Title: Quantum Information Lecture

Speakers: Eduardo Martin-Martinez

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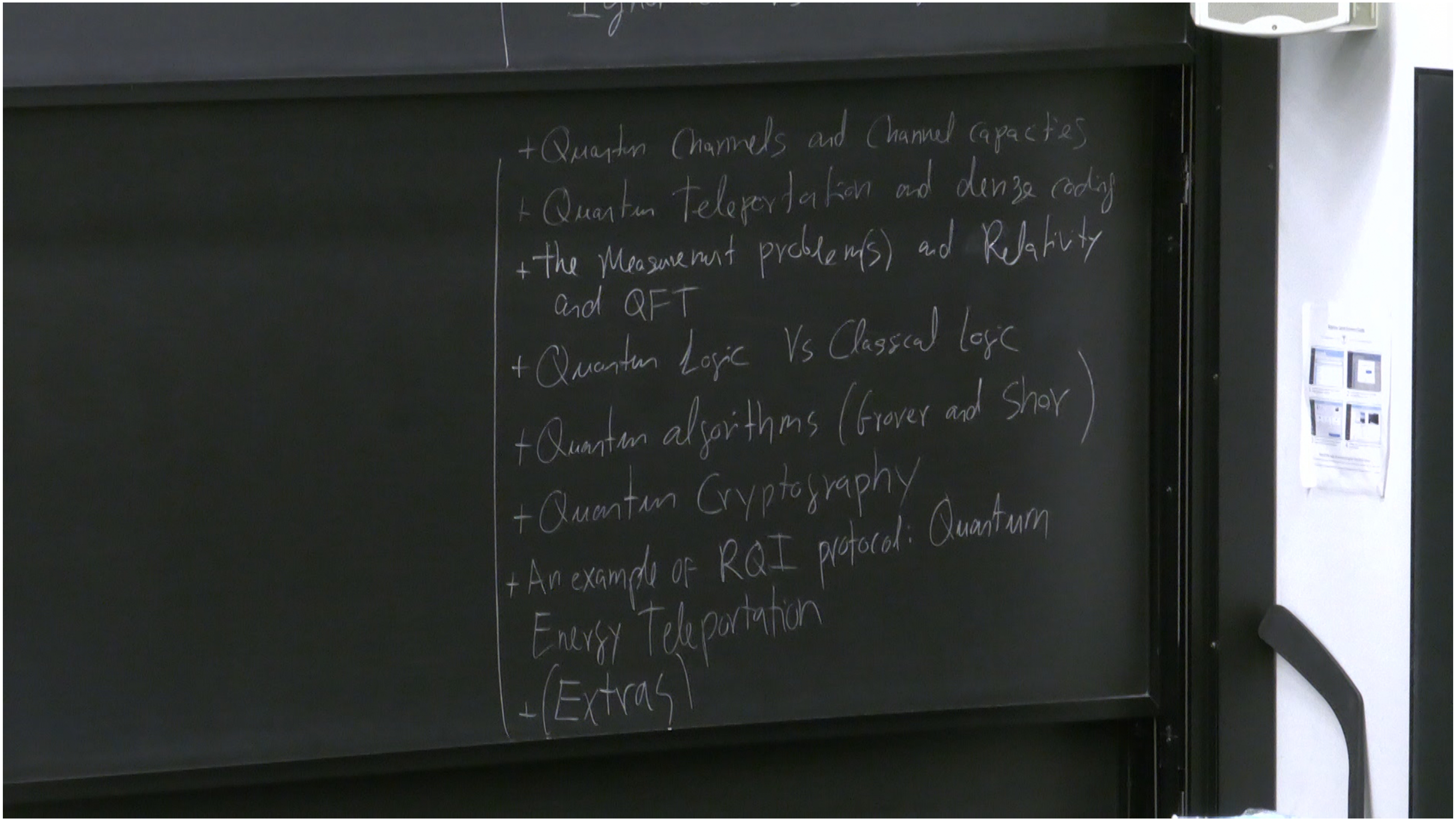
+ Classical Information Intro
+ Review of QM with an Info perspective
+ Shanon and Von Neumann Entropies Vs thermodynamic entropy
+ Multipartite quantum systems
+ Entanglement Vs Classical correlations
+ EPR argument and Violations of local realism
+ Peres criterion and Entanglement measures
+ Mutual Information and Quantum Discord
+ Measurements in QM and Quantum information
+ The church of the Larger Hilbert space

Ignorance Vs Entanglement

+ Quantum Channels and Channel capacities


+ Quantum Channels and Channel capacities
+ Quantum Teleportation and dense coding
+ the Measurement problem(s) and Relativity and QFT
+ Quantum Logic Vs Classical logic
+ Quantum algorithms (Grover and Shor)
+ Quantum Cryptography
+ An example of RQI protocol: Quantum Energy Teleportation
+ (Extras)

Consider a Probability distribution $P(X)$ for a random variabl

$(P_i = P(x_i))$ Shannon Measure of Ignorance: $H(X) = \langle$

What is $S_u(\mathcal{X}) \equiv S_u(P(\mathcal{X}))$? $\mathcal{X}$ sets of outcom

