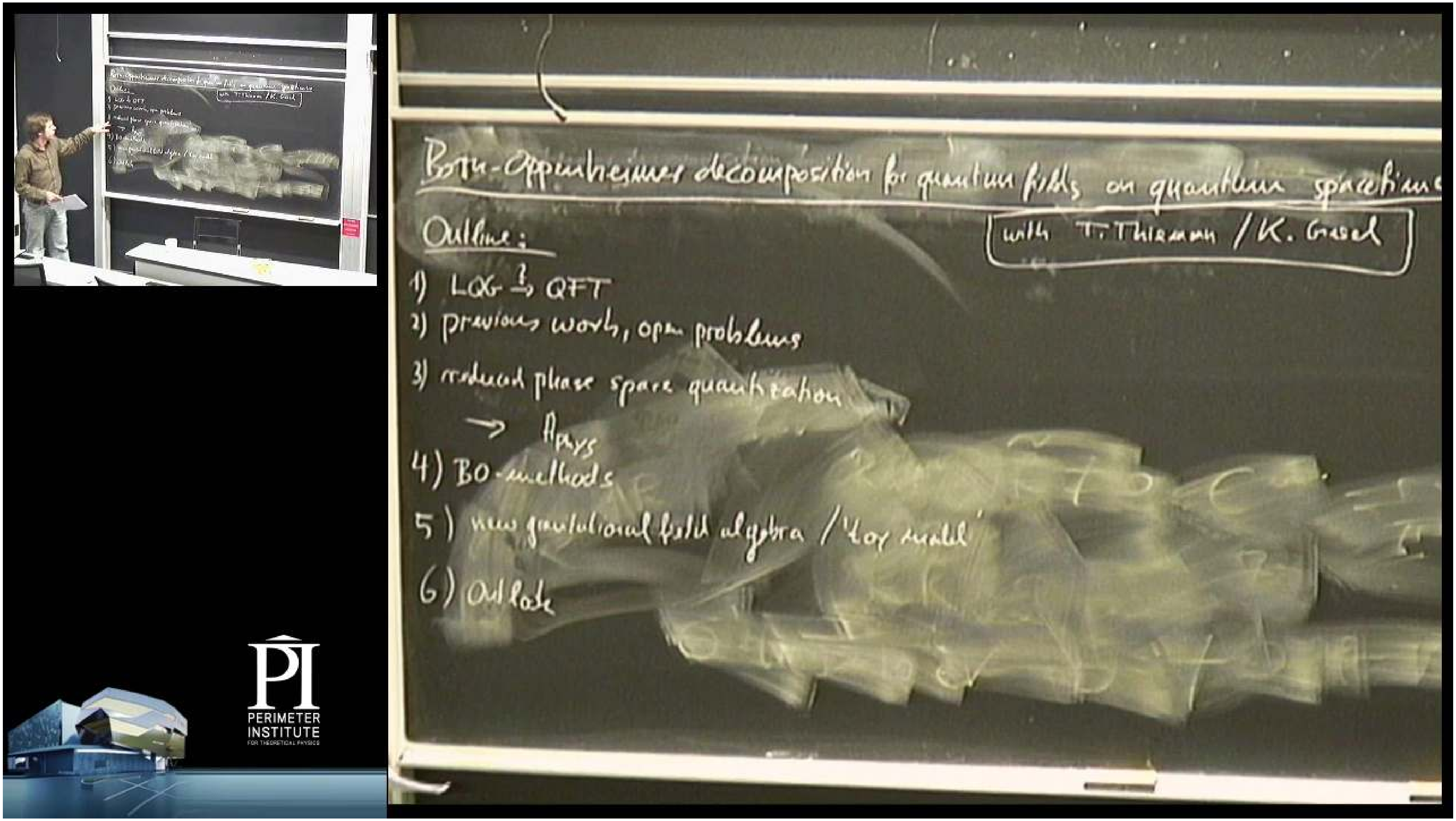
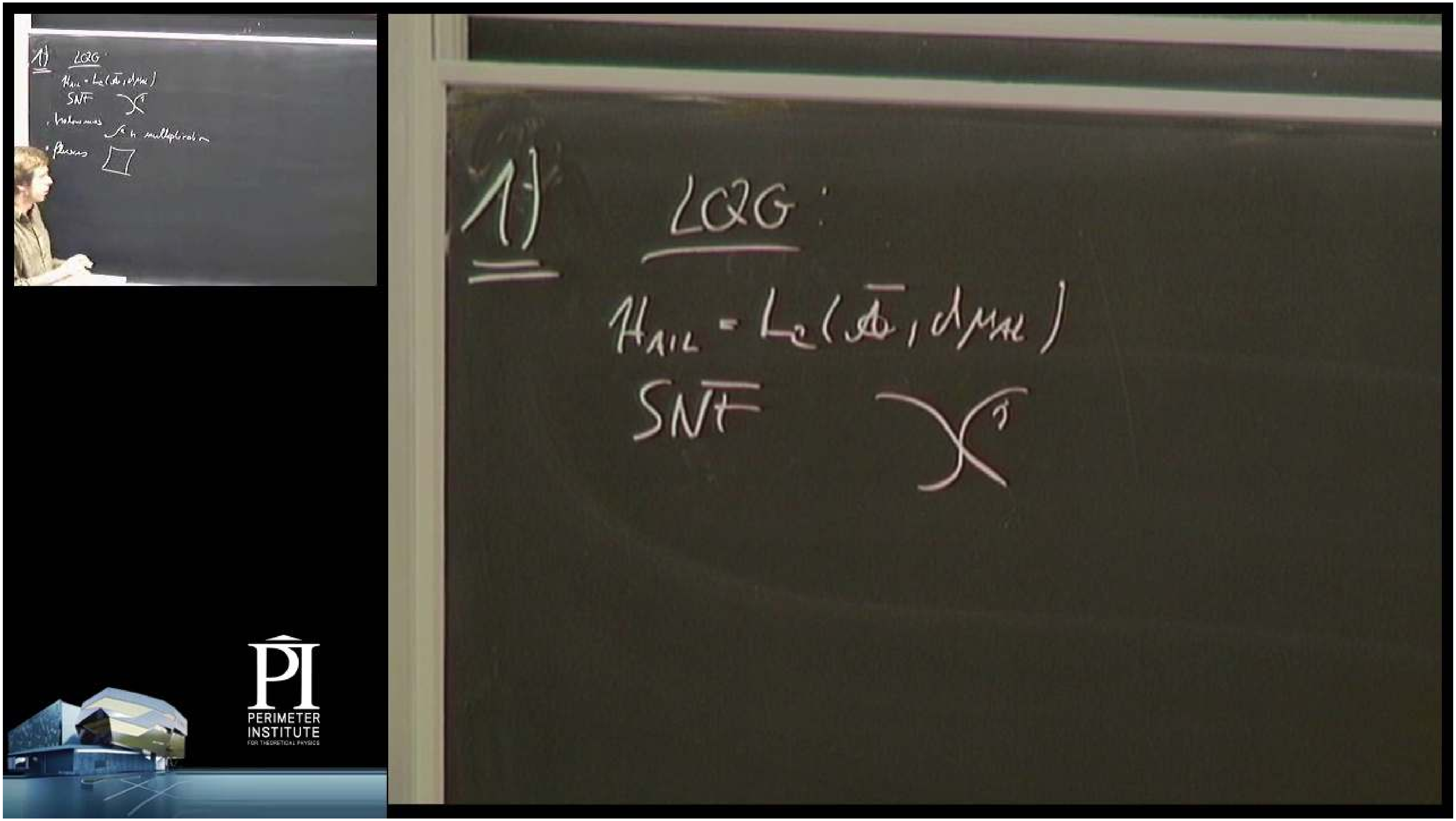
Title: Born--Oppenheimer approximation for quantum fields on quantum spacetimes

