

Title: Mathematical Seminar - Davide Gaiotto

Date: Sep 25, 2017 10:00 AM

URL: <http://pirsa.org/17090072>

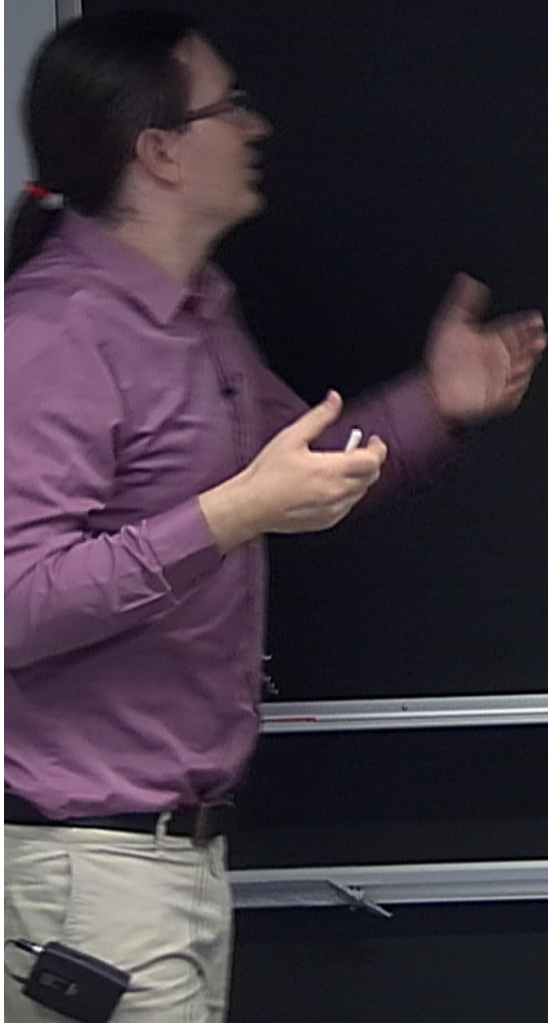
Abstract: <p>He will discuss relations between Virasoro and Kac-Moody conformal blocks, character varieties and quantum groups, and AGT. </p>

$J^{\circ}(z)$

LIVE IV

g^*

, SECTIONS OF K
MEROMO



$J^{\circ}(z)$

LIVE IN

g^*

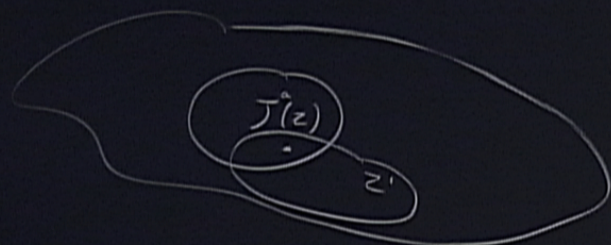
SECTIONS OF K

K

BEHAVE AS MEROMORPHIC

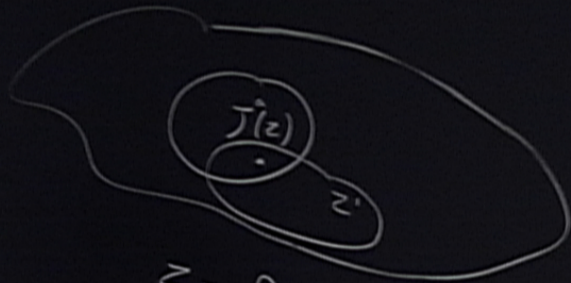
(1,0)

FORMS



$$z = f(z')$$

$\mathcal{J}^a(z)$ LIVE IN g^* , SECTIONS OF K
 BEHAVE AS MEROMORPHIC $(1,0)$ FORMS



$$z = f(z')$$

$$\mathcal{J}^a(z) = \mathcal{J}^a(z') \frac{dz'}{dz}$$

$$\mathcal{J}^a(z) \mathcal{J}^b(w) \sim \frac{\kappa \delta^{ab}}{(z-w)^2} + \frac{f_c^{ab} \mathcal{J}^c(w)}{z-w} + \dots$$

\mathbb{C} RIEMANN SURFACE

$$\langle \rangle_{\mathbb{C}}$$

$\langle J(z) \rangle_{\mathbb{C}}$ HOL 1-FORM ON \mathbb{C}

$\langle J^a(z) J^b(w) \rangle$ MEROMORPHIC ON $\mathbb{C} \times \mathbb{C}$

POLE ON DIAGONAL

$\langle J^a(z_1) J^b(z_2) J^c(z_3) \rangle$ SYMMETRIC $z \leftrightarrow w$

.....

CAUTION
DO NOT STAND ON LIMBS AND BRACKETS
PANELS ARE NOT TO BE TOUCHED BY THE STUDENT
IT IS ESSENTIAL TO WEAR SEAT BELTS
WHEN BOARDING

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CAUTION
DO NOT TOUCH THE BOARD SURFACE
OR THE BOARD BY THE BOARD
IT IS IMPORTANT TO KEEP
THE BOARD SURFACE CLEAN
PLEASE DO NOT TOUCH THE BOARD

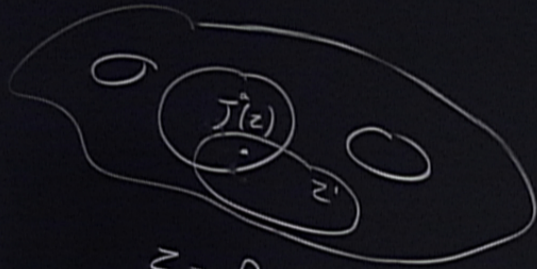
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$\mathcal{J}^a(z)$ LIVE IN \mathfrak{g}^* , SECTIONS OF \mathcal{K}
 BEHAVE AS MEROMORPHIC $(1,0)$ FORMS

$$\mathcal{J}^a(z) \mathcal{J}^b(w) \sim \frac{\kappa \delta^{ab}}{(z-w)^2} + \frac{f_c^{ab} \mathcal{J}^c(w)}{z-w} + \dots$$

$$\mathcal{J}^a(z') \frac{dz'}{dz}$$

$\mathcal{J}^a(z)$ LIVE IN \mathcal{g}^* , SECTIONS OF \mathcal{K}
 BEHAVE AS MEROMORPHIC $(1,0)$ FORMS



$$z = f(z')$$

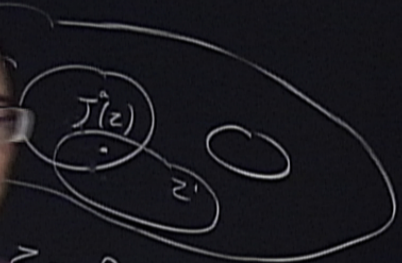
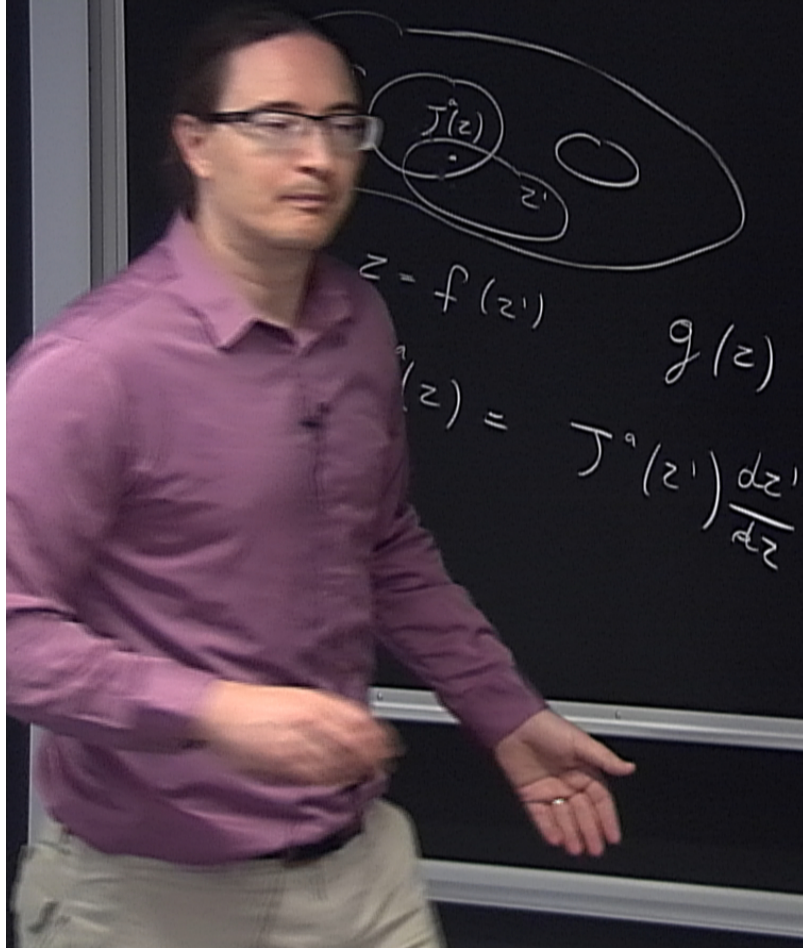
$$g(z)$$

$$\mathcal{J}^a(z) = \mathcal{J}^a(z') \frac{dz'}{dz}$$

$$\mathcal{J}^a(z) \mathcal{J}^b(w) \sim \frac{\kappa \delta^{ab}}{(z-w)^2} + \frac{f_c^{ab} \mathcal{J}^c(w)}{z-w} + \dots$$

C , E \mathbb{S} -BUNDLE ON C

$J^a(z)$ LIVE IN g^* , SECTIONS OF K
 BEHAVE AS MEROMORPHIC $(1,0)$ FORMS

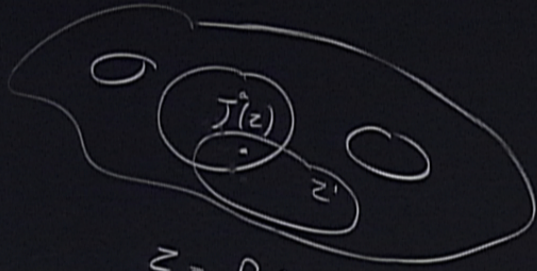


$z = f(z')$
 $g(z) = J^a(z') \frac{dz'}{dz}$

$$J^a(z) J^b(w) \sim \frac{\kappa \delta^{ab}}{(z-w)^2} + \frac{f_c^{ab} J^c(w)}{z-w} + \dots$$

