

Title: Cutting Cosmological Correlators

Speakers: Harry Goodhew

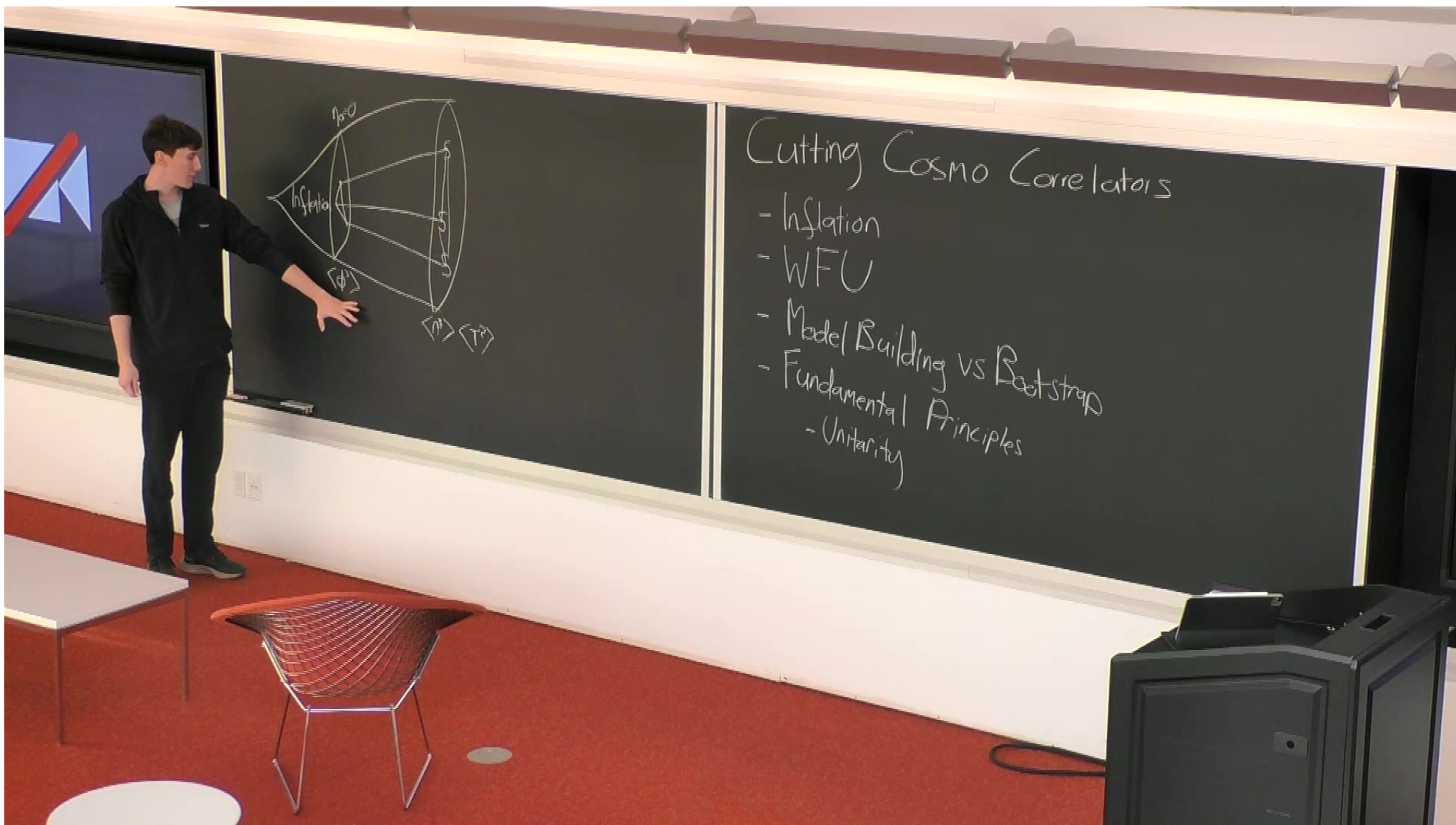
Series: Cosmology & Gravitation

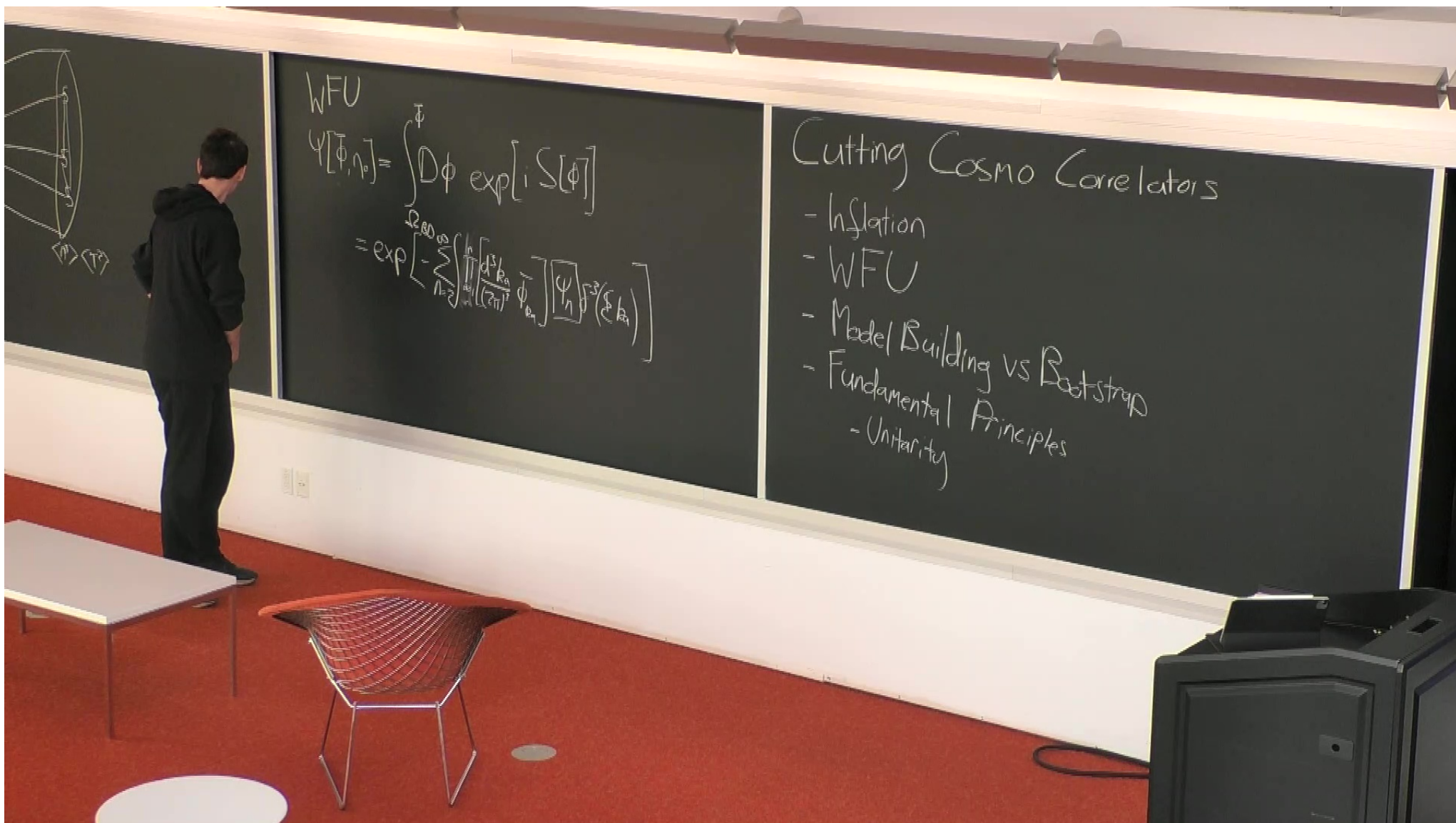
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Abstract: The initial conditions of our universe appear to us in the form of a classical probability distribution that we probe with cosmological observations. In the current leading paradigm, this probability distribution arises from a quantum mechanical wavefunction of the universe. In this talk I will discuss how we can adapt flat space bootstrapping techniques to the quantum fluctuations in the early universe, in particular showing that the requirement of unitary time evolution, colloquially the conservation of probabilities, fixes the analytic structure of the wavefunction and of all the cosmological correlators it encodes.