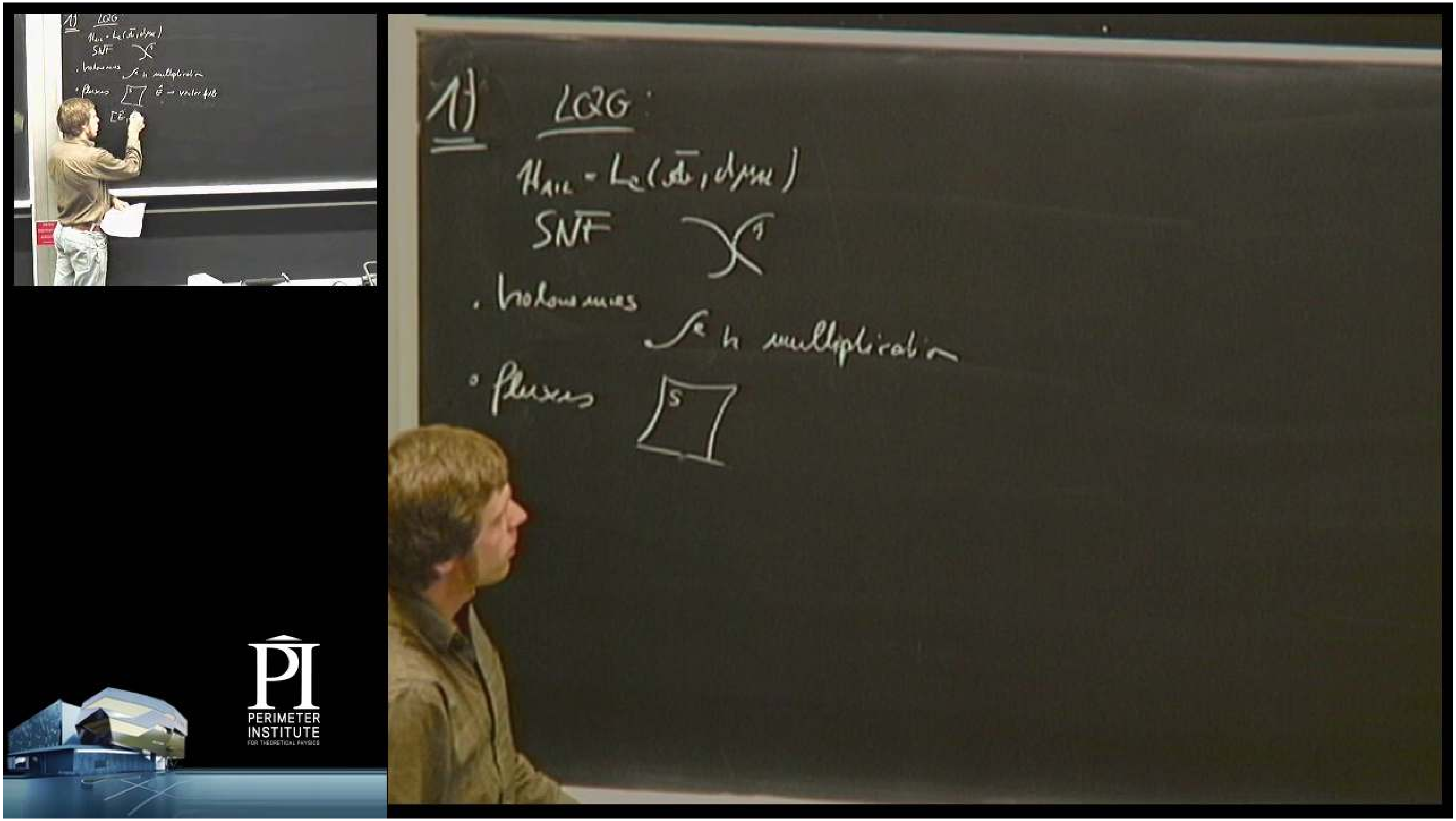
Date: Nov 25, 2009 04:00 PM

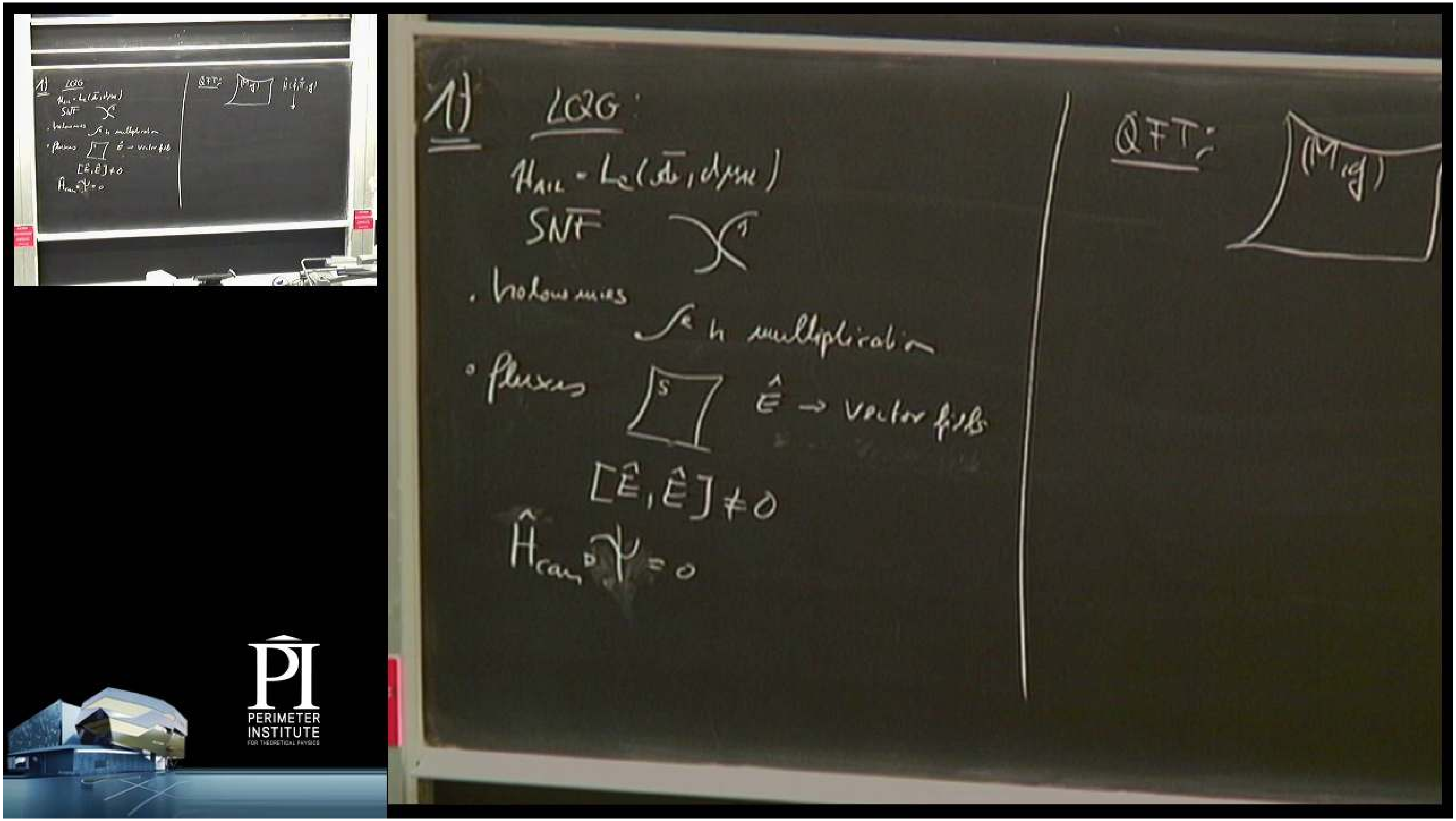
URL: http://pirsa.org/09110142

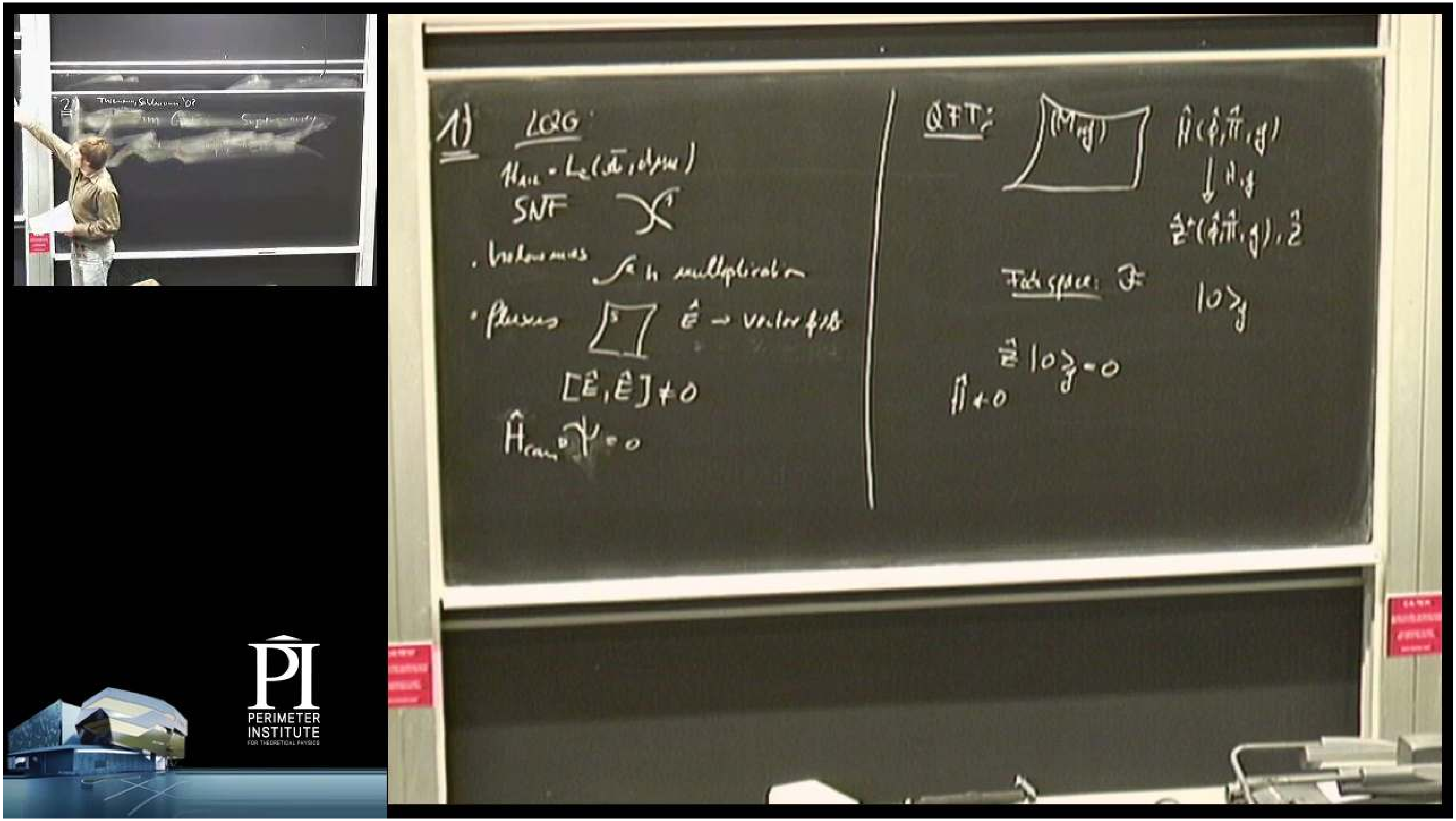
Abstract: The relation between loop quantum gravity (LQG) and ordinary quantum field theory (QFT) on a fixed background spacetime still bears many obstacles. When looking at LQG and ordinary QFT from a mathematical perspective it turns out that the two frameworks are rather different: Although LQG is a true continuum theory its Hilbert space is defined in terms of certain embedded graphs which are labeled by irreducible representations of SU(2). The natural arena for ordinary QFT, on the other hand, is a Fock space which strongly uses the metric properties of the underlying continuum spacetime. In this talk I will review this issue and show how one can use Born--Oppenheimer methods to further progress towards an understanding of (matter) quantum field theories from first principles.

