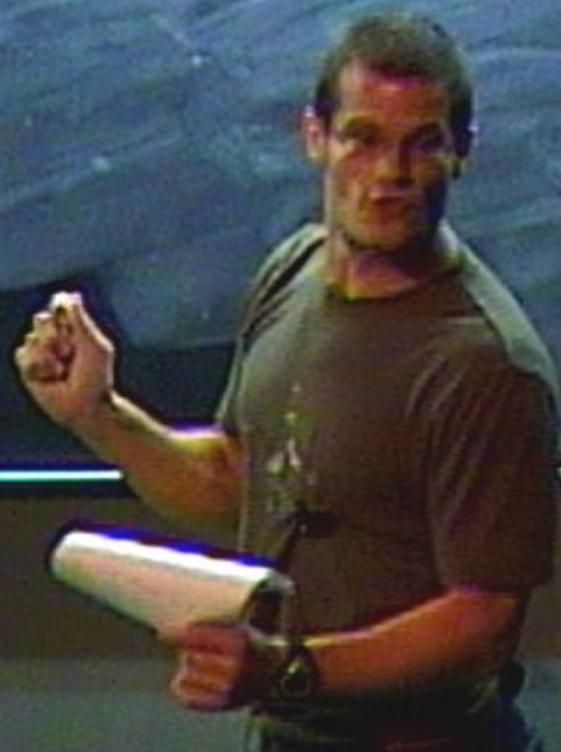
$$\begin{array}{c} \text{Diagram showing a function } \chi(\mathbf{t}) \text{ decomposed into two parts:} \\ \chi(\mathbf{t}) = \chi_{(1)}^{(*)}(\mathbf{t}) + \tilde{\chi}_{(1)}^{(*)}(\mathbf{t}) \\ \text{and its refinement:} \\ \chi_{(1)}^{(*)}(\mathbf{t}) = \chi_{(1)}^{(1)}(\mathbf{t}) + \tilde{\chi}_{(1)}^{(1)}(\mathbf{t}) \\ \text{Further refinements:} \\ \chi_{(1)}^{(1)}(\mathbf{t}) = \chi_{(1)}^{(1,1)}(\mathbf{t}) + \tilde{\chi}_{(1)}^{(1,1)}(\mathbf{t}) \\ \chi_{(1)}^{(*)}(\mathbf{t}) = \chi_{(1)}^{(2)}(\mathbf{t}) + \tilde{\chi}_{(1)}^{(2)}(\mathbf{t}) \\ \chi_{(1)}^{(2)}(\mathbf{t}) = \chi_{(2)}^{(1)}(\mathbf{t}) + \tilde{\chi}_{(2)}^{(1)}(\mathbf{t}) \\ \chi_{(1)}^{(2)}(\mathbf{t}) = \chi_{(2)}^{(2)}(\mathbf{t}) + \tilde{\chi}_{(2)}^{(2)}(\mathbf{t}) \\ \text{Final refined form:} \\ \chi(\mathbf{t}) = \chi_{(1,2)}^{(1,2)}(\mathbf{t}) + \tilde{\chi}_{(1,2)}^{(1,2)}(\mathbf{t}) \end{array}$$











The interpolating theory: dilatation operator

$$\mathcal{D}_1 = -2 \chi(1),$$



The interpolating theory: dilatation operator

$$\mathcal{D}_1 = -2 \chi(1) ,$$



The interpolating theory: dilatation operator

- deformed pure scattering term
- anti-hermitean contributions: removed by non-unitary similarity trafo