Zoom link: <https://pitp.zoom.us/j/95812107239?pwd=bVZMcWdHTVM0Y0tFZGMxS2FCVGF0Zz09>



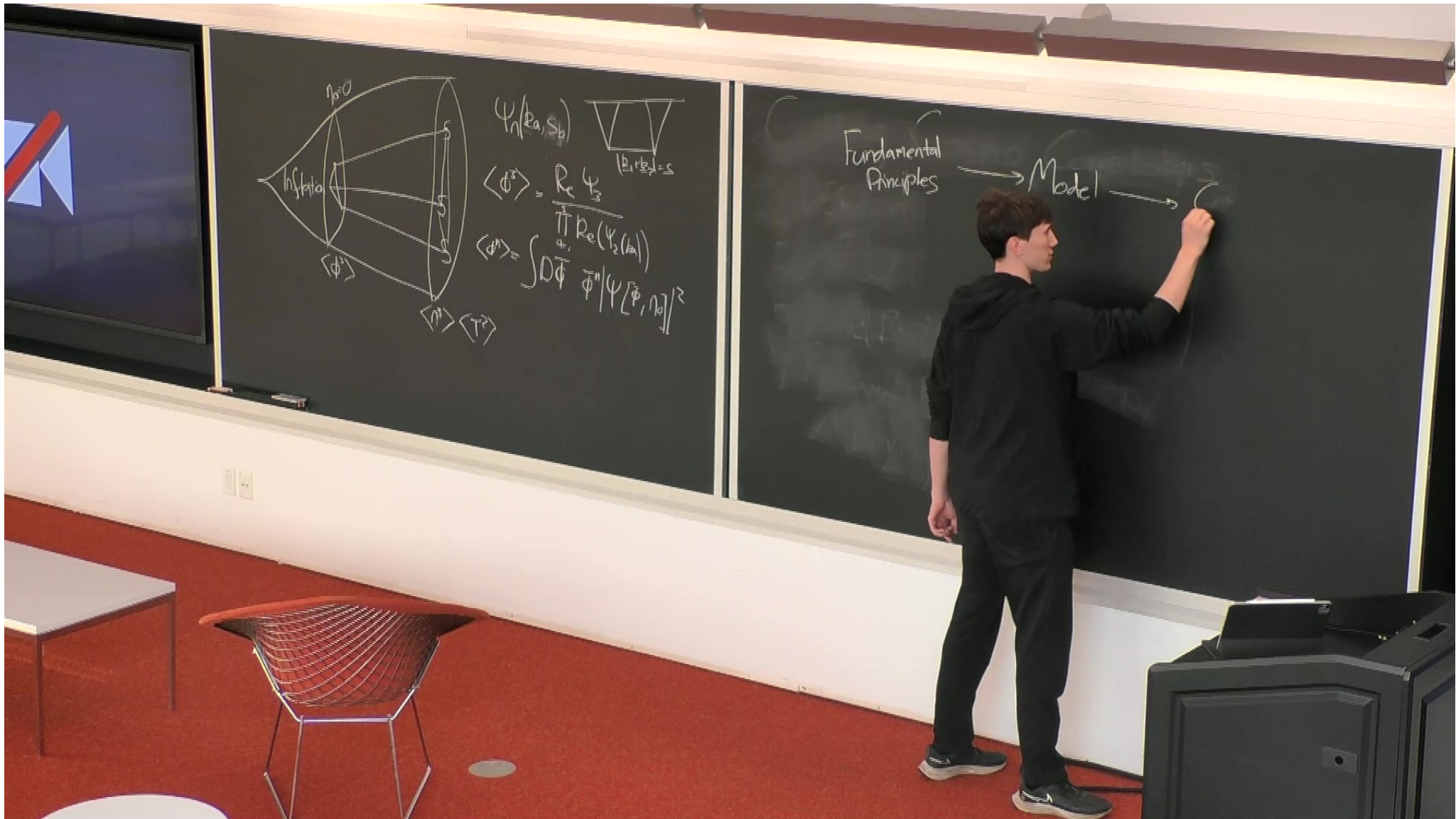