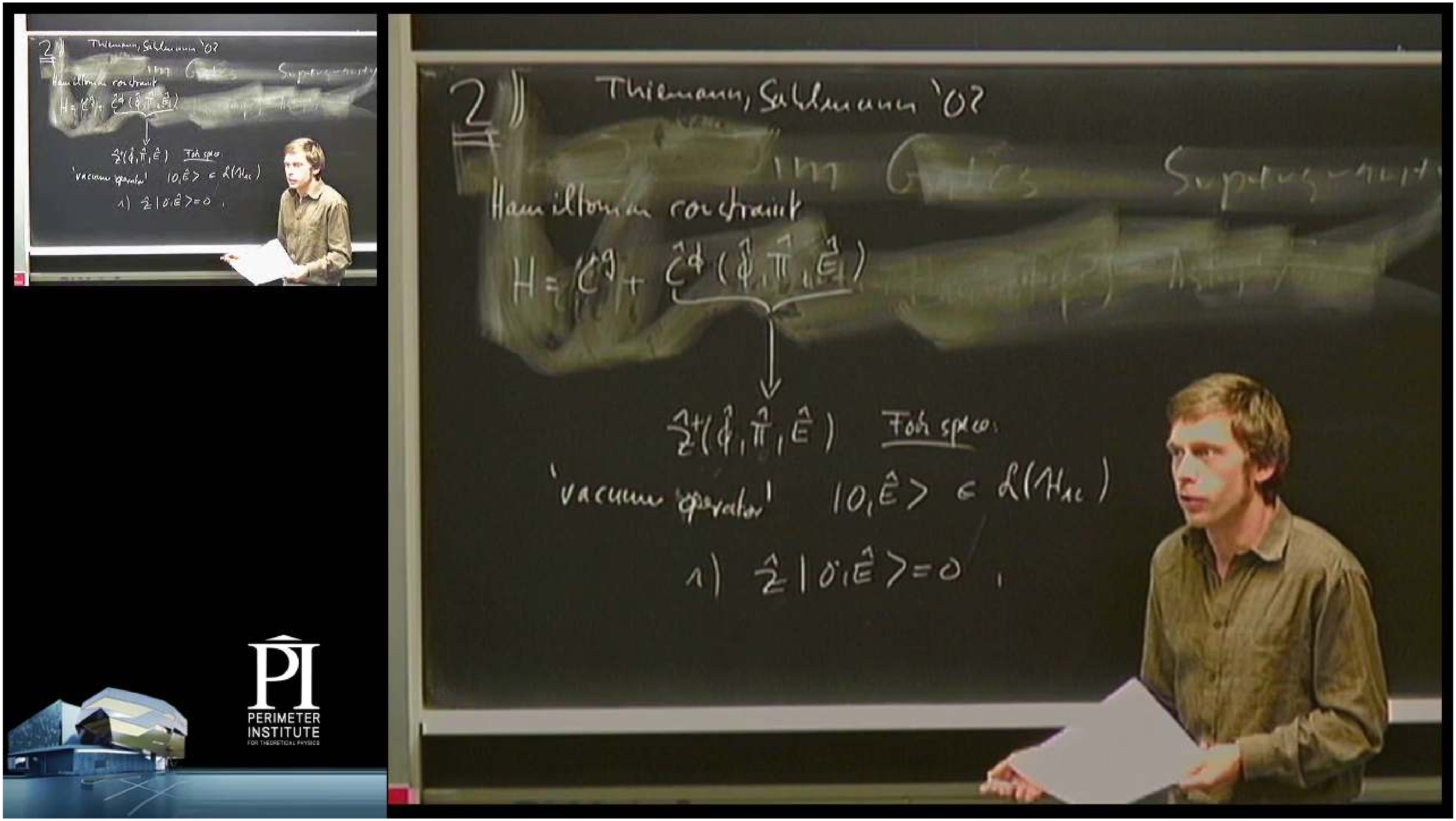

Born-Oppenheimer decomposition for quantum fields on quantum spacetime
with T. Thiemann / K. Giesel
Outline:
1) LQG →? QFT
2) previous work, open problems
3) reduced phase space quantization
→ A_phys
4) BO-methods
5) new gravitational field algebra / 'toy model'
6) outlook
PERIMETER INSTITUTE
FOR THEORETICAL PHYSICS