$$\mathcal{D}_1 = -2\chi(1),$$

$$\mathcal{D}_2 = -2(\chi(1,2) + \chi(2,1)) + 2(\rho + \hat{\rho})\chi(1)$$

$$\begin{aligned}\mathcal{D}_3 = & -4(\chi(1,2,3) + \chi(3,2,1) - 2(\rho + \hat{\rho})(\chi(1,2) + \chi(2,1)) \\ & + \chi(1,2,1) + \chi(2,1,2) + (\rho + \hat{\rho})^2\chi(1)) \\ & - 4(\hat{\rho}\chi_{(*,*)}^{(*,*)}(1,3) + \rho\tilde{\chi}_{(*,*)}^{(*,*)}(1,3)) + 2(\chi(2,1,3) - \chi(1,3,2)) \\ & + 2\zeta(3)(\rho - \hat{\rho})((\rho - \hat{\rho})\chi(1) \\ & - \hat{\rho}(\chi_{(1)}^{(*)}(1) + \tilde{\chi}_{(2)}^{(*)}(1)) + \rho(\chi_{(2)}^{(*)}(1) + \tilde{\chi}_{(1)}^{(*)}(1)) \\ & - \chi_{(2)}^{(*)}(1,2) + \chi_{(1,2)}^{(*,3)}(1,2) + \chi_{(2)}^{(*)}(2,1) + \chi_{(2,3)}^{(1,*)}(2,1) \\ & + \tilde{\chi}_{(2)}^{(*)}(1,2) - \tilde{\chi}_{(1,2)}^{(*,3)}(1,2) - \tilde{\chi}_{(2)}^{(*)}(2,1) - \tilde{\chi}_{(2,3)}^{(1,*)}(2,1))\end{aligned}$$

The interpolating theory: dilatation operator

- deformed pure scattering term
- maximal transcendental contributions $\rightarrow h^2(\rho, \hat{\rho}), f(\rho, \hat{\rho})$

$$D_1 = -2\chi(1),$$

$$D_2 = -2(\chi(1, 2) + \chi(2, 1)) + 2(\rho + \hat{\rho})\chi(1)$$

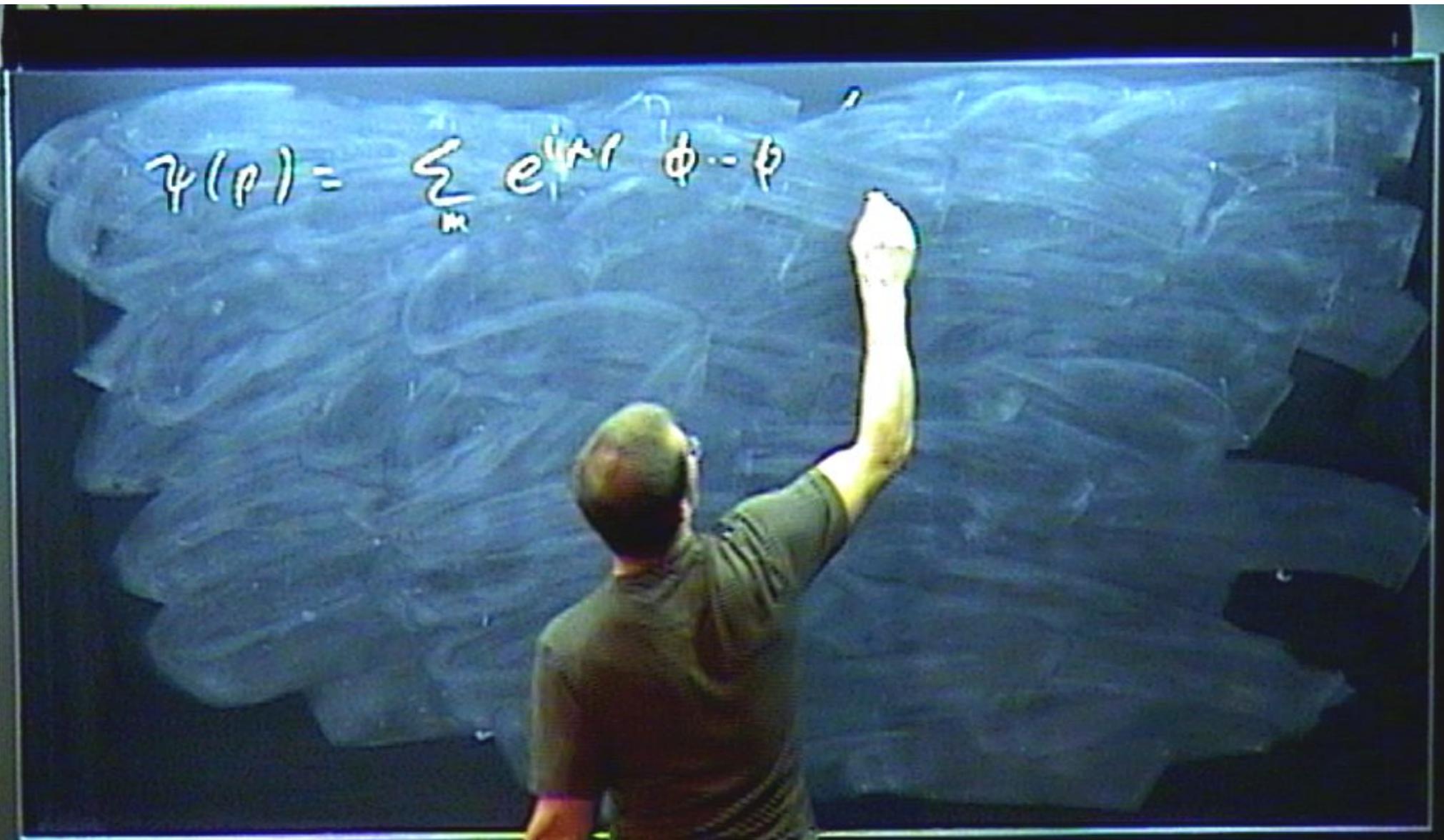
$$D_3 = -4(\chi(1, 2, 3) + \chi(3, 2, 1) - 2(\rho + \hat{\rho})(\chi(1, 2) + \chi(2, 1)) \\ + \chi(1, 2, 1) + \chi(2, 1, 2) + (\rho + \hat{\rho})^2\chi(1))$$

