Title: Manybody Physics meets Quantum Engineering

Date: Jun 26, 2007 09:00 AM

URL: http://pirsa.org/07060071

Abstract:

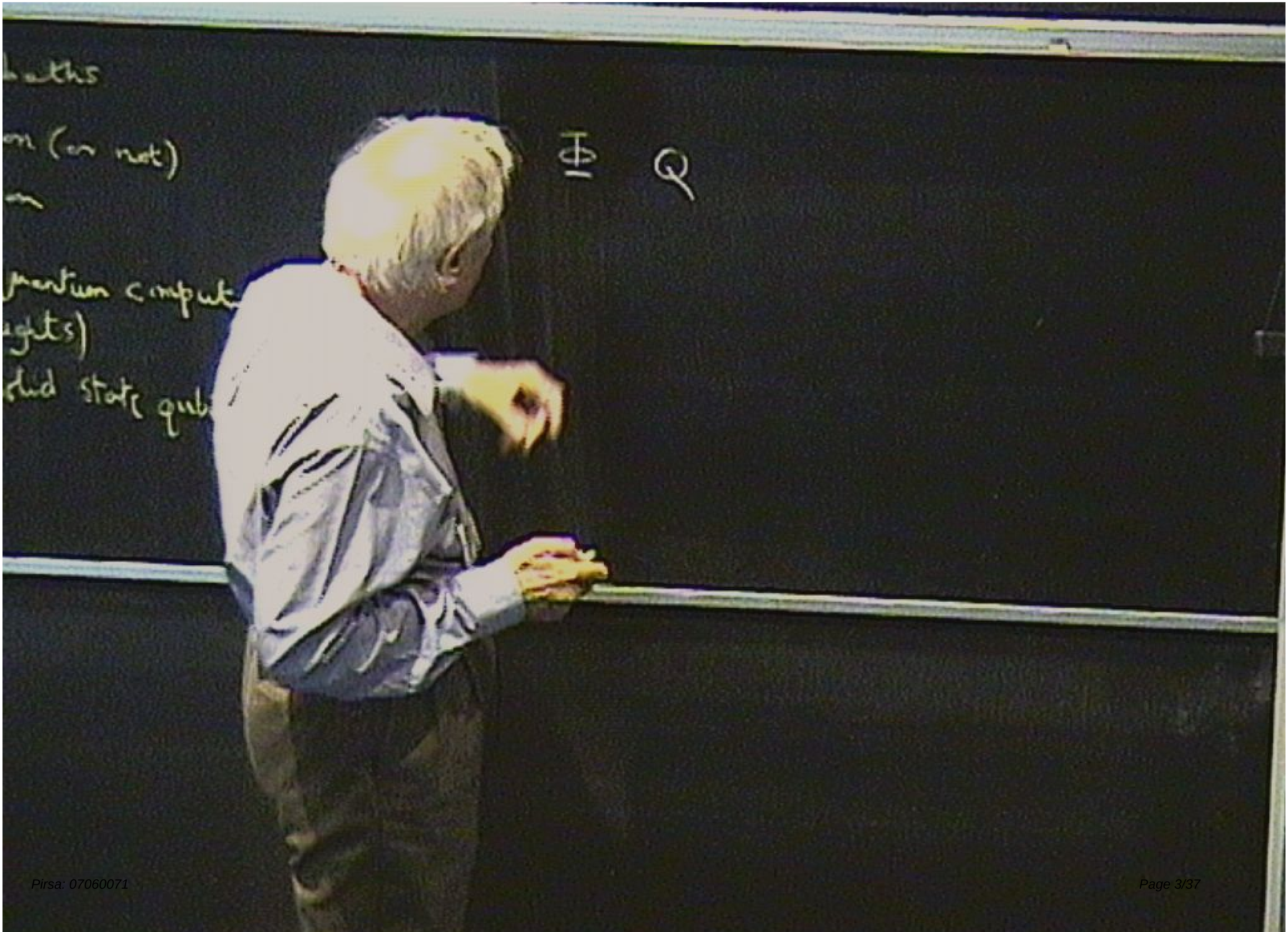
1. Oscillator baths

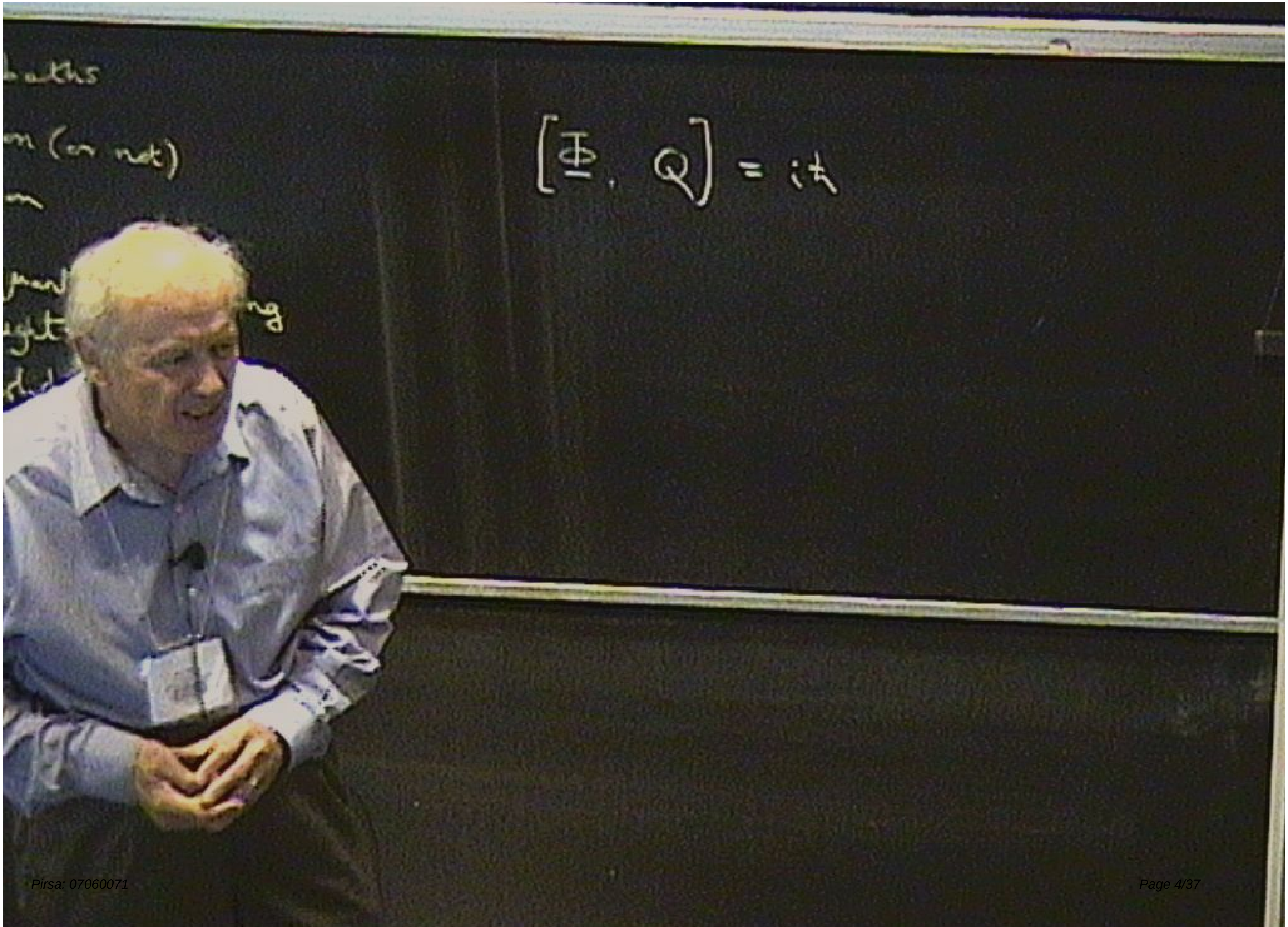
(a) justification (or not)