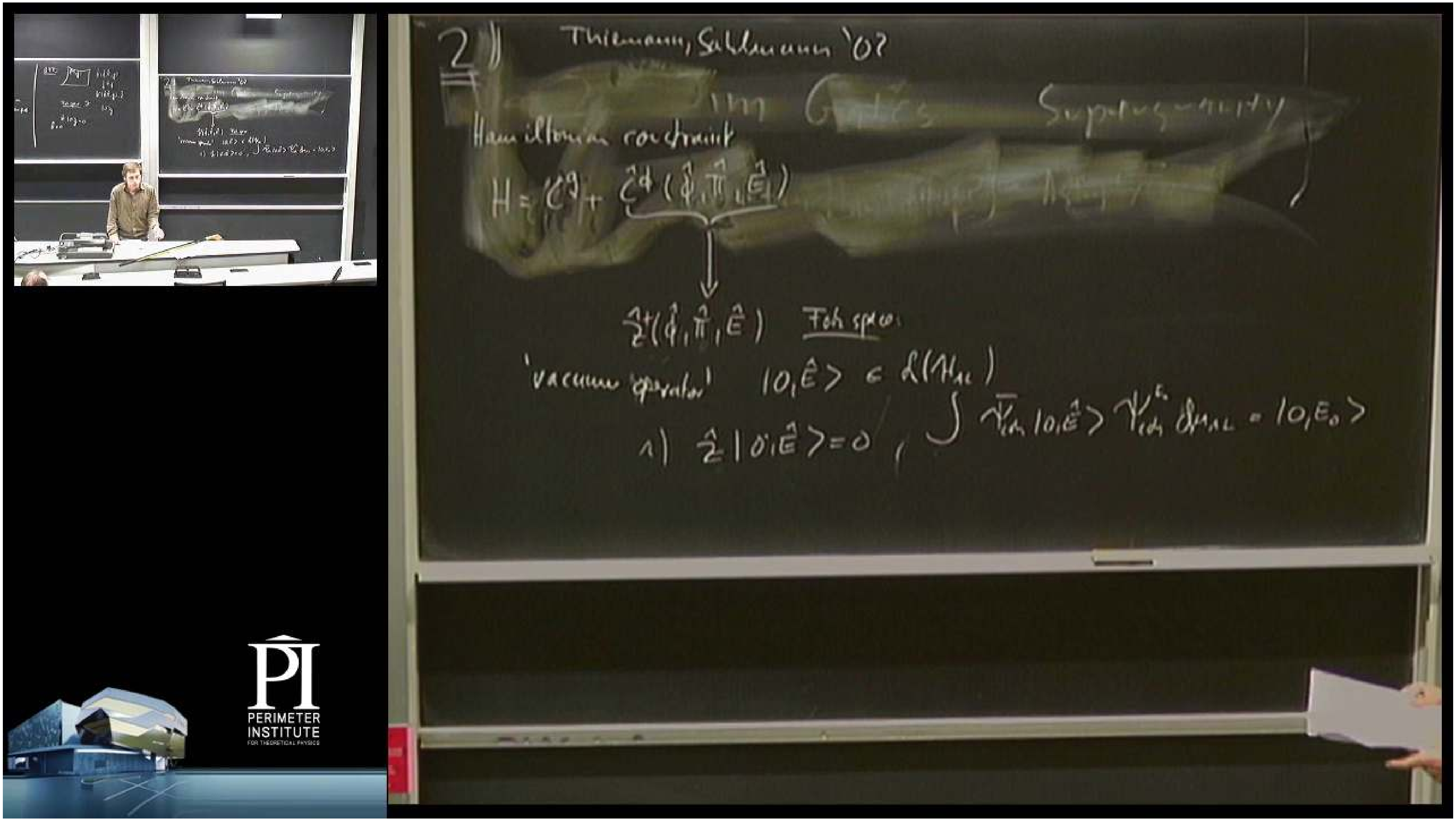

1)
LQG :
H_AIL = L_2(A, dμ_AL)
SNF
PERIMETER
INSTITUTE

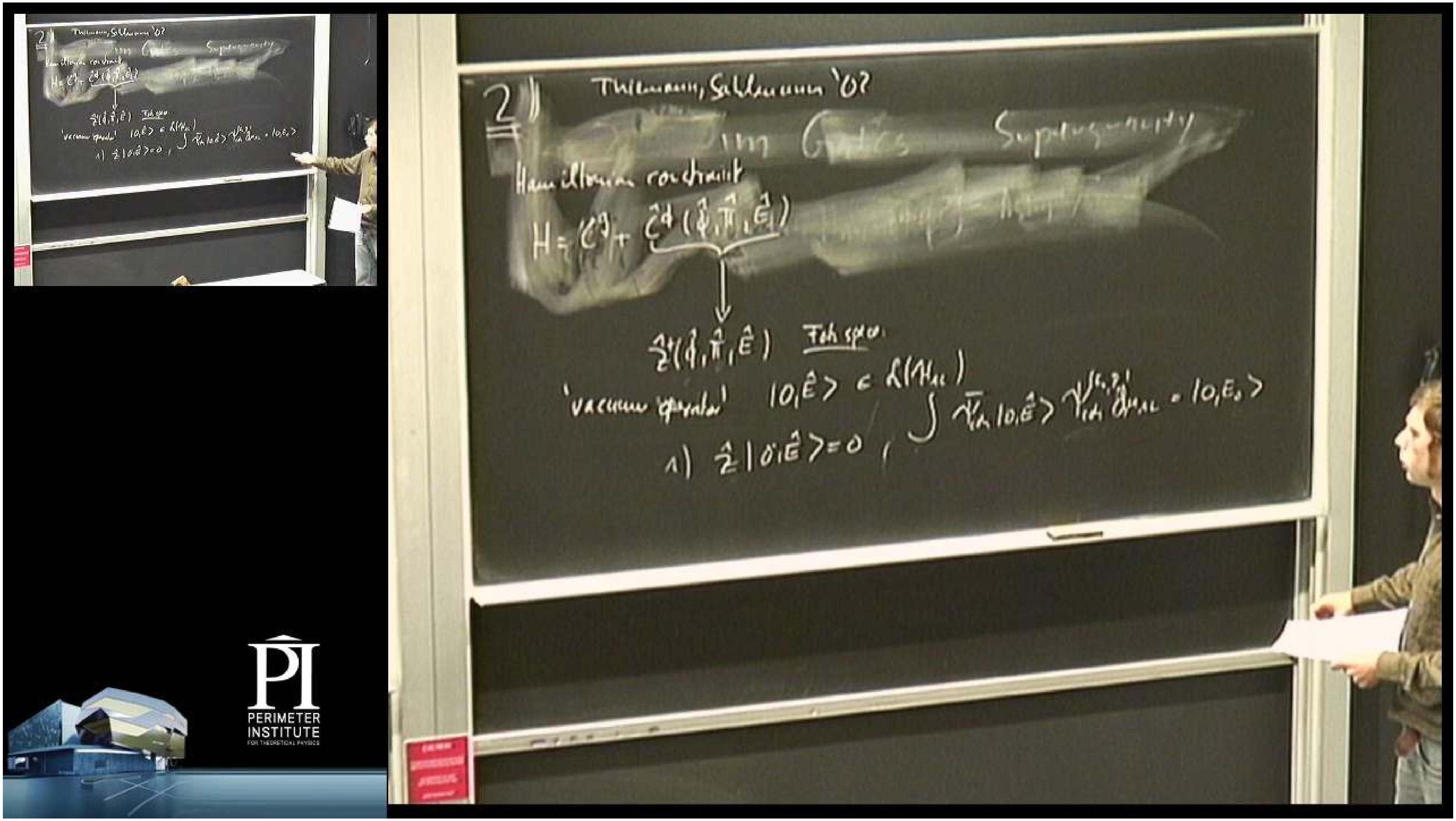

1)
LQG:
SNF
holonomies
multiplication
fluxes
S
PERIMETER
INSTITUTE
FOR THEORETICAL PHYSICS

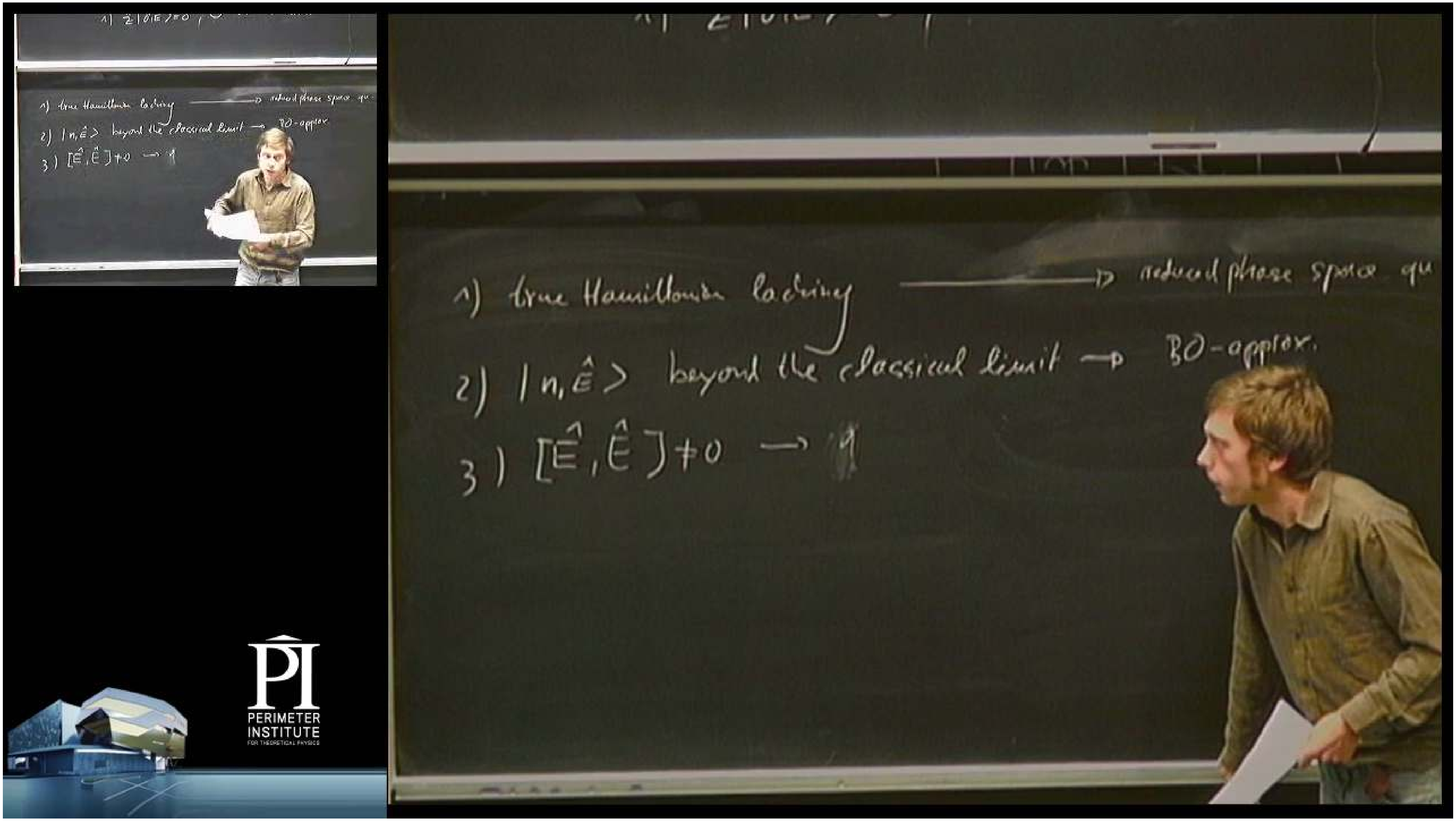

1) LQG :
SNF
. holonomies
multiplication
° fluxes
Ê → vector fields
[Ê, Ê] ≠ 0
QFT:
(M, g)
PERIMETER
INSTITUTE
FOR THEORETICAL PHYSICS

