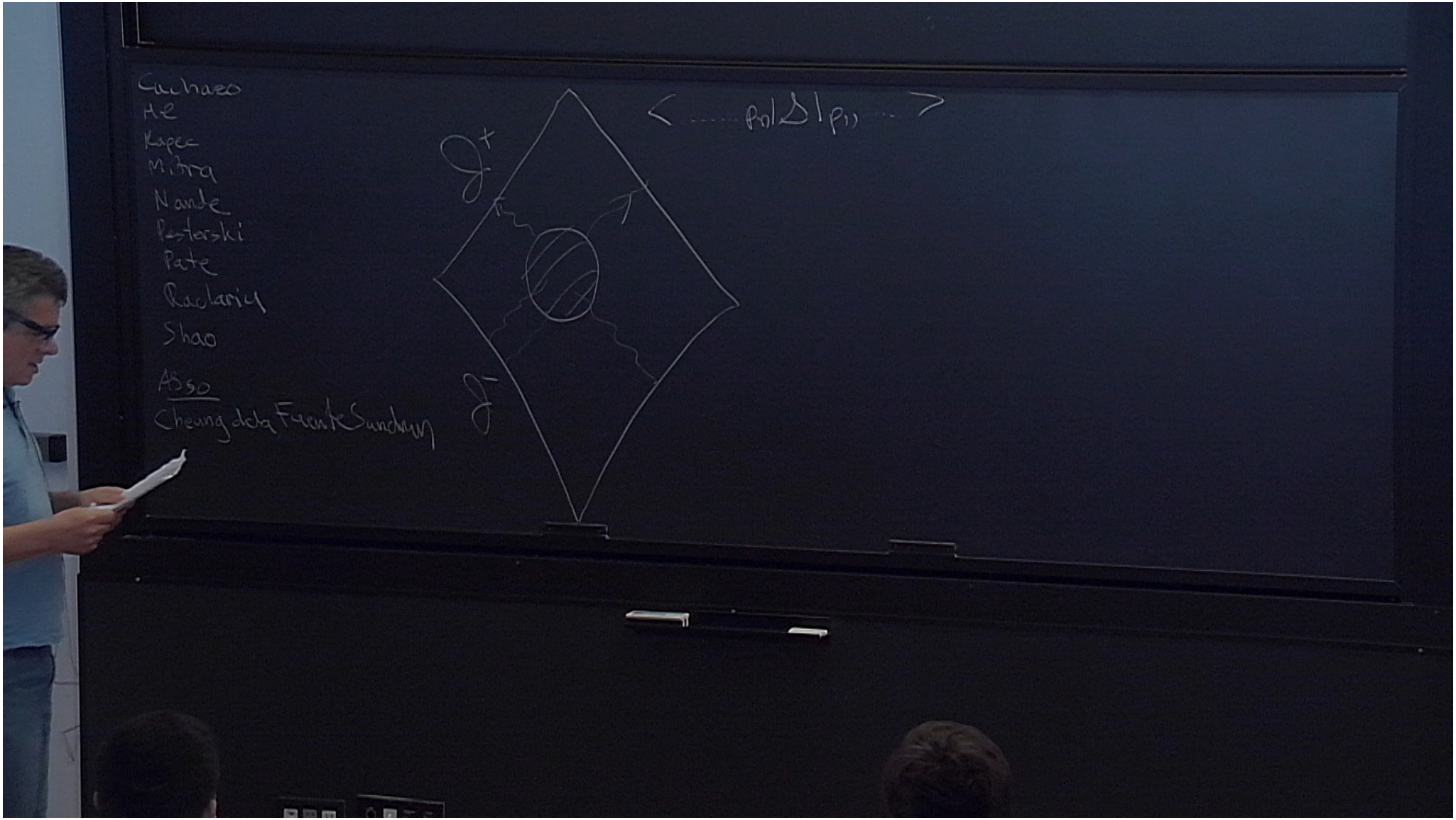
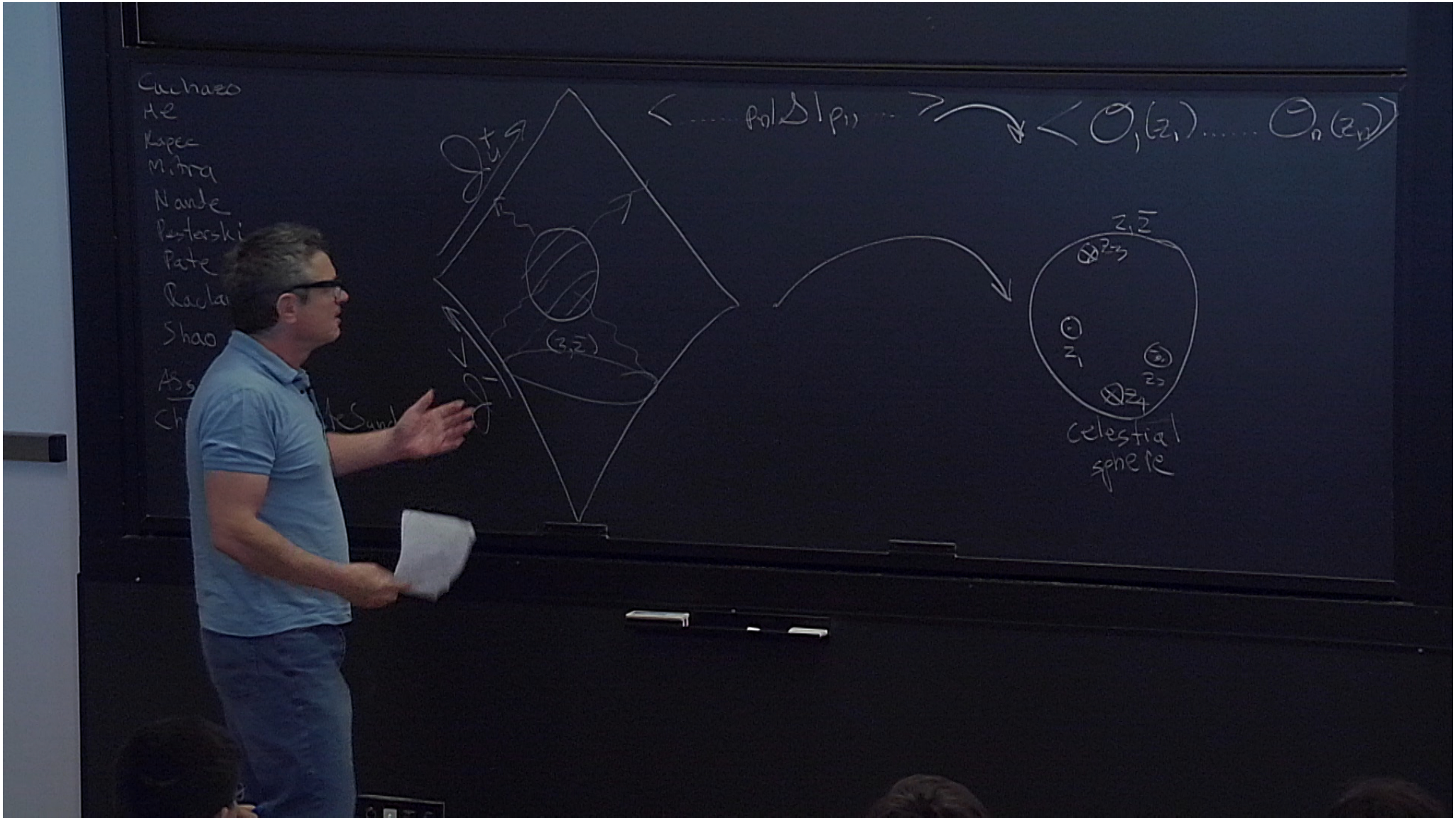
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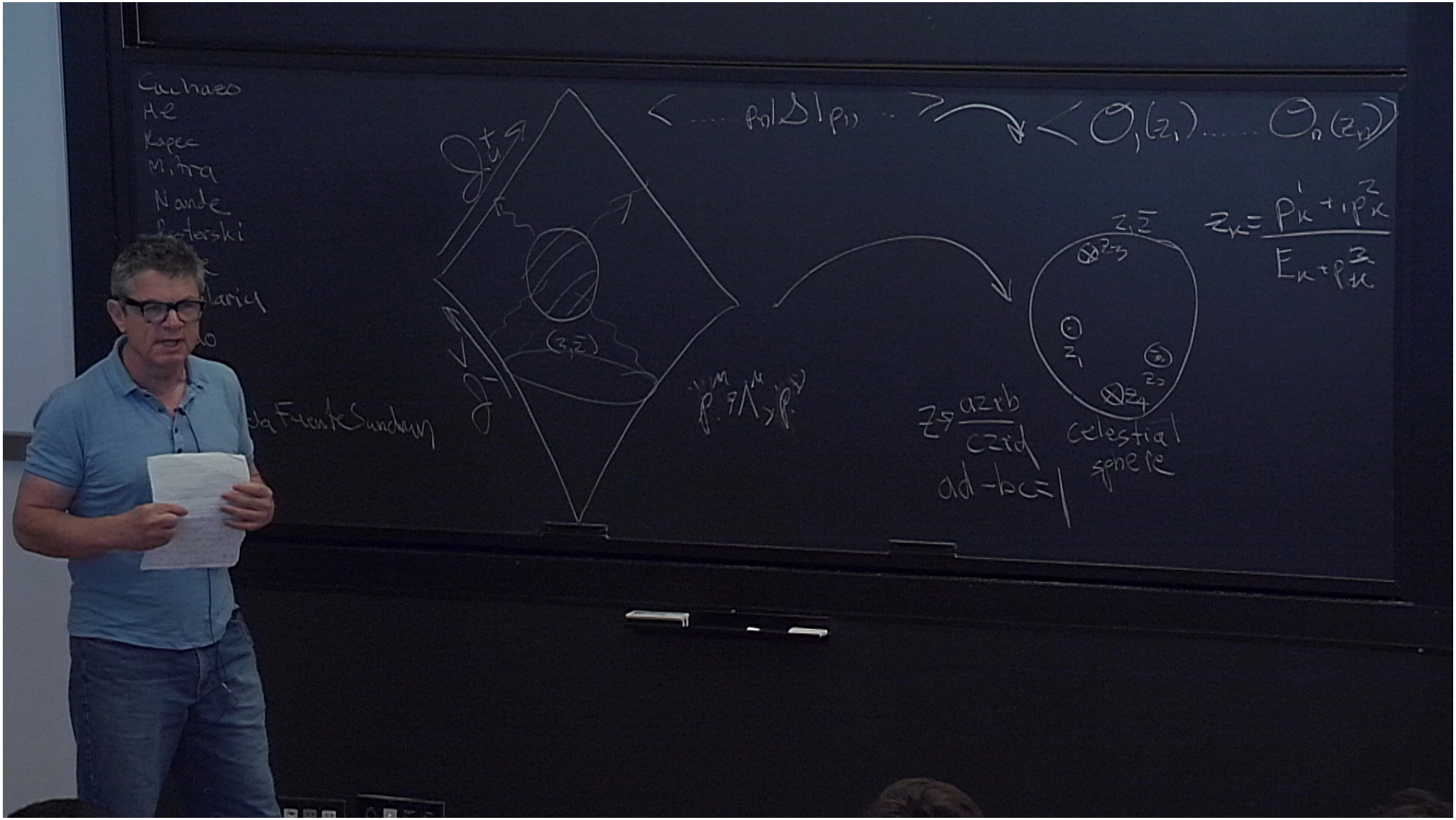
Date: May 17, 2017 10:00 AM