(b) application

2. Topological quantum computing (heretical thoughts)

3. Hybrid optical-solid state qubits


(or not)
state


$[\Phi, Q] = i\hbar$

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1) $T = 0$
2) TRI
3)

puting

ubits

$$[\Phi, Q] = i\hbar$$

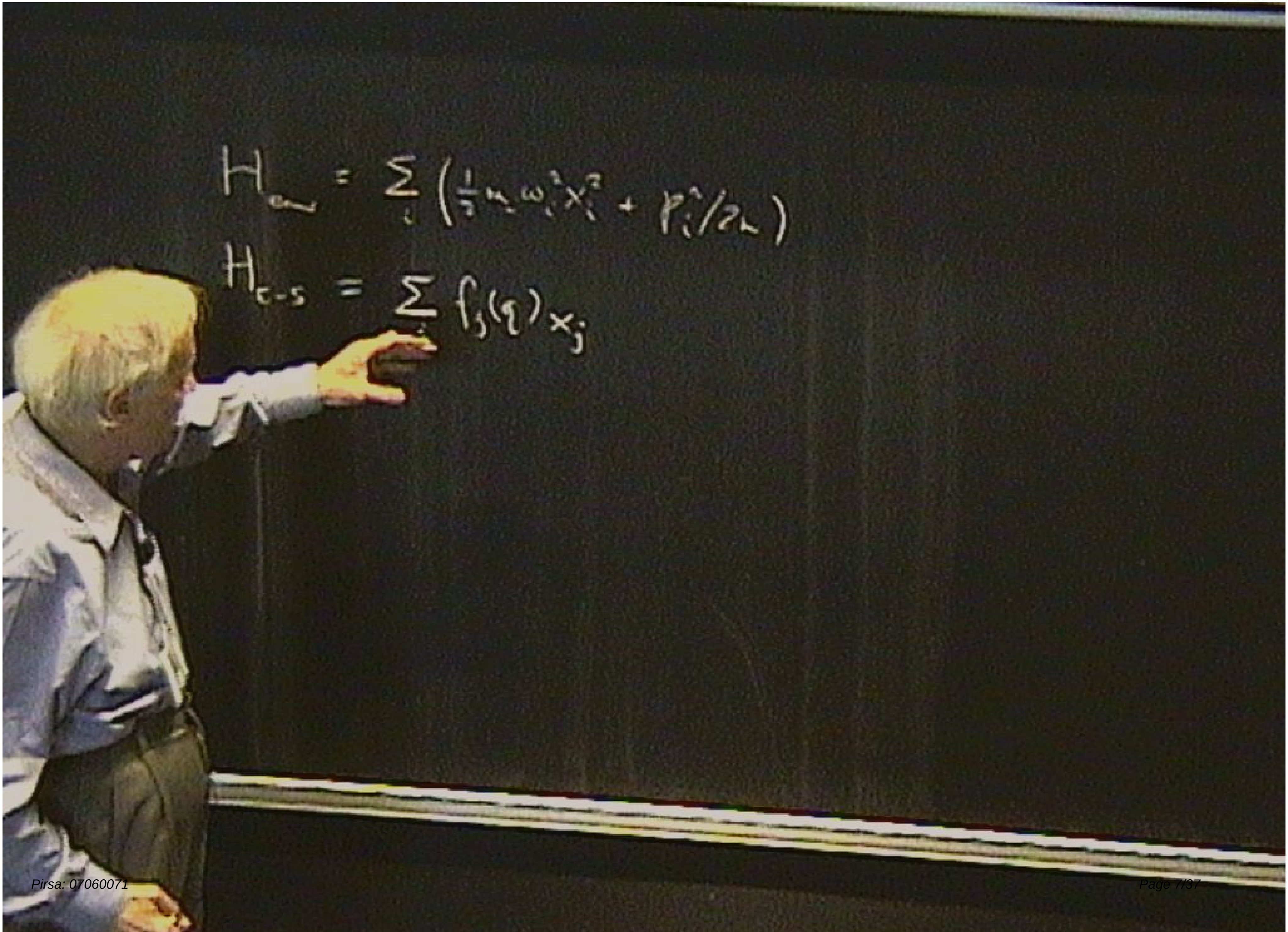
1) $T = 0$

2) TRI

3) any one DOF of env't
weakly perturbed

...ing

...s

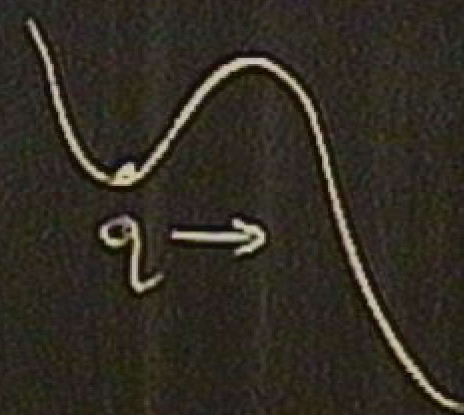

$H_{env} = \sum_i \left( \frac{1}{2} m \omega_i^2 x_i^2 + p_i^2/2m \right)$
$H_{c-s} = \sum_j f_j(q) x_j$

