Title: Quantum Matter Lecture (230419)

Speakers: Ganapathy Baskaran

Collection: Quantum Matter (2022/2023)

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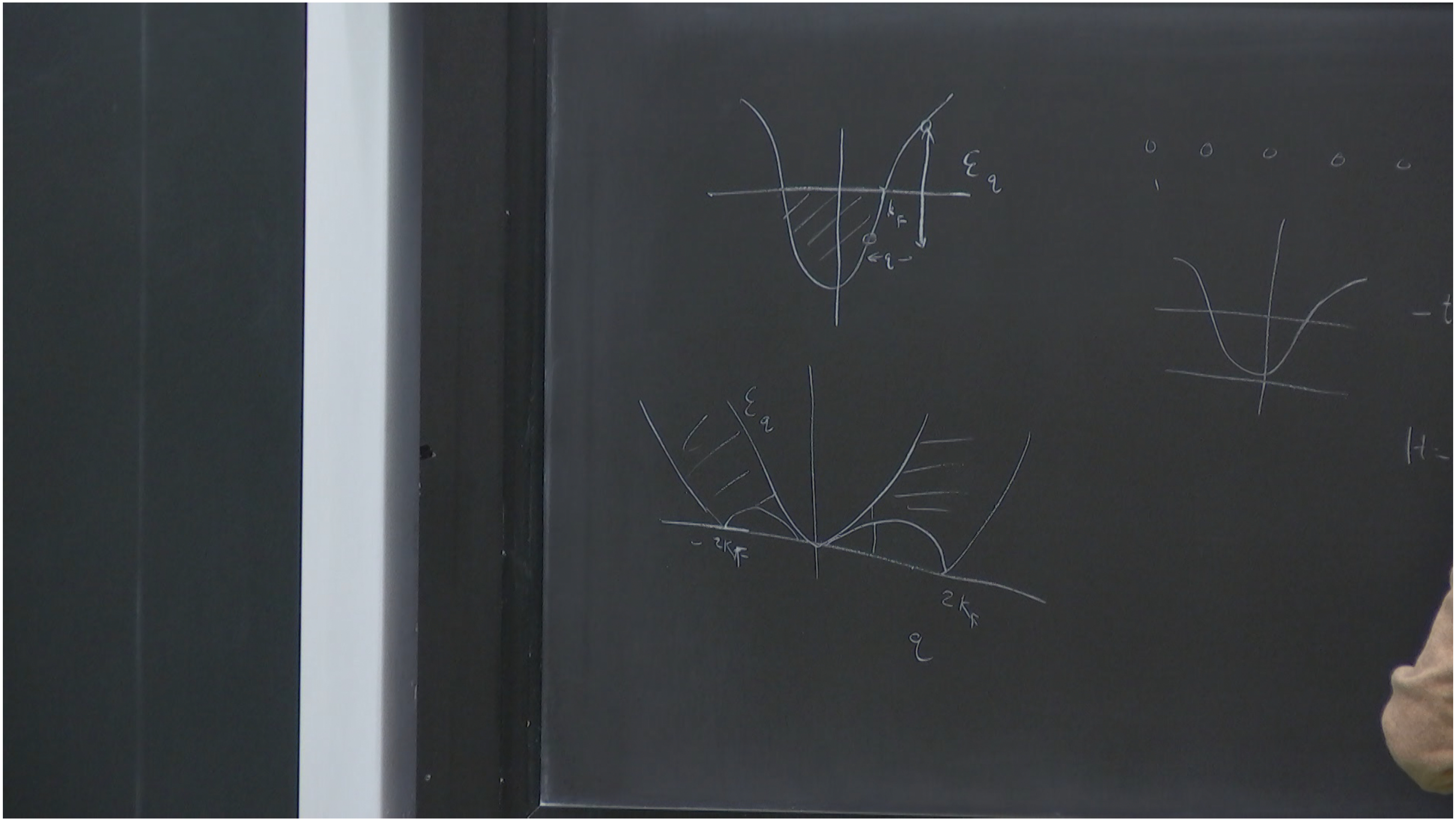
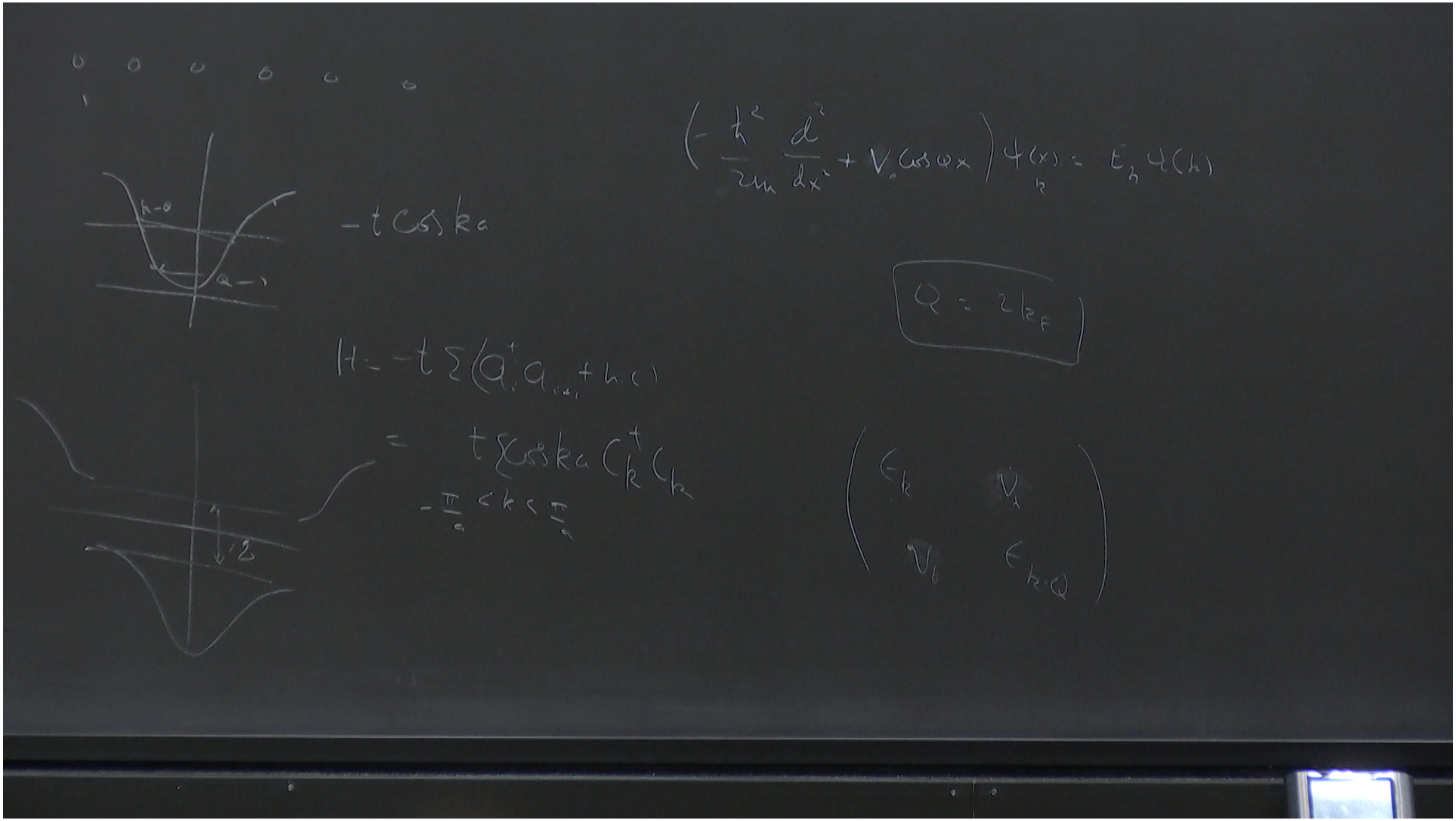