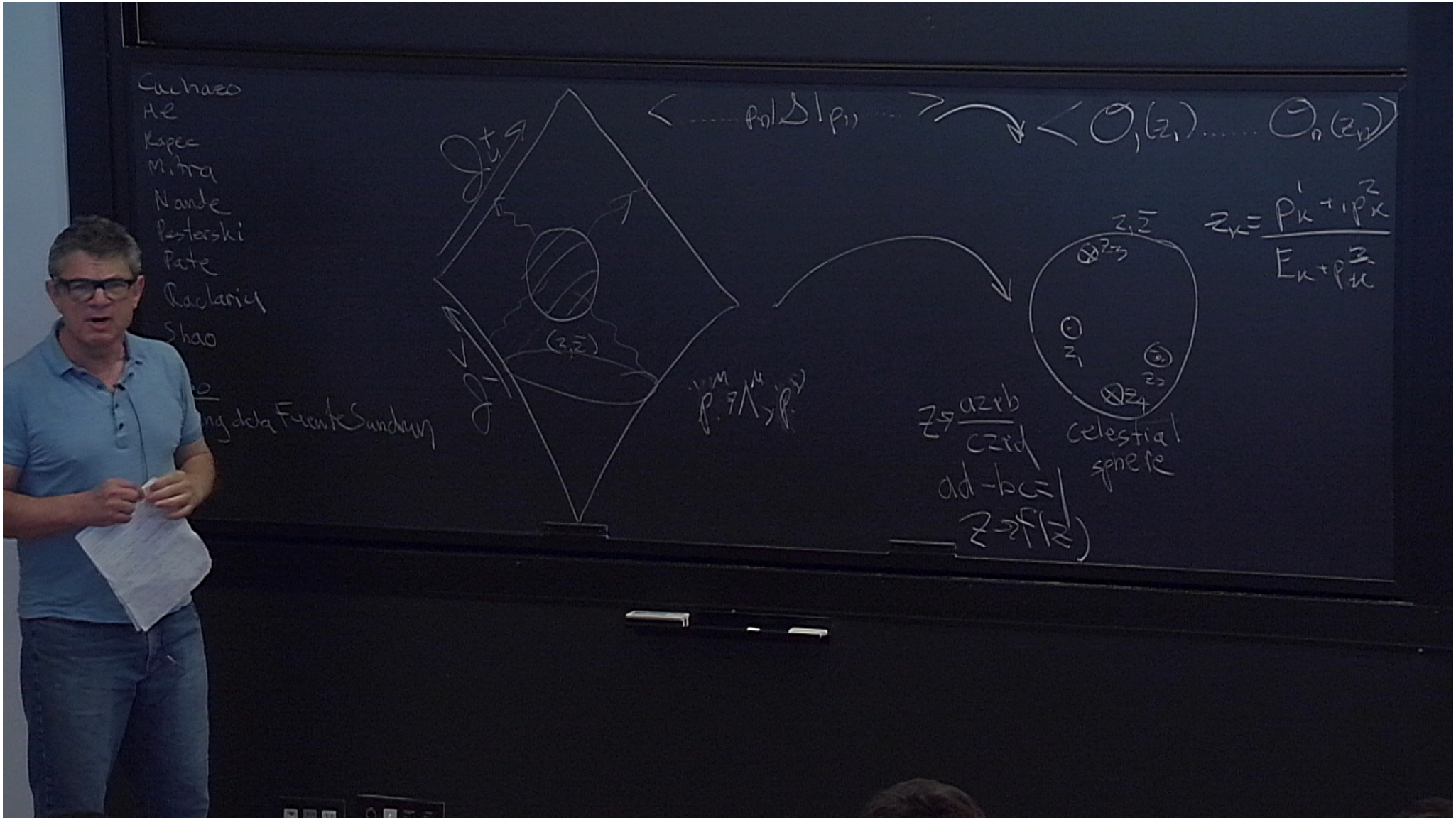
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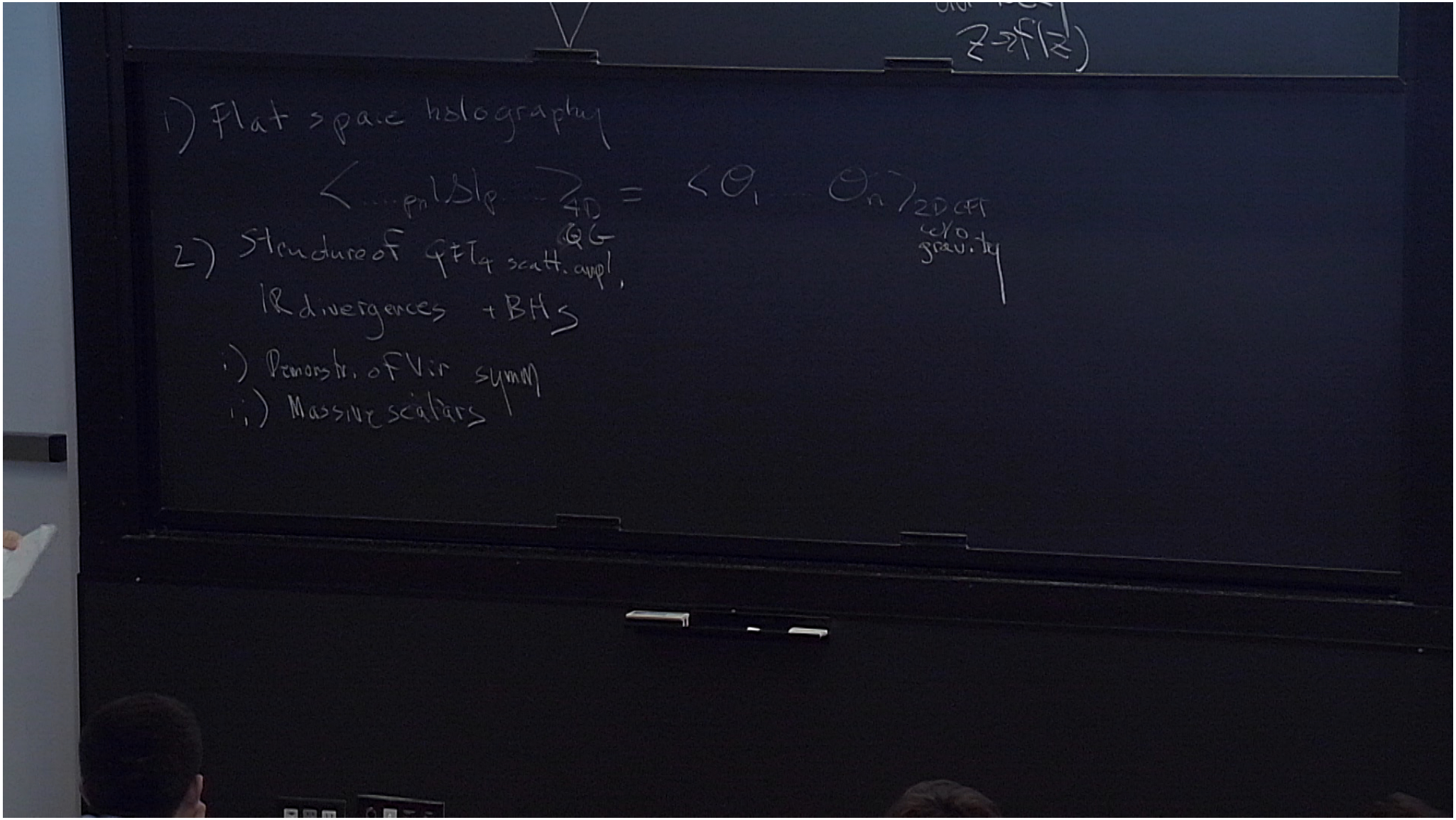
Abstract: Abstract TBA