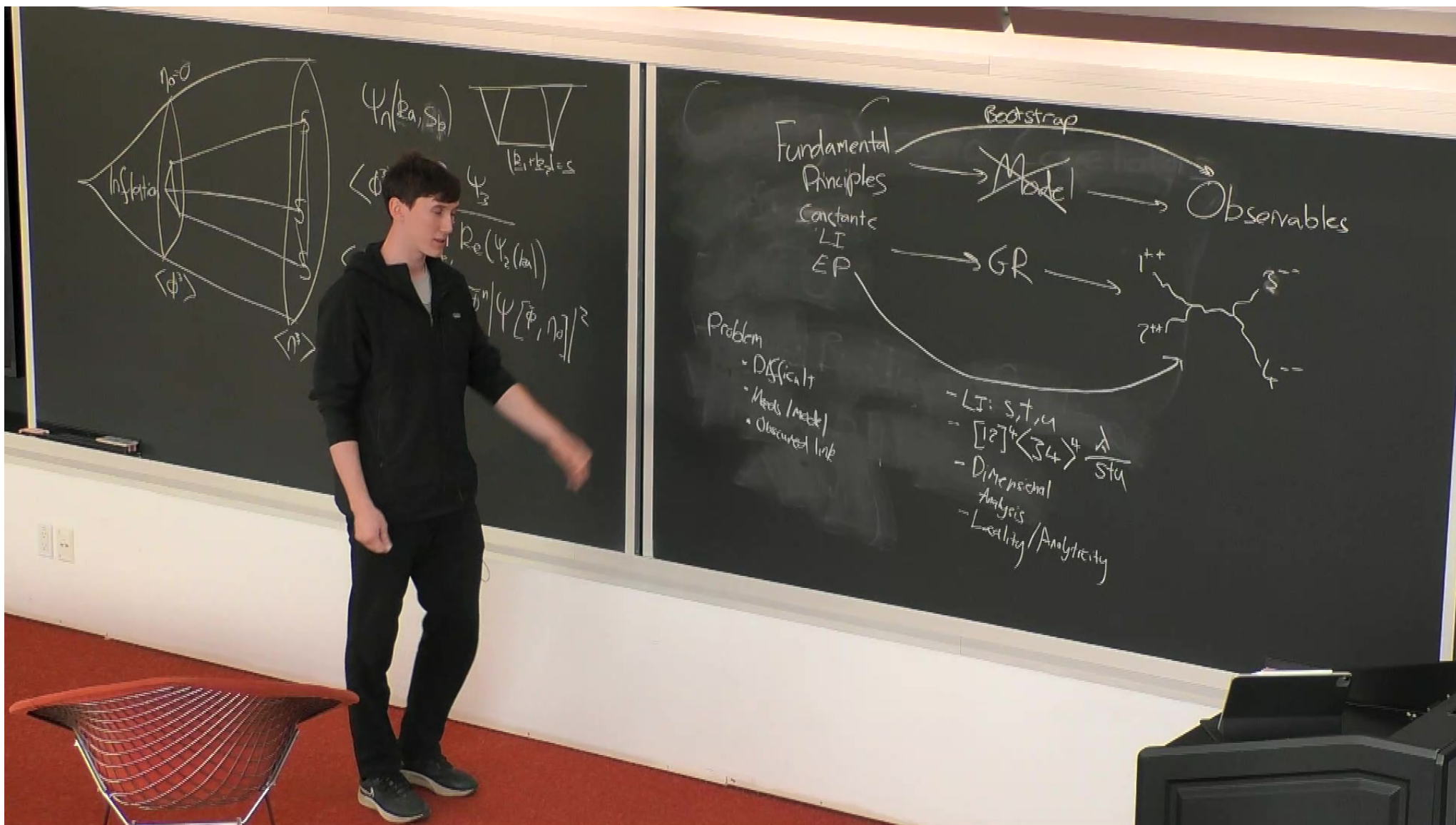
WFO

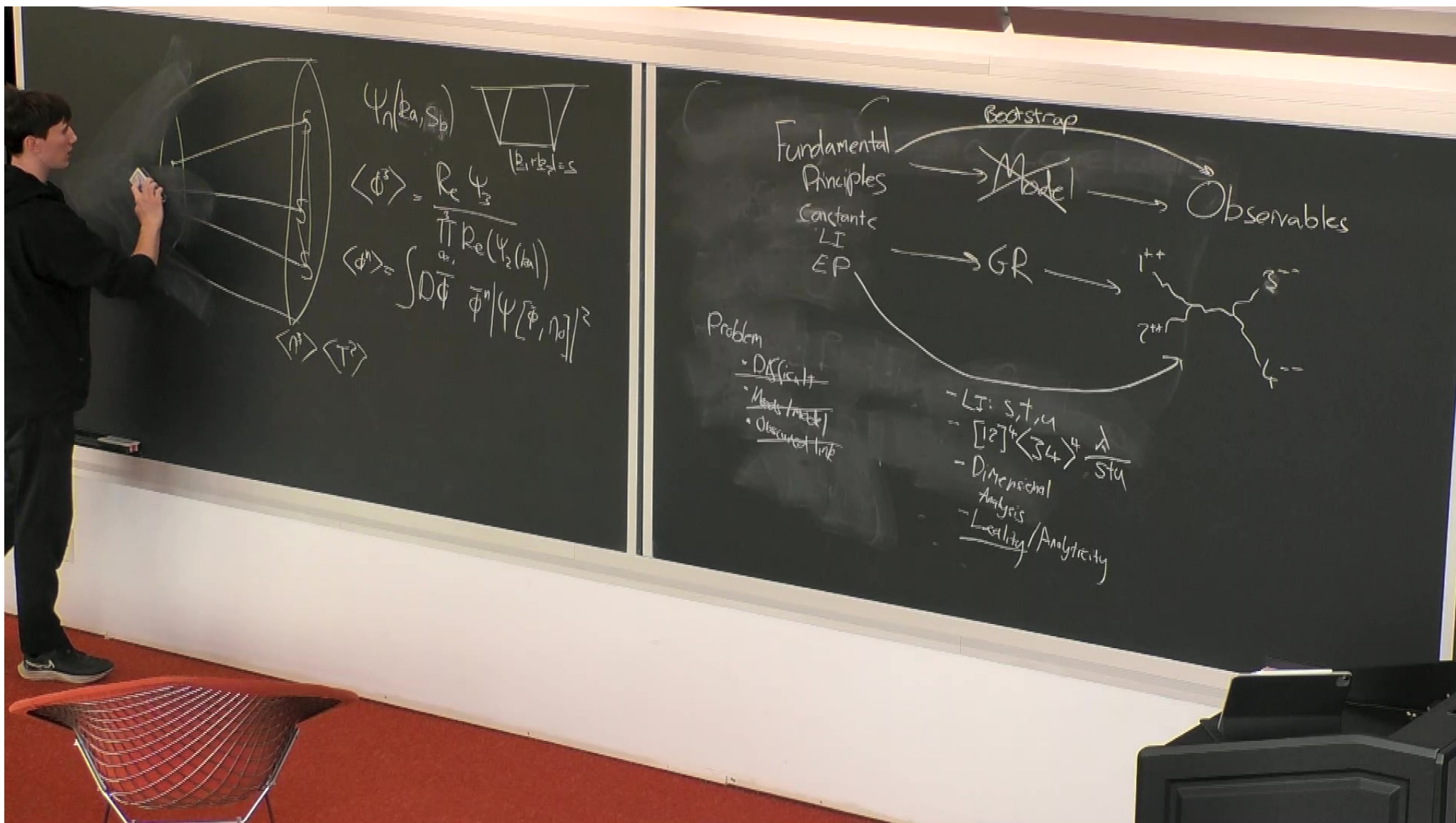
$$\Psi[\bar{\Phi}, \eta] = \int D\phi \exp[iS[\phi]]$$
$$= \exp \left[- \sum_{n=2}^{\infty} \int d^4x \left(\frac{d^4k}{(2\pi)^4} \right) \bar{\phi}_n \left[\Psi \right] \delta^3(x-k) \right]$$