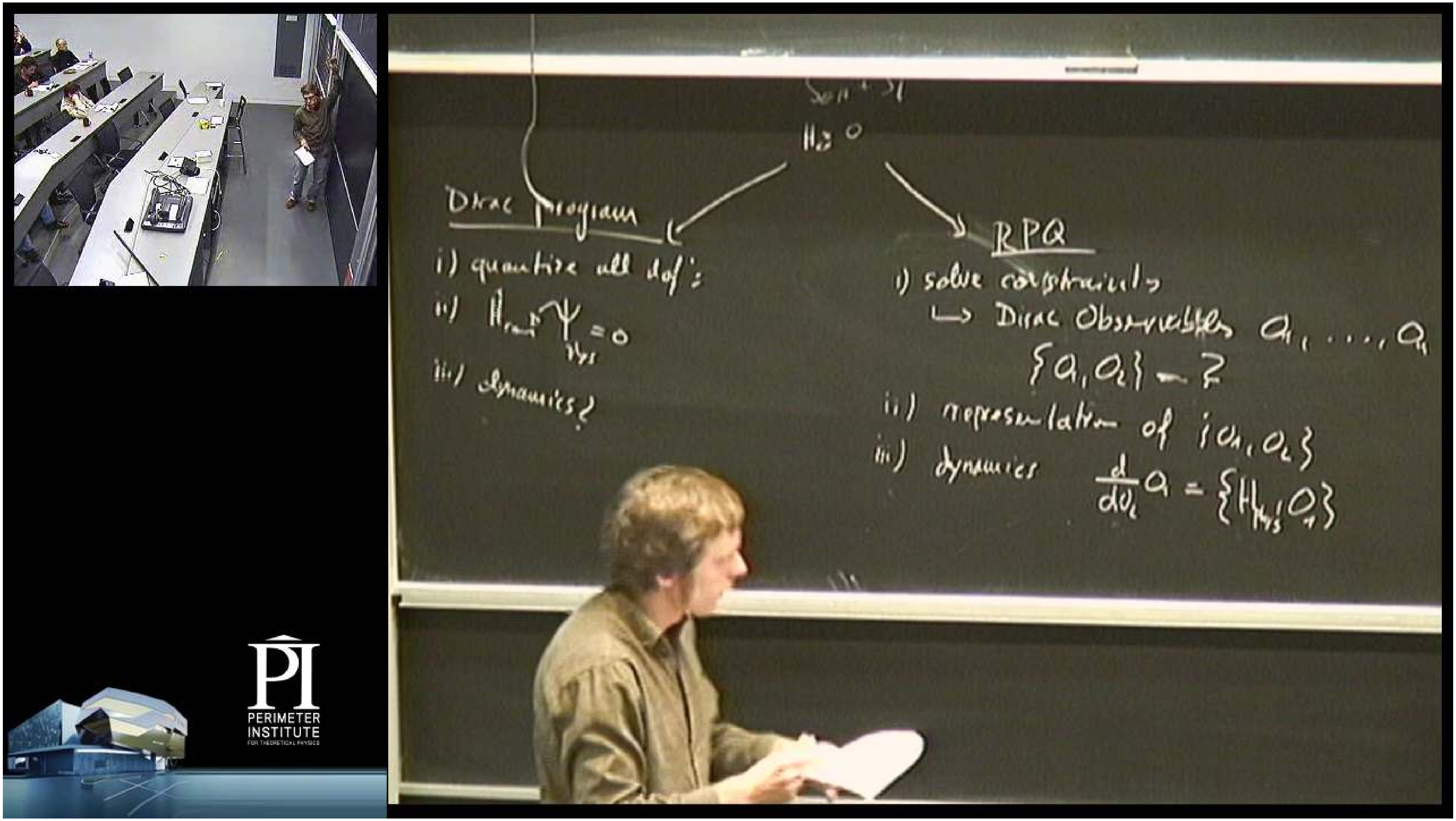

LQG
SNF
QFT:
[Ê, Ê] ≠ 0
PERIMETER
INSTITUTE

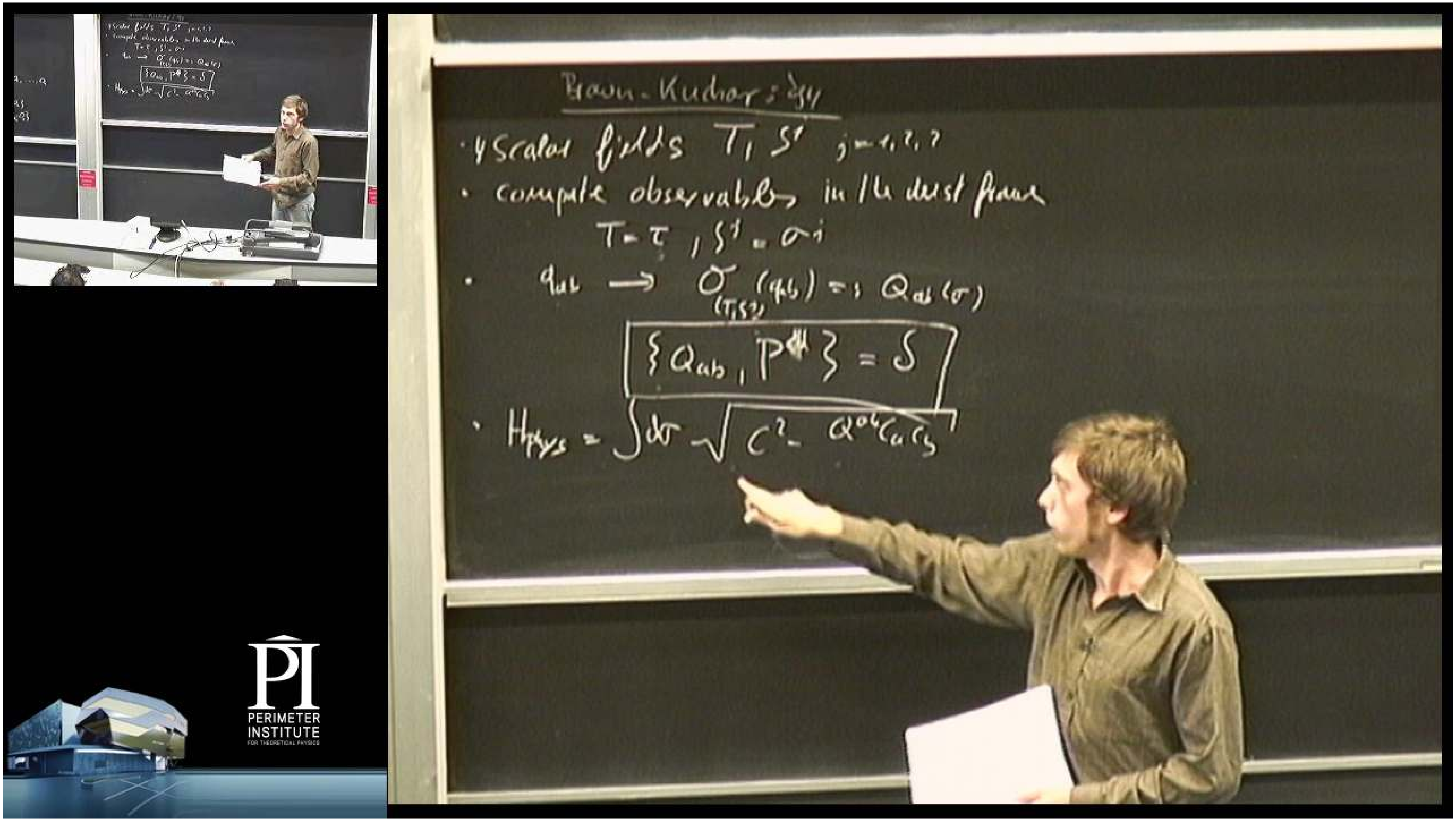

Hamiltonian constraint
'vacuum operator'
PERIMETER
INSTITUTE
FOR THEORETICAL PHYSICS