Cachazo
He
Kapec
Mitra
Nande
Pasterski
Pate
Raclariu
Shao
Also
Cheung deka Fuente Sundrum


Cachazo
He
Kapec
Mitra
Nande
Pasterski
Pate
Shao
celestial sphere


celestial sphere


Cachazo
He
Kapec
Mitra
Nande
Pasterski
Pate
Raclariu
Shao
celestial sphere


1) Flat space holography
4D QG
2D CFT
zero gravity
2) Structure of QFT4 scatt. ampl,
IR divergences + BMS
i) Renorm. of Vir symm
ii) Massive scalars

1) Flat space holography

$$\langle \dots p_n | S | p \dots \rangle_{4D\ QG} = \langle \theta_1 \dots \theta_n \rangle_{2D\ CFT\ w/o\ grav.\ dy}$$

2) Structure of $q \neq 1$ scatt. ampl., IR divergences + BHs

i) Demonstr. of Vir symm

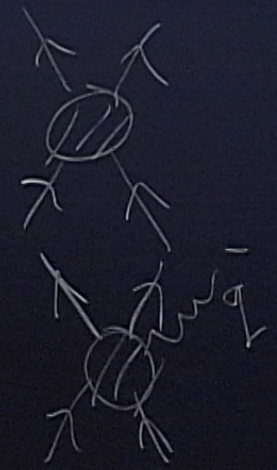
ii) Massive scalars

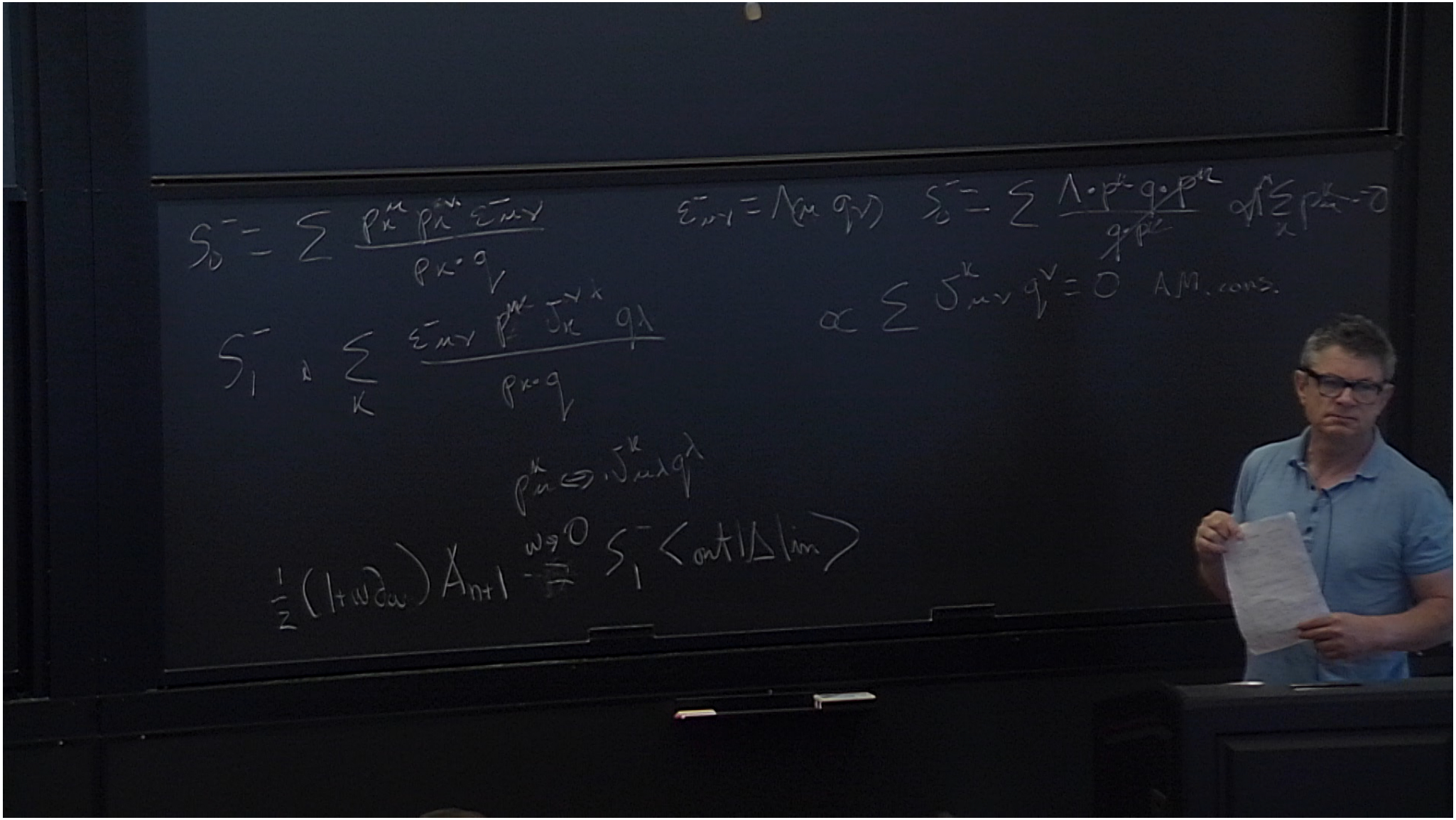
iii)

