Title: Witnessing nonclassicality with measurement dependence.

Speakers: George Moreno

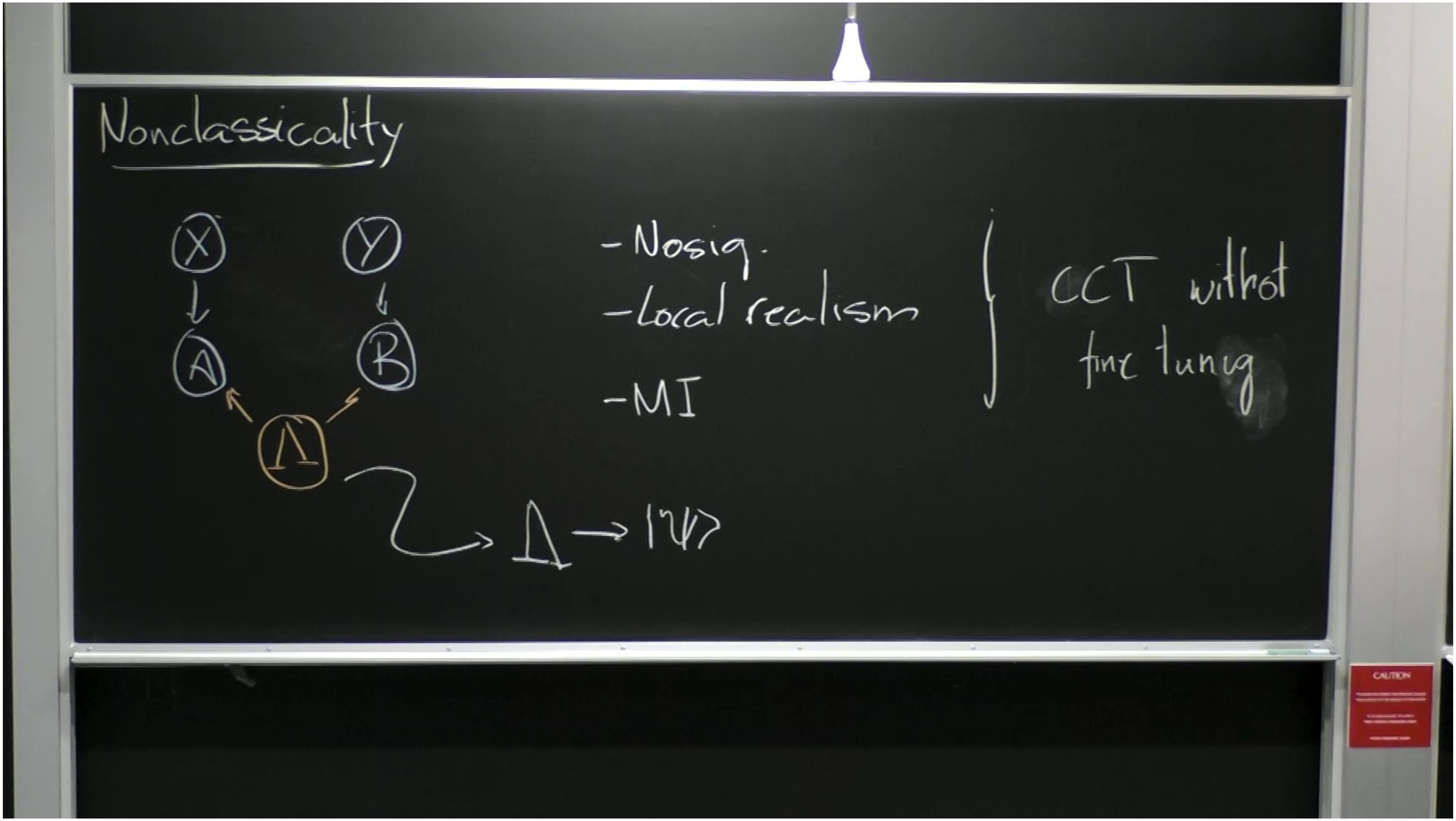
Series: Quantum Foundations

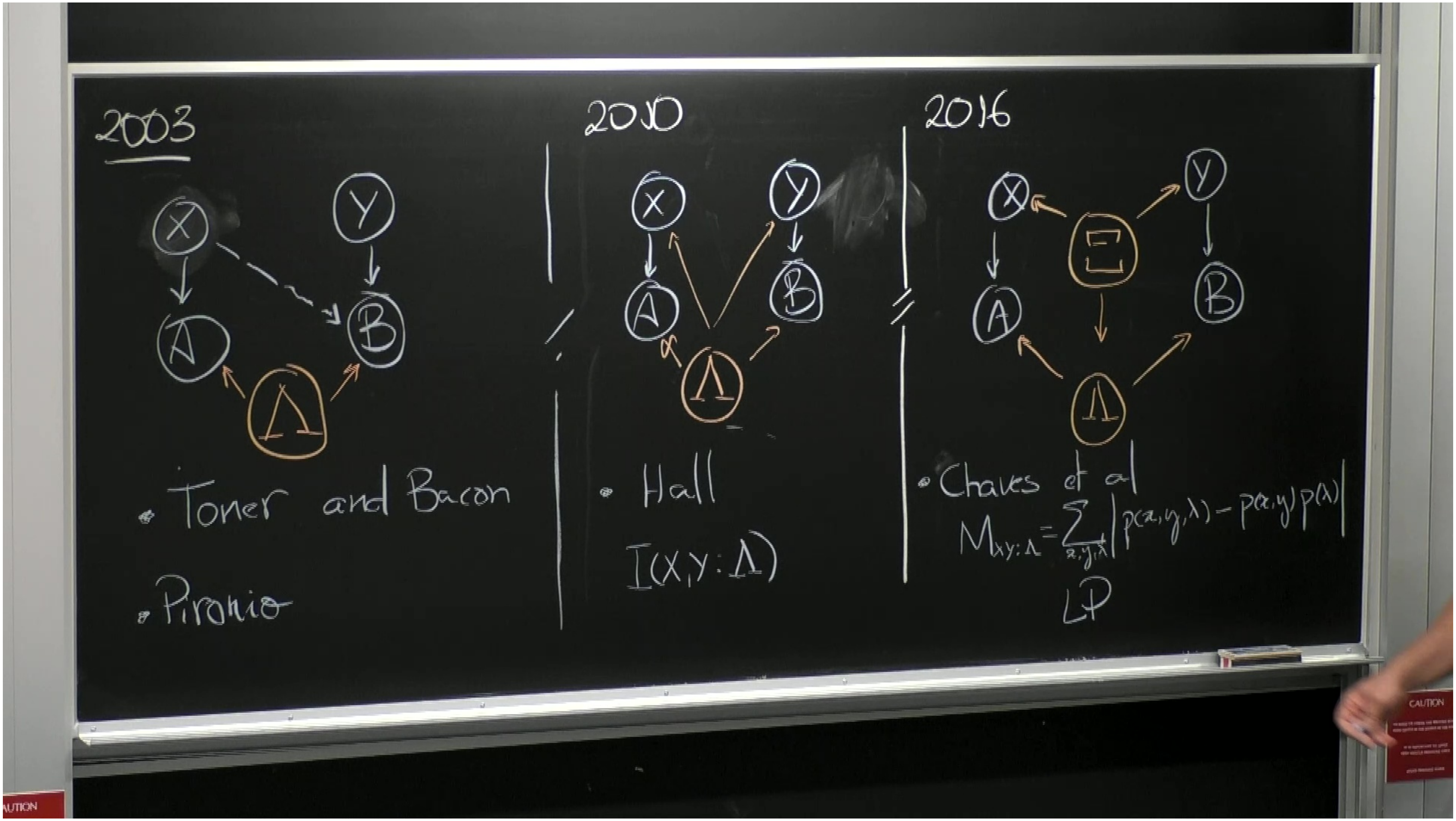
Date: January 23, 2023 - 11:30 AM

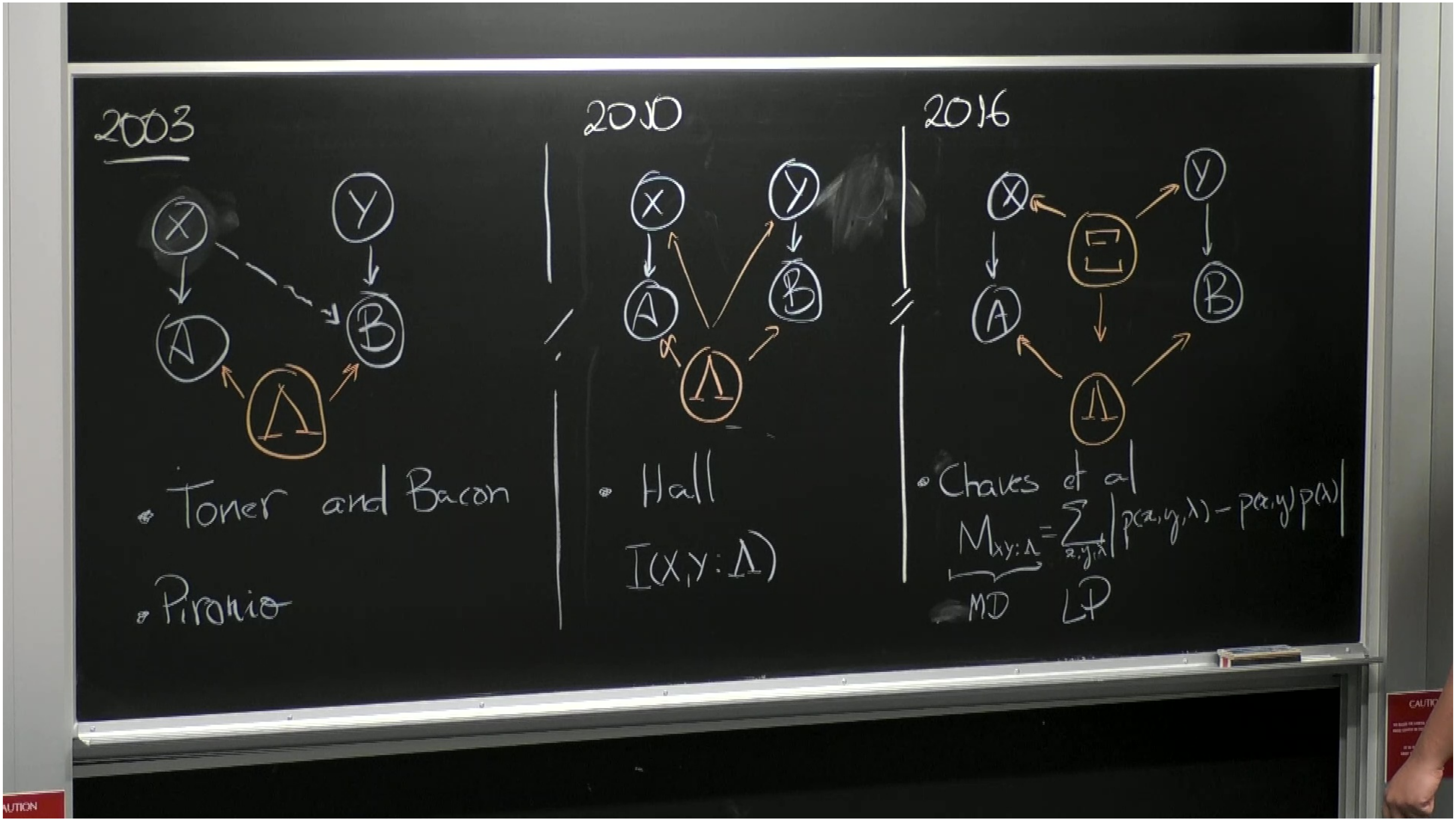
URL: https://pirsa.org/23010111

Abstract: Nonclassicality, as witnessed by the incapacity of Classical Causal Theory (CCT) of explaining a system's behavior given its causal structure, come to be one of the hottest topics in Quantum Foundations over the last decades, a movement that was motivated both by its vast range of practical applications and by the powerful insights it provides about the rules of the quantum world. Among the many attempts at understanding/quantifying this phenomenon, we highlight the idea of inquiring how further would it be necessary to relax the causal structure associated with a given system in order to have its nonclassical behavior explained by CCT. More recently, we showed that the relaxation demanded to explain the behavior of a subset of variables in a given experiment may not be allowed by the embedding causal structure when considering the behavior of the remaining variables, which led to a new way of witnessing nonclassicality. In this seminar, we discuss a new way of quantifying this incompatibility and possible generalizations of this approach to different scenarios.