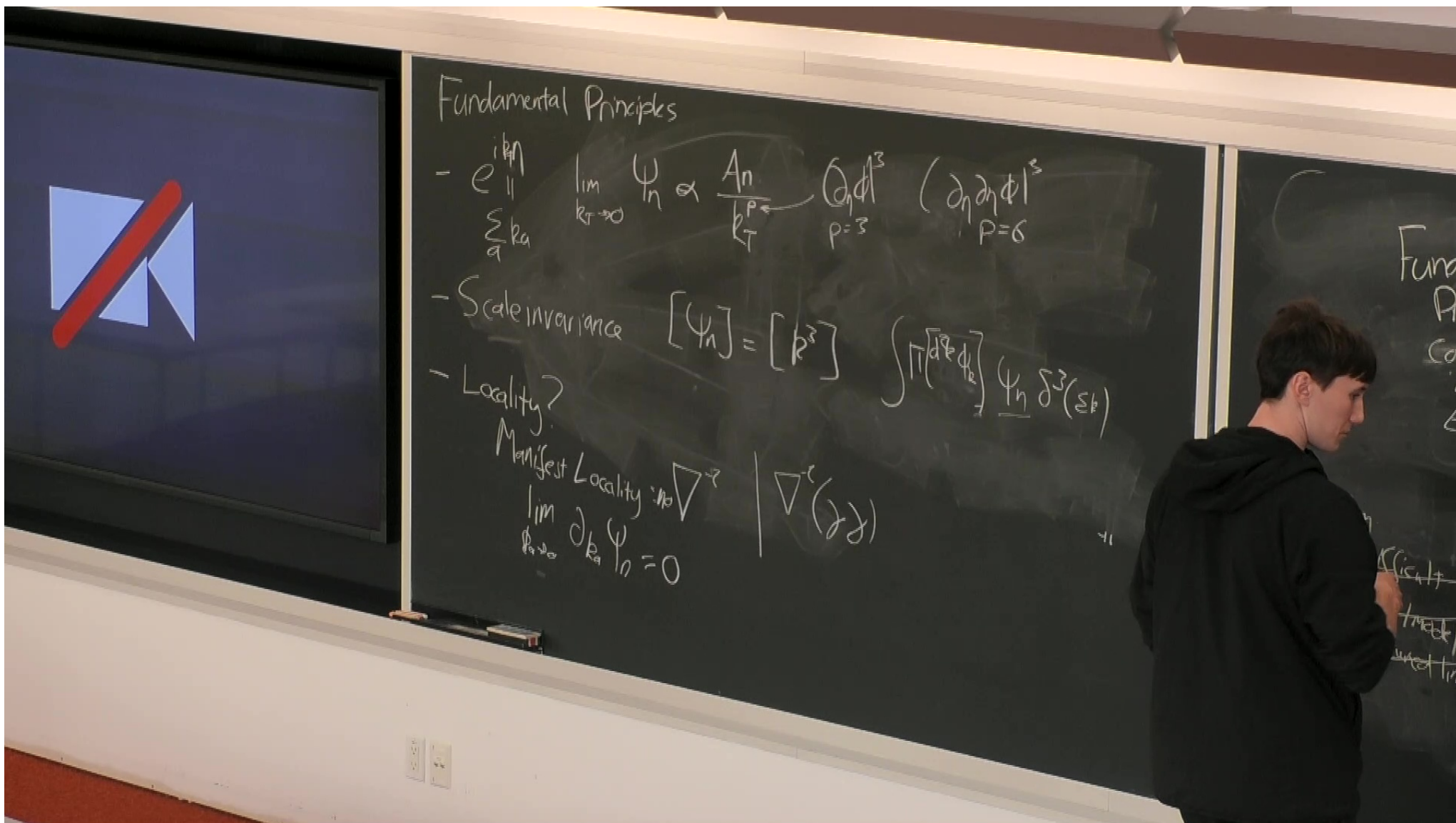
Cutting Cosmo Correlators

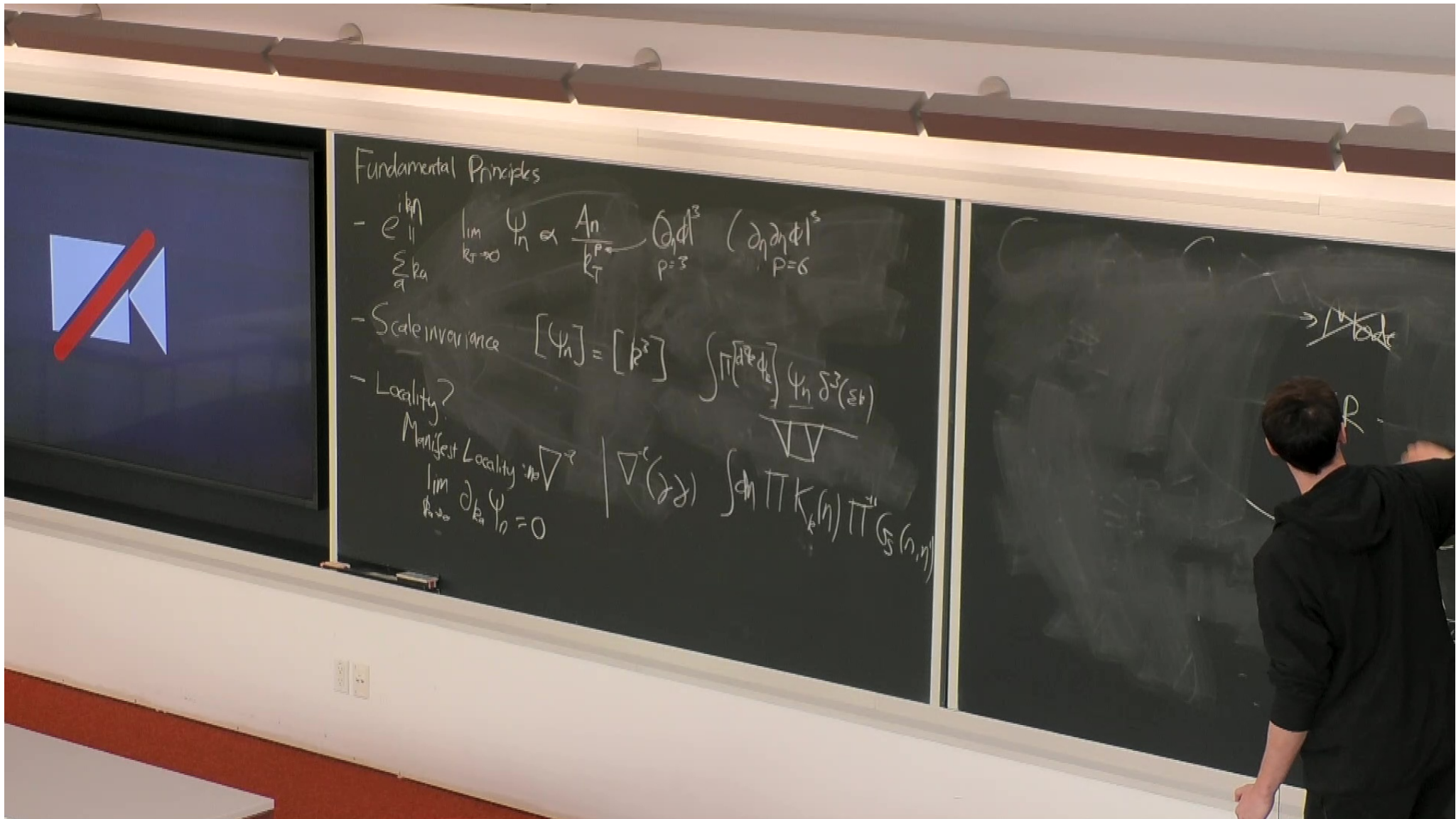
- Inflation
- WFO
- Model Building vs Bootstrap
- Fundamental Principles
 - Unitarity











Fundamental Principles

$$- e^{i k \eta} \lim_{k_T \rightarrow 0} \psi_n \propto \frac{A_n}{k_T^{p+}} \prod_{p=3}^3 d^3 \left(\partial_\eta \partial_\eta \phi \right)_{p=6}$$

$$- \text{Scale invariance } [\psi_n] = [k^z] \int \prod d^3 \phi_k \psi_n \delta^3(\epsilon t) \frac{\prod}{\prod}$$

- Locality?

$$\text{Manifest Locality } \nabla^2 \quad \lim_{k \rightarrow 0} \partial_k \psi_n = 0 \quad \left| \nabla^2(x) \int d\eta \prod K_k(\eta) \prod G_{\tilde{S}(\eta, \eta)} \right|$$

Fundamental Principles

$$e^{i\mathbf{p}\cdot\mathbf{r}} \lim_{k_T \rightarrow 0} \psi_n \propto \frac{A_n}{k_T^{p-1}} \prod_{p=3}^6 d\phi^p \quad (\partial_n \partial_n \phi^p)_{p=6}$$