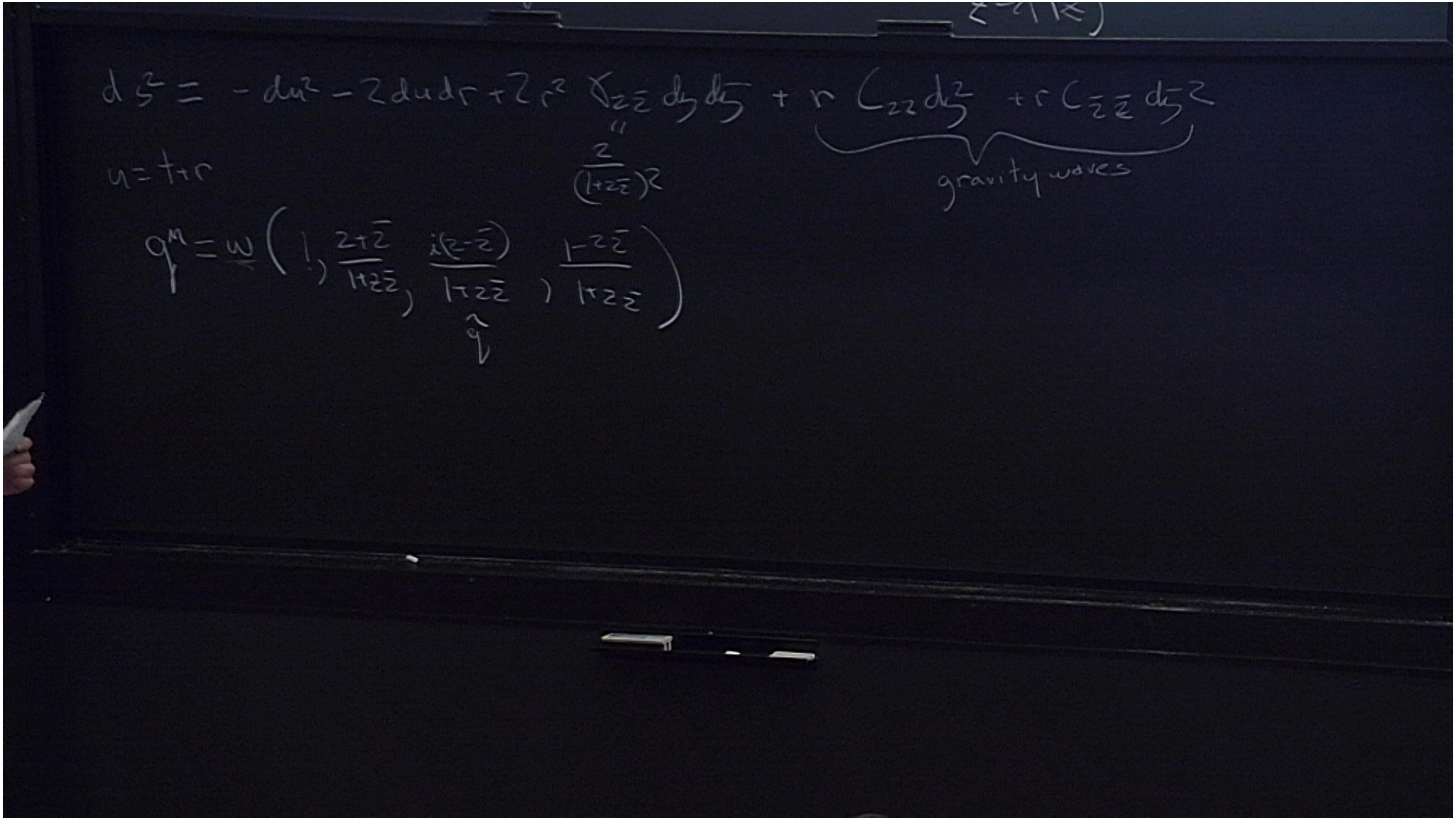
$$A_n = \langle out | S | in \rangle$$

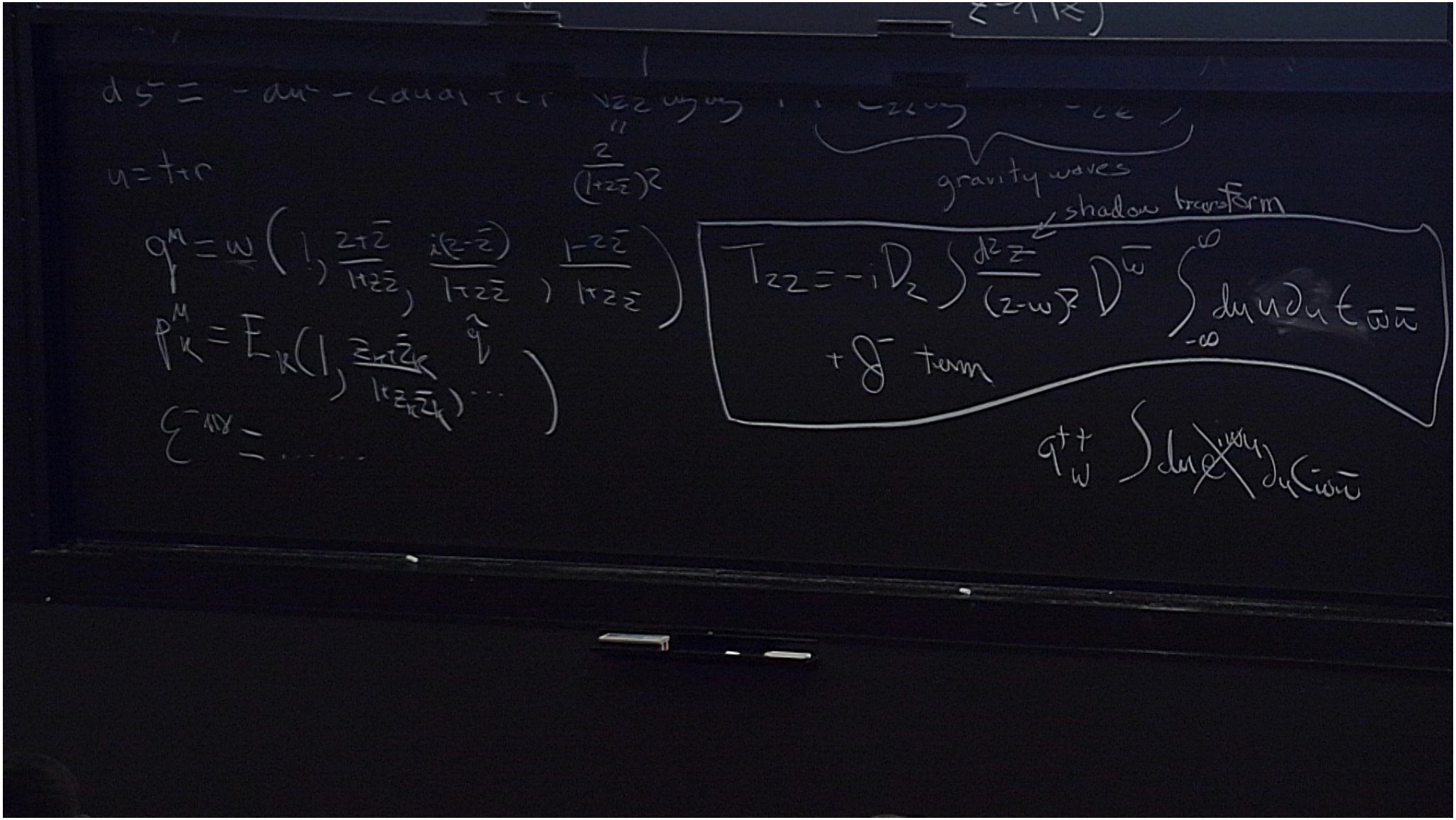