Zoom link: https://pitp.zoom.us/j/96051313203?pwd=bFNhOEhkSVhXWk8yd1hVZWVVa0U4UT09


Nonclassicality
X
Y
A
B
Λ
- Nosig.
- Local realism
- MI
CCT withot
fine tunig
Λ → |ψ⟩


2003
X
Y
A
B
Λ
Toner and Bacon
Pironio
2010
X
Y
A
B
Λ
Hall
I(X,Y:Λ)
2016
X
Y
Ξ
A
B
Λ
Chaves et al
$M_{XY:\Lambda} = \sum_{x,y,\lambda} |p(x,y,\lambda) - p(x,y)p(\lambda)|$
LP
CAUTION


2003
X
Y
A
B
Λ
Toner and Bacon
Pironio
2010
X
Y
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Hall
I(X,Y:Λ)
2016
X
Y
Ξ
A
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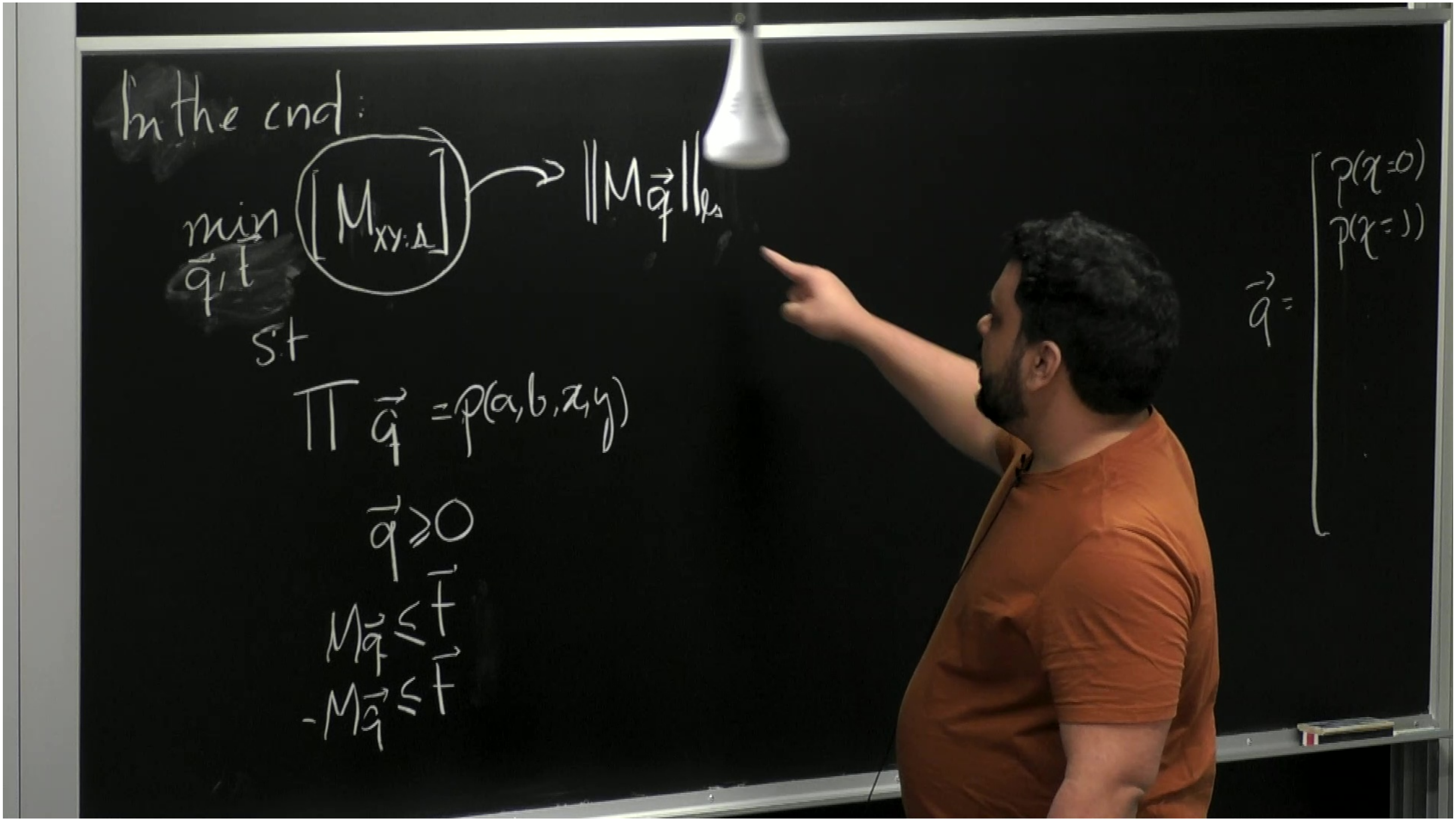
Λ
Chaves et al
M_{XY:Λ} = Σ_{x,y,λ} |p(x,y,λ) − p(x,y) p(λ)|
MD
LP


In the end:
$\min_{\vec{q},\vec{t}} \left[M_{xy:\lambda} \right] \rightarrow \|M\vec{q}\|_{\ell_1}$
s.t
$\Pi \vec{q} = p(a,b,x,y)$
$\vec{q} \geq 0$
$M\vec{q} \leq \vec{t}$
$-M\vec{q} \leq \vec{t}$
$\vec{q} =$
$p(x=0)$
$p(x=1)$