ε_q
k_F
q
ε_q
-2k_F
2k_F
q
-t
H=


$-t\cos ka$
$H = -t\sum(a_i^\dagger a_{i+1} + h.c.)$
$= t\sum \cos ka\, c_k^\dagger c_k$
$-\frac{\pi}{a} < k < \frac{\pi}{a}$
$\left(-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V_0\cos Qx\right)\psi_k(x) = E_k\psi(x)$
$Q = 2k_F$
$\begin{pmatrix} \epsilon_k & V_1 \\ V_1 & \epsilon_{k-Q} \end{pmatrix}$

$$\lambda = \frac{2\pi}{Q} \quad \Big| \quad \frac{2\pi}{2k_F}$$

$$\left(-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V_0 \cos Qx\right)\psi_k(x) = \epsilon_k \psi(x)$$

$-t \cos ka$

$\langle k | V(x) | k+Q \rangle = V_0$

$$H = -t_0 \sum_i \left(a_i^\dagger a_{i+1} + h.c.\right) + \sum_i \left(\frac{P_i^2}{2M} + \frac{1}{2}k\left(u_i - u_{i+1}\right)^2\right)$$

$= t \sum \cos ka \, c_k^\dagger c_k$

$-\frac{\pi}{a} < k < \frac{\pi}{a}$

$$+ -\left(t_0 + \alpha\left(u_i - u_{i+1}\right)\right) a_i^\dagger a_{i+1}$$

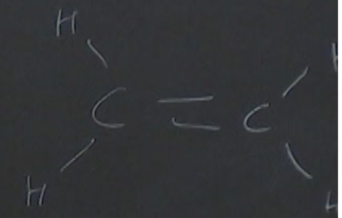
$E(k) = \frac{\epsilon_k + \epsilon_{k+Q}}{2} \pm \sqrt{(}$

$V_0 \left(a_k^\dagger a_{k+Q}\right.$

$V_q \sum a_k^\dagger a_{k+q} \left(b_q + b_q^\dagger\right)$

$$\Delta E = -V_0^2 \ln\left(\frac{\epsilon_F}{V_0}\right) + K V_0^2$$

$$\int_{-V_0}^{V_0} \left(E(k) - \epsilon(k)\right) dk \sim \boxed{V_0^2\, \rho(\epsilon_F) \ln\left(\frac{\epsilon_F}{V_0}\right)}$$