$g_{a(z)}^{b'}$ $g_{b'(w)}^{a'}$

$J^a(z)$ LIVE IN g^* , SECTIONS OF K
 BEHAVE AS MEROMORPHIC $(1,0)$ FORMS



$$z = f(z')$$

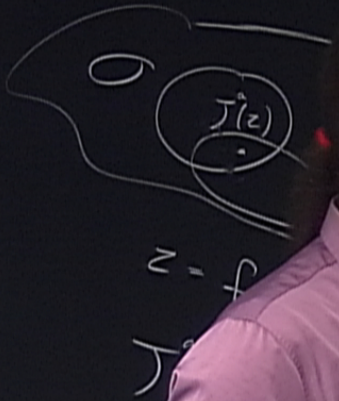
$$g(z)$$

$$J^a(z) = J^a(z') \frac{dz'}{dz}$$

$$J^a(w) \sim \frac{\kappa g^{ab}}{(z-w)^2} + \frac{f_c^{ab} J^c(w)}{z-w}$$

$$J^a(w) \sim \kappa \left\{ \frac{g_{a1}^a(z) g_{51}^b(w)}{(z-w)^2} + \frac{f_{99} J}{z-w} \right\}$$

$J^a(z)$ LIVE IN g^* , SECTIONS OF K
 BEHAVE AS MEROMORPHIC $(1,0)$ FORMS



$$J^a(z) J^b(w) \sim \frac{\kappa g^{ab}}{(z-w)^2} + \frac{f_c^{ab} J^c(w)}{z-w} + \dots$$

$$\begin{aligned}
 g_{a_1(z)}^{b_1(z)} g_{b_2(w)}^{b_2(w)} &\sim \kappa g^{ab'} \frac{g_{a_1(z)}^{a_1(z)} g_{b_2(w)}^{b_2(w)}}{(z-w)^2} + \frac{f_{c_1 c_2} J^{c_1} J^{c_2}}{z-w} \\
 &= \frac{\kappa g^{ab}}{(z-w)^2} + \frac{\kappa g^{a_1 a_2} g_{b_1 b_2}(w)}{z-w} + \frac{f J}{z-w}
 \end{aligned}$$

$$(z-u)^2 + \frac{f(u)g(u)}{z-u} + \frac{f_g J}{z-u}$$

$$J^e(z)' = g_b^a(z) J^{\perp}(z) - \kappa(g^{\perp} \partial g)^{\sharp}$$

C, E \mathcal{G} -BUNDLE ON C

CONFORMAL BLOCKS STILL WELL DEFINED

$$(t^a, t^b] = f_c^{ab} t^c$$

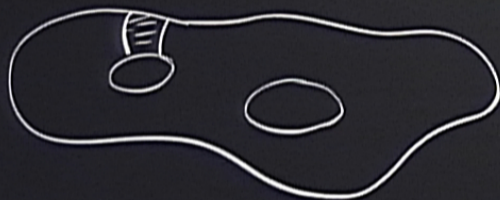
$$(z-u)^2 + \frac{g(u)}{z-u} + \frac{f_g J}{z-u}$$