In the end:

$$\min_{\vec{q},\vec{t}} \langle \vec{J}, \vec{t} \rangle$$

s.t.

$$\Pi \vec{q} = p(a,b,x,y)$$

$$\vec{q} \geq 0$$

$$M\vec{q} \leq \vec{t}$$

$$-M\vec{q} \leq \vec{t}$$

num. evidence

$$\min_{p(x)} \left[M_{xy:\Lambda} \right] = \max \left\{ 0, \frac{(I_\Delta - 2)}{4} \right\}$$

In the end:

$$\min_{\vec{q}, \vec{t}} \langle \vec{J}, \vec{t} \rangle$$

s.t.

$$\Pi \vec{q} = p(a,b,x,y)$$

$$\vec{q} \geq 0$$

$$M\vec{q} \leq \vec{t}$$

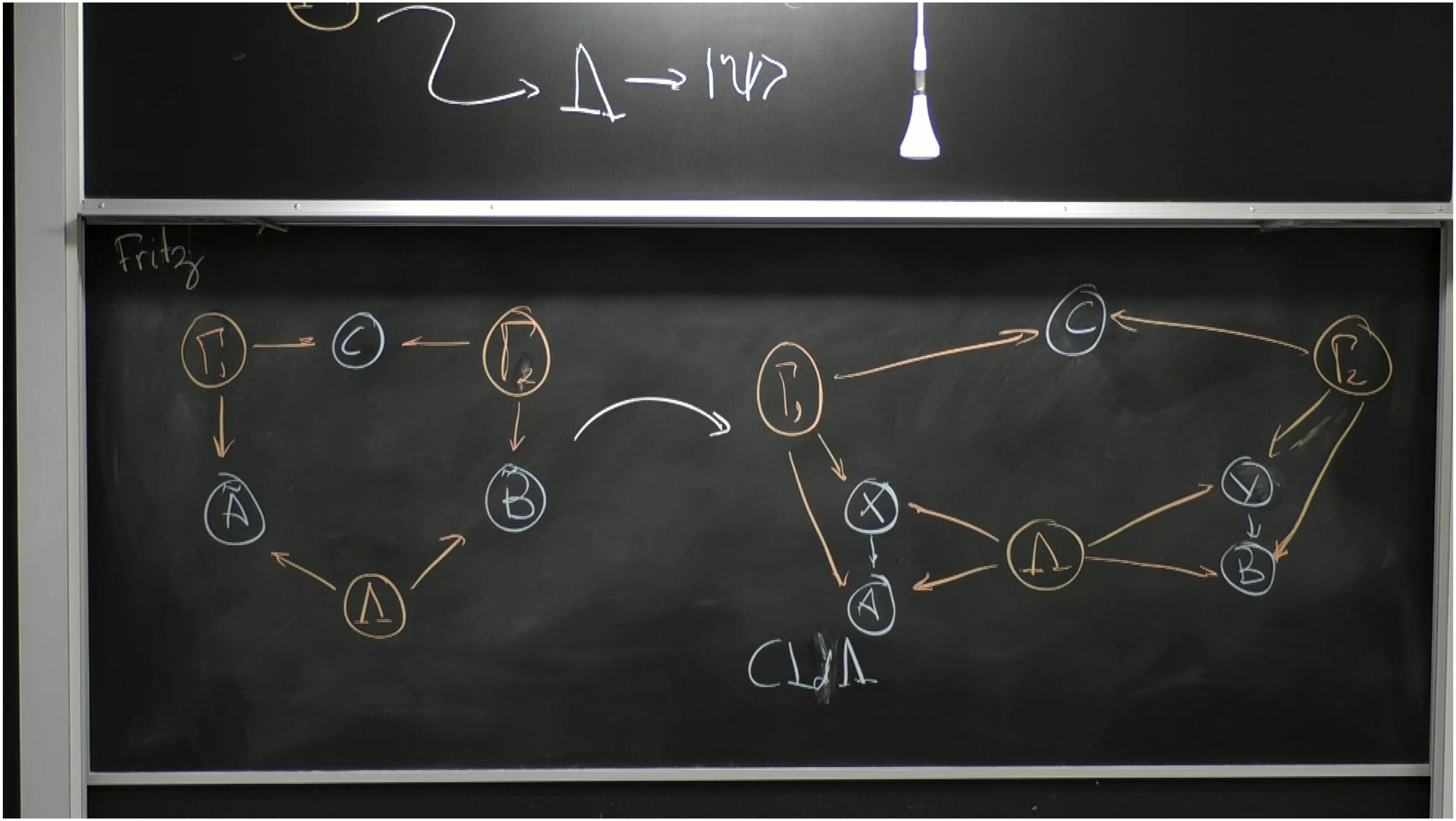
$$-M\vec{q} \leq \vec{t}$$

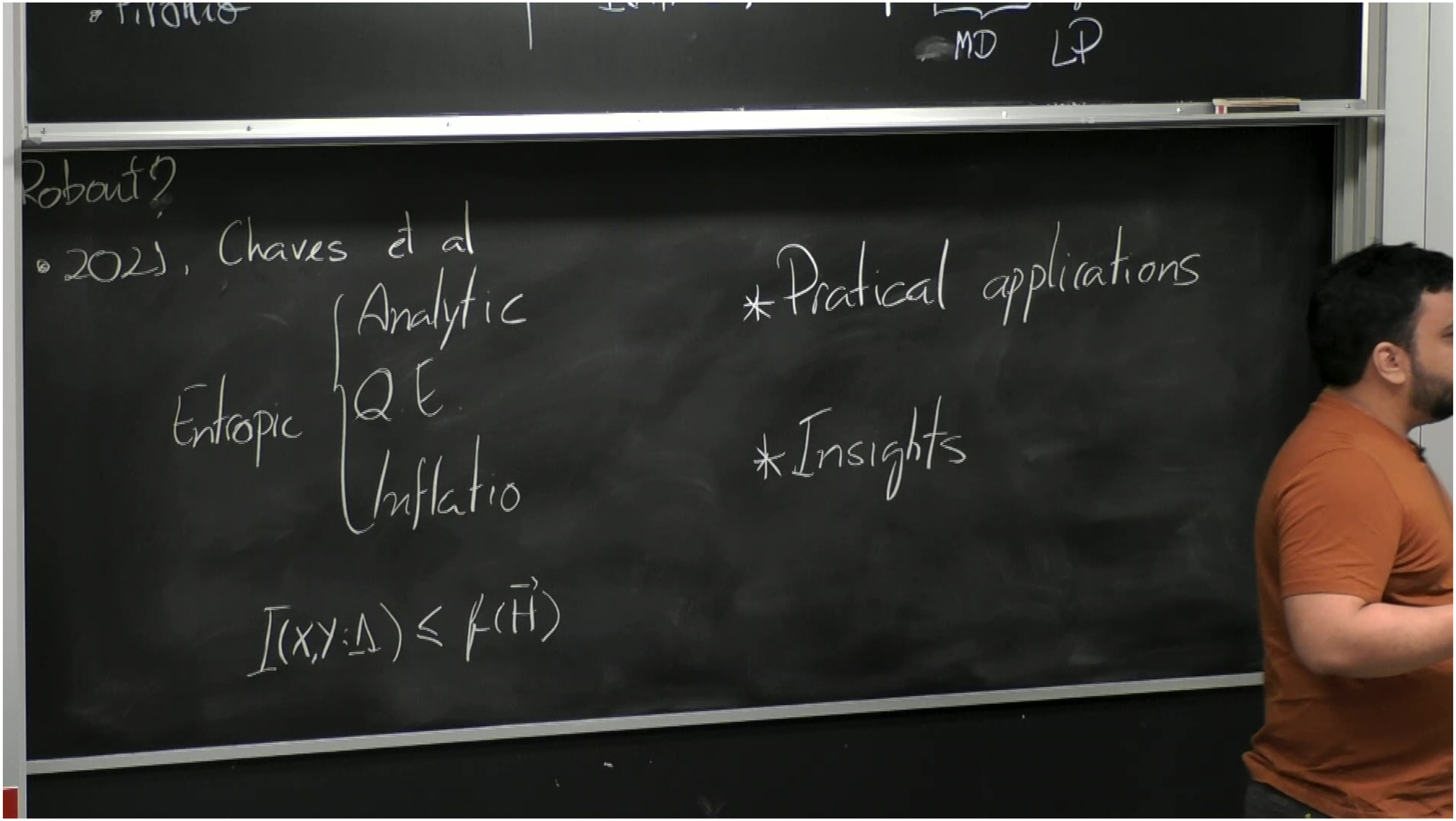
num. evidence

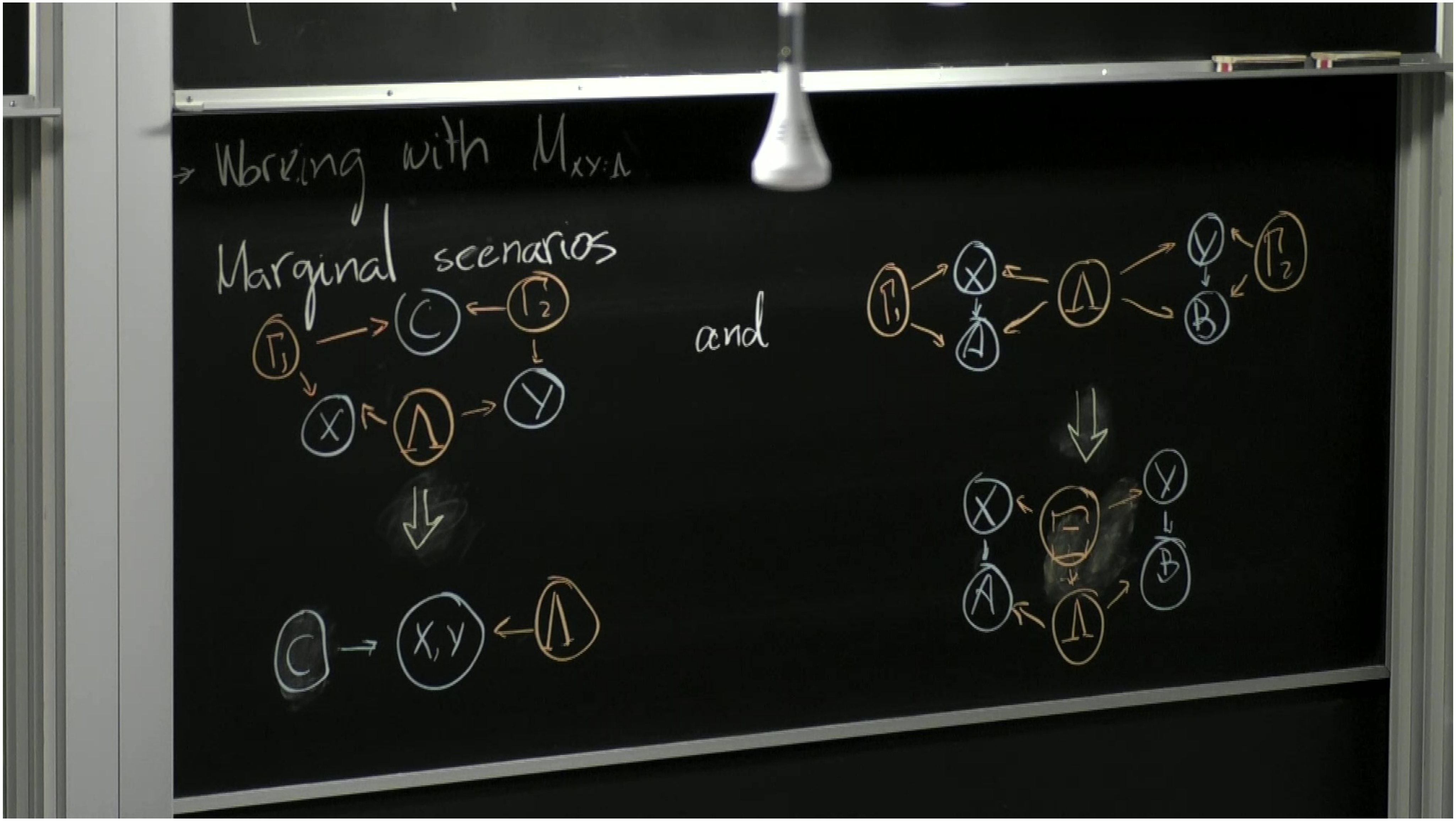
$$\min_{p(x)} \left[M_{XY:\Lambda} \right] = \max \left\{ 0, \frac{(I_{\Lambda} - 2)}{4} \right\}$$