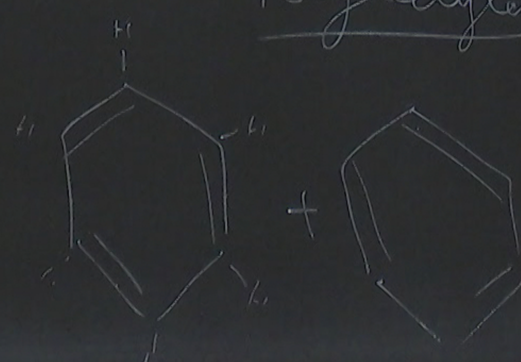
CH_4

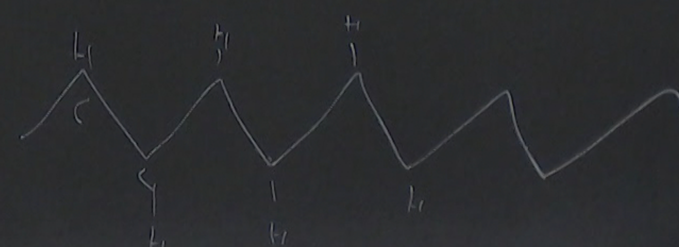
V_0

$(CH)_6$

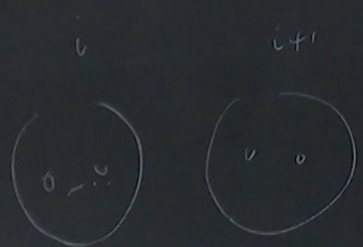
Polyacetylene $(CH)_n$

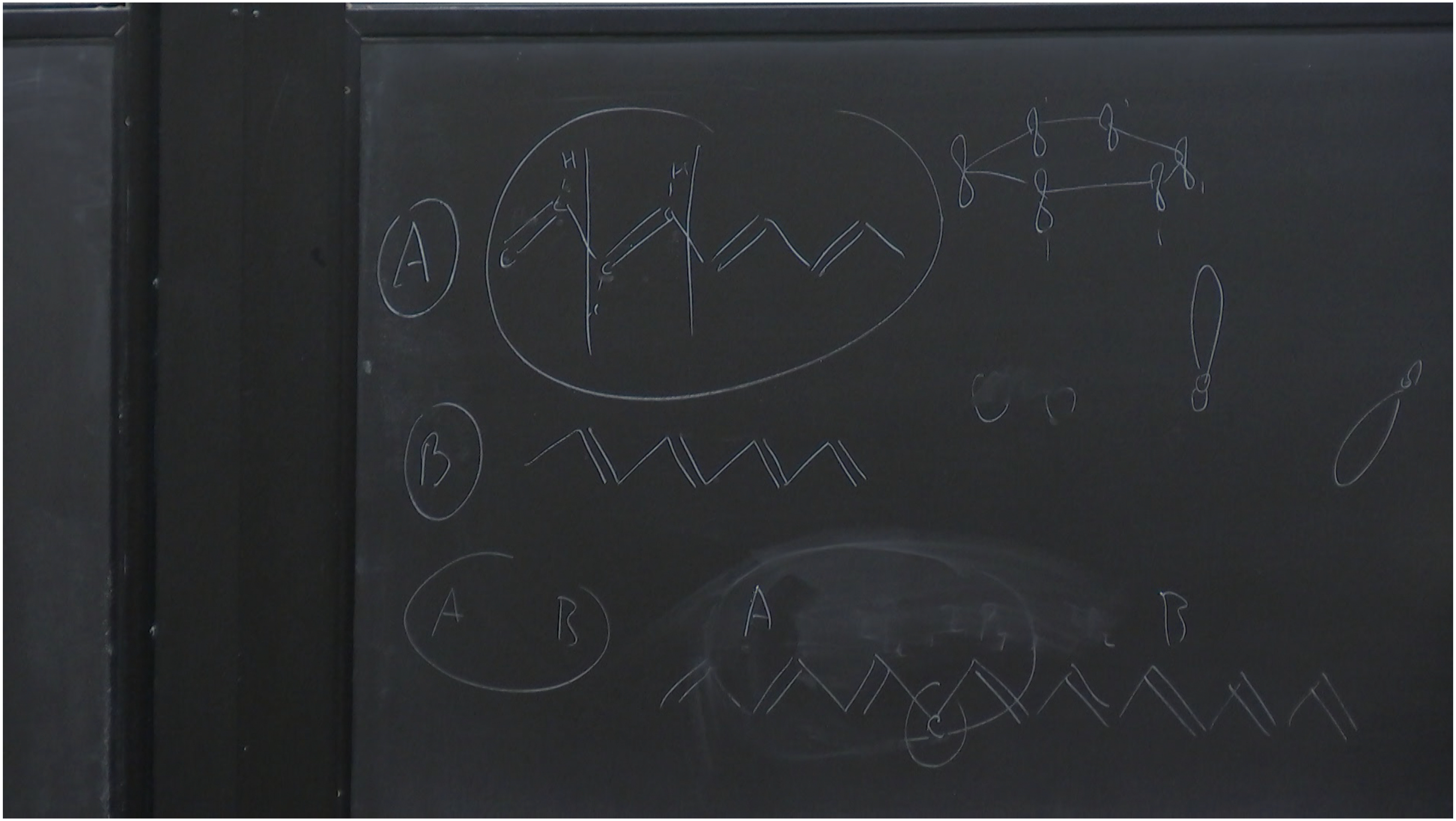
$$\pm \sqrt{\left(\frac{\epsilon_k - \epsilon_{k+\phi}}{2}\right)^2 + \Delta^2}$$