$$A_{n+1}(q_i^-) = \langle out, q^- | S | in \rangle$$

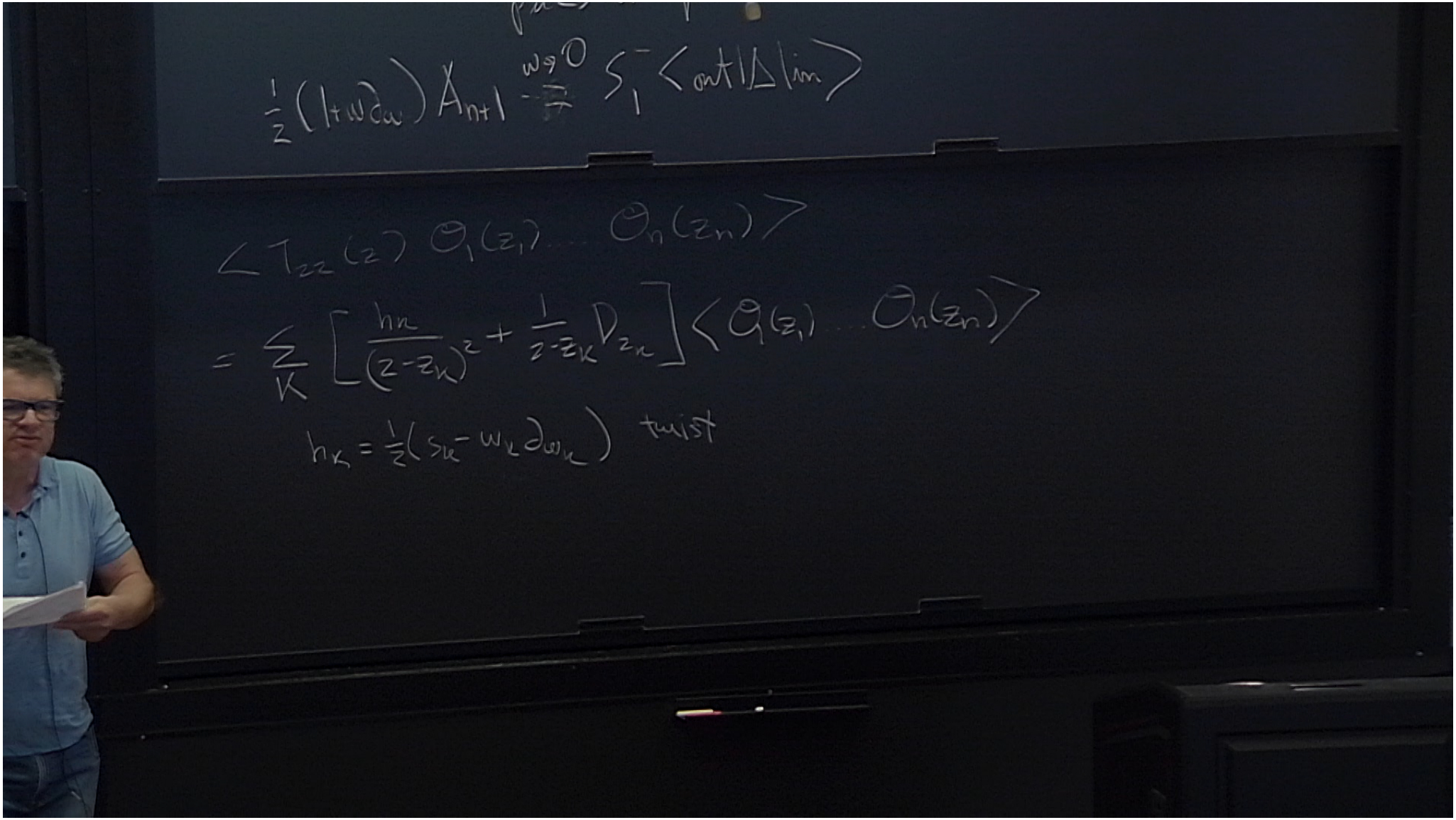
$$q \to 0 \quad = [S_0 + S_1 + O(q)] A_n$$