$$J^k(z)' = g_b^a(z) J^k(z) - W(g^i \partial g)^k$$

~~$W \partial J$~~

C , E \mathbb{S} -BUNDLE ON C

CONFORMAL BLOCKS STILL WELL DEFINED

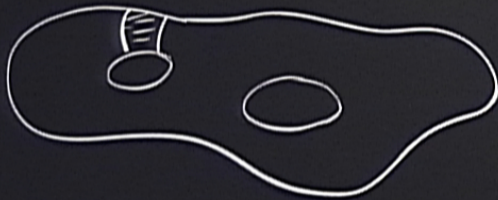


C, E \mathbb{S} -BUNDLE ON C

CONFORMAL BLOCKS

STILL WELL DEFINED

$$g = 1 + \epsilon(z)$$



C , E \mathbb{S} -BUNDLE ON C

CONFORMAL

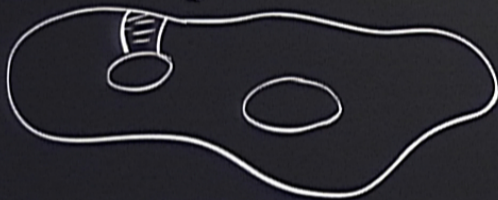
BLOCKS

STILL

WELL

DEFINED

$$g = 1 + \epsilon(z) t^2$$



C , E \mathbb{S}^1 -BUNDLE ON C

CONFORMAL

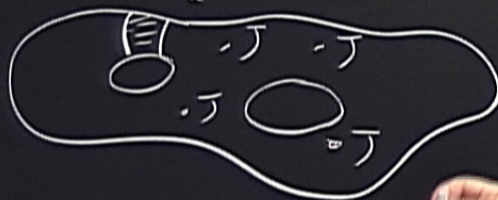
BLOCK

STILL

WELL

DEFINED

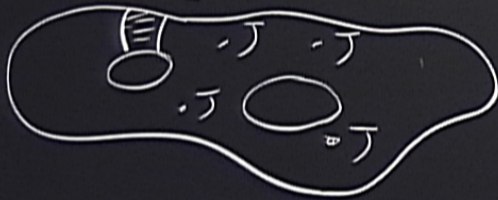
$$g = 1 + \epsilon(z) t^2$$



\mathbb{C} , E \mathbb{S} -BUNDLE ON \mathbb{C}

CONFORMAL

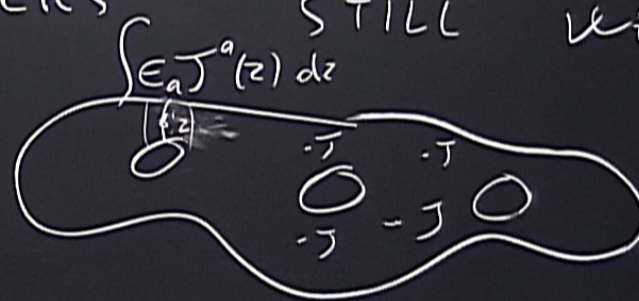
$$g = 1 + \epsilon(z) t^2$$

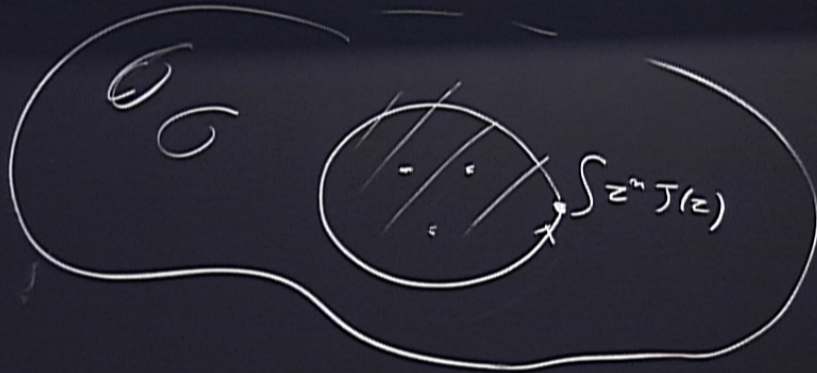


BLOCKS

STILL

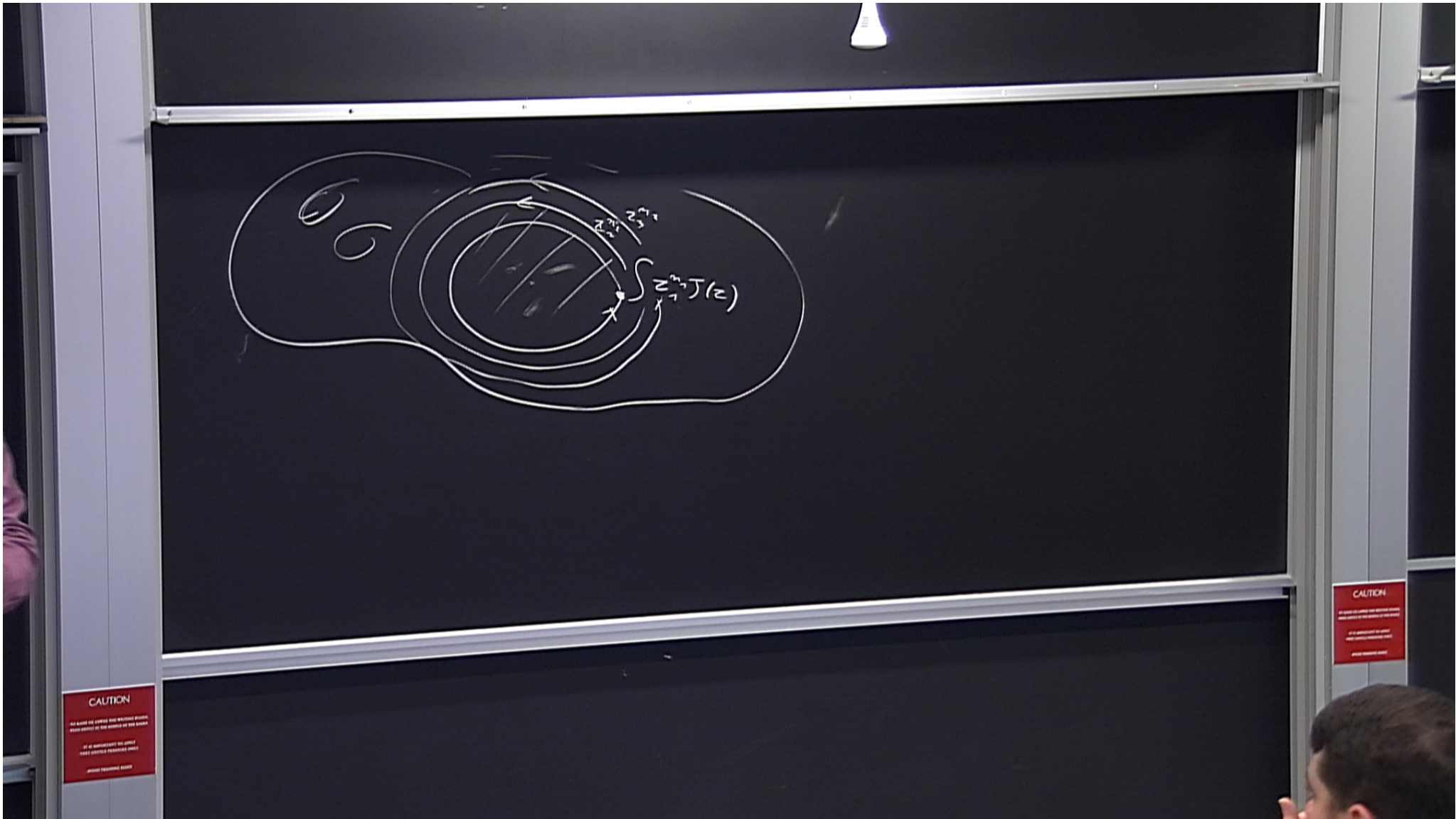
WELL DEFINED

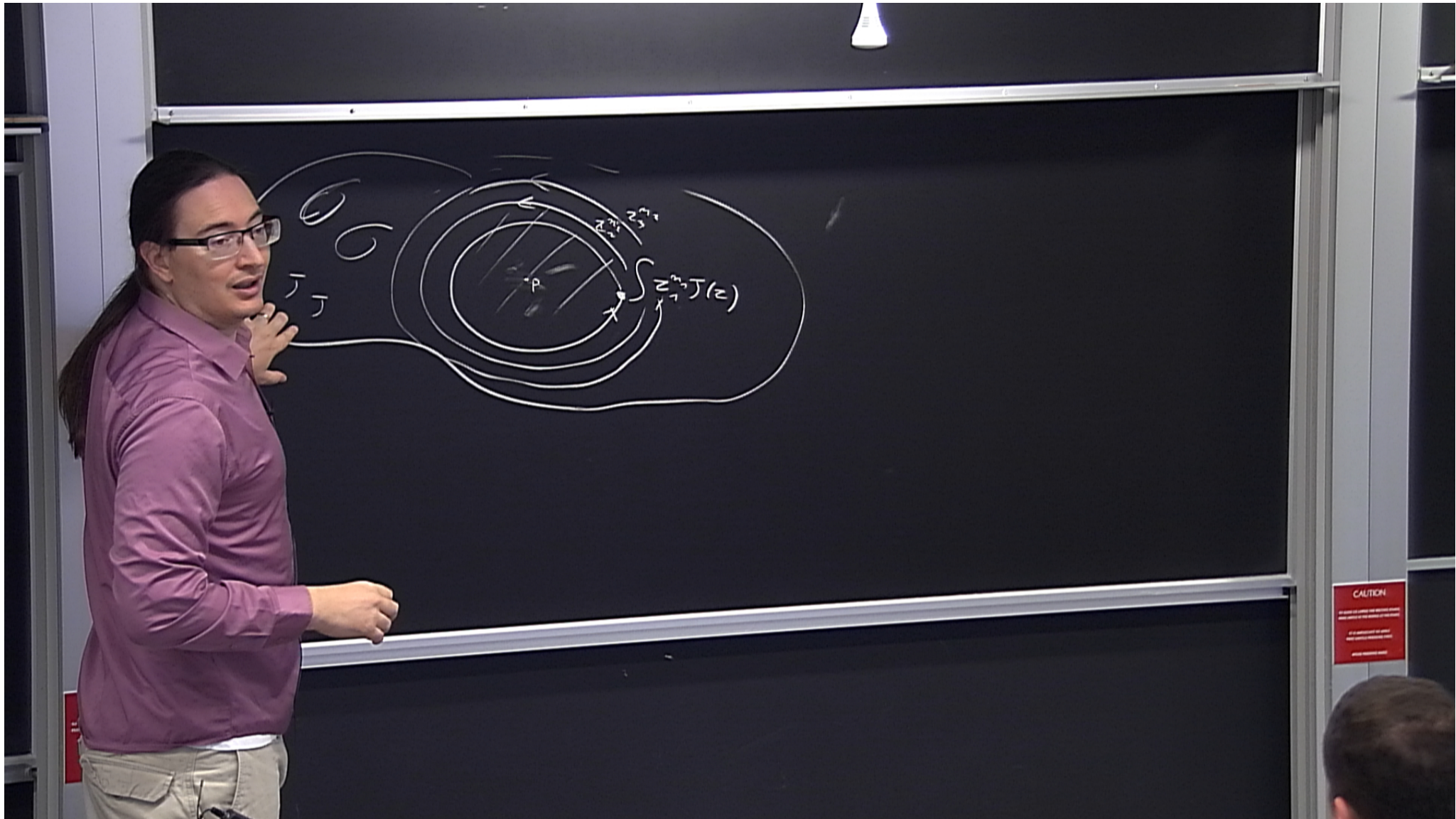


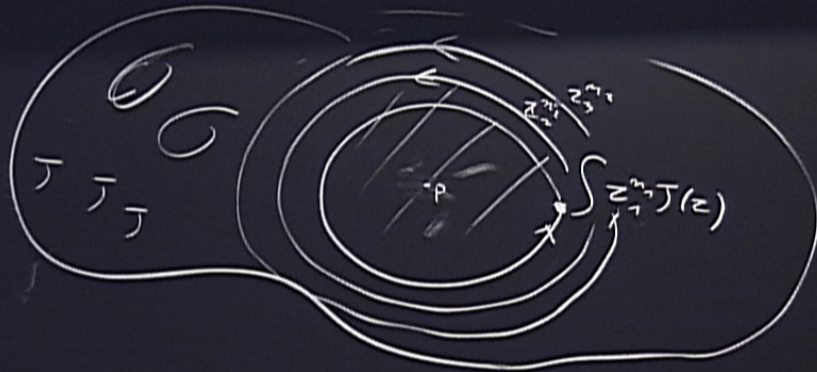


CAUTION
DO NOT TOUCH THE BOARD OR THE BOARDER
BEFORE THE BOARD IS CLEANED
IF AN ACCIDENT OCCURS
PLEASE REPORT TO THE
BOARD OPERATOR

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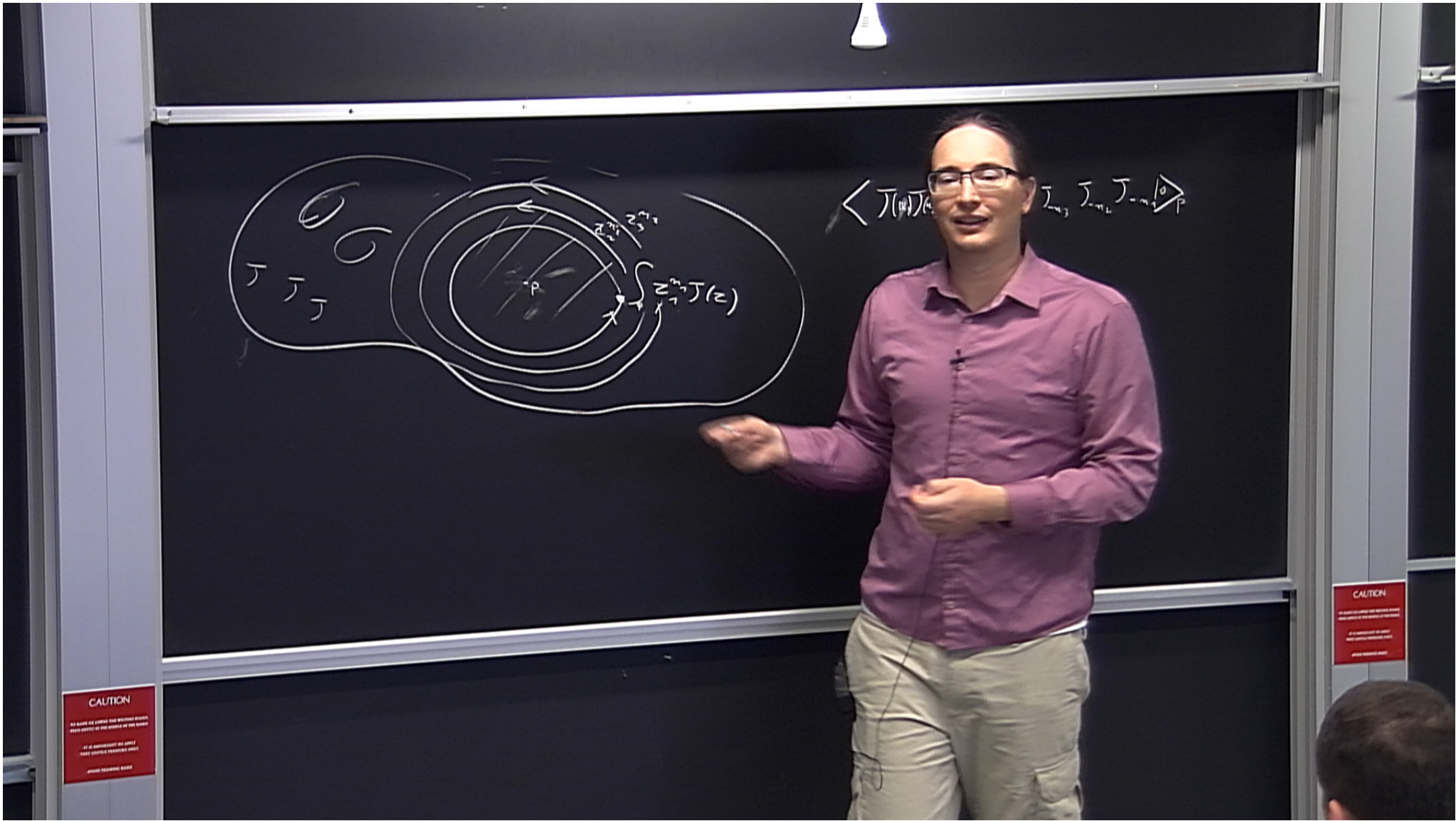




$$\langle \gamma(z) \gamma(z) \gamma(z) \gamma(z) \mid \sum_{-m_1} \sum_{-m_2} \sum_{-m_3} \sum_{-m_4} \rangle_p$$

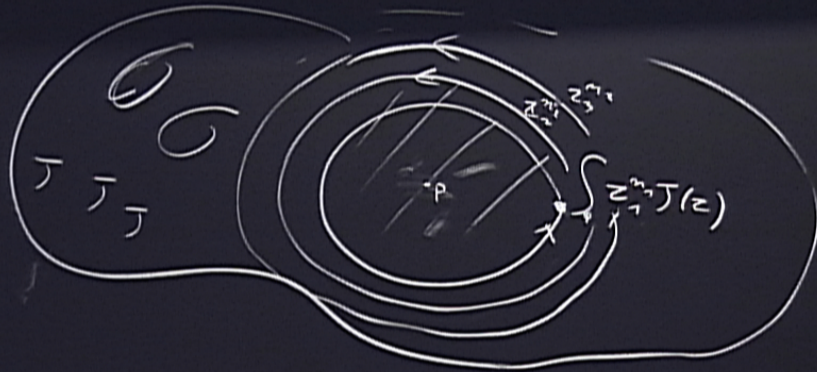
CAUTION
 DO NOT USE LIFELINES AND WALKING STICKS
 BEHIND OBJECTS IN THE MIDDLE OF THE ROOM
 IT IS ESSENTIAL TO KEEP
 THESE OBJECTS POSITIONED CORRECTLY
 PLEASE REARRANGE THEM