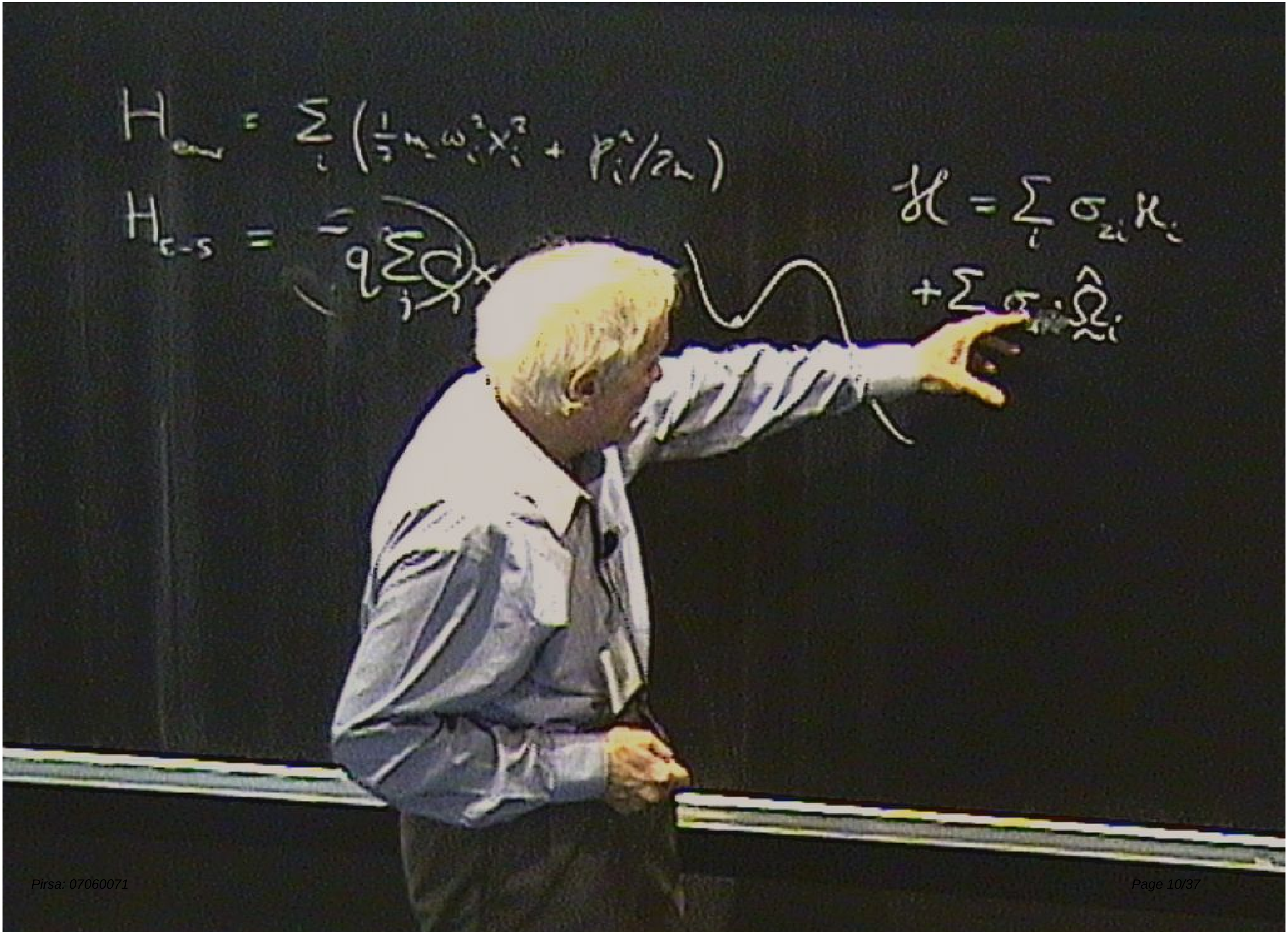
$$H_{env} = \sum_i \left( \frac{1}{2} m_i \omega_i^2 x_i^2 + p_i^2/2m \right)$$

$$H_{E-S} = \sum_j f_j(q) x_j$$

$$H_{env} = \sum_i \left( \frac{1}{2} m_i \omega_i^2 x_i^2 + p_i^2/2m \right)$$

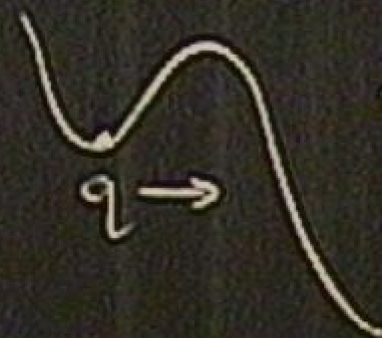
$$H_{E-S} = q \sum_j c_j x_j$$




$H_{env} = \sum_i \left( \frac{1}{2} m \omega_i^2 x_i^2 + p_i^2/2m \right)$
$H_{c-s} =$
$\mathcal{H} = \sum_i \sigma_{zi} K_i$
$+ \sum$

$$H_{env} = \sum_i \left( \tfrac{1}{2} m_i \omega_i^2 x_i^2 + p_i^2/2m_i \right)$$

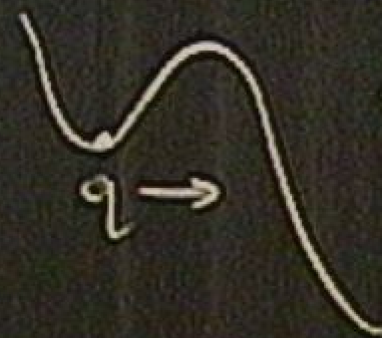
$$H_{c-s} = -q \sum_j C_j x_j$$




$$\mathcal{H} = \sum_i \sigma_{zi} h_i + \sum_i \sigma_{xi} \hat{\Omega}_i$$

$$H_{env} = \sum_i \left( \tfrac{1}{2} m_i \omega_i^2 x_i^2 + p_i^2/2m \right)$$

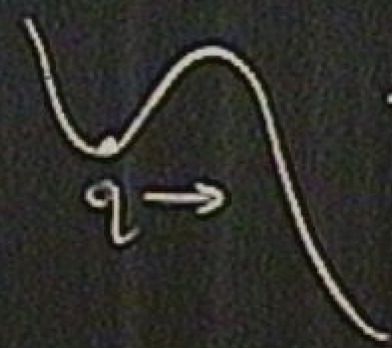
$$H_{t-s} = -q \sum_j C_j x_j$$




$$\mathcal{H} = \sum_i \sigma_{zi} K_i + \sum_i \sigma_{xi} \hat{\Omega}_i$$

$$H_{em} = \sum_i \left( \tfrac{1}{2} m_i \omega_i^2 x_i^2 + p_i^2/2m \right)$$

$$H_{c-s} = -q \sum_j C_j x_j$$




$$\mathcal{H} = \sum_i \sigma_{zi} K_i$$

$$+ \sum_i \sigma_{zi} \hat{\Omega}_i$$

$$H_{env} = \sum_i \left(\tfrac{1}{2} m_i \omega_i^2 x_i^2 + p_i^2/2m_i\right)$$

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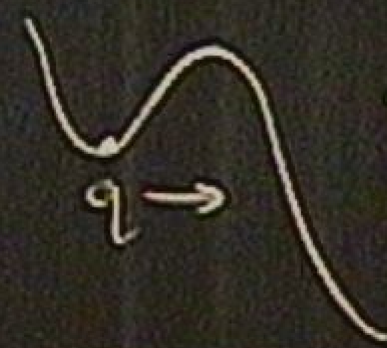