$$- 4(\hat{\rho}\chi_{(*, *)}^{(*, *)}(1, 3) + \rho\tilde{\chi}_{(*, *)}^{(*, *)}(1, 3))$$

$$+ 2\zeta(3)(\rho - \hat{\rho})((\rho - \hat{\rho})\chi(1)$$

$$- (\rho + \hat{\rho})(\chi_{(1)}^{(1)}(1) - \chi_{(2)}^{(2)}(1) - \tilde{\chi}_{(1)}^{(1)}(1) + \tilde{\chi}_{(2)}^{(2)}(1)))$$

$$\psi(r) = \sum_m e^{im\phi} \cdot f$$



$$\Psi(\rho) = \sum_m e^{im\phi} (\rho) \langle \alpha | \hat{q}^m | \beta \rangle$$

$$\tilde{\Psi}(\rho) = \Psi(\rho) \Big|_{\frac{\partial}{\partial \phi} \tilde{\alpha}}$$

$$E(\rho) = \sqrt{1 + h^2(g, f) \times h}$$



$$\Psi(\rho) = \sum_m e^{im\phi} (\rho) \alpha^m - \beta$$

$$\tilde{\Psi}(\rho) = \Psi(\rho) \Big|_{\substack{\rho \rightarrow \frac{1}{\rho} \\ \alpha \rightarrow \frac{1}{\alpha}}}$$

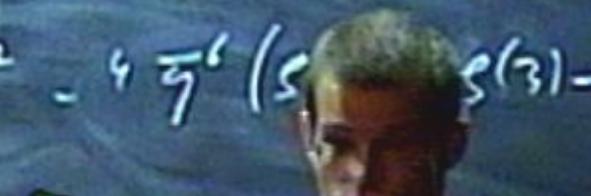
$$E(\rho) = \sqrt{1 + h^2(g, f) \times h} - 1 + A(g, f)(g - \hat{g} + \sin$$

$$\Psi(\rho) = \sum_m e^{im\phi} (\rho) \langle q' | \cdot | q \rangle$$

$$\tilde{\Psi}(\rho) = \Psi(\rho) \Big|_{\substack{q \sim \hat{q} \\ q \in \mathcal{A}}}$$

$$E(\rho) = \sqrt{1 + h^2(\xi, \bar{\xi}) \times \rho} - 1 + A(\xi, \bar{\xi}) (S - S_{\text{threshold}})$$

$$h^2(\xi, \bar{\xi}) = 4 |\bar{\xi}|^2 - 4 \bar{\xi}'(S) - \dots$$



$$\Psi(\rho) = \sum_m e^{im\phi} (\rho^m)^{\frac{1}{2}} - \frac{1}{2}$$

$$\tilde{\Psi}(\rho) = \Psi(\rho) \Big|_{\begin{subarray}{l} 0 \leq \theta \leq \pi \\ \alpha \in \mathbb{R} \end{subarray}}$$