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CAUTION
DO NOT USE LAMP OR BRUSHES
BEFORE CHECKING THE STATE OF THE BOARD
IT IS ESSENTIAL TO USE
THE BOARD PROPERLY
PLEASE RESPECT THE BOARD

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$$\begin{aligned}
 & \langle J(\gamma) J(\gamma) \dots J \mid J_{-m_1}^a J_{-m_2}^b J_{-m_3}^c \rangle_P \\
 & \parallel \\
 & \langle \dots \mid J_{-m_2}^b J_{-m_3}^a J_{-m_4}^c \rangle \\
 & + f_c^{ab} \langle \dots \mid J_{-m_2}^c J_{-m_3}^a J_{-m_4}^b \rangle \\
 & + K \sum_{m_1, m_2, \dots, m_n} \langle \dots \mid J_{-m_1} \rangle
 \end{aligned}$$

CAUTION
 DO NOT USE STAIRS AND ESCAPE ROUTES
 BEING ADVISED BY THE SOUND OF THE BELL
 IT IS ESSENTIAL TO KEEP
 THESE ROUTES CLEAR AT ALL TIMES
 PLEASE RECOGNISE SIGNS

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$$[T_n^a, T_m^b] = f_c^{ab} T_{n+m}^c + \kappa m \delta_{n+m, 0}$$

$$[T_n^a, T_m^b] = f_c^{ab} T_{n+m}^c + \kappa m \delta_{n+m, 0}$$

$$T_n^a |0\rangle = 0 \quad n \geq 0$$

$$[T_n^a, T_m^b] = f_c^{ab} T_{n+m}^c + Km \delta_{n+m, 0} T_0^a$$

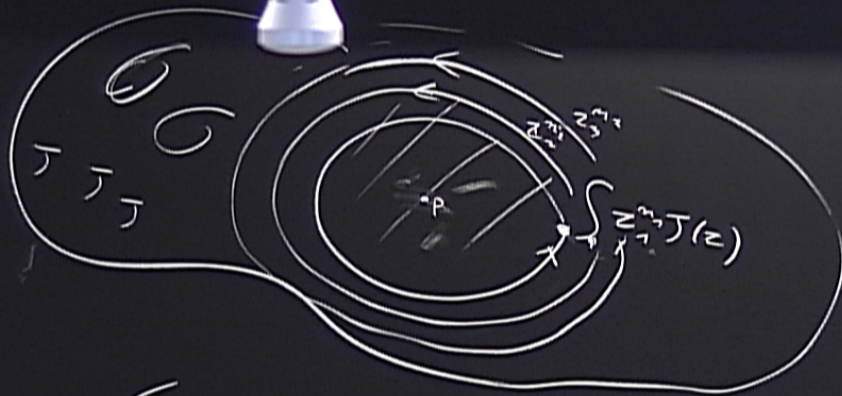
$$T_n^a |0\rangle = 0 \quad n \geq 0$$

$$[T_n^a, T_m^b] = f_c^{ab} T_{n+m}^c + \kappa m \delta_{n+m, 0} T_0^a$$

$$T_n^a |0\rangle = 0 \quad n \geq 0$$

VACUUM MODULE \mathcal{V}_0

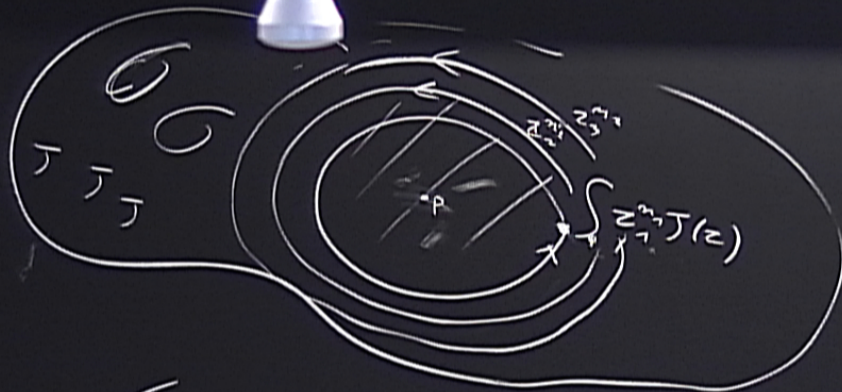
$$\begin{aligned} &|0\rangle \\ &T_{-1}^a |0\rangle \\ &T_{-1}^a T_{-1}^b |0\rangle \\ &T_{-2}^a |0\rangle \\ &\vdots \end{aligned}$$



$$\langle JJJJ | v \rangle_P \quad v \in \mathcal{W}_0$$

$$= \langle J(\infty) J(z) J \mid J_{-n_3}^a J_{-n_2}^b J_{-n_1}^c | 0 \rangle_P$$

$$\begin{aligned} & \langle J_{-n_2}^b J_{-n_3}^a J_{-n_1}^c \mid \dots \rangle \\ & + f_c^{ab} \langle \dots \mid J_{-n_2-n_3}^c J_{-n_1} \rangle \\ & + k \delta_{n_1+n_2+n_3=0} \langle \dots \mid J_{-n_1} \rangle \end{aligned}$$



$$\langle TTTT \rangle_P \quad v \in \mathcal{W}_0$$

$$= \langle T(\mathbb{1})T(z)T(z) \mid T_{-m_1}^a T_{-m_2}^b T_{-m_1}^c \mid 0 \rangle_P$$

$$\begin{aligned} & \langle \dots \mid T_{-m_2}^b T_{-m_1}^a T_{-m_1}^c \dots \rangle \\ & + f_c^{ab} \langle \dots \mid T_{-m_2-m_1}^c \dots \rangle \\ & + K \delta_{m_2+m_1,0} \langle \dots \mid T_{-m_1} \dots \rangle \end{aligned}$$

$$[T_n^a, T_m^b] = f_c^{ab} T_{n+m}^c + \kappa m \delta_{n+m, 0} T_0^a$$

$$T_n^a |0\rangle = 0 \quad n \geq 0$$

VACUUM MODULE \mathcal{V}_0

$$\begin{aligned} &|0\rangle \\ &T_{-1}^a |0\rangle \\ &T_{-1}^a T_{-1}^b |0\rangle \\ &T_{-2}^a |0\rangle \\ &\vdots \end{aligned}$$

$$(t^a, t^b) = f_c^{ab} t^c$$

$$(z-u)^2 + \frac{d \log(u)}{z-u} + \frac{f_g J}{z-u}$$

R_2 FINITE IPRES OF g $\mathcal{J}(z) = x(g(z))$

$$(t^a, t^b) = f_c^{ab} t^c$$

$$(z-u)^2 + \frac{d \log(u)}{z-u} + \frac{f_2 J}{z-u}$$

R_2 FINITE IRRED OF g

$|i\rangle \in R_2$ UNDER J_a

$$J_a |i\rangle = (t_1^a, |j\rangle)$$

$$(t^a, t^b) = f_c^{ab} t^c$$

$$(z-u)^2 + \frac{d \log(u)}{z-u} + \frac{f_{ij}}{z-u}$$

R_2 FINITE IRRED OF g

$|i\rangle \in R_2$ UNDER J_a

$$J_{-1}^a |i\rangle$$

$$J_{-1}^a J_{-1}^b |i\rangle, J_{-2}^a |i\rangle \dots$$

$$J_0^a |i\rangle = (t_{ij}^a, |j\rangle)$$

$$[t^a, t^b] = f_{ab}^c t^c$$

$$(z-u)^2 + \frac{d \log(u)}{z-u} + \frac{f_{ij} J}{z-u}$$

R_2 FINITE IRRED OF g

$$|i\rangle \in R_2$$

UNDER

$$T_n^a |i\rangle = 0 \quad n > 0$$

$$T_0^a$$

$$T_0^a |i\rangle = (t_{ij}^a)^c |j\rangle$$

$$T_{-1}^a |i\rangle$$

$$T_{-1}^a T_{-1}^b |i\rangle$$

$$, T_{-2}^a |i\rangle \dots$$

$$\langle O_i(P) \rangle$$
$$\langle J^a(z) O_i(P) \rangle$$

CAUTION
DO NOT TOUCH THE BOARD SURFACE
OR POINTS IN THE AREA OF THE BOARD
IF IT APPEARS TO BE
HOT OR VERY HOT
PLEASE CONTACT THE
SERVICE CENTER

$$\langle O_i(p) \rangle$$

$$\langle J^a(z) O_i(p) \rangle$$

$$J^a(z) O_i(p) \underset{z \rightarrow p}{\sim} \frac{(t^a)^i_j O_j(p)}{z-p} + \dots$$

CAUTION
 DO NOT LEAN ON THE BOARD
 DO NOT WRITE ON THE BOARD
 DO NOT WRITE ON THE BOARD

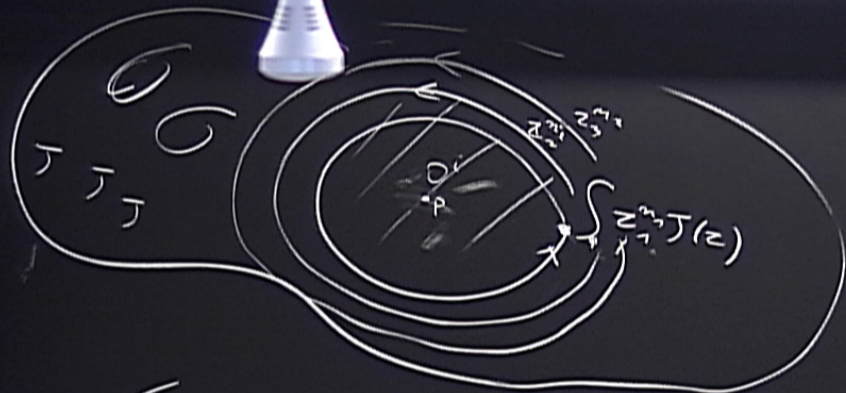
$$\langle O_i(p) \rangle$$

$$\langle J^a(z) O_i(p) \rangle$$

$$\langle J^a(z) J^b(u) O_i(p) \rangle$$

$$J^a(z) O_i(p) \underset{z \rightarrow p}{\sim} \frac{(t^a)^i_j O_j(p)}{z-p} + \dots$$

