Title: Condensed Matter Review-15

Date: Feb 13, 2015 09:00 AM

URL: http://pirsa.org/15020012

Abstract:

$$\psi \in \mathcal{H}_R \subset \mathcal{H} = \mathcal{H}_A \otimes \mathcal{H}_B$$

$\uparrow$ Haar measure $\qquad d_B \gg d_A$

$\Downarrow$

almost always ψ_A has the max. possible entropy

$\downarrow$ energy constraint $\underline{\mathrm{Tr}[H\psi] = E} = \mathrm{Tr}[H e^{-\beta H}/Z]$

$$\psi_A = \frac{e^{-\beta H_A}}{Z}$$

$$|\psi\rangle = |\psi_A\rangle \otimes |\psi_B\rangle \qquad t = 0$$

$$H \rightarrow \psi(t) = e^{-iHt}(\psi_A \otimes \psi_B)$$

$$H \longrightarrow U^{\dagger} H U$$

$$\lim_{t \to \infty} \left[\left\| \psi_A(t) - \frac{e^{-\beta H_A}}{Z_A} \right\| \right]$$ is very small

$$|\psi\rangle = |\psi_A\rangle \otimes |\psi_B\rangle \qquad t = 0$$

$$H \to \psi(t) = e^{-iHt}(\psi_A \otimes \psi_B) \qquad H \to U^\dagger H U$$

$$\lim_{t\to\infty}\left[\|\psi_A(t) - e^{-\beta H_A}/Z_A\|\right] \text{ is very small}$$

$$H(t) = \sum_x H_x(t)$$

$$U(0,\tau) = \mathcal{T}\exp\left[-i\int_0^\tau H(s)\,ds\right]$$

$$|\psi\rangle = |\psi_A\rangle \otimes |\psi_B\rangle \qquad t = 0$$

$$H \to \psi(t) = e^{-iHt}(\psi_A \otimes \psi_B) \qquad H \to U^\dagger H U$$

$$\lim_{t\to\infty} \left[\left\| \psi_A(t) - \frac{e^{-\beta H_A}}{Z_A} \right\| \right]$$ is very small

$$H(t) = \sum_x H_x(t)$$

$$U(0,\tau) = \mathcal{T} \exp\left[-i\int_0^\tau H(s)\,ds\right] \approx \prod_{j=1}^{n} \prod_x \exp\left[-i H_x(j\Delta t)\Delta t\right]$$

$$n\Delta t = \tau$$

ETH Hypothesis

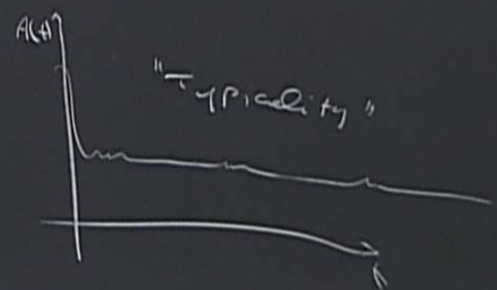
$$H \rightarrow |E\rangle \text{ eigenstates}$$