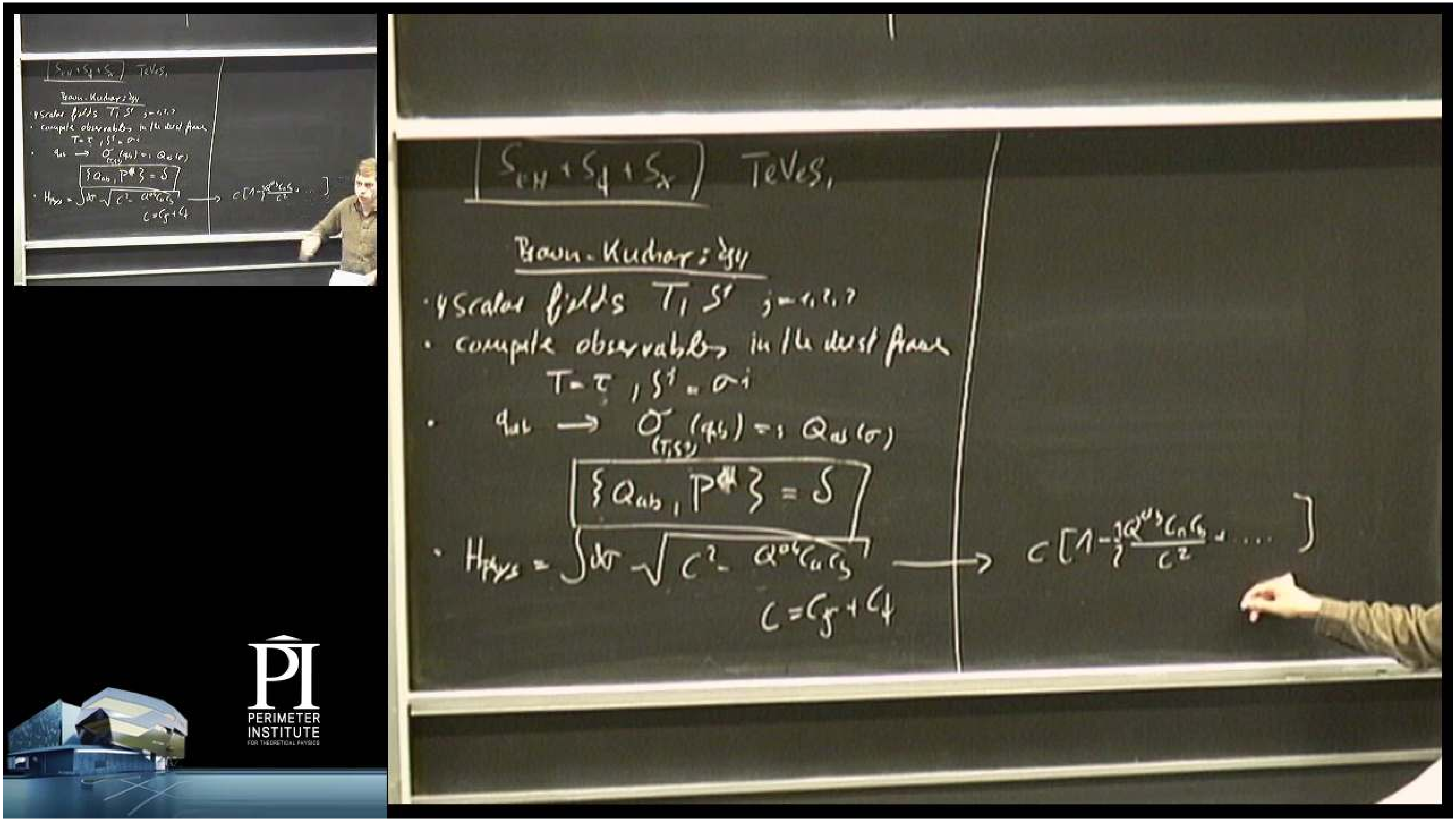

Hamiltonian constraint
Fock space
'vacuum operator'
PERIMETER INSTITUTE

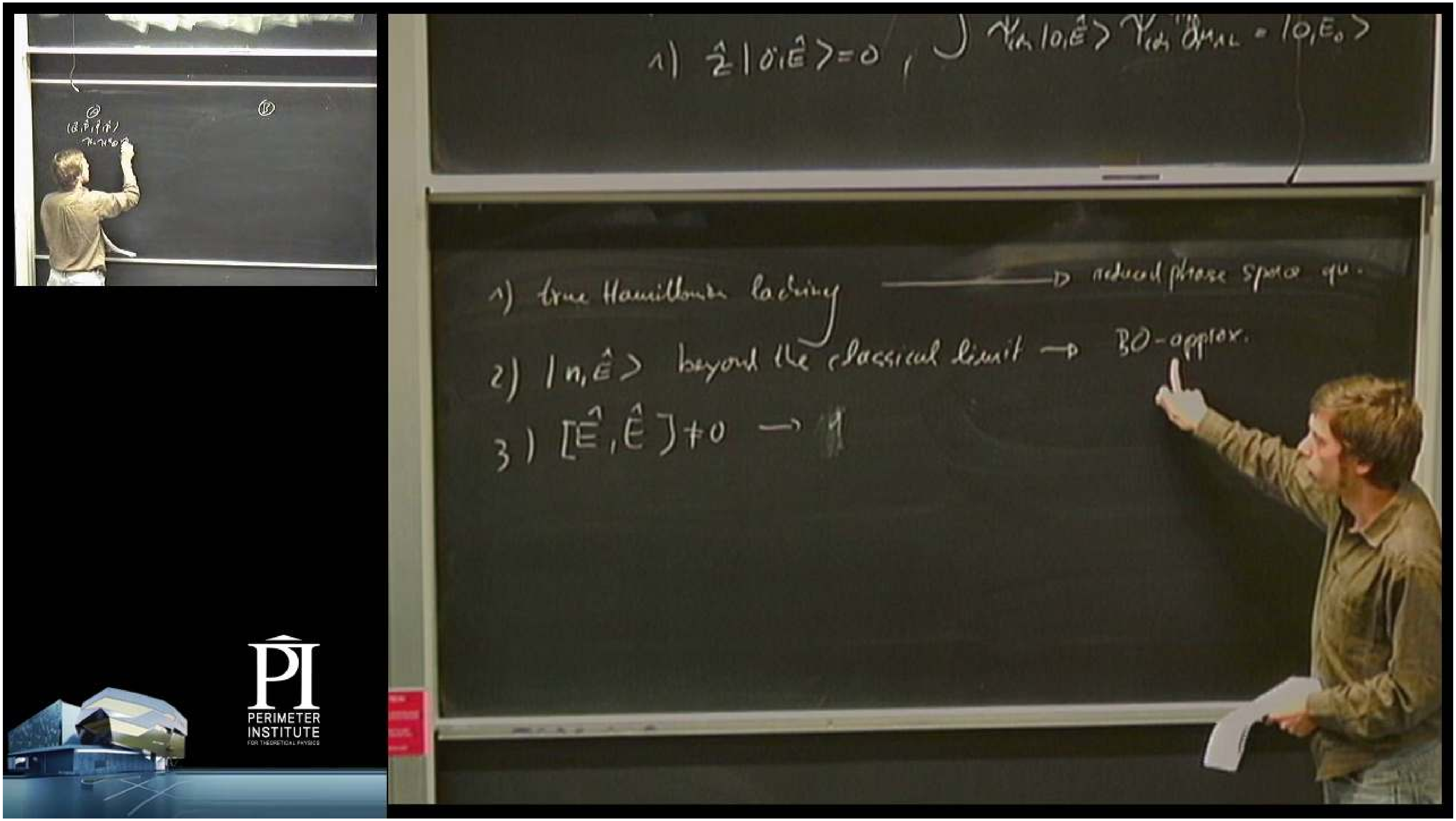

PERIMETER
INSTITUTE

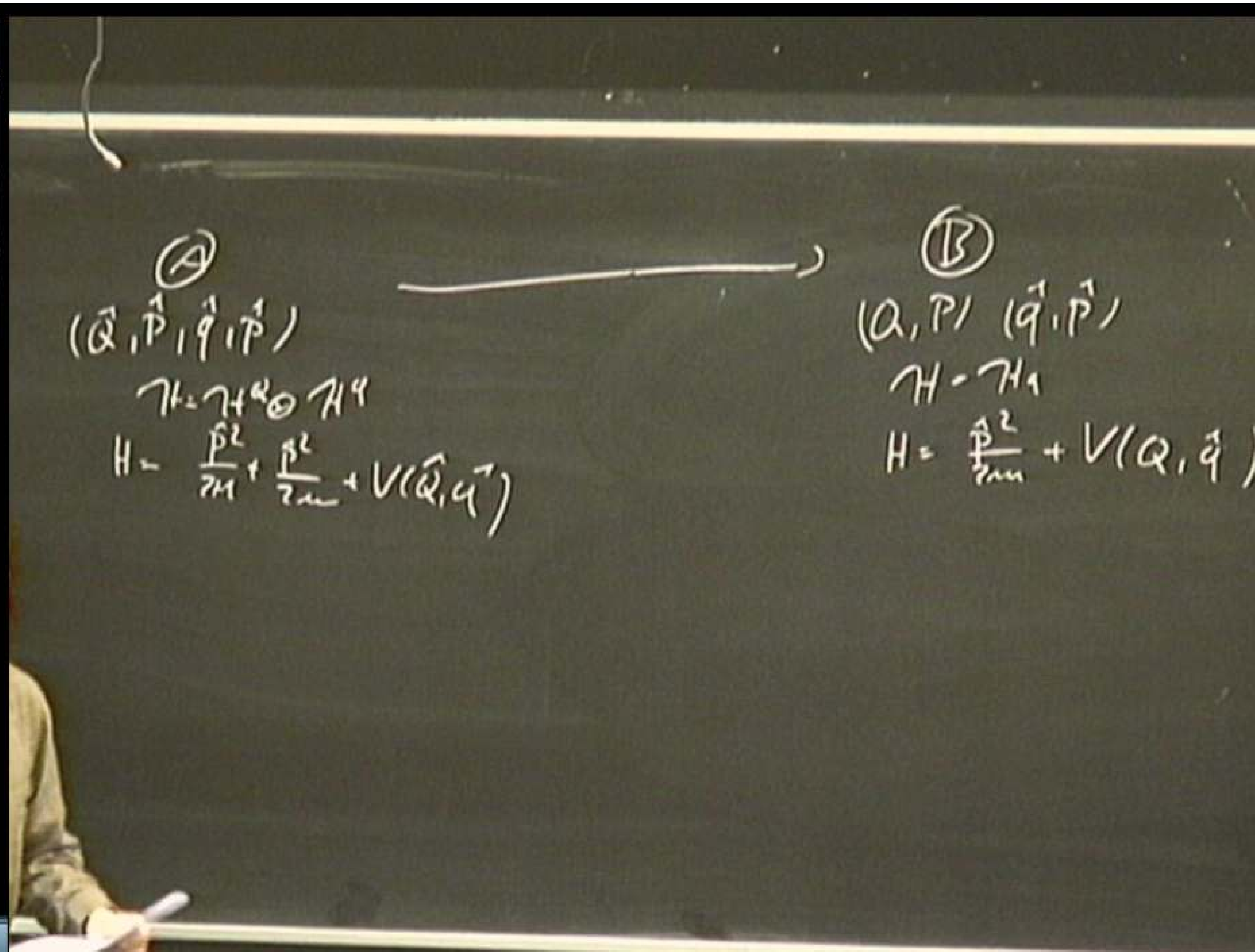

1) true Hamiltonian lacking → reduced phase space qu
2) |n,Ê> beyond the classical limit → BO-approx.
3) [Ê,Ê] ≠ 0 →
PERIMETER
INSTITUTE

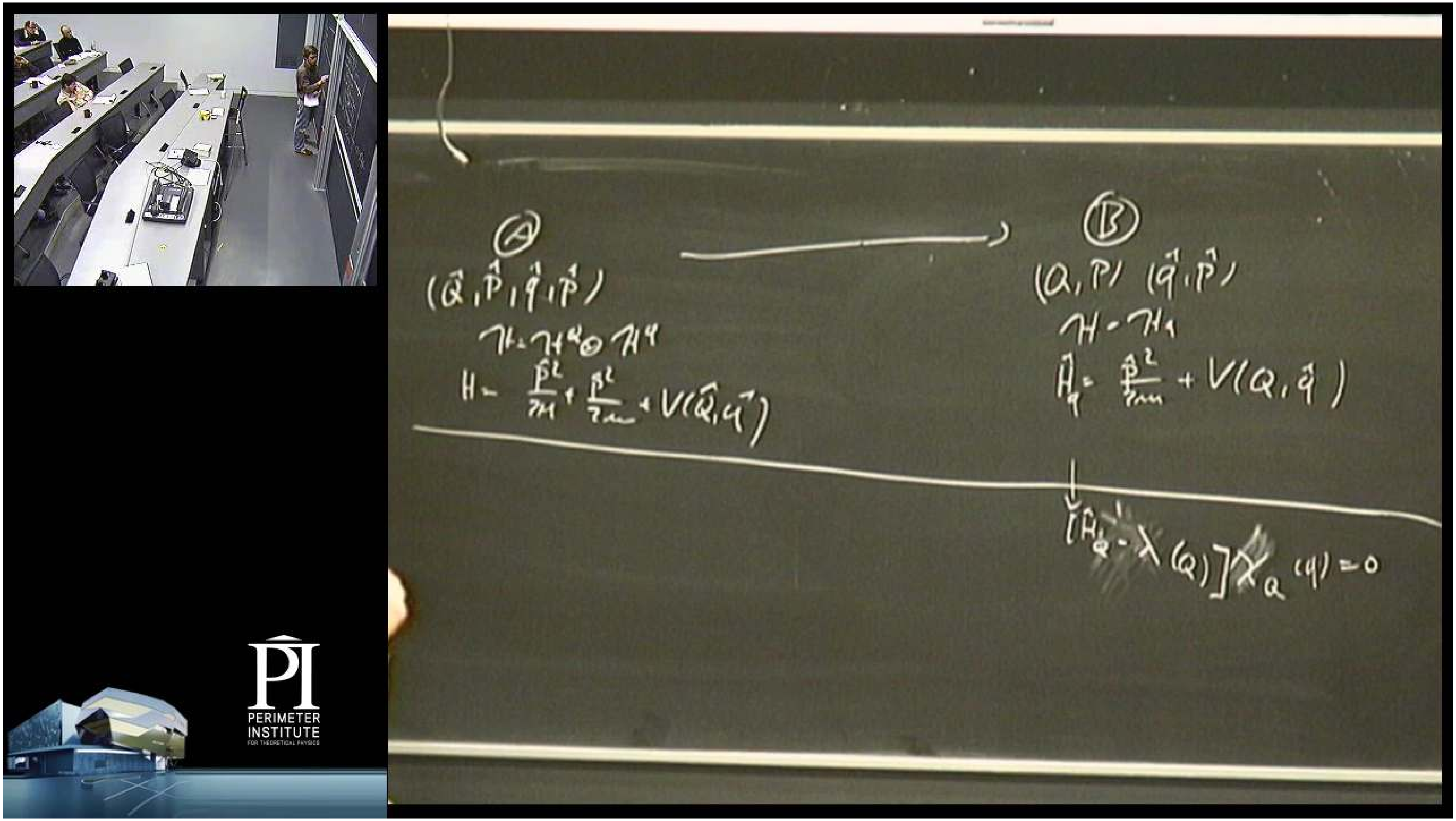

Dirac program
i) quantize all dof's
iii) dynamics?
RPQ
i) solve constraints
Dirac Observables
ii) representation of
iii) dynamics
PERIMETER
INSTITUTE