CAUTION
DO NOT LEAN ON THE BOARD
DO NOT TOUCH THE BOARD
DO NOT TOUCH THE BOARD



$$\langle TTTT \dots \rangle_P \quad v \in \mathcal{W}_0$$

$$= \langle T(z)T(z)T \dots | \sum_{-n_3}^a \sum_{-n_2}^b \sum_{-n_1}^c | 0 \rangle_P \rangle$$

$$\llcorner$$

$$\langle \dots | \sum_{-n_2}^b \sum_{-n_3}^a \sum_{-n_1}^c \dots \rangle$$

$$+ f_c^{ab} \langle \dots | T_c^{c} \dots \rangle$$

$$+ K \sum_{n_1, n_2, n_3} \langle \dots | T_{-n_1} \dots \rangle$$

$$\langle O_i^{(A)}(p) \rangle$$

$$\langle T^a(z) O_i^{(A)}(p) \rangle$$

$$\langle T^a(z) T^b(u) O_i^{(A)}(p) \rangle$$

$$T^a(z) O_i^{(A)}(p) \underset{z \rightarrow p}{\sim} \frac{(t^a)_i^j O_j^{(A)}(p)}{z-p}$$

CAUTION
DO NOT LEAN ON THE BOARD
OR OTHER SURFACES
IF NECESSARY USE HANDS
TO HOLD THE BOARD
PLEASE HOLD THE BOARD

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$$\begin{aligned}
 & \langle J^a(z) J^b(u) J\bar{J}J \rangle \\
 &= \frac{h\delta}{(z-u)^2} \langle J\bar{J}J \rangle + \frac{f^{ab}}{z-u} \langle J^c(u) J\bar{J}J \rangle + \langle (J^a J^b)(u) J\bar{J}J \rangle
 \end{aligned}$$

CAUTION

$$\begin{aligned}
 & \langle J^a(z) J^b(u) J \bar{J} J \bar{J} \rangle \\
 &= \frac{h\bar{c}}{(z-u)^2} \langle J \bar{J} J \bar{J} \rangle + \frac{f^{ab}}{z-u} \langle J^c(u) J \bar{J} J \bar{J} \rangle + \langle (J^a J^b)(u) J \bar{J} J \bar{J} \rangle \\
 T(z) &= \frac{1}{4+h} (J^a J^a)(z)
 \end{aligned}$$

CAUTION

$$\langle J^a(z) O_i^{(A)}(p) \rangle$$

$$\langle J^a(z) J^b(u) O_i^{(A)}(p) \rangle$$

$$T(z) J^c(u) \sim \partial_u \left(\frac{1}{z-u} J(u) \right)$$

$$\sim \frac{1}{(z-u)^2} J(u) + \frac{1}{z-u} J'(u)$$

$$T(z) v(z) = \int_{\gamma} \dots$$

Diagram: A circle with points $J_{z_1}, J_{z_2}, J_{z_3}, J_{z_4}$ inside. An arrow labeled $T(z)v(z)$ points to the circle. Below the circle is an equals sign followed by a minus sign.

$z \rightarrow p$
 $\frac{1}{z-p}$

CAUTION
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 IT IS IMPORTANT TO ALWAYS...
 ALWAYS WEAR YOUR SEATBELT

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$$(t^a, t^b) = f_c^{ab} t^c$$

$$(z-u)^2 + \frac{d^2 g(u)}{z-u} + \frac{f_g J}{z-u}$$

$$J \rightarrow g \cdot J + \kappa g^{-1} \partial g$$

R_2 FINITE IPRES

$$J^a = g \cdot J^a \cdot J^{-1}(z) = \kappa (g \partial g)^a$$

$|i\rangle \in R_2$ UNDER

$$J_n^a |i\rangle = 0 \quad n > 0$$

$$J_{-1}^a |i\rangle$$

$$J_0^a$$

$$J_0^a |i\rangle = (t_2^a)^i |i\rangle$$

$$J_{-1}^a J_{-1}^b |i\rangle$$

$$, J_{-2}^a |i\rangle \dots$$

$$= \frac{h\delta}{(z-u)^2} \langle TTT \rangle + \frac{f^{ab}}{z-u} \langle J^c (TTT) \rangle + \langle (J^a J^b)(u) TTT \rangle$$

$$\bar{T}(z) = \frac{1}{k+h} (J^a J^a)(z)$$

$$T(z)\bar{T}(u) \sim \frac{c}{(z-u)^4} + \frac{2T(u)}{(z-u)^2} + \frac{\partial T(u)}{z-u}$$

CAUTION

$$= \frac{h\delta}{(z-u)^2} \langle JTTJ \rangle + \frac{f^{ab}}{z-u} \langle J^c (JTTJ) \rangle + \langle (J^a J^b)(u) JTTJ \rangle$$

$$T(z) = \frac{1}{k+h} (J^a J^a)(z)$$

$$c = \frac{\dim \mathfrak{K}}{k+h}$$

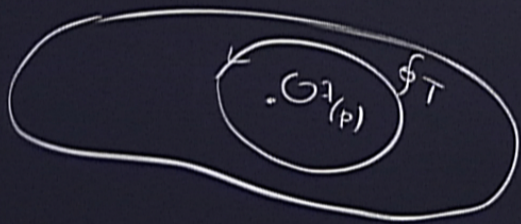
$$T(z)T(u) \sim \frac{c}{(z-u)^4} + \frac{2T(u)}{(z-u)^2} + \frac{\partial T(u)}{z-u}$$

CAUTION

$$\langle O_i^{(A)}(P) \rangle$$

$$\langle J^a(z) O_i^{(A)}(P) \rangle$$

$$\langle J^a(z) J^b(w) O_i^{(A)}(P) \rangle$$

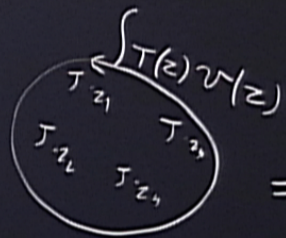


$$J^a(z) O_i^{(A)}(P) \underset{z \rightarrow P}{\sim} \frac{(t^a)^i O_i^{(A)}(P)}{z-P}$$

$$T(z) J^c(w) \sim \partial_w \left(\frac{1}{z-w} J(w) \right)$$

$$\sim \frac{1}{(z-w)^2} J(w) + \frac{1}{z-w} J'(w)$$

$$= \sum_{i,j} T_{ij} = \sum_{i,j} T_{-i, j} + v(w)$$



CAUTION
DO NOT TOUCH THE BOARD OR THE BOARD COVER BY THE HANDLE OF THE BOARD.
SI NE TOUCHATE PAS LE TABLEAU NI LE COUVERCLE DU TABLEAU PAR LE MANCHON DE LA TABLEAU.
NE PAS TOUCHER LE TABLEAU NI LE COUVERCLE DU TABLEAU PAR LE MANCHON DE LA TABLEAU.

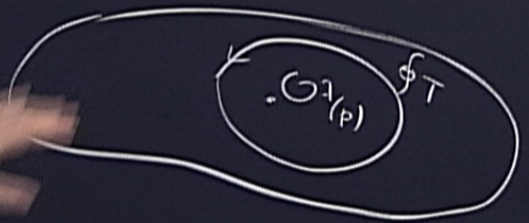
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$$\langle O_i^{(A)}(P) \rangle \quad \langle \partial_P O_i^{(A)}(P) \dots \rangle = \frac{1}{u+h} \langle E \rangle \langle (J, O) \dots \rangle$$

$$J^a(z) O_i^{(A)}(P) \sim \frac{(t^a)^i}{z-p} O_i^{(A)}(P)$$

$$\langle J^a(z) O_i^{(A)}(P) \rangle$$

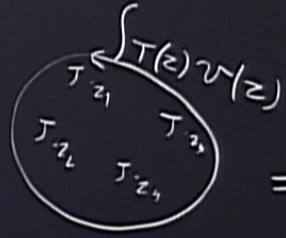
$$\langle J^a(z) J^b(u) O_i^{(A)}(P) \rangle$$



$$T(z) J^c(u) \sim \partial_u \left(\frac{1}{z-u} J(u) \right)$$

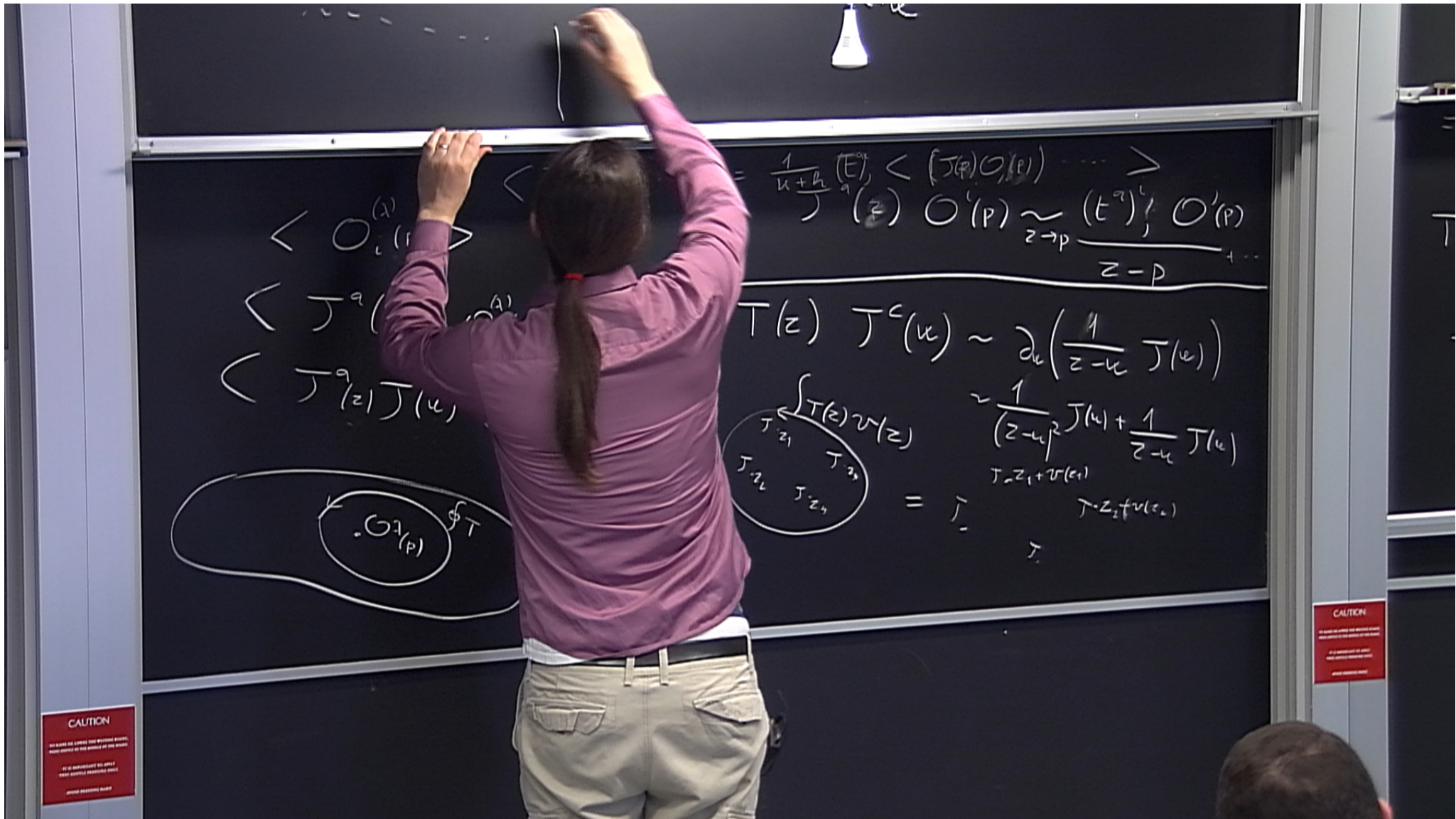
$$\sim \frac{1}{(z-u)^2} J(u) + \frac{1}{z-u} J'(u)$$