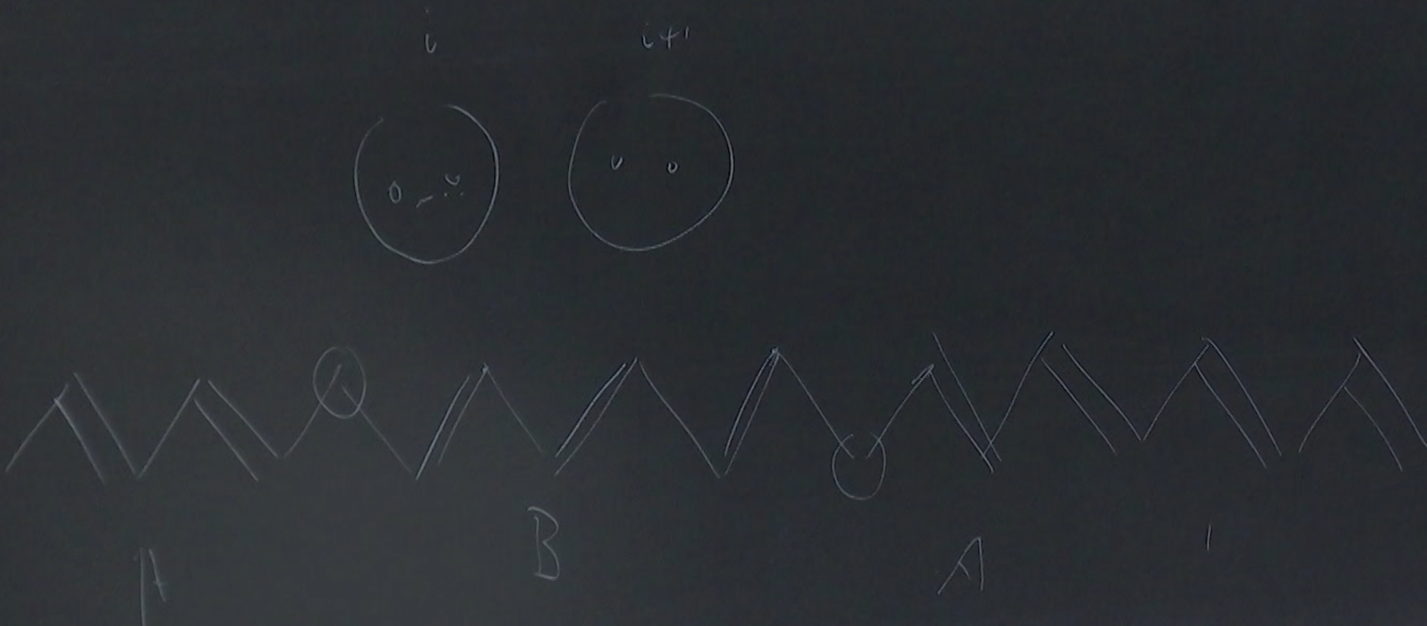


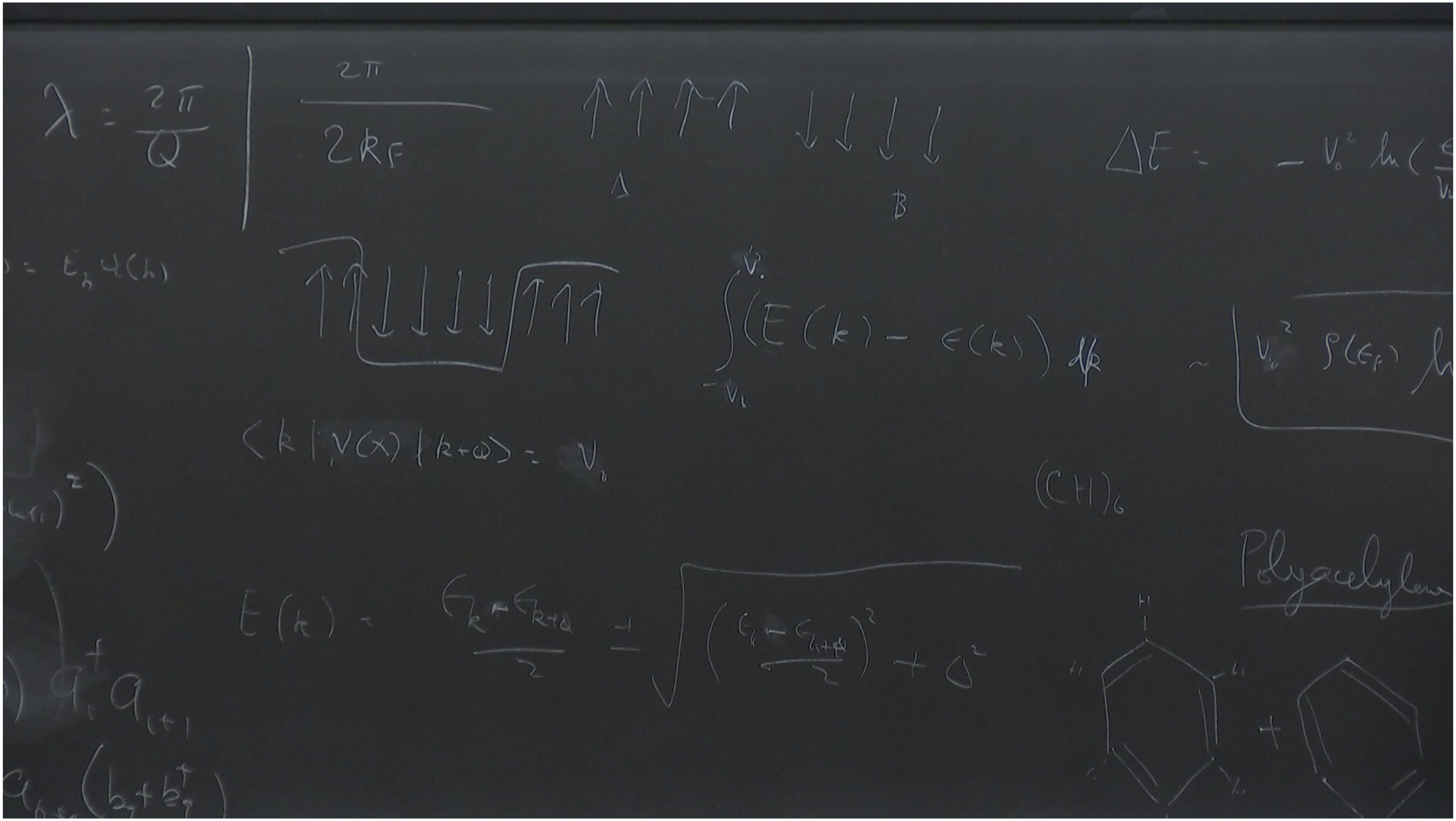
$$H = \sum_i w(a_i^\dagger b_{i+1} + h.c.) + v(a_{i+1}^\dagger b_i + h)$$