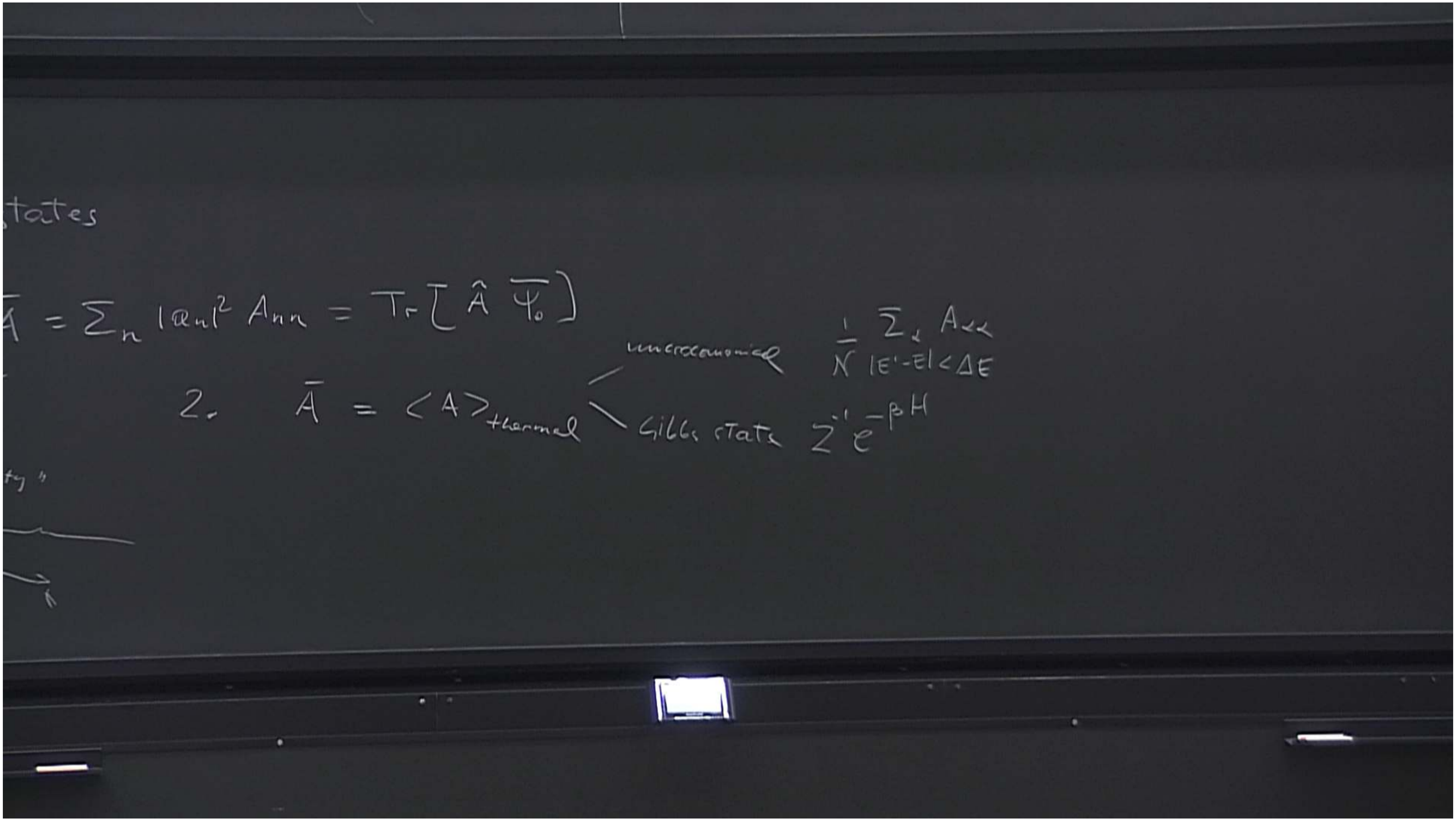
$$\langle A(t)\rangle \xrightarrow[\text{dephasing}]{t \text{ long}} \bar{A} = \sum_n |a_n|^2 A_{nn} = \mathrm{Tr}\left[\hat{A}\,\overline{\Psi_0}\right]$$

few-bodies

$$|\psi_0\rangle = \sum_n a_n |E_n\rangle$$

$$\begin{pmatrix} |a_1|^2 & & \\ & \ddots & \\ & & |a_N|^2 \end{pmatrix}$$

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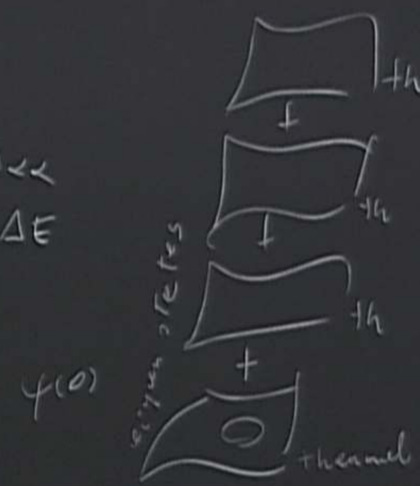
$\bar{A} = \sum_n |a_n|^2 A_{nn} = \mathrm{Tr}[\hat{A}\ \bar{\Psi}_0]$
microcanonical
$\frac{1}{N} \sum_{\alpha,\ |E'-E|<\Delta E} A_{\alpha\alpha}$
2. $\bar{A} = \langle A \rangle_{thermal}$
Gibbs state $Z^{-1} e^{-\beta H}$
ty "