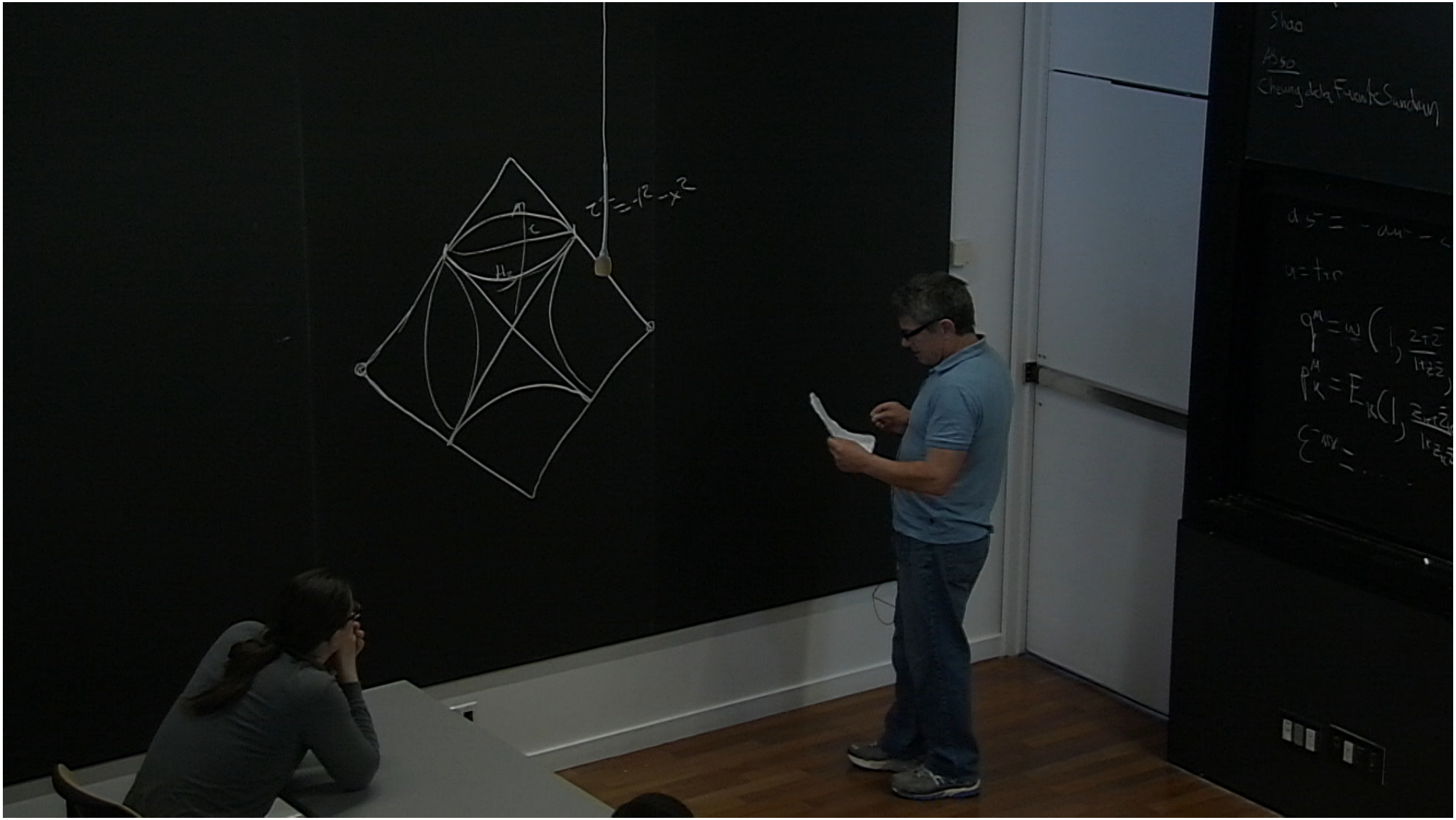


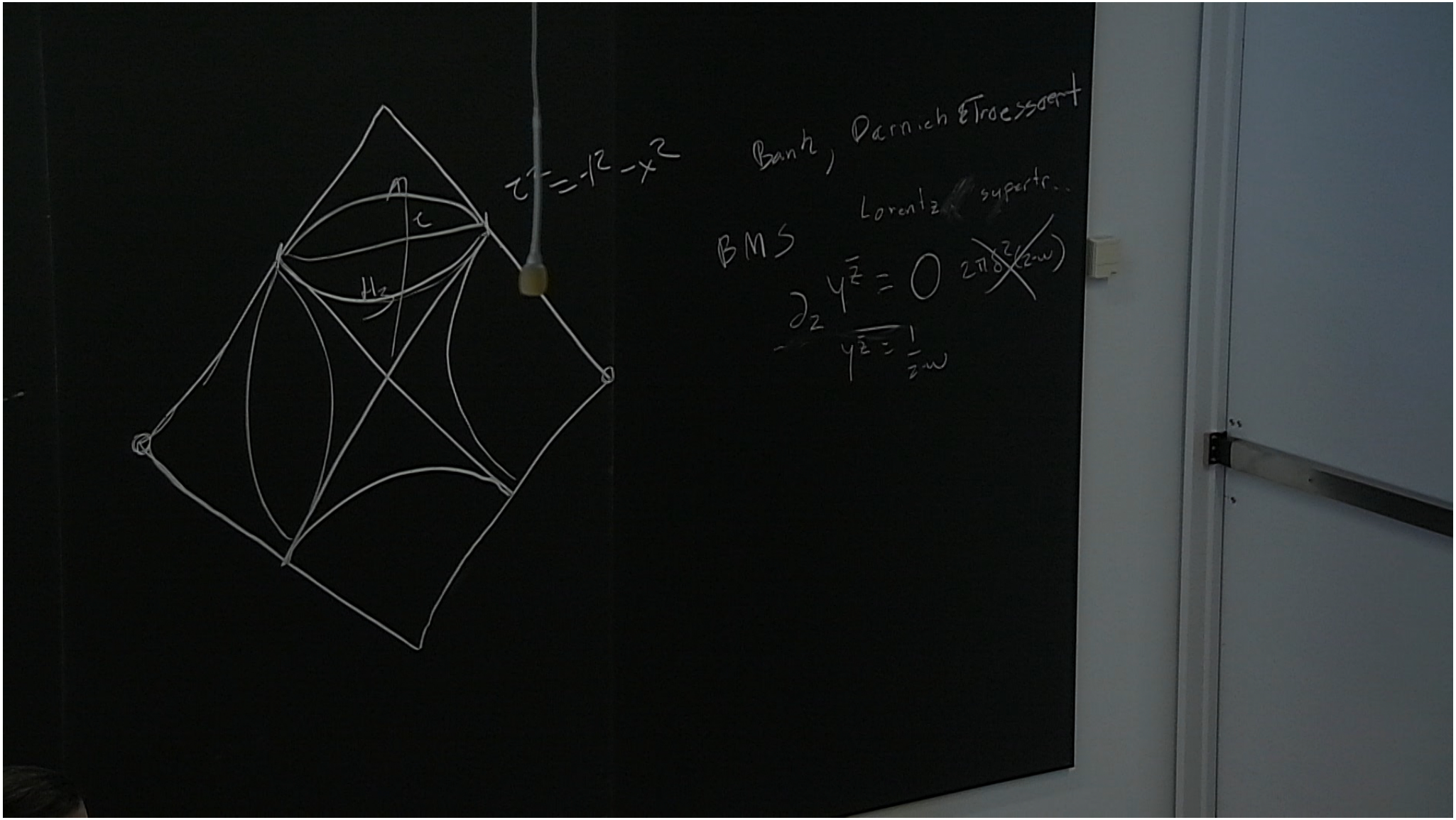

$S_0^- = \sum \frac{p_k^\mu p_k^\nu \varepsilon^-_{\mu\nu}}{p_k \cdot q}$
$\varepsilon^-_{\mu\nu} = \Lambda(\mu, q, \nu)$
$S_0^- = \sum \frac{\Lambda \cdot p_k \cdot q \cdot p_k}{q \cdot p_k}$
$\propto \sum_k p_k^\mu = 0$
$S_1^- = \sum_k \frac{\varepsilon^-_{\mu\nu} p_k^\mu J_k^{-\nu\lambda} q_\lambda}{p_k \cdot q}$
$\propto \sum J^k_{\mu\nu} q^\nu = 0$ A.M. cons.
$p_\mu^k \Rightarrow J^k_{\mu\lambda} q^\lambda$
$\frac{1}{2}(1+w^2 c_w) A_{n+1} \xrightarrow{w \to 0} S_1^- \langle out | \Delta | in \rangle$