$$E(\rho) = \sqrt{1 + h^2(\xi, \bar{\xi}) \times \rho} - 1 + A(\xi, \bar{\xi})(S - S_{\text{threshold}})$$

$$h^2(\xi, \bar{\xi}) = 4 \bar{\xi}^2 - 4 \bar{\xi}'^2 (S - \bar{S})^2 - S(S) + \dots$$



$$\psi(p) = \sum_m e^{im\phi} p^m q^m$$

$$\tilde{\psi}(p) = \psi(p) \Big|_{\substack{q \mapsto \bar{q} \\ u \mapsto \bar{u}}} \quad \text{Gadde Rastelli}$$

$$E(p) = \sqrt{1 + h^2(s, \bar{s}) \times h} - 1 + A(s, \bar{s})(s - \bar{s}) \text{Rising p}$$

$$h(s, \bar{s}) = 4 \bar{s}^2 - 4 \bar{s}'(s - \bar{s})^2 s(\beta) + \dots$$

$$A(s, \bar{s}) = -2 \bar{s}' (\epsilon^2 - \bar{s}^2) s(\beta)$$

$$\Psi(\rho) = \sum_m e^{im\phi} \rho^m \theta(\rho - 1)$$

$$\tilde{\Psi}(\rho) = \Psi(\rho) \Big|_{\rho > 1} \quad \text{Bogoliubov Ansatz}$$

$$E(\rho) = \sqrt{1 + h^2(s, \bar{s}) \times \rho} - 1 + A(s, \bar{s})(s - \bar{s}) \exp(\rho)$$