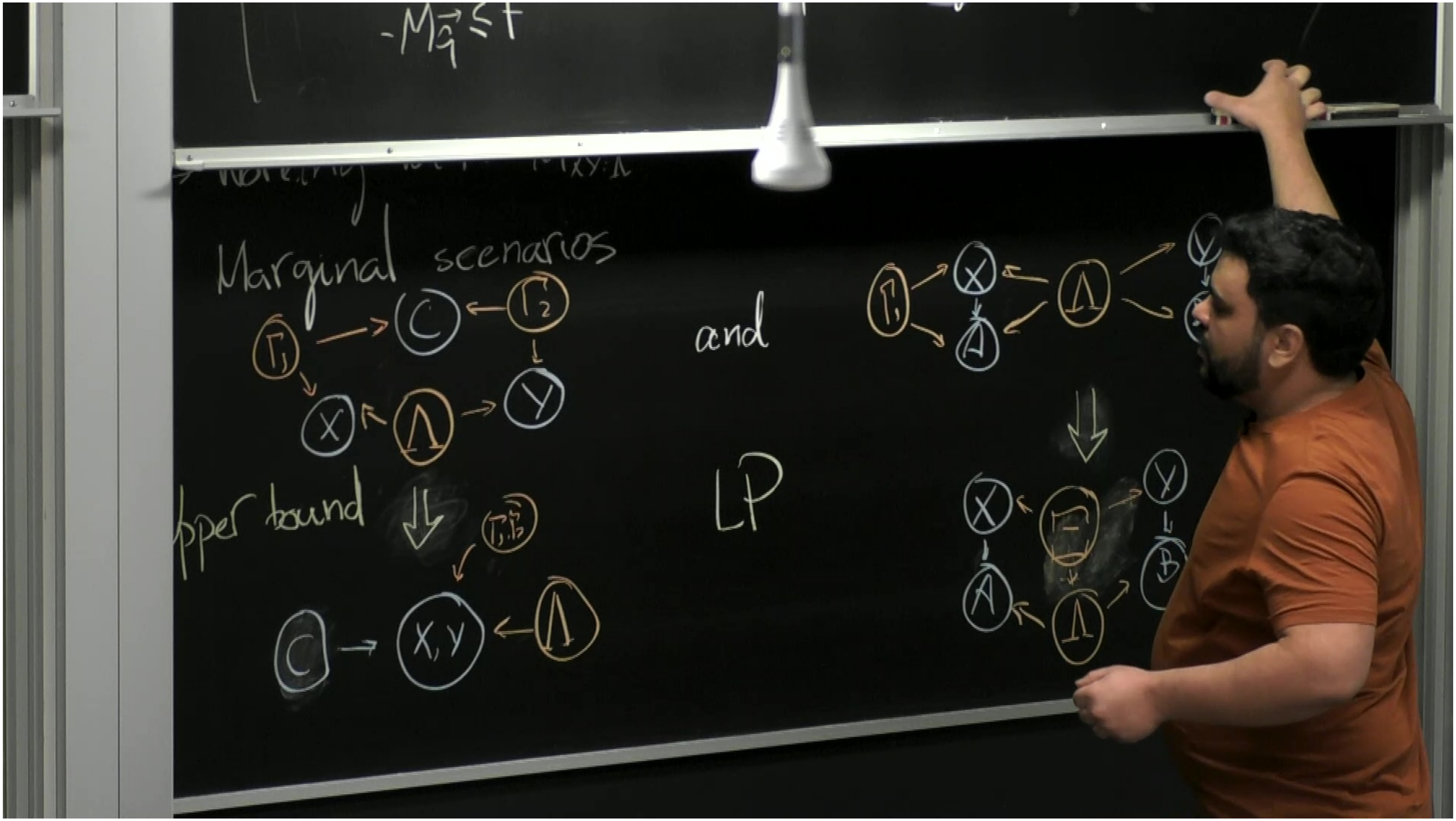
- Pinsker

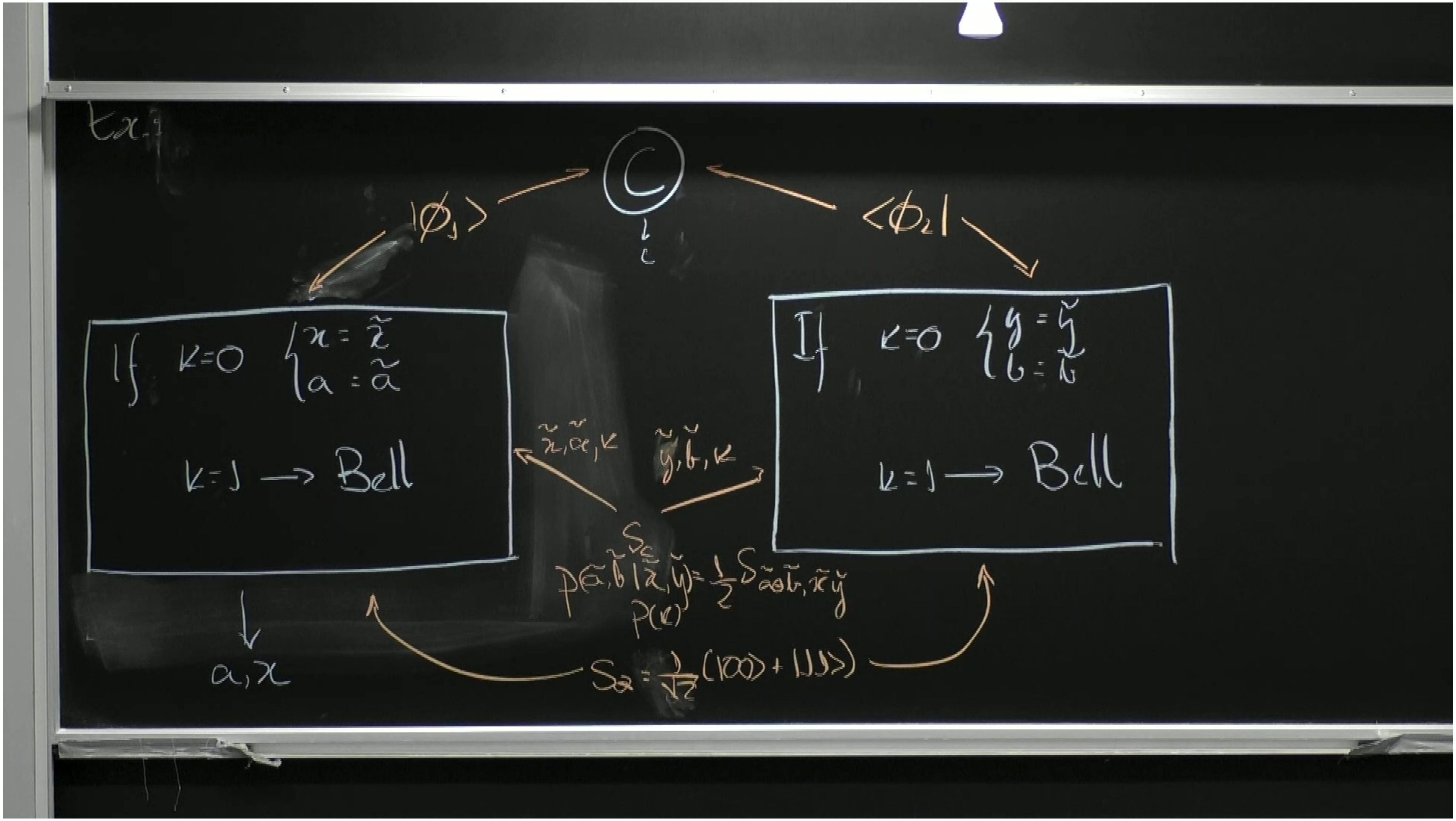
$$\frac{I(X,Y:\Lambda)}{\log_2 e} \geq \left(\min_{p(x)} \left[M_{XY\Lambda} \right] \right)^2$$

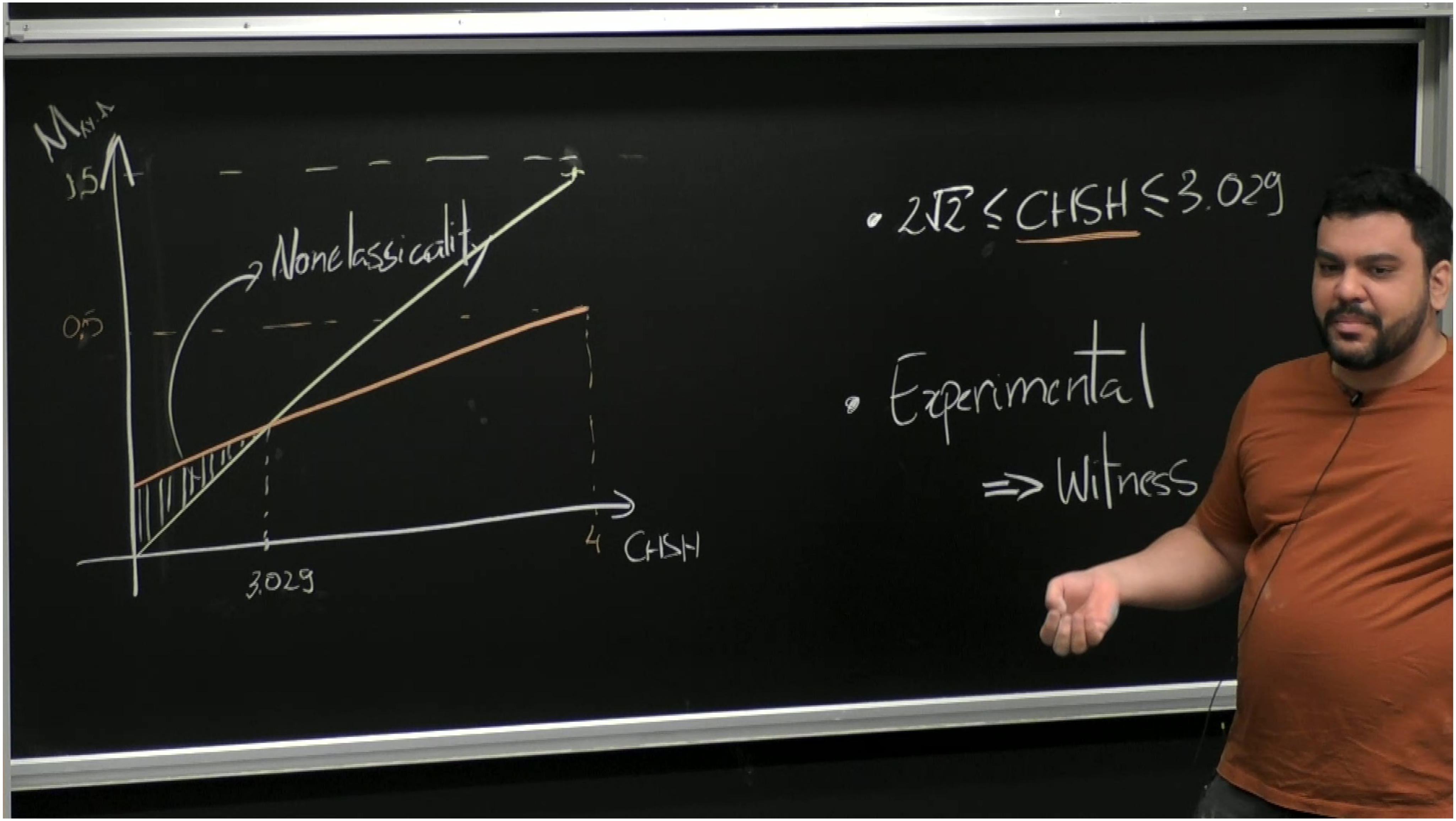

Λ → |Ψ⟩
Fritz
Γ1
C
Γ2
Ã
B
Λ
X
Y
A
CL(Λ)