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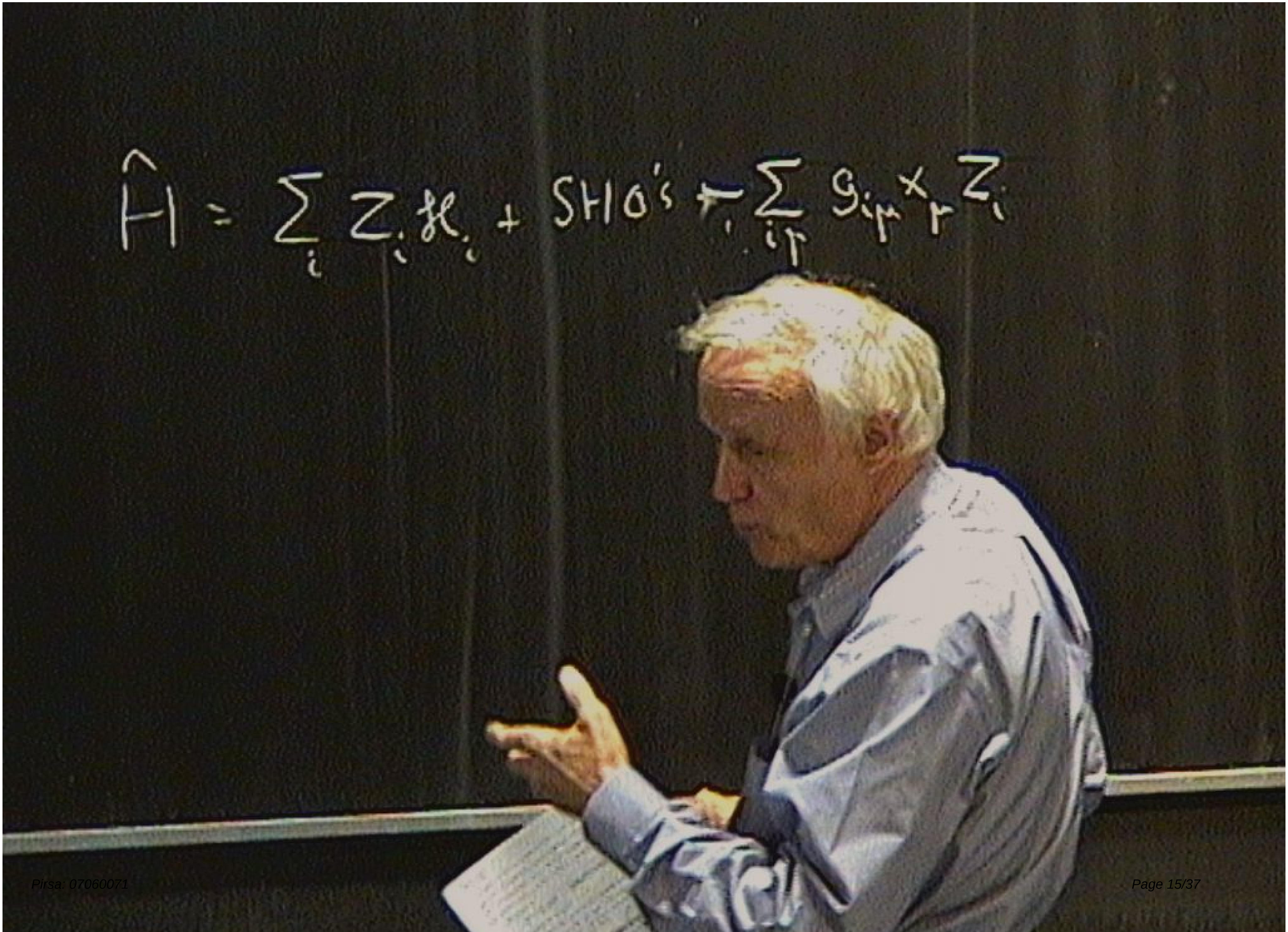
$$\hat{\Omega}_i = \sum_k g_{ik} x_k$$


$\hat{H} = \sum_i Z_i \mathcal{H}_i + \text{SHO's} + \sum_{i\mu} g_{i\mu} x_\mu Z_i$

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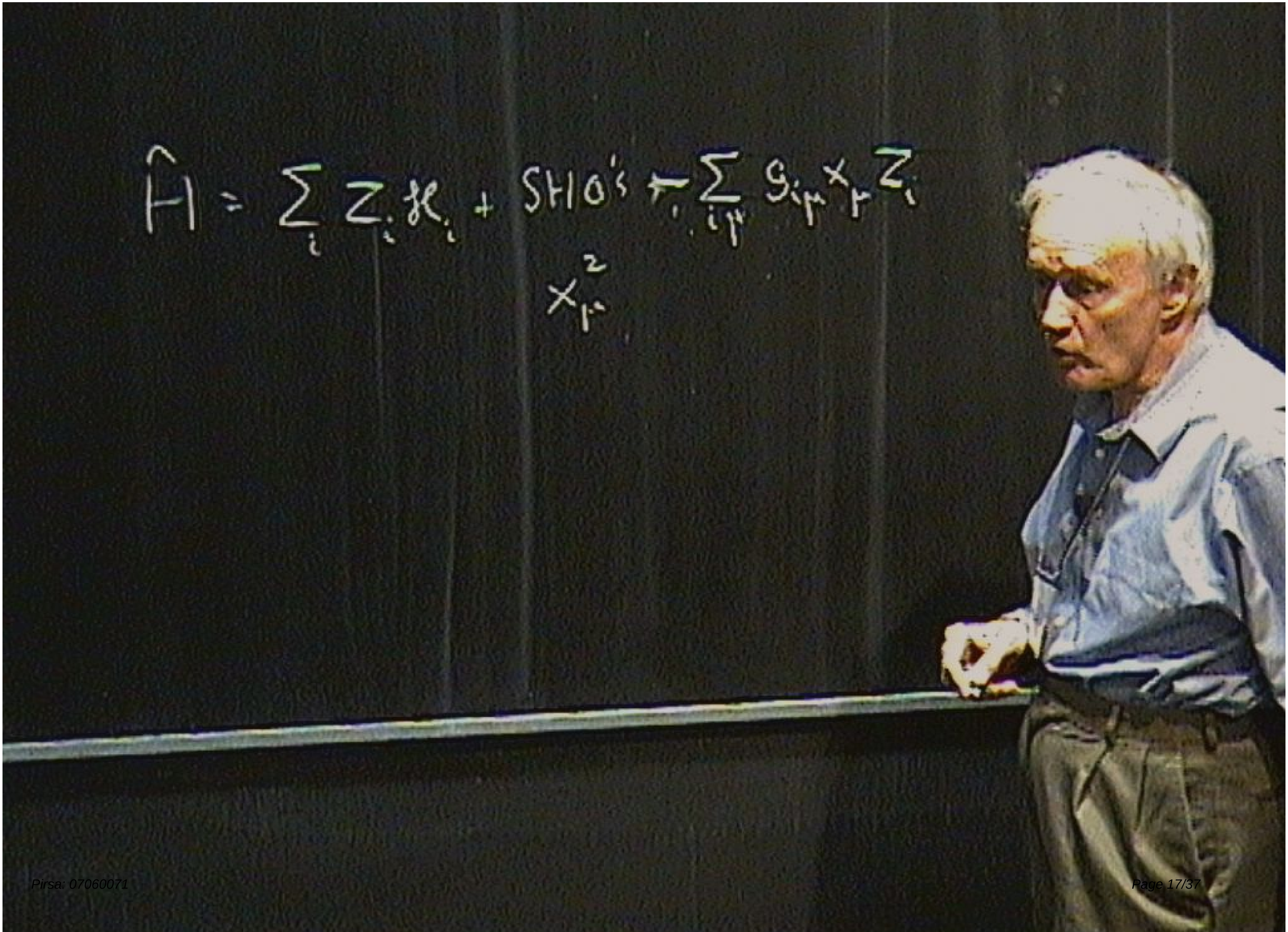
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$x_\mu^2$

$$\hat{H} = \sum_i Z_i \mathcal{H}_i + \text{SHO's} + \sum_{i\mu} g_{i\mu} x_\mu Z_i$$

$$\tilde{x} = x - \frac{gZ}{m\omega}$$

$$x_\mu^2$$

$$\hat{H} = Z\mathcal{H} + \left(\frac{p^2}{2m} + \frac{1}{2} m\omega^2 \tilde{x}^2\right) - \cancel{\frac{1}{2}\frac{g^2}{m\omega^2}} Z^2$$

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Exact solution of TDSE for shifted initial condition:

$$\psi(x,t) = \exp -i\left(E_n - \tfrac{1}{2} m\omega^2 x_0^2\right)t/\hbar \cdot$$
$$\exp - \frac{im\omega^2}{\hbar}(x + x_0)\, x_0 \sin 2\omega t \cdot$$
$$\exp - \frac{im\omega^2}{4\hbar} x_0^2 \sin 2\omega t \cdot$$
$$\psi_n\left(x + x_0(1 - \cos\omega t)\right)$$

$$x_0(Z) \equiv gZ/m\omega^2$$

for single-qubit, single-mode case, $x_0^2$ terms constant.