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1. $S_u(\mathcal{X}) = S_u(P(\mathcal{X}))$ is mononotonically decreasing with P. the larger the
2. $S_u(\mathcal{X}) \geq 0$ (the amount of info learned from an experiment is either zero or p
3. $S_u(\mathcal{X}) = 0 \iff P(\mathcal{X}) = 1$ if you already knew, you are not surprised!
4. $S_u(\mathcal{X} = \{x_1, x_2\}) = S_u(P_1 P_2) = S_u(P_1) + S_u(P_2)$

From 4: $S_u(P_1 P_2) = S_u(P_1) + S_u(P_2) \xrightarrow{\partial_{P_1}} P_2\, S_u'(P_1 P_2) = S_u'(P_1)$

$\rightarrow S_u'(\underbrace{P_1 P_2}_{P}) + \underbrace{P_2 P_1}_{P}\, S_u''(\underbrace{P_1 P_2}_{P}) = 0 \longrightarrow S_u'(p) + p\, S_u''(p) = 0$

$\Rightarrow \left(p\, S_u'(p)\right)' = 0 \Rightarrow p\, S_u'(p) = k \Rightarrow S_u'(p) = \frac{k}{p} \Rightarrow S_u(p) = k \log$

From 3: $C = 0$, From 2: $k < 0$ (since $\log(p) \leq 0$)

$\boxed{S_u(p) = -\log_a p}$ We pick $S_u(x) = -\log_2(P(x))$

) for a random variable X that can take n values $x_1, \dots, x_n$ with

nce: $H(X) = \langle S_u(X) \rangle = \sum_i P(x_i) S_u(x_i) = \sum_i P_i$

$\mathcal{X}$ sets of outcomes of evaluating the random variable / Entro

g with P_i the larger the probability the less surprised you will be! (the larger p th

periment is either zero or positive)

you are not surprised!

5. $S_u(\mathcal{X}) = S_u(P(\mathcal{X}))$ should be a smooth an

$$H(X) = -\sum_i P_i \log_2(P_i)$$

t can take n values $x_1, \dots, x_n$ with probabilities $P_1, \dots, P_n$

$$\rangle = \sum_i P(x_i)\, S_u(x_i) = \sum_i P_i\, S_u(x_i) \qquad \sum P_i = 1$$

aluating the random variable

Entropy Axioms

the less surprised you will be! (the larger p the less information you learned)

$\dots S_u(x) = S_u(P(x))$ should be a smooth enough function of P

$P_i \,\mathrm{Log}_2(P_i)$

Shannon Entropy

From 4: $S_u(P_1 P_2) = S_u(P_1) + S_u(P_2) \xrightarrow{\partial_{P_1}} P_2 S_u'(P_1 P$

$\rightarrow S_u'(\underbrace{P_1 P_2}_{p}) + \underbrace{P_2 P_1}_{p} S_u''(\underbrace{P_1 P_2}_{p}) = 0 \longrightarrow S_u'(p) + p S$

$\Rightarrow (p S_u'(p))' = 0 \Rightarrow p S_u'(p) = \kappa \Rightarrow S_u'(p) = \frac{\kappa}{p} \Rightarrow S$

From 3: $C = 0$, From 2: $\kappa < 0$ (since $\log(p) \leq 0$)

$\boxed{S_u(p) = -\log_a p}$ $\underbrace{\text{We pick } S_u(x) = -\log_2(P(x))}$

$\hat{H} = \frac{\hat{p}^2}{2m} + m\omega \hat{x}^2$ $\hat{H} = \frac{\hat{p}^2}{2m} + m\omega \hat{x}^2 +$

$$\ldots P_1 P_2) + \underbrace{P_2 P_1}_{p} S_u''(\underbrace{P_1 P_2}_{p}) = 0 \longrightarrow S_u'(p) + p\, S_u''(p) = 0 \Rightarrow$$

$$\ldots))' = 0 \Rightarrow p\, S_u'(p) = \kappa \Rightarrow S_u'(p) = \frac{\kappa}{p} \Rightarrow S_u(p) = \kappa \log p$$

From 2 : $\kappa < 0$ $\left(\text{since } \log(p) \leq 0\right)$

$$\rho = \frac{1}{2}\left(|01\rangle \ldots\right.$$

$\log_a p$

$\underbrace{\text{We pick } S_u(x) = -\log_2(p(x))}$

$$|\psi\rangle = \frac{1}{\sqrt{2}}\left(|0 \ldots\right.$$

$$\hat{H} = \frac{\hat{p}^2}{2m} + m\omega \hat{x}^2 + i\underbrace{[\hat{x}, \hat{p}]}_{i\hbar \mathbb{1}} \cosh\left(\hat{x}^5 \hat{p}^7\right)$$

$$\frac{\hat{p}^2}{2m} + m\omega \hat{x}^2$$

$P(x_i)\, S_u(x_i) = \sum_i P_i\, S_u(x_i)$ $\sum P_i = 1$

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ised you will be!

Entropy Axioms

(the larger p the less information you learned)

$S_u(P(x))$ should be a smooth enough function of P

$H = \hat{P}^{1/2} \hat{X} \hat{P}^{1/2}$

Shannon Entropy

$H = XP$

$\hat{H} = \frac{1}{2}(\hat{X}\hat{P} + \hat{P}\hat{X})$