$$h^2(s, \bar{s}) = 4 \bar{s}^2 - 4 \bar{s}'(s - \bar{s})^2 s(3) + \dots$$

$$A(s, \bar{s}) = -2 \bar{s}' (c^2 - \bar{s}^2) s(3)$$

$$\mathcal{D}' = e^{-x} \Delta e^x$$

x = expansion in Feynman diagrams

$$E \rightarrow E(r)$$

$$\mathcal{D}' = e^{-x} \Delta e^x$$

x = expansion in Feynman diagrams

$$E - E(r') = \sqrt{1 + k^2 r'^2} - 1 + f(s, \vec{s}) (s \cdot \vec{s}')$$

$$\omega' = e^{-x} \Delta e^x$$

x = expansion in Feynman diagrams

$$E - E(p') = \sqrt{1 + k^2 \gamma u} - 1 - f(s, \bar{s})(s \cdot \bar{s})$$

$$p' = p \pm i \bar{g}' (e^a - \xi^a) \delta(z)$$

$$\mathcal{D}^1 = e^{-\chi} \Delta e^\chi$$

χ = expansion in Feynman diagrams

$$E - E(p') = \sqrt{1 + k^2 \gamma u} - 1 - f(s, \vec{s}) (s \cdot \vec{s})$$

$$p' = p \pm i \vec{q}' (\vec{e}^2 - \vec{\xi}^2) \vec{s}(z)$$

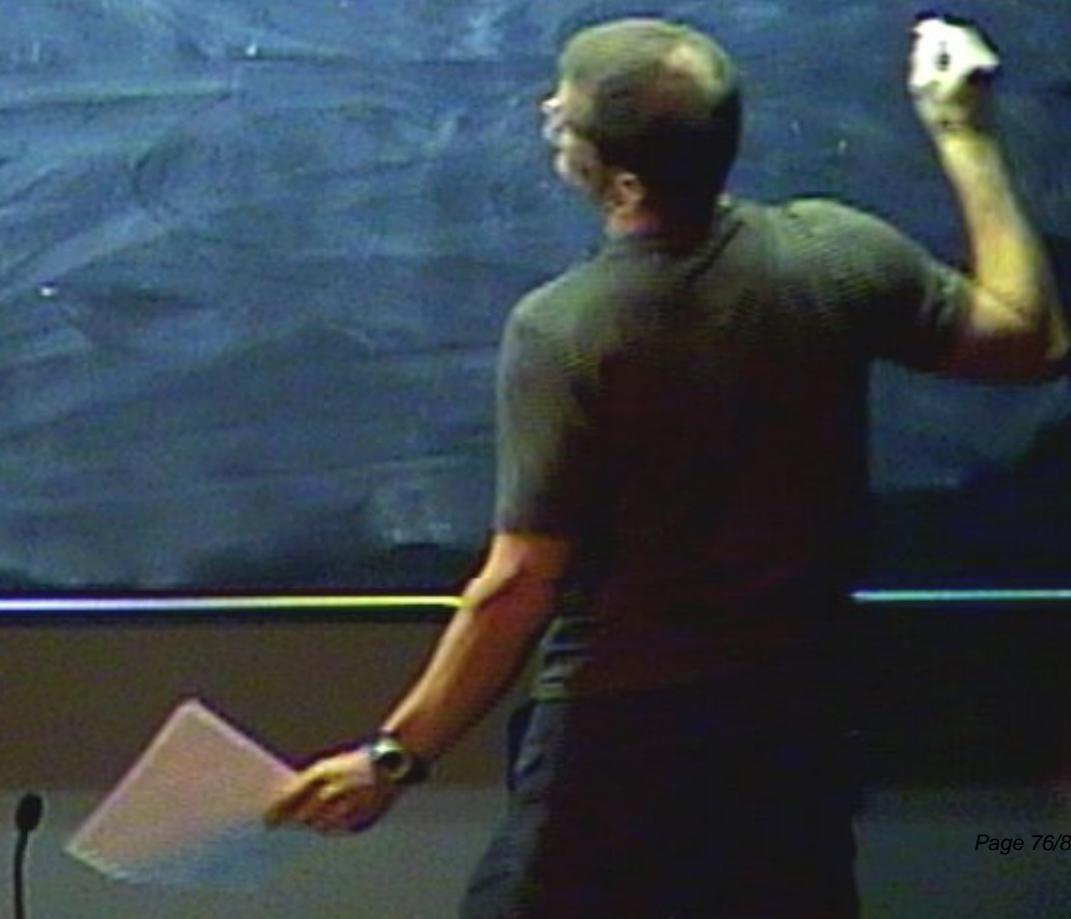
p

Hawthorn



Remark i

- $h(\xi, \eta)$ must be translatable as in ABM(1)



Remark 8:

- $h(\xi, \eta)$ mixed transmuted or in ABY(4)
case
also in the ABY case



Remark:

- high δ_1 measured transversal to σ in AB³⁽⁴⁾ case
also in the AB⁴ case: deformation of σ
Summary: at 6-loops

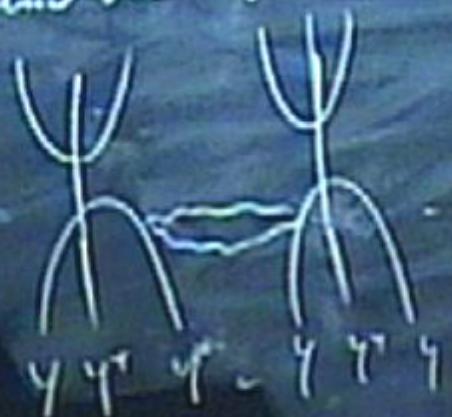


Remark:

- $h(5,3)$ was not transmuted as in $AB^3(4)$

(case

also in the AB^4 one : deformation of tree
summarize : at 6-loops



- in the interpolation theory:
Sectors \rightarrow Sel(1), Sel(7) of $N=4$

- in the interpolation theory:
Sectors $\rightarrow S_{\text{ell}}(1), S_{\text{ell}}(\pi)$ or $N=4$

$$\frac{1}{t} \cdot \frac{\{ \}}{\{ \}} \longrightarrow \sum_i = -2 \pi \rho^{2(n-i)} \begin{array}{c} \text{triangle} \\ \sim S_{\text{ell}}(3) \end{array}$$

- in the interpolation theory:
Sectors \leftrightarrow Sel(1), Sel(7) of $N=4$

$$\text{Diagram: } \frac{\text{Sector}}{\text{Sectors}} \rightarrow \sum_i = -2 \pi \sum_{g,g}^{\rho^{2(a-\varepsilon)}} \sim S(3)$$