Many-qubit, many-mode case:

$$\prod_k \psi(x_k, t) \qquad (\omega \to \omega_k)$$

$$x_{0k}\{Z_i\} \equiv \sum_i \left(g_{ki} Z_i / m\omega_k^2\right)$$

$x_{0k}^2$ terms nontrivial, but independent of $n_k$.
(for strictly harmonic case)

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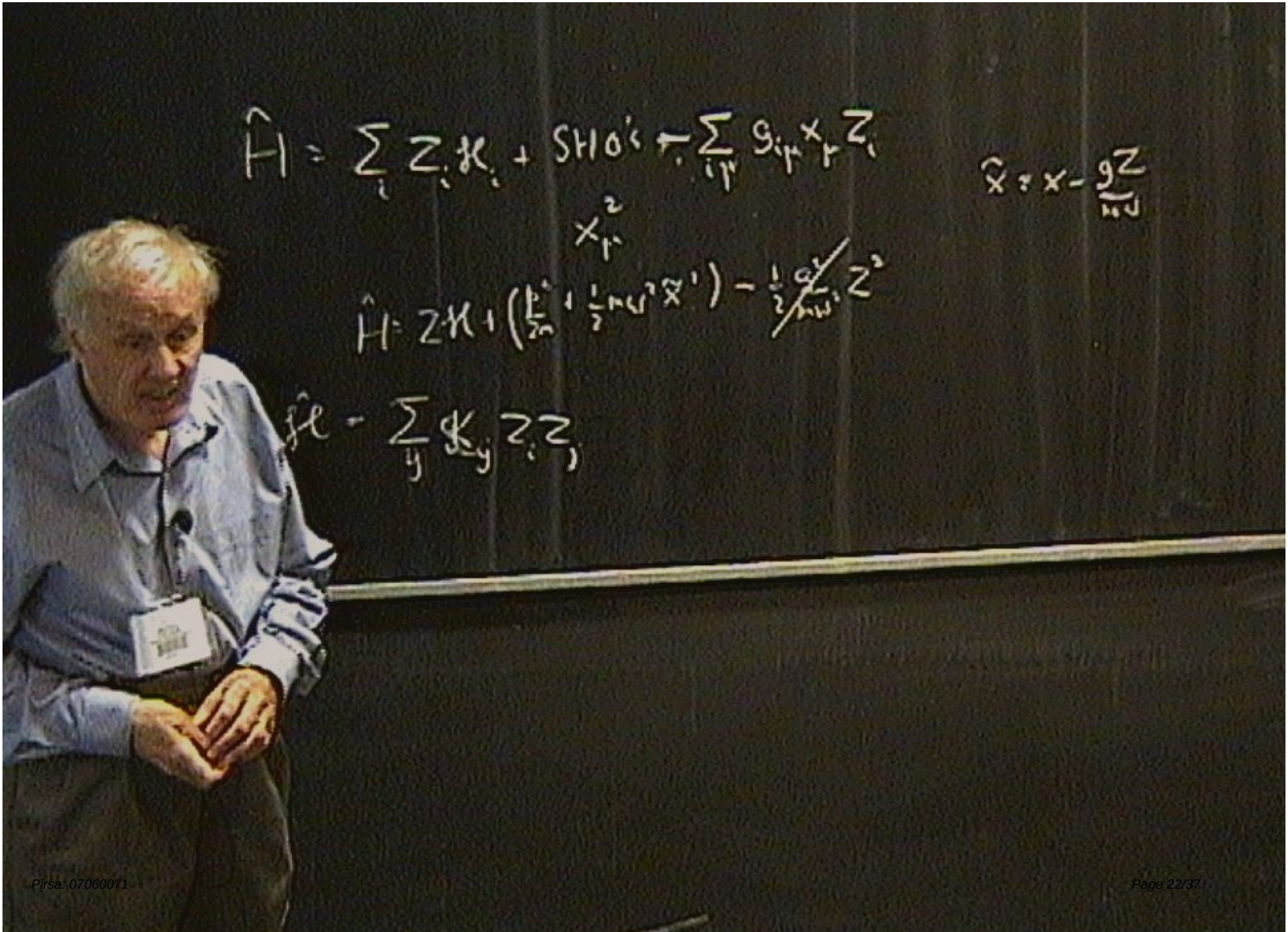
$\hat{H} = \sum_i Z_i K_i + \text{SHO's} - \sum_{i\mu} g_{i\mu} x_\mu Z_i$
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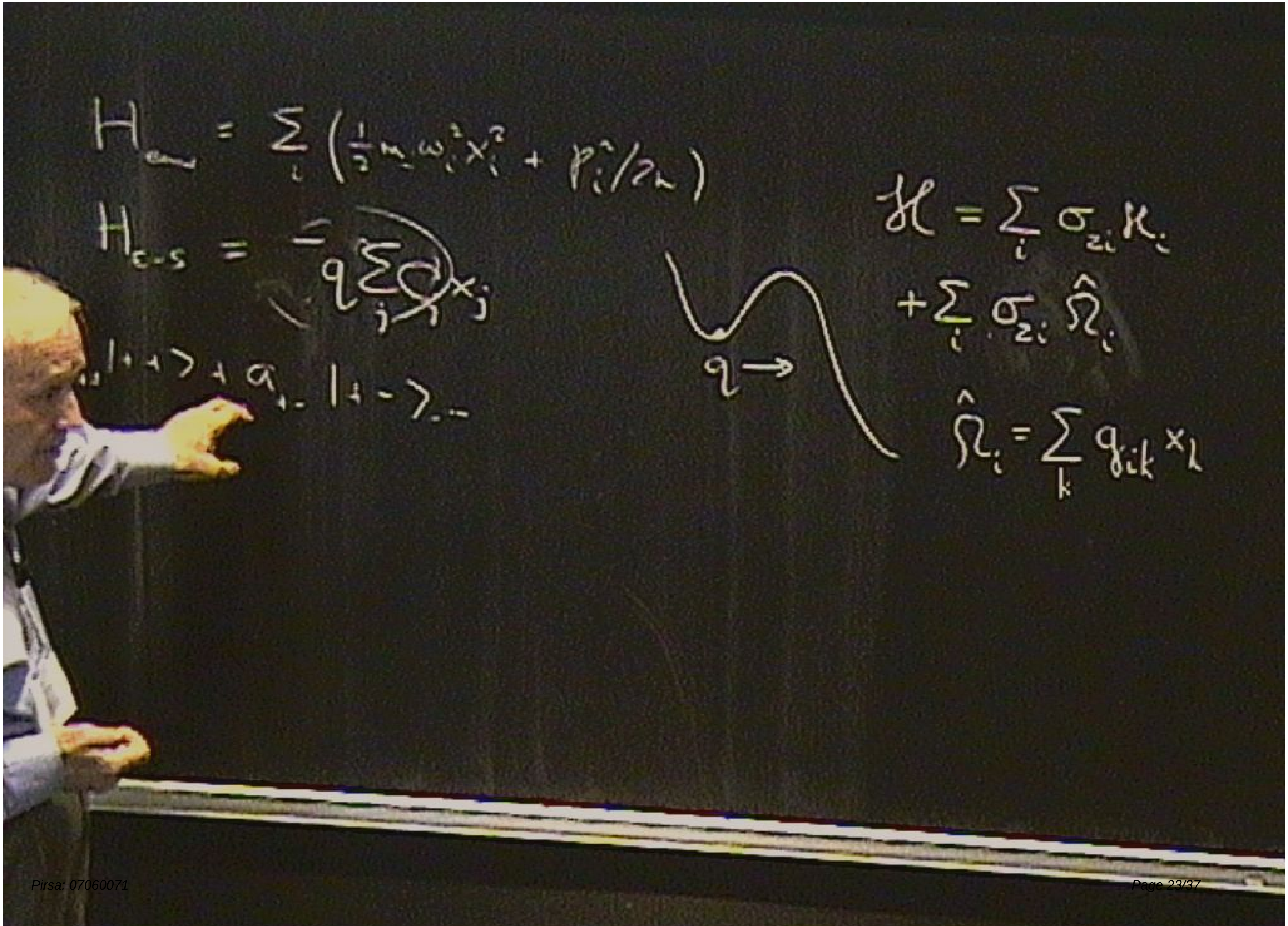