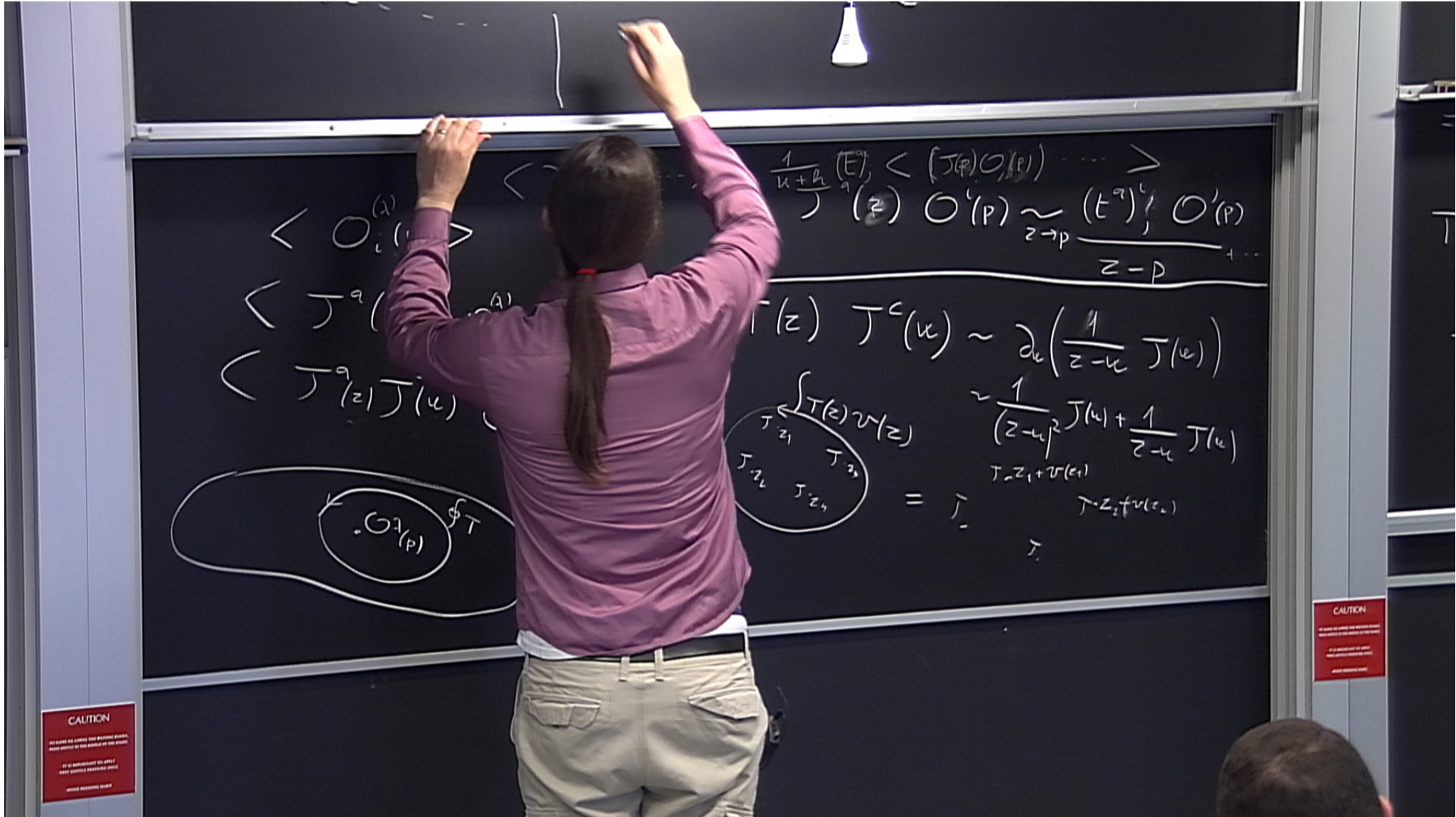
$$= \int_{T'} \frac{T(z) v(z)}{z-u} dz$$



CAUTION
DO NOT TOUCH THE BOARD OR THE BOARDER
IF YOU ARE NOT A MEMBER OF THE BOARD

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CAUTION
 DO NOT USE LAMPS THAT WITHOUT PROTECTIVE GRILLS.
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 THANK YOU FOR YOUR COOPERATION.

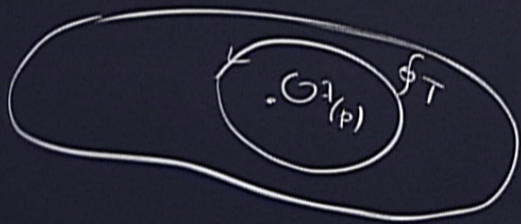
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$$\langle O_i^{(A)}(P) \rangle \quad \langle \partial_P O_i^{(A)}(P) \dots \rangle = \frac{1}{u+h} \langle E \rangle, \quad \langle J(P) O_i^{(A)}(P) \dots \rangle$$

$$J^a(z) O_i^{(A)}(P) \sim \frac{(t^a)^i}{z-P} O_i^{(A)}(P)$$

$$\langle J^a(z) O_i^{(A)}(P) \rangle$$

$$\langle J^a(z) J^b(u) O_i^{(A)}(P) \rangle$$



$$J^a(z) O_i^{(A)}(P) = \frac{(t^a)^i}{z-P} O_i^{(A)}(P) + (J(P) O_i^{(A)}(P))$$

$$\partial_P - \frac{1}{h+p} t^a J^a(P) \langle O_i^{(A)}(P) \dots \rangle = 0$$

$$J^a(z) f^a(z)$$

CAUTION
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IF YOU ARE NOT A MEMBER OF THE BOARD
OR A MEMBER OF THE STAFF
PLEASE ASK THE BOARDER

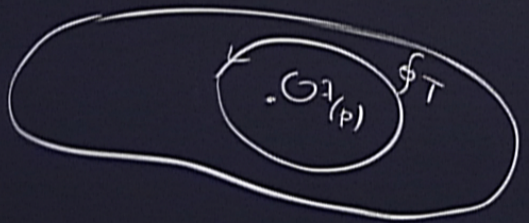
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$$\langle O_i^{(A)}(P) \rangle \quad \langle \partial_P O_i^{(A)}(P) \dots \rangle = \frac{1}{k+h} \langle (E) \rangle \quad \langle (J(P) O_i^{(A)}(P)) \dots \rangle$$

$$J^a(z) O_i^{(A)}(P) \sim \frac{(t^a)^i}{z-P} O_i^{(A)}(P)$$

$$\langle J^a(z) O_i^{(A)}(P) \rangle$$

$$\langle J^a(z) J^b(u) O_i^{(A)}(P) \rangle$$



$$J^a(z) O_i^{(A)}(P) = \frac{(t^a)^i}{z-P} O_i^{(A)}(P) + (J^a(P) O_i^{(A)}(P))$$

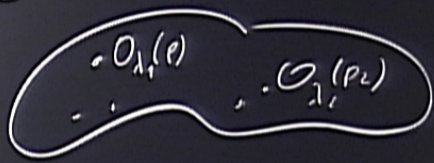
$$\partial_P - \frac{1}{k+h} t^a J^a(P) \langle O_i^{(A)}(P) \dots \rangle = 0$$

$$J^a(z) f^i(z)$$

CAUTION
BE CAREFUL OF LINES THAT CROSS OTHERS.
DO NOT CROSS THE LINES OF THE BOARD.
IT IS ESSENTIAL TO OPEN THE BOARD PROPERLY.
PLEASE BE CAREFUL.

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POLE ON DIAGONAL
 SYMMETRIC $\leftrightarrow \kappa$



$$\langle O_i^{(A)}(p) \rangle$$

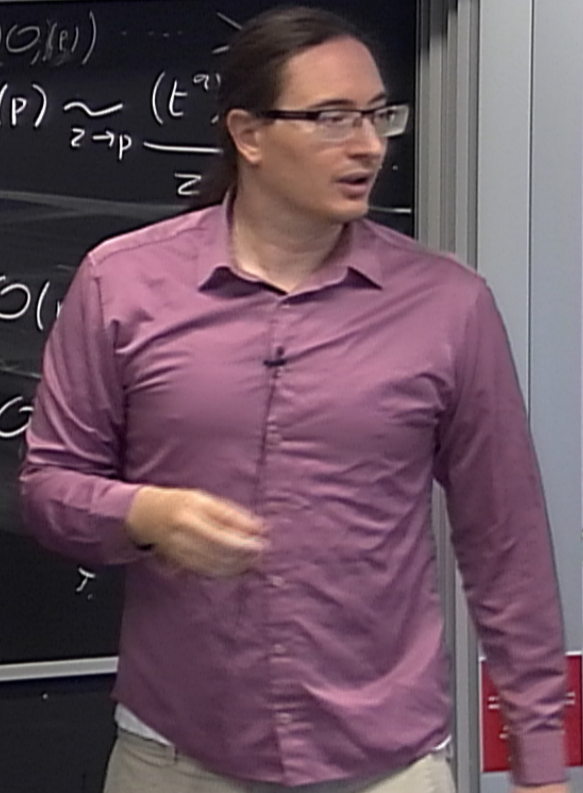
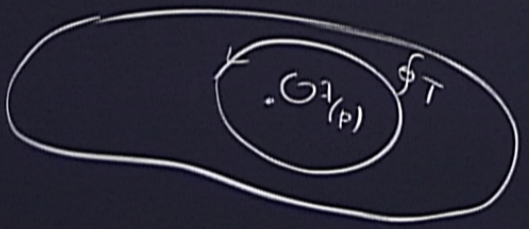
$$\langle J^a(z) O_i^{(A)}(p) \rangle = \frac{1}{\kappa+h} \langle E^a \rangle \langle J^a(p) O_i^{(A)}(p) \rangle$$