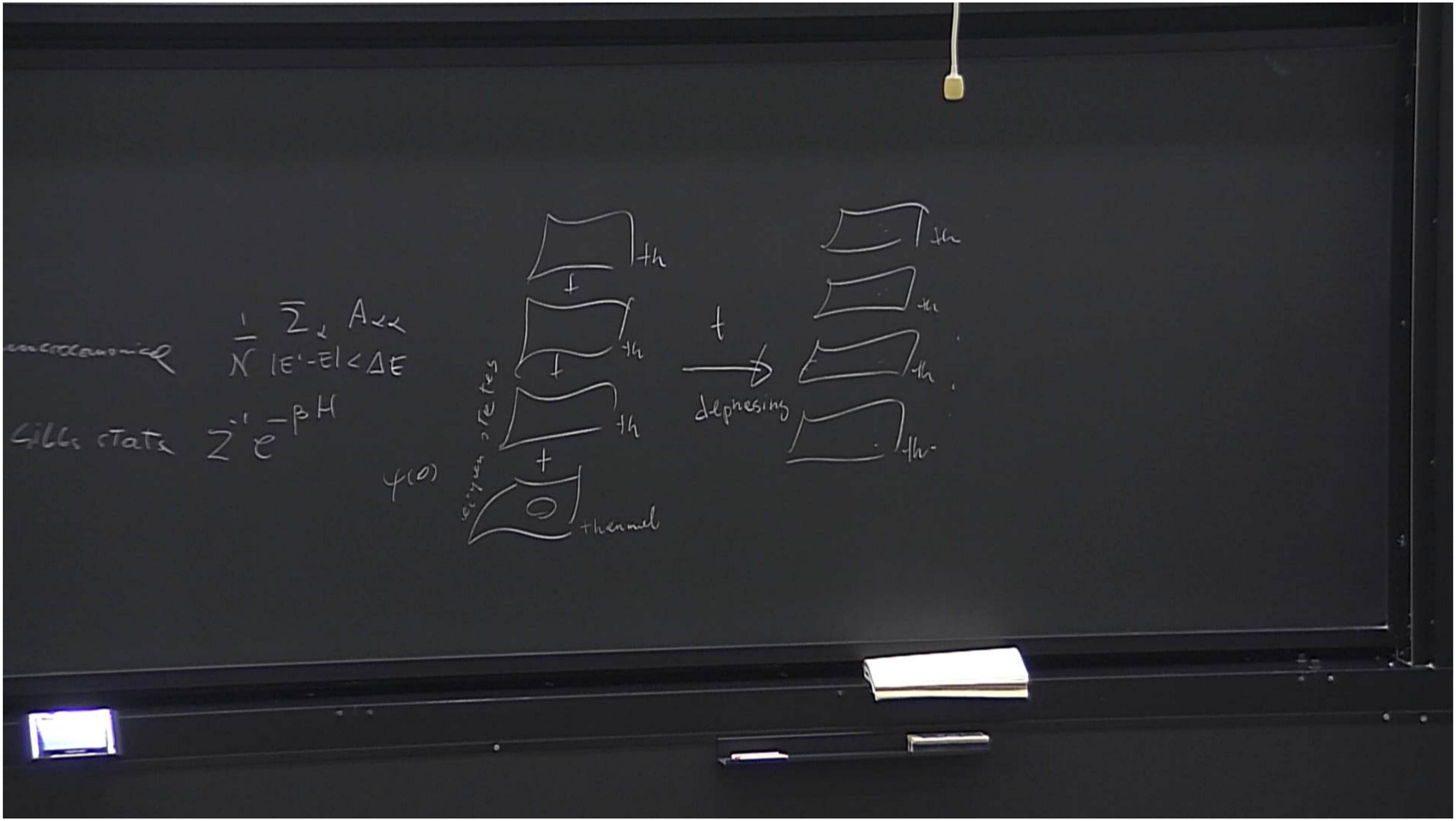
$c_n|^2 A_{nn} = \mathrm{Tr}[\hat{A}\ \overline{\Psi_0}]$