$H_{env} = \sum_i \left( \frac{1}{2} m_i \omega_i^2 x_i^2 + p_i^2/2m \right)$
$H_{c-s} = -q \sum_j x_j$
$|++\rangle + a_{+-} |+-\rangle$
$q \rightarrow$
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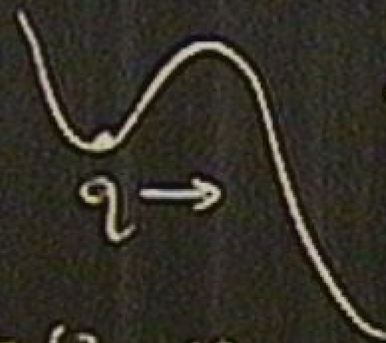
$$a_{++}|++\rangle + a_{+-}|+-\rangle \ldots_{--}$$

$$e^{i\varphi_{++}}$$

$$\varphi_{++} - \varphi_{+-} = \varphi_{-+} - \varphi_{--}$$

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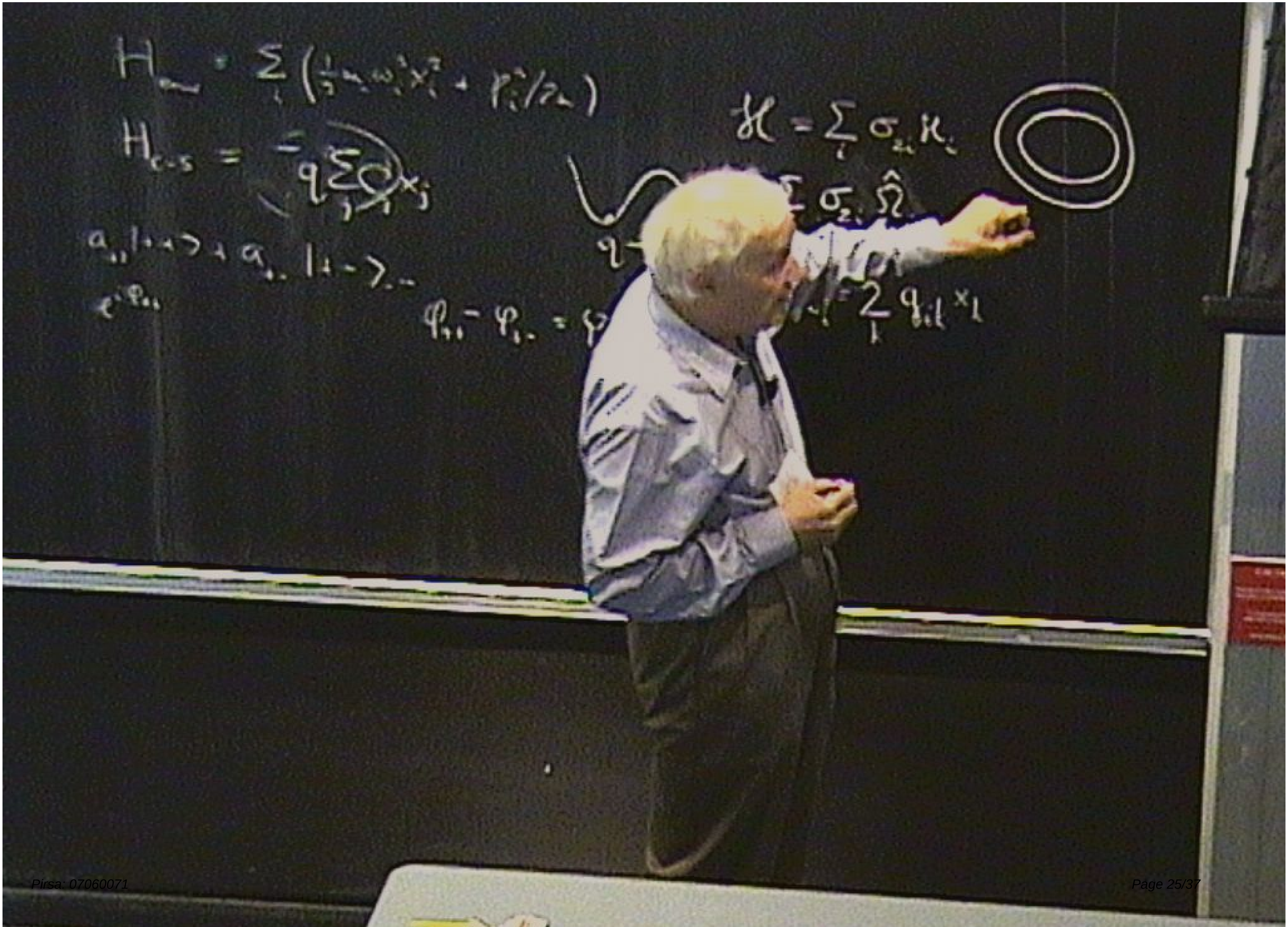