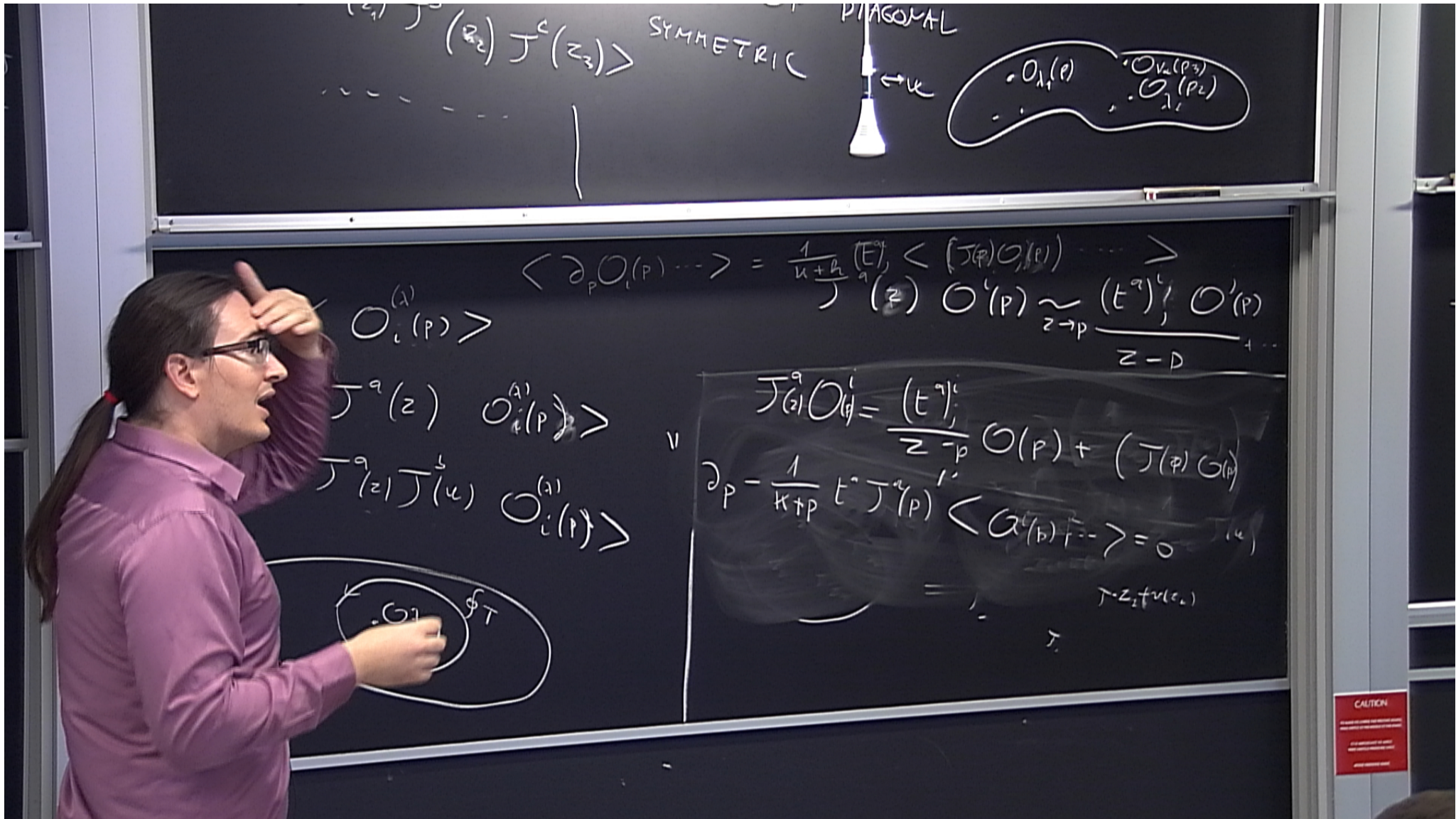
$$\langle J^a(z) O_i^{(A)}(p) \rangle \sim \frac{(t^a)^i}{z-p}$$

$$\langle J^a(z) J^b(u) O_i^{(A)}(p) \rangle$$

$$\langle J^a(z) O_i^{(A)}(p) \rangle = \frac{(t^a)^i}{z-p} \langle O_i^{(A)}(p) \rangle$$

$$\partial_p - \frac{1}{\kappa+p} t^a J^a(p) \langle O_i^{(A)}(p) \rangle$$





$(z_1) \dots (z_2) J^c(z_3) \dots$
 SYMMETRIC
 DIAGONAL
 $\leftarrow k$
 $\begin{matrix} \cdot O_{\lambda_1}(p) \\ \cdot O_{\lambda_2}(p_2) \\ \cdot O_{\lambda_1'} \end{matrix}$

$$\langle \partial_P O_i^{(A)}(P) \dots \rangle = \frac{1}{k+p} \langle E \rangle, \langle (J(P) O_i(P)) \dots \rangle$$

$$J^q(z) O_i^{(A)}(P) \sim \frac{(E^q)_i}{z-p} O_i^{(P)}$$

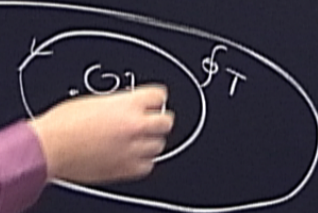
$$J^q(z) O_i^{(A)}(P) >$$

$$J^q(z) J^l(u) O_i^{(A)}(P) >$$

$$J^q(z) O_i^{(A)} = \frac{(E^q)_i}{z-p} O_i(P) + (J(P) O_i(P))$$

$$\partial_P - \frac{1}{k+p} E^q J^q(P) \langle O_i^{(A)} \dots \rangle = 0$$

$J \cdot z_1 + \dots$



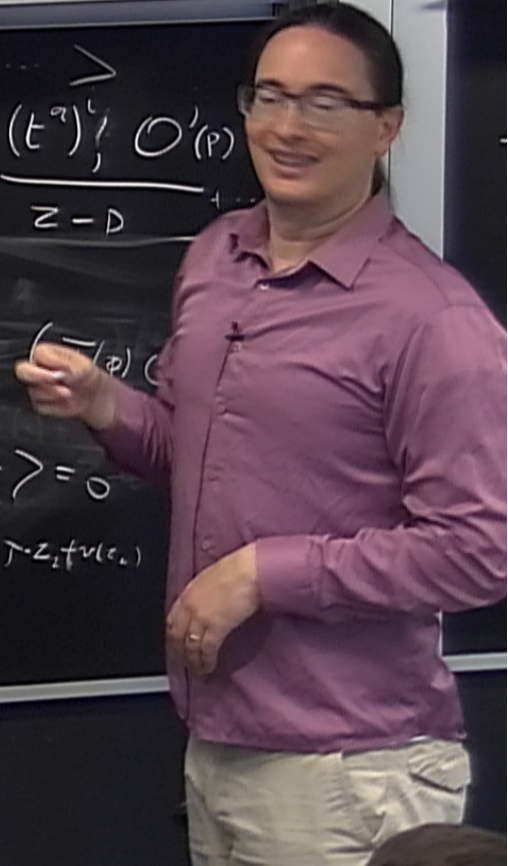
$(z_1) \dots (z_2) J^c(z_3) \dots$
 SYMMETRIC
 DIAGONAL
 $\rightarrow \mu$
 $\cdot O_{\lambda_1}(p)$
 $\cdot O_{\lambda_2}(p_2)$
 $\cdot O_{\lambda_1}$

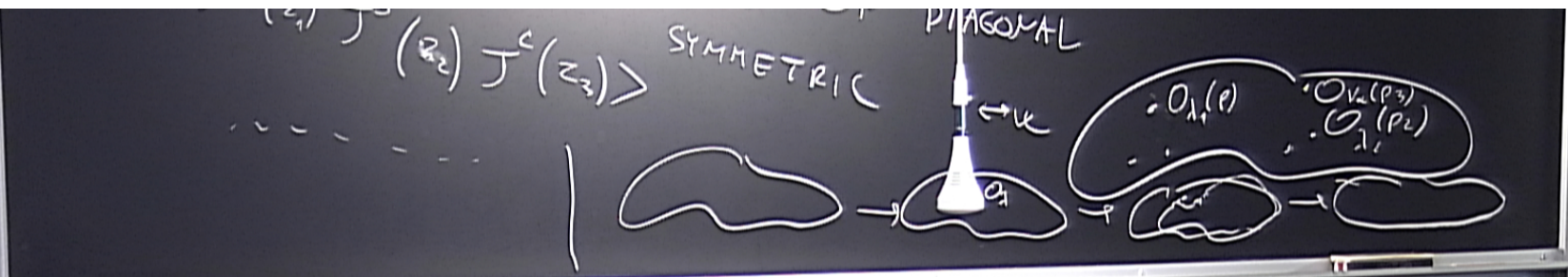
$\langle O_{i_1}^{(A)}(p) \rangle$
 $\langle J^q(z) O_{i_1}^{(A)}(p) \rangle$
 $\langle J^q(z) J^l(u) O_{i_1}^{(A)}(p) \rangle$

$\langle \partial_P O_{i_1}^{(A)}(p) \dots \rangle = \frac{1}{k+l} \binom{E}{q} \langle J^q(p) O_{i_1}^{(A)}(p) \dots \rangle$
 $J^q(z) O_{i_1}^{(A)}(p) \sim_{z \rightarrow p} \frac{(t^q)_i}{z-p} O_{i_1}^{(A)}(p)$

$J^q(z) O_{i_1}^{(A)}(p) = \frac{(t^q)_i}{z-p} O_{i_1}^{(A)}(p) + \dots$
 $\partial_P - \frac{1}{k+l} t^q J^q(p) \langle O_{i_1}^{(A)}(p) \dots \rangle = 0$
 $J \cdot z_i + \nu(\dots)$