2. $\bar{A} = \langle A \rangle_{thermal}$

microcanonical $\frac{1}{N} \sum_{\alpha,\ |E'-E|<\Delta E} A_{\alpha\alpha}$

Gibbs state $Z^{-1} e^{-\beta H}$




microcanonical
1/N Σ_{|E'-E|<ΔE} A_{αα}
Gibbs state Z^{-1} e^{-βH}
ψ(0)
eigenstates
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thermal
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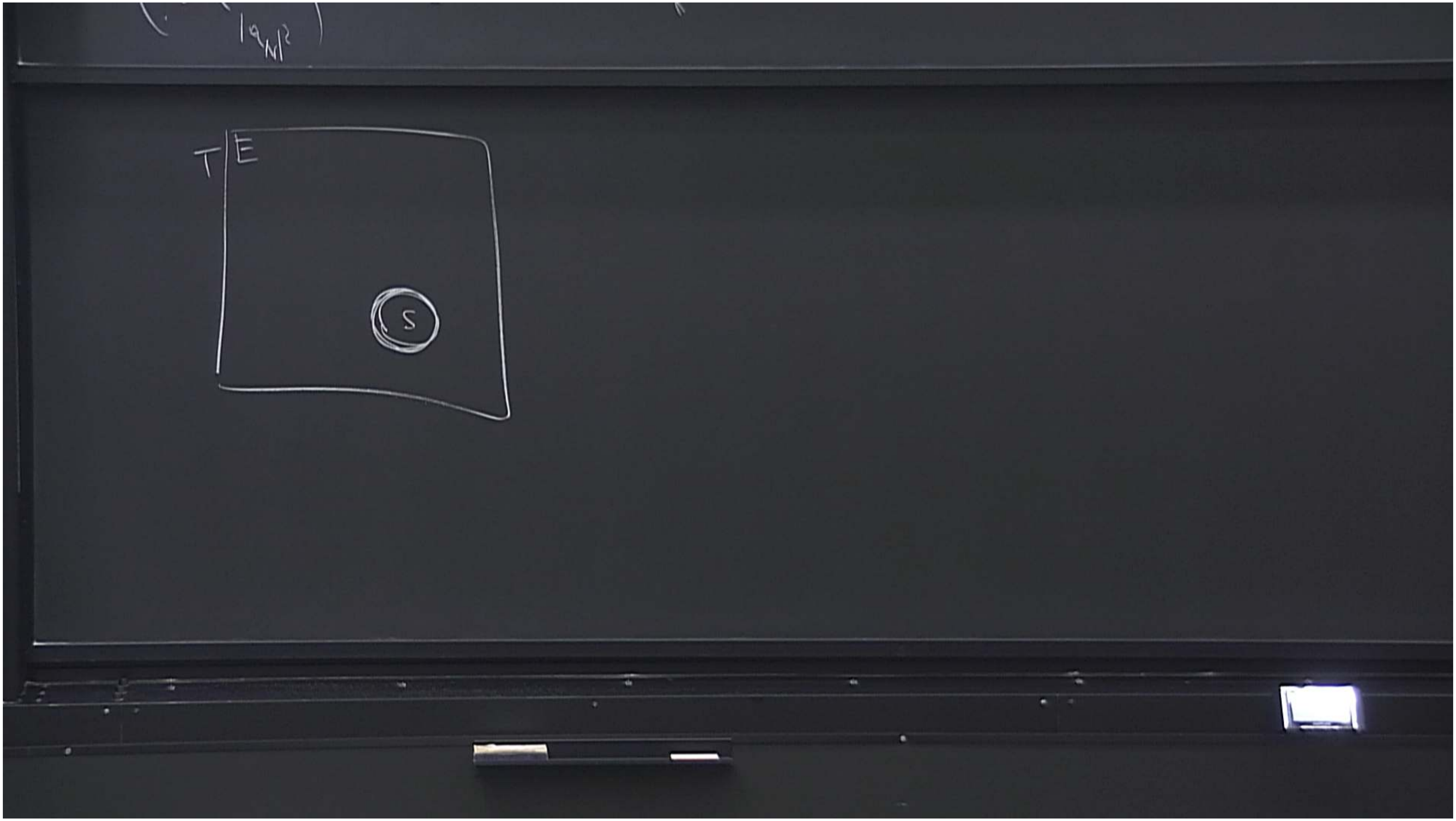
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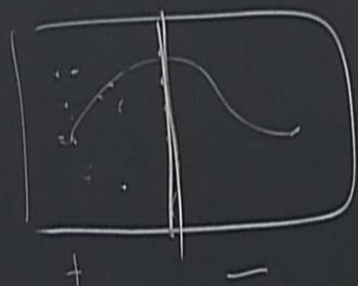
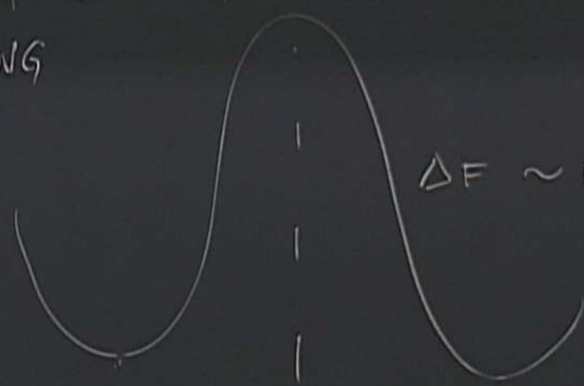
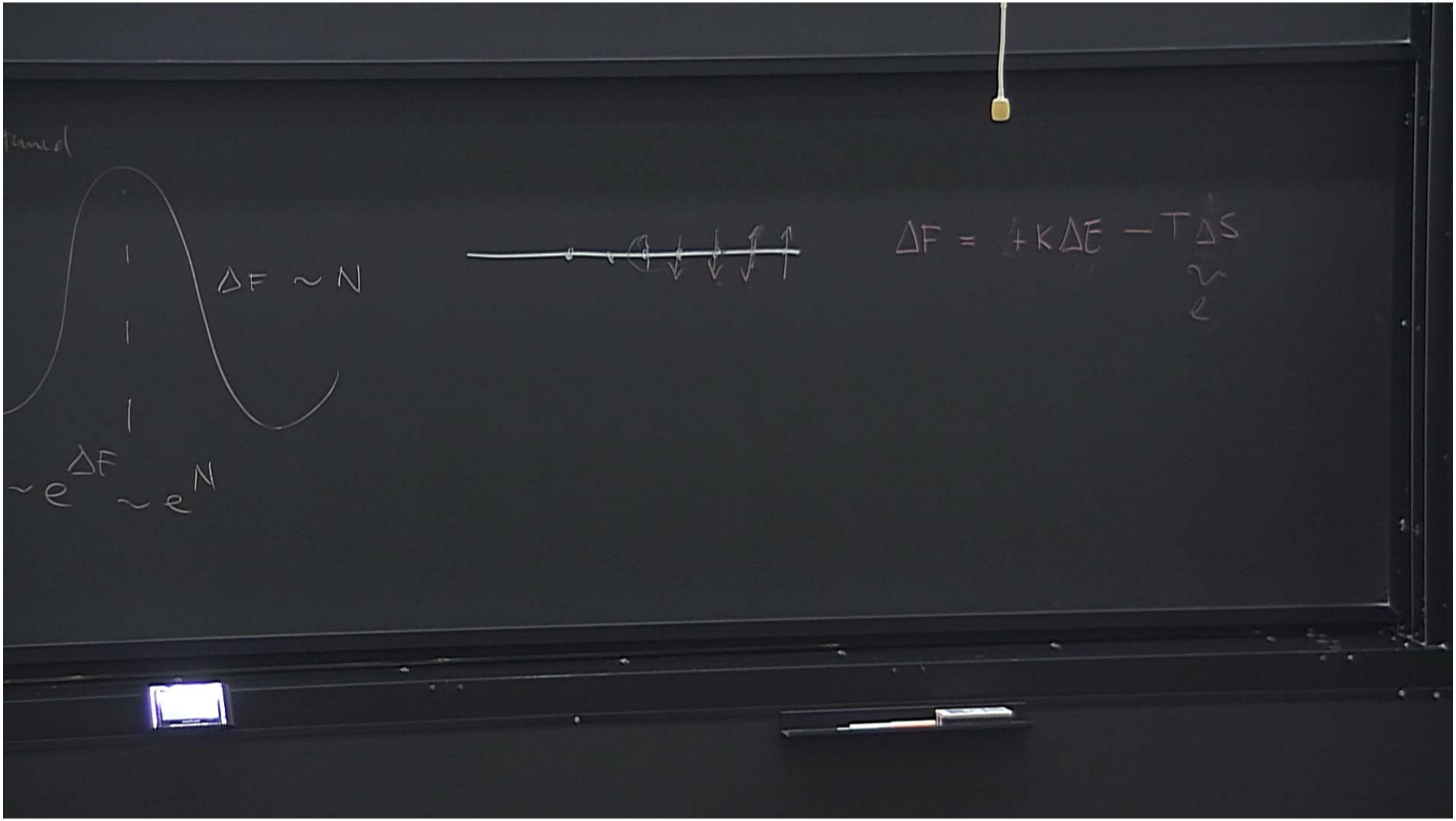
1. Integrable Systems fine-tuned
2. SYMMETRY BREAKING