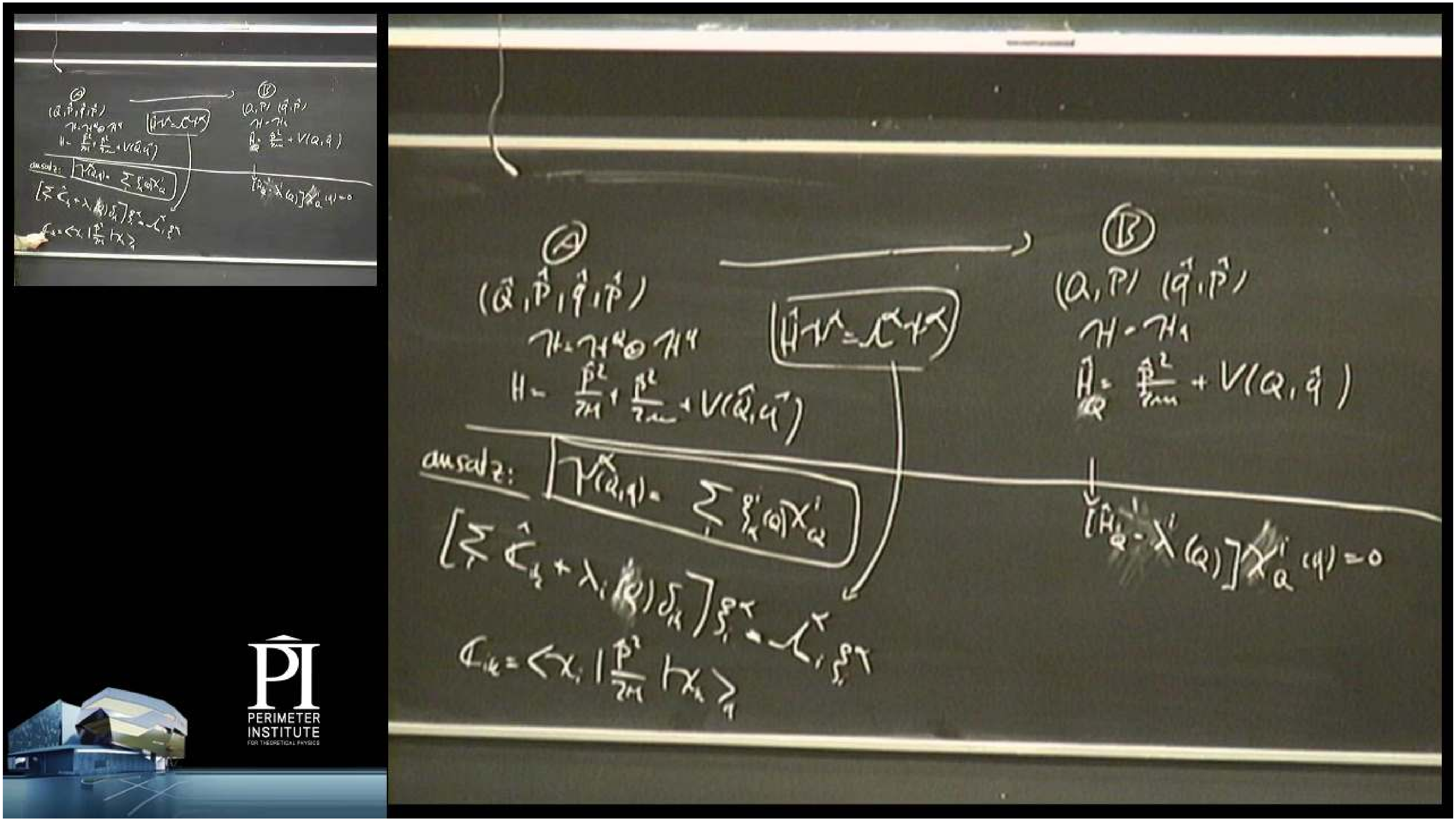

Brown-Kuchar: dust
· 4 scalar fields T, S^j j=1,2,3
· complete observables in the dust frame
T = τ, S^j = σ^j
· q_ab → O_(T,S^j)(q_ab) =: Q_ab(σ)
{Q_ab, P^cd} = δ
· H_phys = ∫dσ √(C² − Q^ab C_a C_b)
PERIMETER INSTITUTE
FOR THEORETICAL PHYSICS

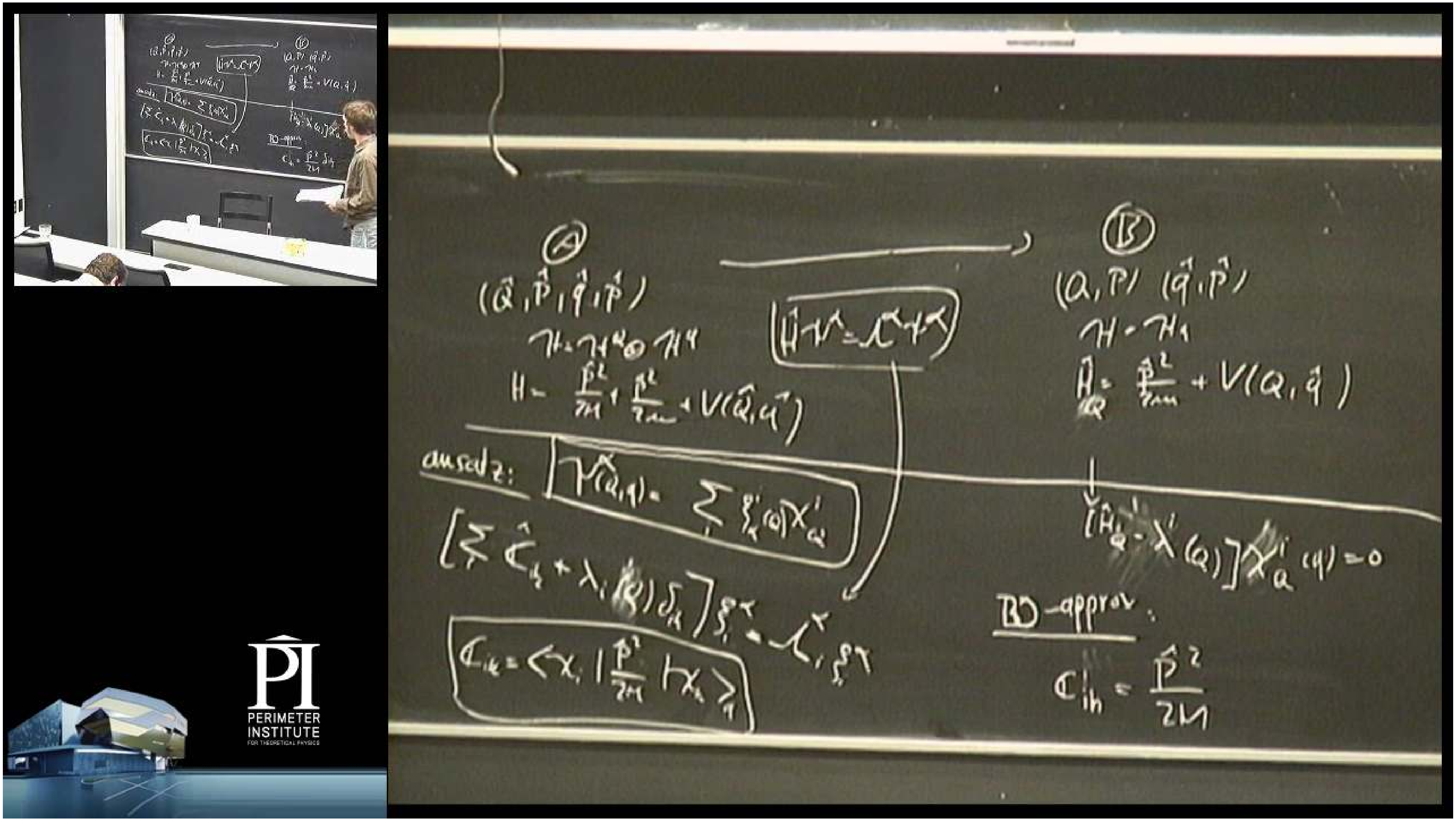

S_EH + S_ϕ + S_χ   TeVeS,
Brown - Kuchar : ϕ_J
· 4 scalar fields T, S^j j = 1,2,3
· compute observables in the dust frame
T = τ , S^j = σ^j
· q_ab → O_(T,S^j)(q_ab) =: Q_ab(σ)
{ Q_ab , P^cd } = δ
· H_phys = ∫dσ √(C² − Q^ab C_a C_b) → C [1 − ½ Q^ab C_a C_b / C² + ...]
C = C_grav + C_ϕ
PERIMETER
INSTITUTE