$\cdot O_{i_1}^{(A)}(p)$





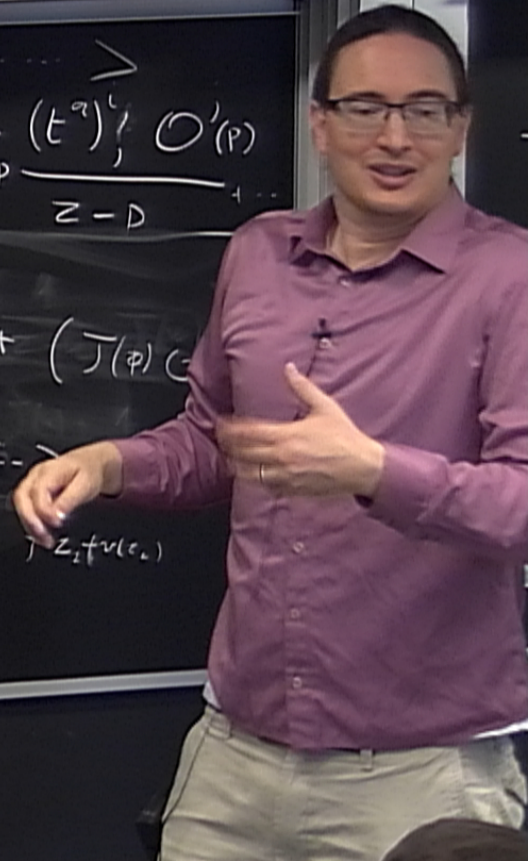
$$\langle O_i^{(A)}(p) \rangle \quad \langle \partial_P O_i^{(A)}(p) \dots \rangle = \frac{1}{k+p} (E^q) \langle (J(p) O_i(p)) \dots \rangle$$

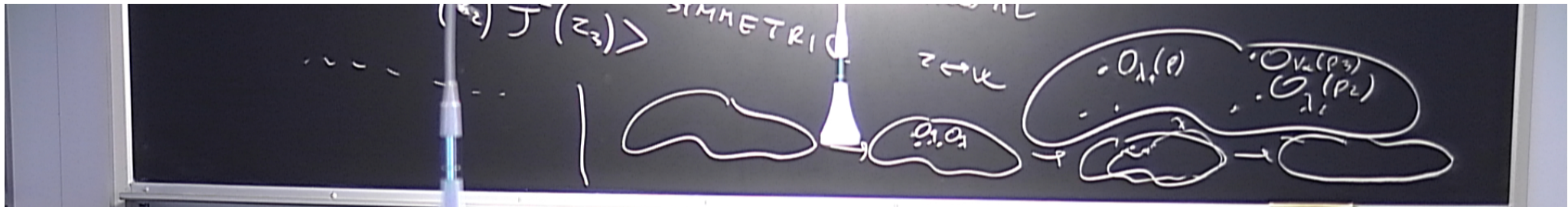
$$\langle J^q(z) O_i^{(A)}(p) \rangle \quad J^q(z) O_i^{(A)}(p) \sim \frac{(E^q)^i}{z-p} O_i^{(A)}(p)$$

$$\langle J^q(z) J^l(u) O_i^{(A)}(p) \rangle \quad \partial_P - \frac{1}{k+p} E^q J^q(p) \langle O_i^{(A)}(p) \dots \rangle$$

$$J^q(z) O_i^{(A)}(p) = \frac{(E^q)^i}{z-p} O_i^{(A)}(p) + (J(p) O_i^{(A)}(p))$$

$$\partial_P - \frac{1}{k+p} E^q J^q(p) \langle O_i^{(A)}(p) \dots \rangle = \dots$$





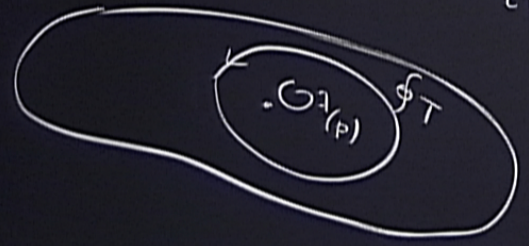
$$\langle \partial_P O_i^{(a)}(P) \dots \rangle = \frac{1}{k+h} \langle (E^q)_q \langle (J(P) O_i^{(a)}(P)) \dots \rangle \rangle$$

$$\langle O_i^{(a)}(P) \rangle$$

$$\langle J^q(z) O_i^{(a)}(P) \rangle$$

$$\langle J^q(z) J^l(w) O_i^{(a)}(P) \rangle$$

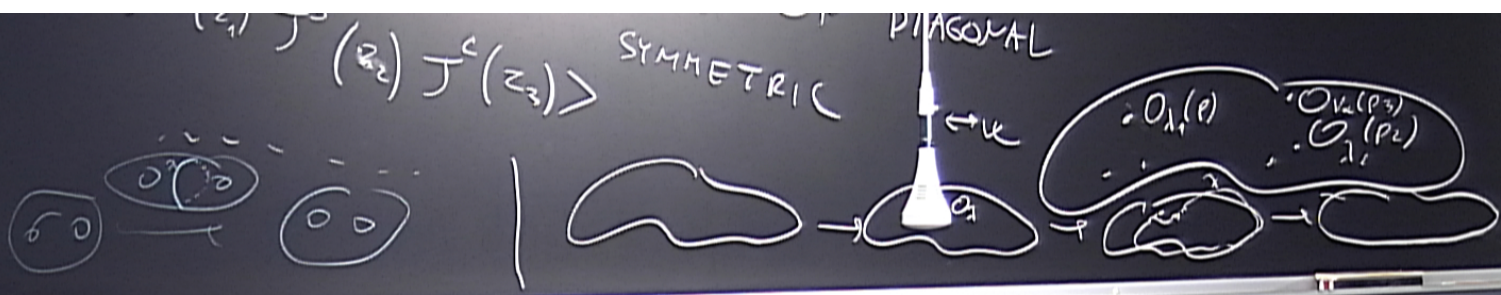
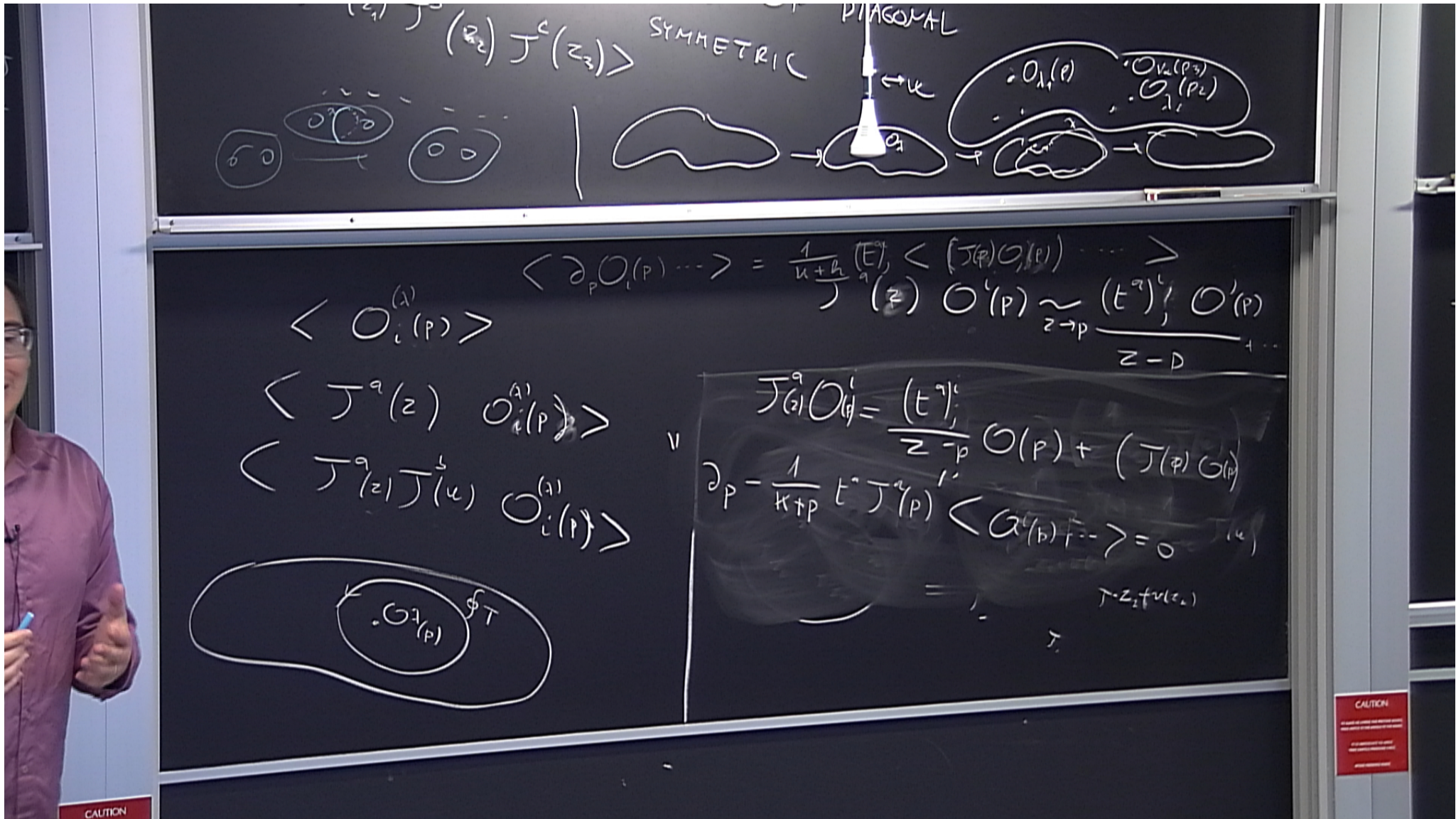
$$\langle (E^q)_q O_i^{(a)}(P) \rangle \sim \frac{(E^q)_q O_i^{(a)}(P)}{z-p}$$



$$J^q(z) O_i^{(a)}(P) = \frac{(E^q)_q}{z-p} O_i^{(a)}(P) + (J^q(P) O_i^{(a)}(P))$$

$$\partial_P - \frac{1}{k+h} (E^q)_q J^q(P) \langle O_i^{(a)}(P) \dots \rangle = 0$$

$$J^q(z) + v(z)$$



$$\langle O_i^{(A)}(p) \rangle \quad \langle \partial_P O_i^{(A)}(p) \dots \rangle = \frac{1}{k+p} \langle (E)_q \rangle \langle (J(p) O_i(p)) \dots \rangle$$

$$J(z) O_i(p) \underset{z \rightarrow p}{\sim} \frac{(E)_q}{z-p} O_i(p)$$

$$\langle J^q(z) O_i^{(A)}(p) \rangle$$

$$\langle J^q(z) J^l(u) O_i^{(A)}(p) \rangle$$

$$J(z) O_i(p) = \frac{(E)_q}{z-p} O_i(p) + (J(p) O_i(p))$$

$$\partial_P - \frac{1}{k+p} E J^q(p)$$

$$\langle O_i^{(A)}(p) \dots \rangle = 0$$

$T = z_1 + \nu(z_2)$