A
H
H
B
A
B
A
B
C

$$H = \sum w\,(a_i^\dagger b_{i+1} + h.c.) + v\,(a_{i+1}^\dagger b_i + h)$$




$\lambda = \frac{2\pi}{Q}$
$\frac{2\pi}{2k_F}$
A
B
$\Delta E = -V_0^2 \ln($
$\int_{-V_0}^{V_0} (E(k) - \epsilon(k))\, dk$
$\langle k | V(x) | k+Q \rangle = V_0$
$(CH)_6$
Polyacetylene

$$\Delta E = -V_0^2 \ln\left(\frac{\epsilon_F}{V_0}\right) + K V_0^2$$

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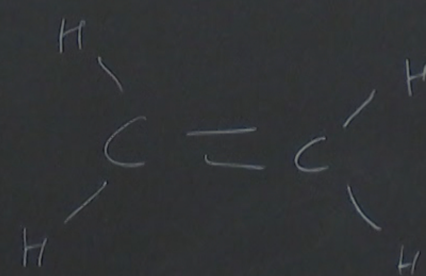
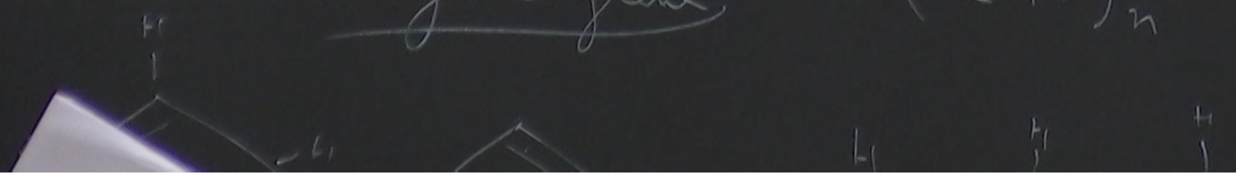
$$) \, dk \sim \boxed{V_0^2 \, \rho(\epsilon_F) \ln\left(\frac{\epsilon_F}{V_0}\right)}$$