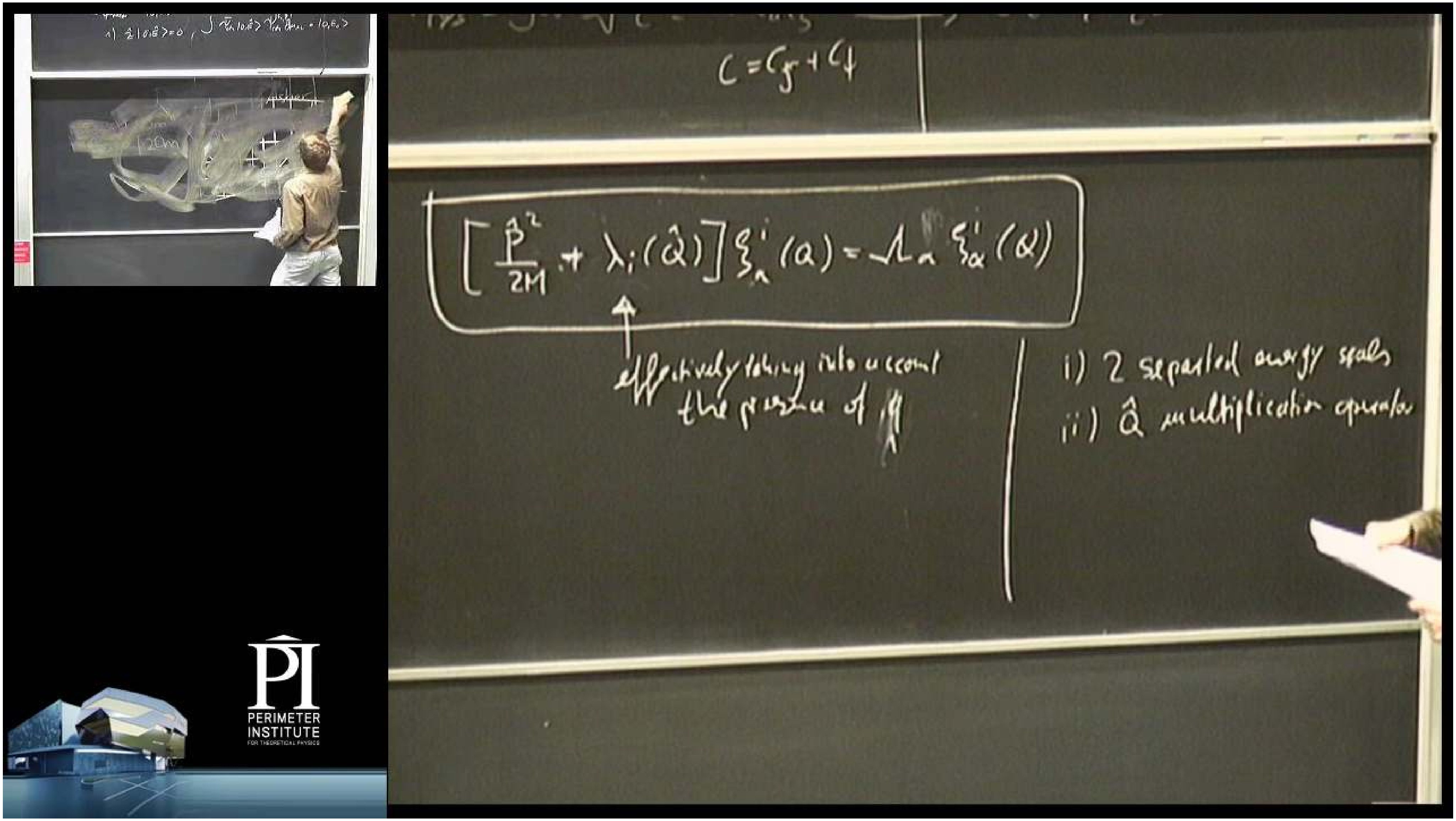

1) true Hamiltonian lacking → reduced phase space qu.
2) |n, Ê> beyond the classical limit → BO-approx.
3) [Ê, Ê] ≠ 0 →
PERIMETER INSTITUTE


A
(Q, P, q, p)
H = H^Q ⊗ H^q
H = P²/2M + p²/2m + V(Q, q)
B
(Q, P) (q, p)
H = H_1
H = p²/2m + V(Q, q)

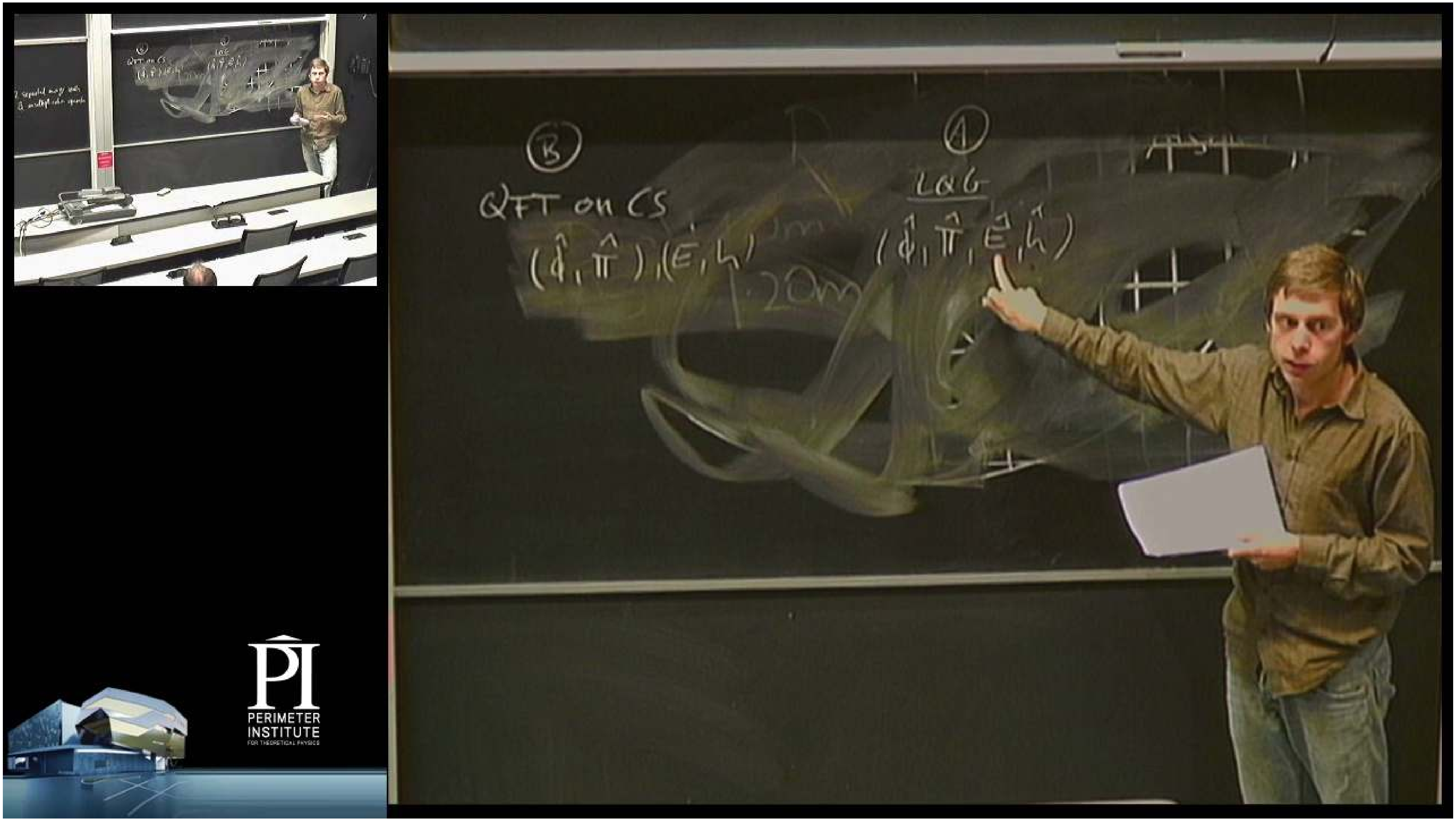

PERIMETER
INSTITUTE
(A)
(B)
(Q, P) (q, p)
H = H_q
V(Q, q)


PERIMETER
INSTITUTE
FOR THEORETICAL PHYSICS

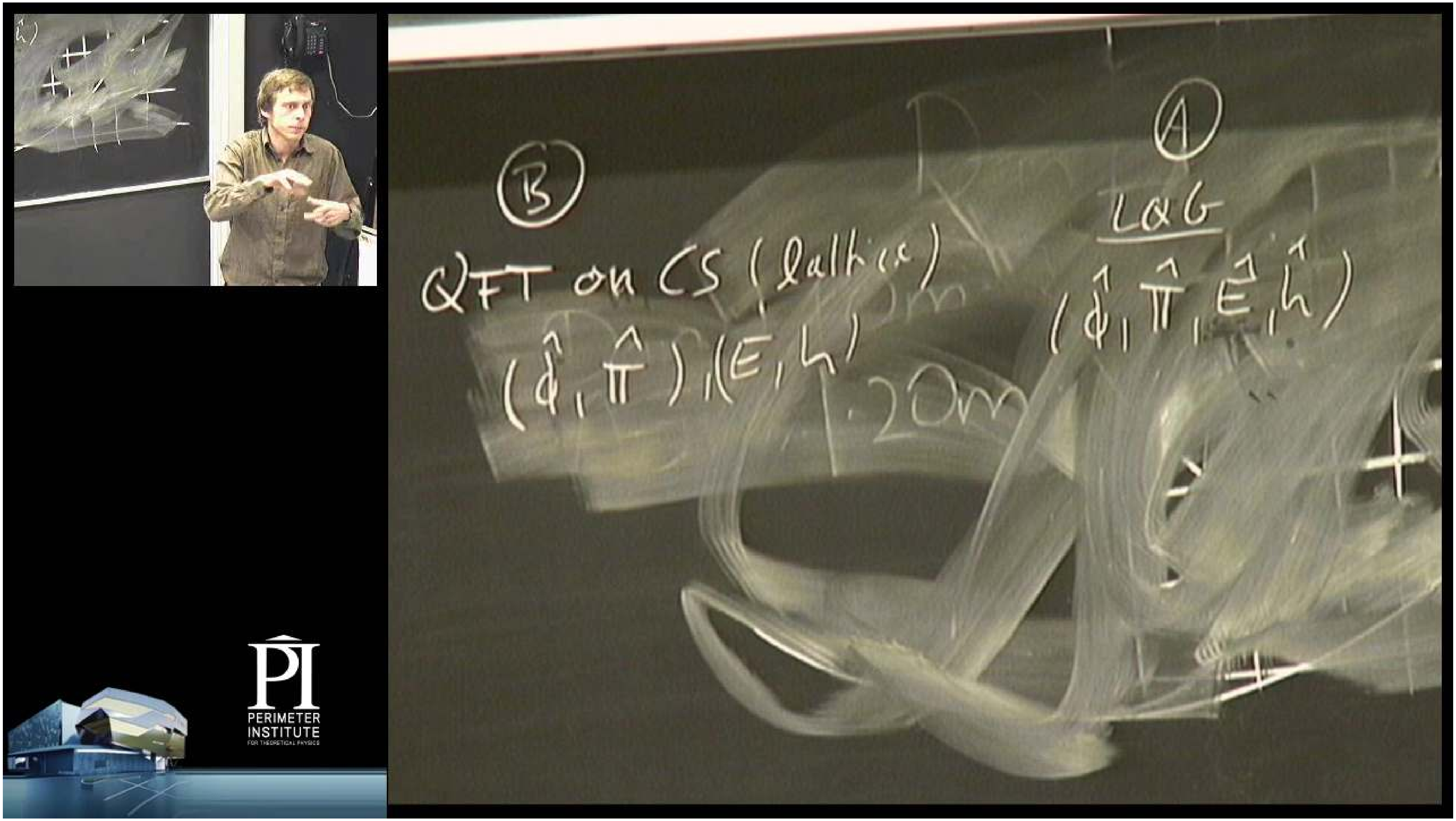

ansatz:
BO-approx.:
PERIMETER INSTITUTE



effectively taking into account
i) 2 separated energy scales
ii) Q̂ multiplication operator
PERIMETER INSTITUTE



B
QFT on CS
A
LQG
PERIMETER
INSTITUTE


B
A
QFT on CS (lattice)
LQG
PERIMETER
INSTITUTE