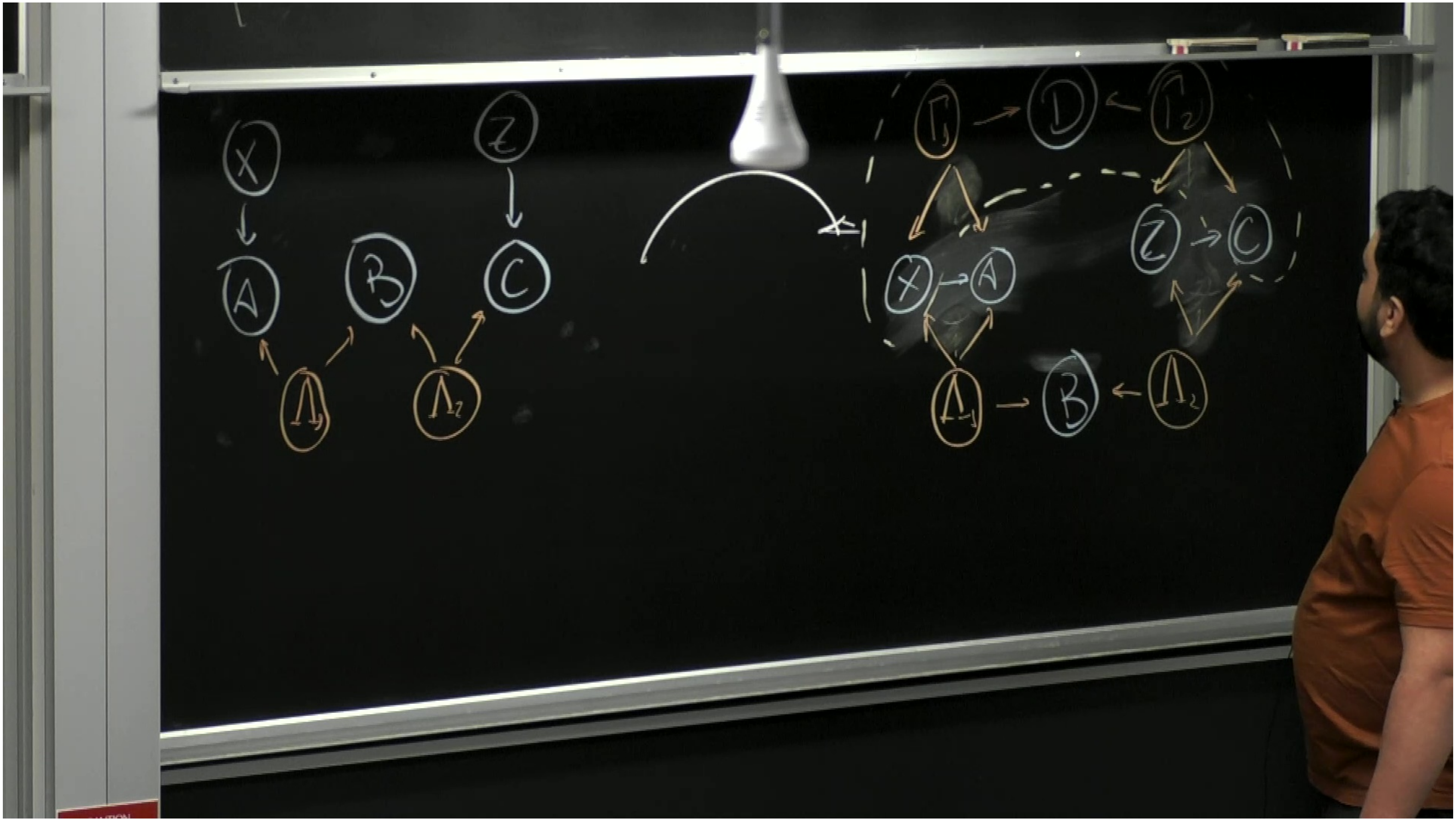

MD LP
Robust?
2021. Chaves et al
Entropic
Analytic
Q.E
Inflatio
I(X,Y:Λ) ≤ f(H)
* Pratical applications
* Insights


→ Working with $M_{XY:\Lambda}$
Marginal scenarios
Γ_1
C
Γ_2
X
Λ
Y
C
X, Y
Λ
and
Γ_1
X
A
Λ
Y
B
Γ_2
X
Y
A
B
Λ


Marginal scenarios
and
LP
pper bound


Ex.
C
|φ1⟩
⟨φ2|
If k=0 {x = x̃, a = ã
k=1 → Bell
If k=0 {y = ỹ, b = b̃
k=1 → Bell
x̃, ã, k
ỹ, b̃, k
S_c
p(ã, b̃ | x̃, ỹ) = 1/2 δ_{ã⊕b̃, x̃ỹ}
p(k)
a, x
S_a = 1/√2 (|00⟩ + |11⟩)


$M_{xy,\Lambda}$
1.5
0.5
Nonclassicality
3.029
4
CHSH
• $2\sqrt{2} \leq$ CHSH ≤ 3.029
• Experimental
$\Rightarrow$ Witness


X
Z
A
B
C
Λ_1
Λ_2
Γ_1
D
Γ_2