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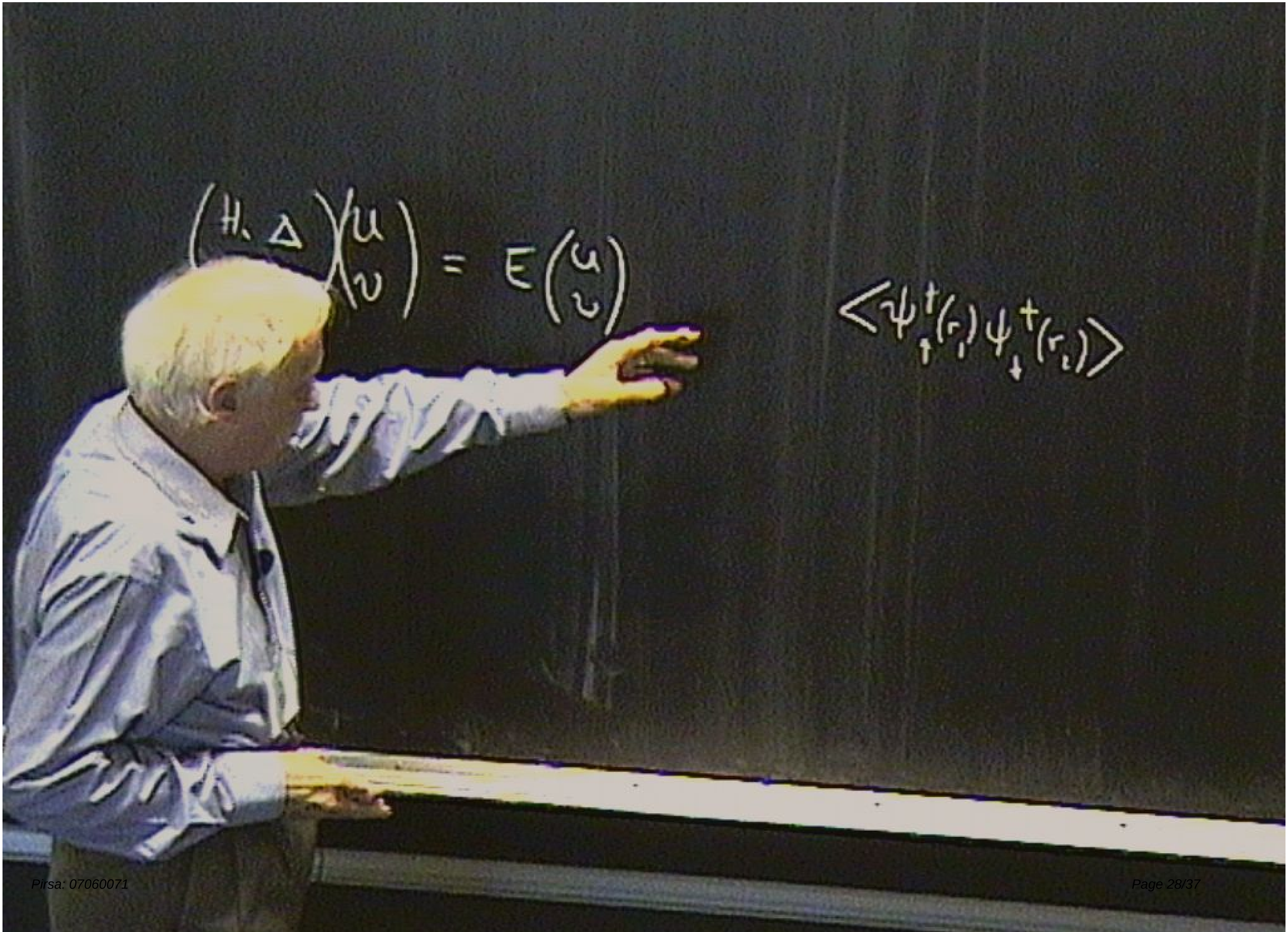
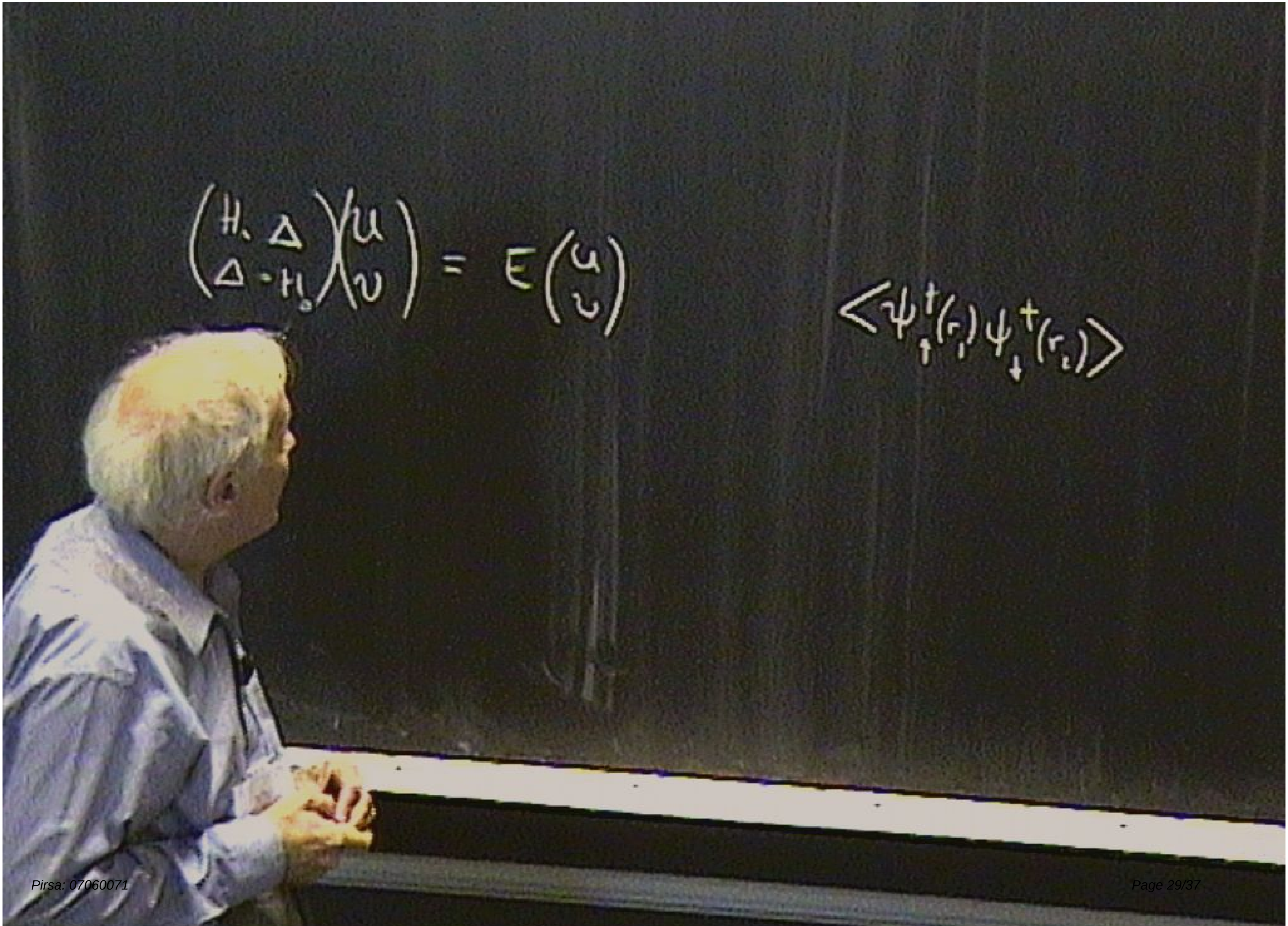
$$\begin{pmatrix} H_0 & \Delta \\ \Delta & -H_0 \end{pmatrix}\begin{pmatrix} u \\ v \end{pmatrix} = E\begin{pmatrix} u \\ v \end{pmatrix}$$


$\begin{pmatrix} H_0 & \Delta \end{pmatrix}\begin{pmatrix} u \\ v \end{pmatrix} = E\begin{pmatrix} u \\ v \end{pmatrix}$
$\langle \psi^\dagger_\uparrow(r_1)\,\psi^\dagger_\downarrow(r_2) \rangle$



$\begin{pmatrix} H_0 & \Delta \\ \Delta & -H_0 \end{pmatrix}\begin{pmatrix} u \\ v \end{pmatrix} = E\begin{pmatrix} u \\ v \end{pmatrix}$
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$$\begin{pmatrix} H_0 & \Delta \\ \Delta & -H_0 \end{pmatrix}\begin{pmatrix} u \\ v \end{pmatrix} = E\begin{pmatrix} u \\ v \end{pmatrix}$$