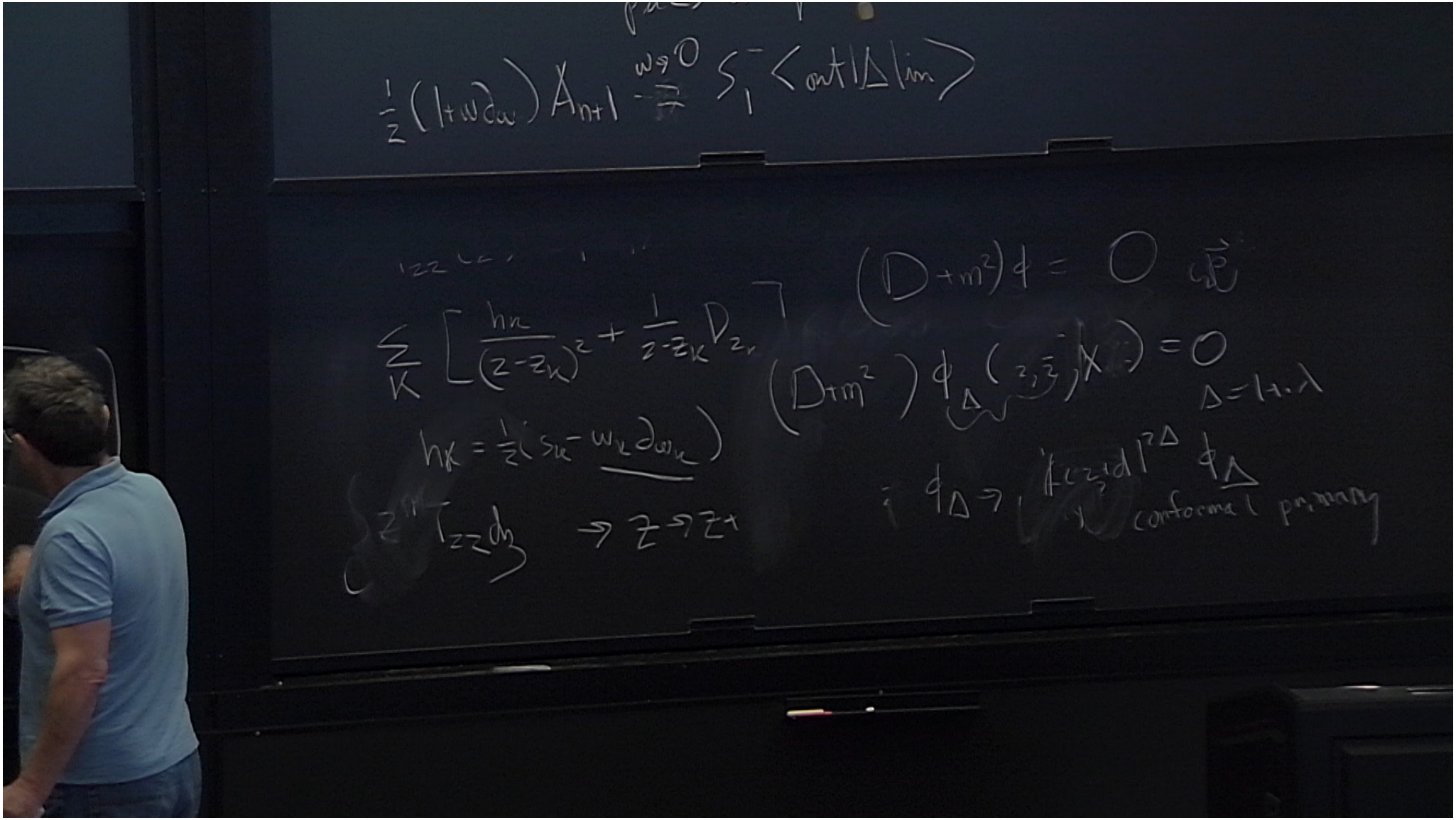

$ds^2 = -du^2 - 2du\,dr + 2r^2 \gamma_{z\bar{z}}\, dz\, d\bar{z} + r\, C_{zz}\, dz^2 + r\, C_{\bar{z}\bar{z}}\, d\bar{z}^2$
$\gamma_{z\bar{z}} = \frac{2}{(1+z\bar{z})^2}$
gravity waves
$u = t - r$
$q^M = w\left(1, \frac{z+\bar{z}}{1+z\bar{z}}, \frac{i(z-\bar{z})}{1+z\bar{z}}, \frac{1-z\bar{z}}{1+z\bar{z}}\right)$
$\hat{q}$