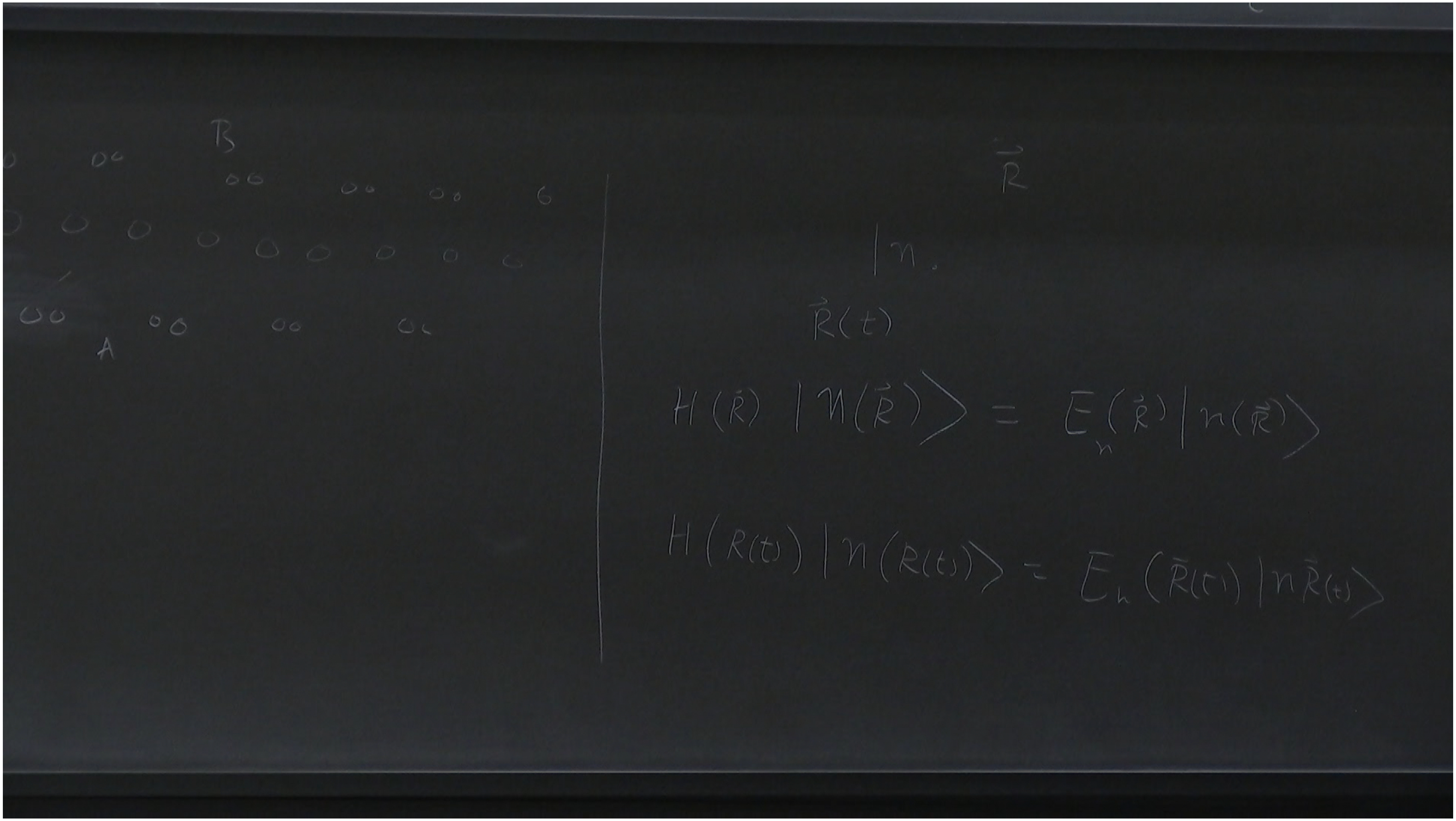


CH_4

$(CH)_6$

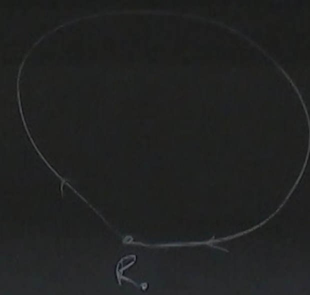
Polyacetylene $(CH)_n$



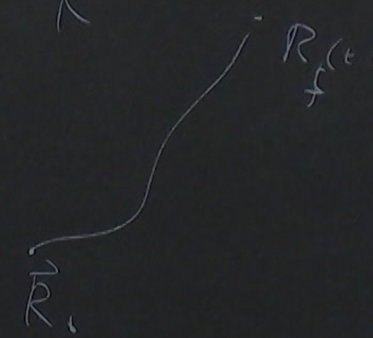

B
A
$\vec{R}$
$|n.$
$\vec{R}(t)$
$H(\vec{R})\,|n(\vec{R})\rangle = E_n(\vec{R})\,|n(\vec{R})\rangle$
$H(R(t))\,|n(R(t))\rangle = E_n(\vec{R}(t))\,|n\vec{R}(t)\rangle$

$$R(t)\rangle = -i\hbar\frac{\partial}{\partial t}|\psi(R(t))\rangle$$

$$e^{i\frac{1}{\hbar}E_0 t}$$



$\vec{R}$



$$\rangle = e^{i\theta(R(t))}|n(R(t))\rangle$$

$$\gamma_n(\vec{R}_0, \vec{R}_f)$$

$\vec{A}$

$$= \frac{1}{\hbar}\int_0^t E_n(R(t'))dt' - i\int_{\vec{R}_0}^{\vec{R}_f}\langle n(R(t'))|\vec{\nabla}_{\vec{R}}|n(R(t'))\rangle d\vec{R}$$