Scale invariance $[\psi_n] = [k^3] \int \prod [d^3 q_k] \psi_n$

Locality? Manifest Locality: ∇^2 $|\nabla^2(\psi)\rangle$

$$\lim_{k_T \rightarrow 0} \partial_{k_n} \psi_n = 0$$

Unitarity

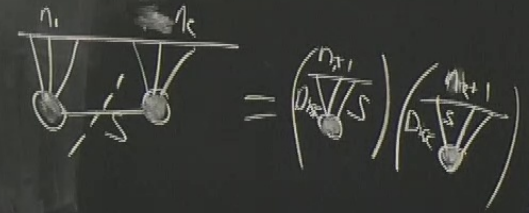
$$- UU^\dagger = \frac{U=1+\delta U}{\delta U + \delta U^\dagger} = -\delta U \delta U^\dagger$$

$$\langle n | \delta U | 0 \rangle + \langle 0 | \delta U^\dagger | n \rangle = \langle n | \prod_{k=1}^n a_k^\dagger | 0 \rangle$$

$$+ \sum \langle n | \delta U | m \rangle \langle m | \delta U^\dagger | 0 \rangle$$

$$\psi_n(k_q, s_q) + \psi_n^*(-k_q^*, s_q^*)$$

$$\int_{-\infty}^{\infty} e^{i(P_{\perp} \cdot \epsilon)} \psi_n(k_q, s_q) + \psi_n^*(-k_q^*, s_q^*)$$



Fundamental Principles

$$\in \frac{1}{\sum_k k_n} \lim_{k_T \rightarrow 0} \psi_n \propto \frac{A_n}{k_T^p} \quad \begin{matrix} p=3 \\ p=6 \end{matrix} \quad (\partial_1 \partial_1 \phi)^3$$

Scale invariance $[\psi] = [k] \left[\frac{1}{\sqrt{k}} \right] (\psi \delta^3(x))$

Locality?

Locality?
Manifest Locality: ∇^2
 $\lim_{\hbar \rightarrow 0} \partial_k \psi_0 = 0$

Unitarity

Unitarity
 $UU^\dagger = I \xrightarrow{U=1+\delta U} \delta U + \delta U^\dagger = -\delta U \delta U^\dagger$

$$|n\rangle = \prod_{q=1}^n a_q^\dagger |0\rangle$$

$$\langle \text{Diagram} \rangle = 2\rho_{\text{SC}} \langle \text{Diagram 1} \rangle + \langle \text{Diagram 2} \rangle \langle \text{Diagram 3} \rangle$$

$$\begin{matrix} n_1 & & n_k \\ \diagdown & & \diagup \\ \text{---} & & \text{---} \\ \diagup & & \diagdown \\ \text{---} & & \text{---} \\ \diagdown & & \diagup \\ \text{---} & & \text{---} \end{matrix} = \binom{n_1}{D_1} \binom{n_k}{D_k}$$

Fundamental Principles

$$e^{i\mathbf{k}\cdot\mathbf{r}} \lim_{k \rightarrow 0} \psi_n \propto \frac{A_n}{k_T^p} \left(\frac{\partial}{\partial \mathbf{r}} \right)^3 \left(\frac{\partial}{\partial \mathbf{r}} \right)^3 \quad p=3 \quad p=6$$

Scale invariance $[\psi_n] = [k^3]$

$$\psi_n \delta^3(\mathbf{r})$$

Locality?

Manifest Locality ∇^2

$$\lim_{k \rightarrow 0} \partial_k \psi_n = 0$$

Unitarity

$$- UU^\dagger = \frac{U \pm iSU}{U \pm iSU} \quad SU + SU^\dagger = -SU SU^\dagger$$

$$\langle n | SU | 0 \rangle + \langle 0 | SU^\dagger | n \rangle^* =$$

$$|n\rangle = \prod_{i=1}^n a_i^\dagger |0\rangle$$

$$= 2^{p_{SC}} \left(\frac{\nabla}{\nabla + i} \right)^n \left(\frac{\nabla}{\nabla + i} \right)^n = 2^{p_{SC}} \left(\frac{\nabla}{\nabla + i} \right)^{2n}$$

$$\log(+1)$$

$$\frac{n_i}{n_k} = \left(\frac{n_{i+1}}{n_{k+1}} \right) \left(\frac{n_{k+1}}{n_{i+1}} \right)$$