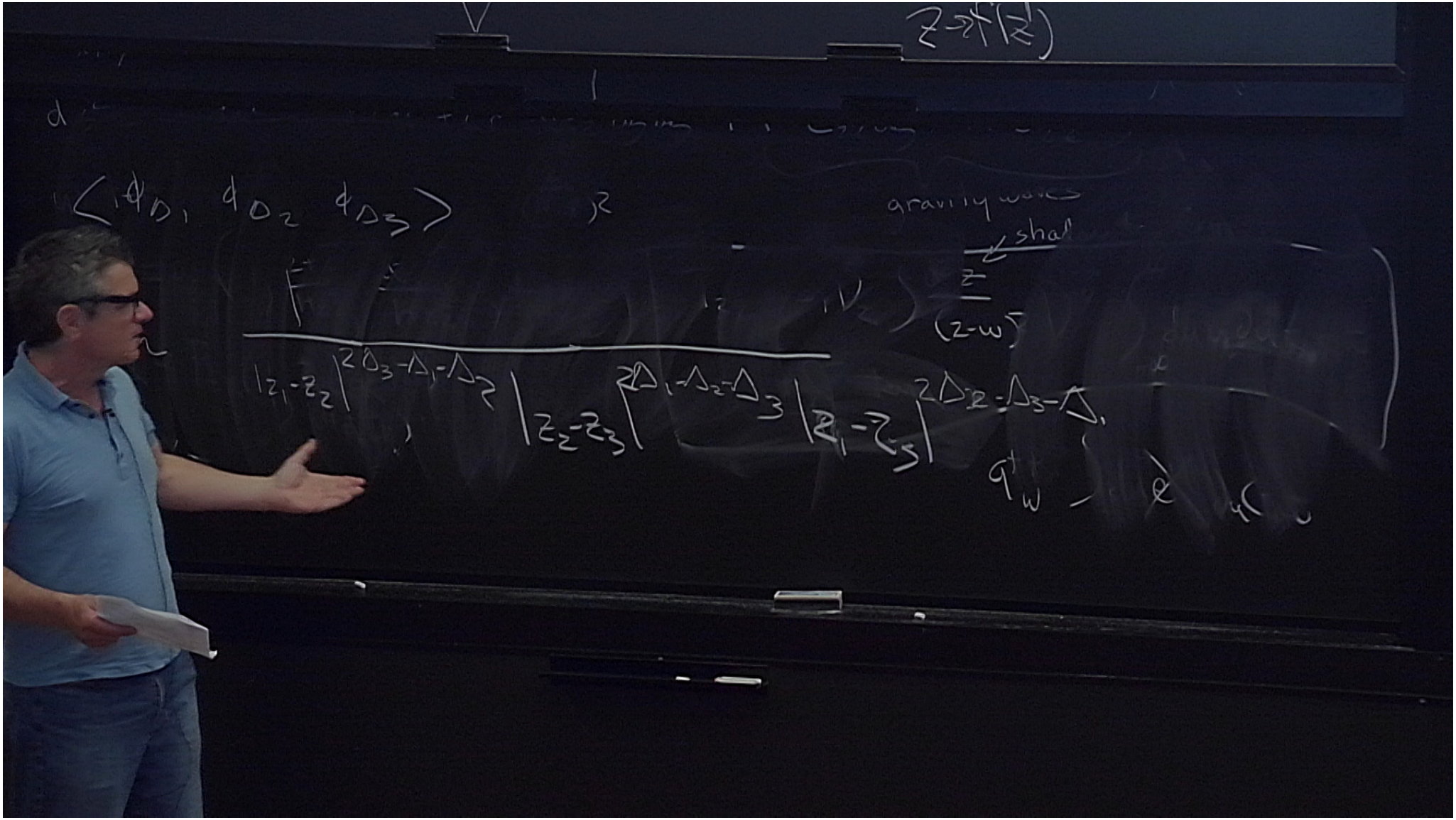

gravity waves
shadow transform
+ subleading term

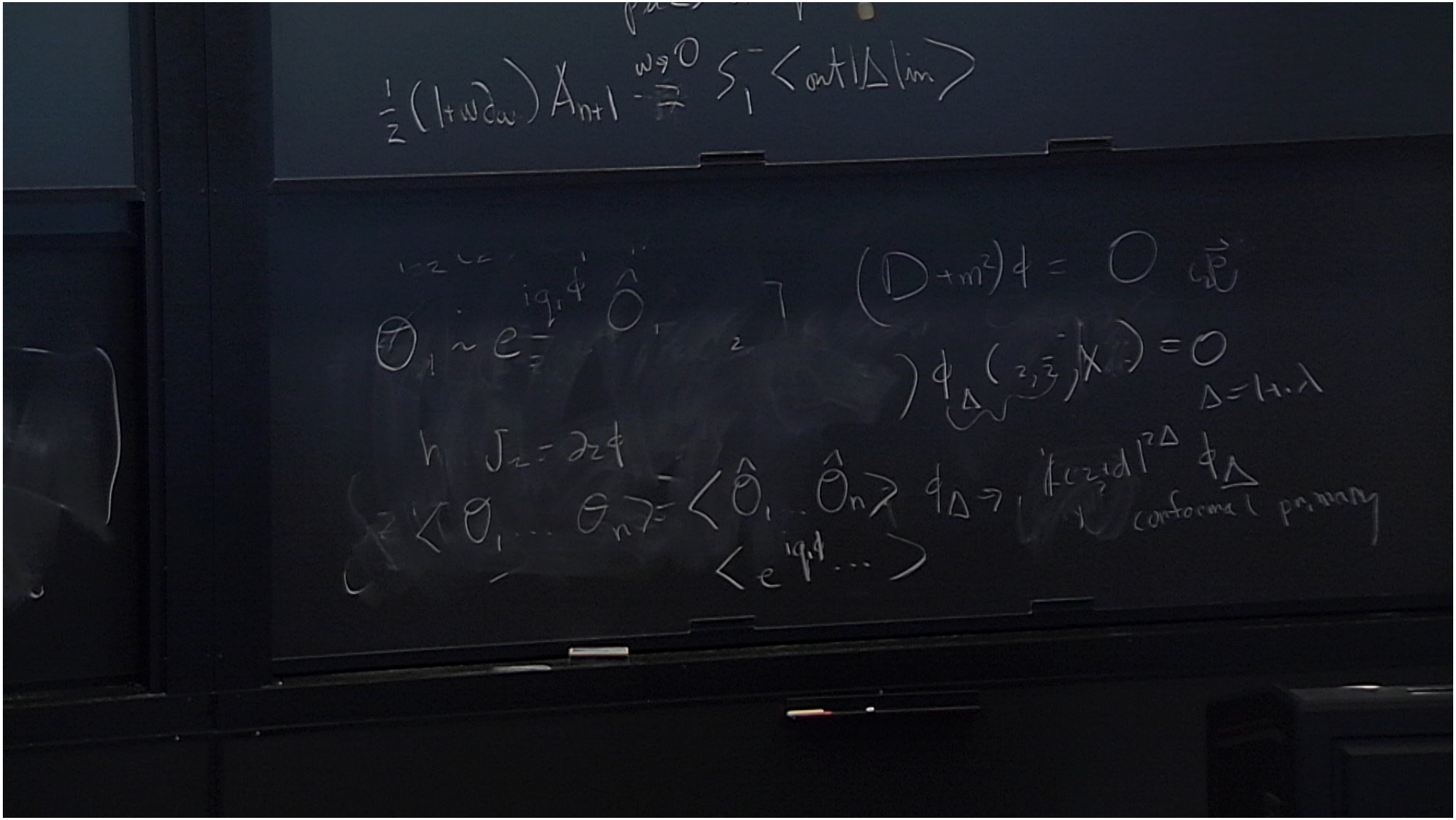

$\frac{1}{2}(1+w\partial_w) A_{n+1} \overset{w\to 0}{\sim} \sum_i \zeta_i^- \langle out | \Delta | in \rangle$
$\langle T_{zz}(z)\, \Theta_1(z_1) \cdots \Theta_n(z_n) \rangle$
$= \sum_k \left[\frac{h_k}{(z-z_k)^2} + \frac{1}{z-z_k} D_{z_k} \right] \langle \Theta_1(z_1) \cdots \Theta_n(z_n) \rangle$
$h_k = \frac{1}{2}(s_k - w_k \partial_{w_k})$ twist


Shao
Cheung-Seeley-Fuente-Sundrum


$\tau^2 = t^2 - x^2$
Barnich & Troessaert
BMS
Lorentz
supertr.
$\partial_{\bar{z}} Y^{\bar{z}} = 0$
$Y^{\bar{z}} = \frac{1}{z-w}$


$\frac{1}{z}(1+w\partial_w)A_{n+1} \overset{w\to 0}{=} \sum_i \epsilon_i^- \langle out|\Delta|in\rangle$
$\sum_K \left[\frac{h_K}{(z-z_K)^2} + \frac{1}{z-z_K}\partial_{z_K}\right]$
$h_K = \frac{1}{2}(s_K - w_K\partial_{w_K})$
$\oint z^{1+} T_{zz} dz \to z \to z+$
$(D+m^2)\phi = 0$
$(D+m^2)\phi_\Delta(z,\bar{z},X) = 0$
$\Delta = 1+i\lambda$
$\phi_\Delta \to \int |z|^{2\Delta} \phi_\Delta$
conformal primary


gravity waves
shall


$\frac{1}{2}(1+w\partial_w) A_{n+1} \overset{w\to 0}{=} \sum_i \langle out | \Delta | in \rangle$
$(D+m^2)\phi = 0$
$\mathcal{O}_i \sim e^{iq_i\phi} \hat{\mathcal{O}}_i$
$\phi_\Delta(z,\bar{z},X) = 0$
$\Delta = 1+\lambda$
$J_z = \partial_z \phi$
$\langle \mathcal{O}_1 \dots \mathcal{O}_n \rangle = \langle \hat{\mathcal{O}}_1 \dots \hat{\mathcal{O}}_n \rangle$
$\phi_\Delta \to \int |z_i|^{2\Delta} \phi_\Delta$
conformal primary
$\langle e^{iq_i\phi} \dots \rangle$