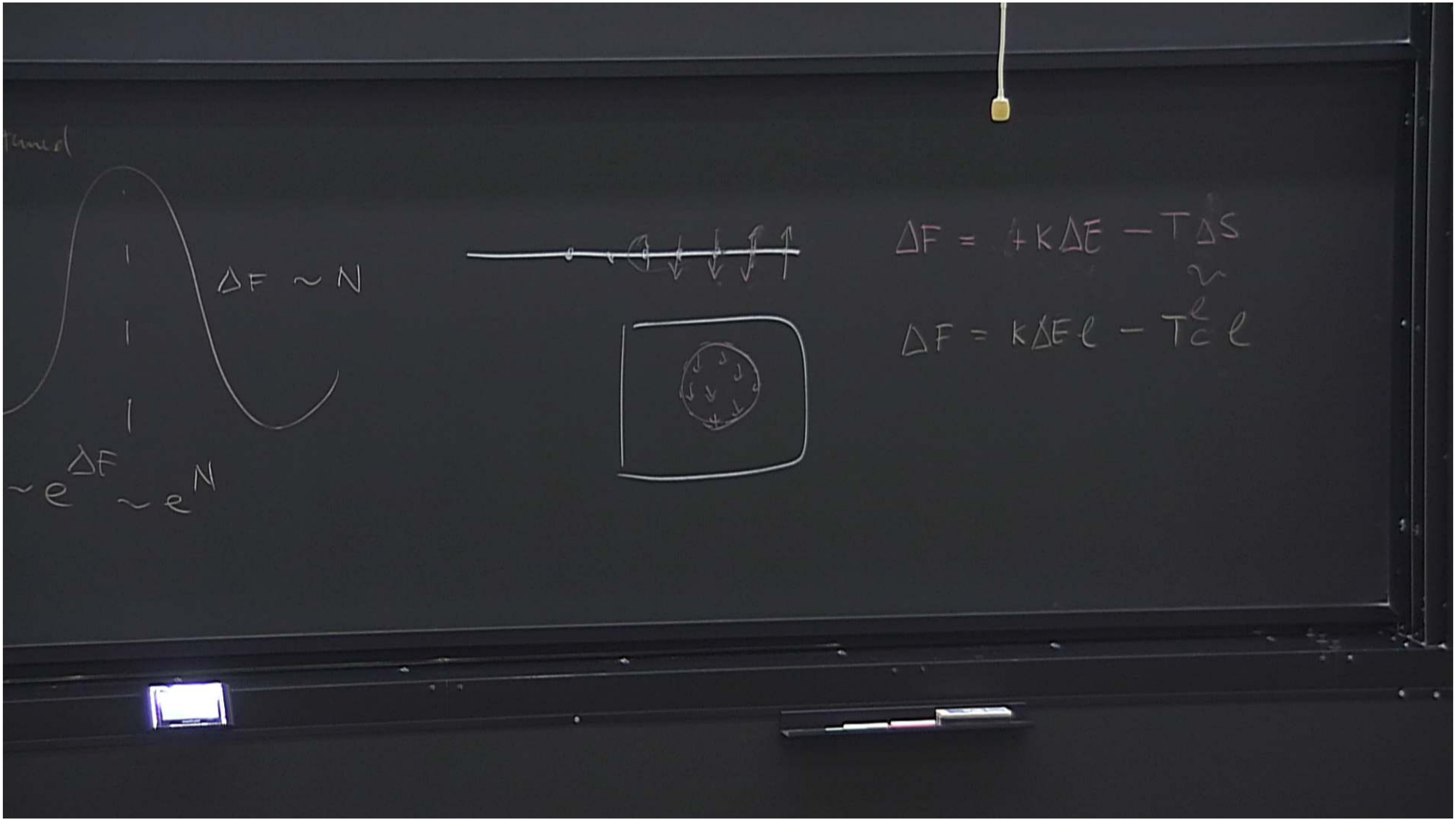


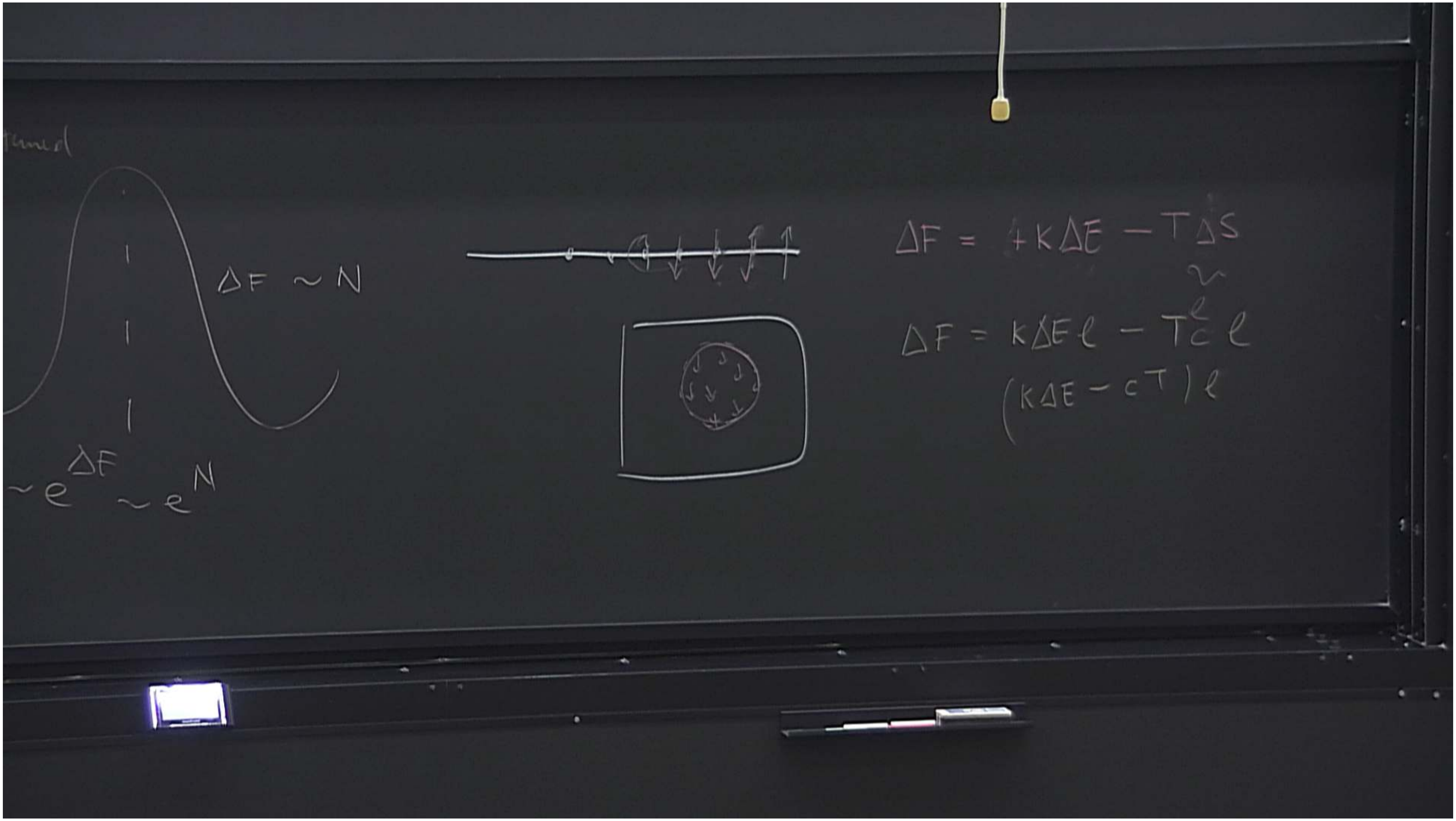


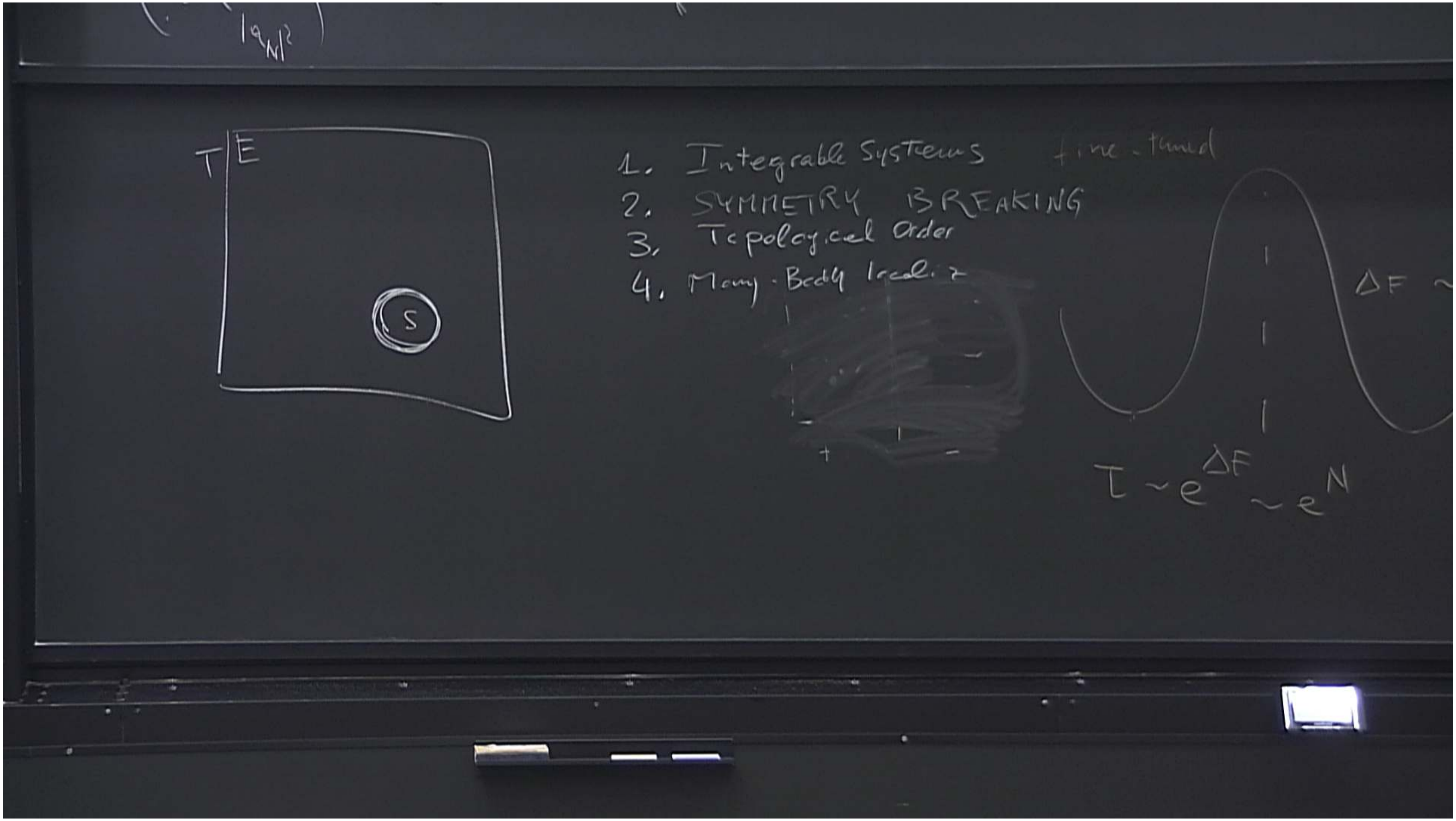
$\Delta F \sim N$

$\tau \sim e^{\Delta F} \sim e^{N}$


ΔF ~ N
~ e^ΔF ~ e^N
ΔF = +KΔE − TΔS


$\Delta F \sim N$
$\sim e^{\Delta F} \sim e^{N}$
$\Delta F = +K\Delta E - T\Delta S$
$\Delta F = K\Delta E \ell - T_c^{\ell} \ell$


$\Delta F \sim N$
$\sim e^{\Delta F} \sim e^{N}$
$\Delta F = +K\Delta E - T\Delta S$
$\Delta F = K\Delta E\,\ell - T c\,\ell$
$(K\Delta E - cT)\,\ell$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1. Integrable Systems fine-tuned
2. SYMMETRY BREAKING
3. Topological Order
4. Many-Body Localiz
ΔF ~
τ ~ e^ΔF ~ e^N