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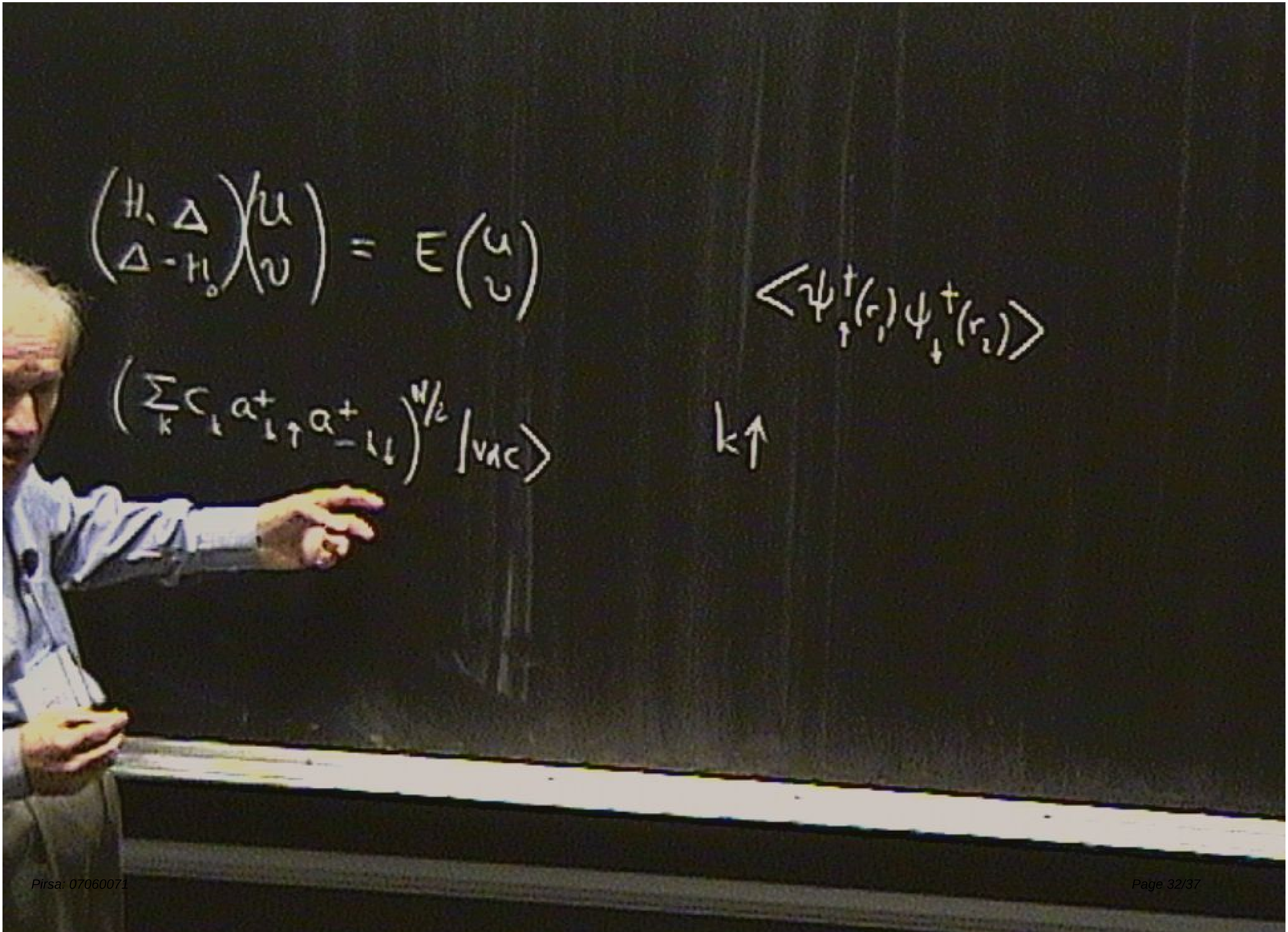
$$\langle \psi_\uparrow^+(r_1)\,\psi_\downarrow^+(r_2)\rangle$$

$$\left(\sum_k c_k\, a^+_{k\uparrow}\, a^+_{-k\downarrow}\right)^{N/2} |\mathrm{vac}\rangle$$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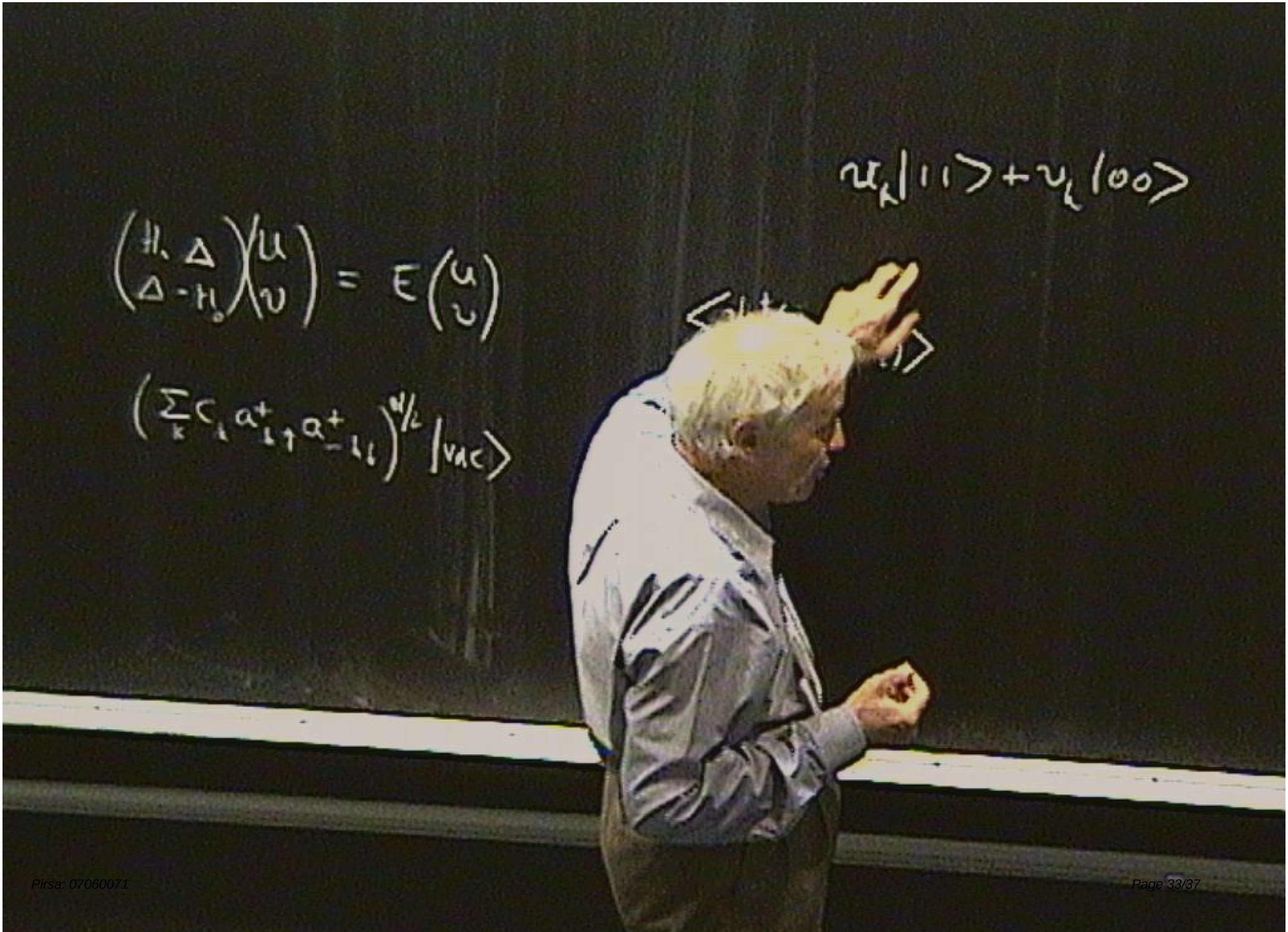
$k\uparrow$


$u_k|11\rangle + v_k|00\rangle$
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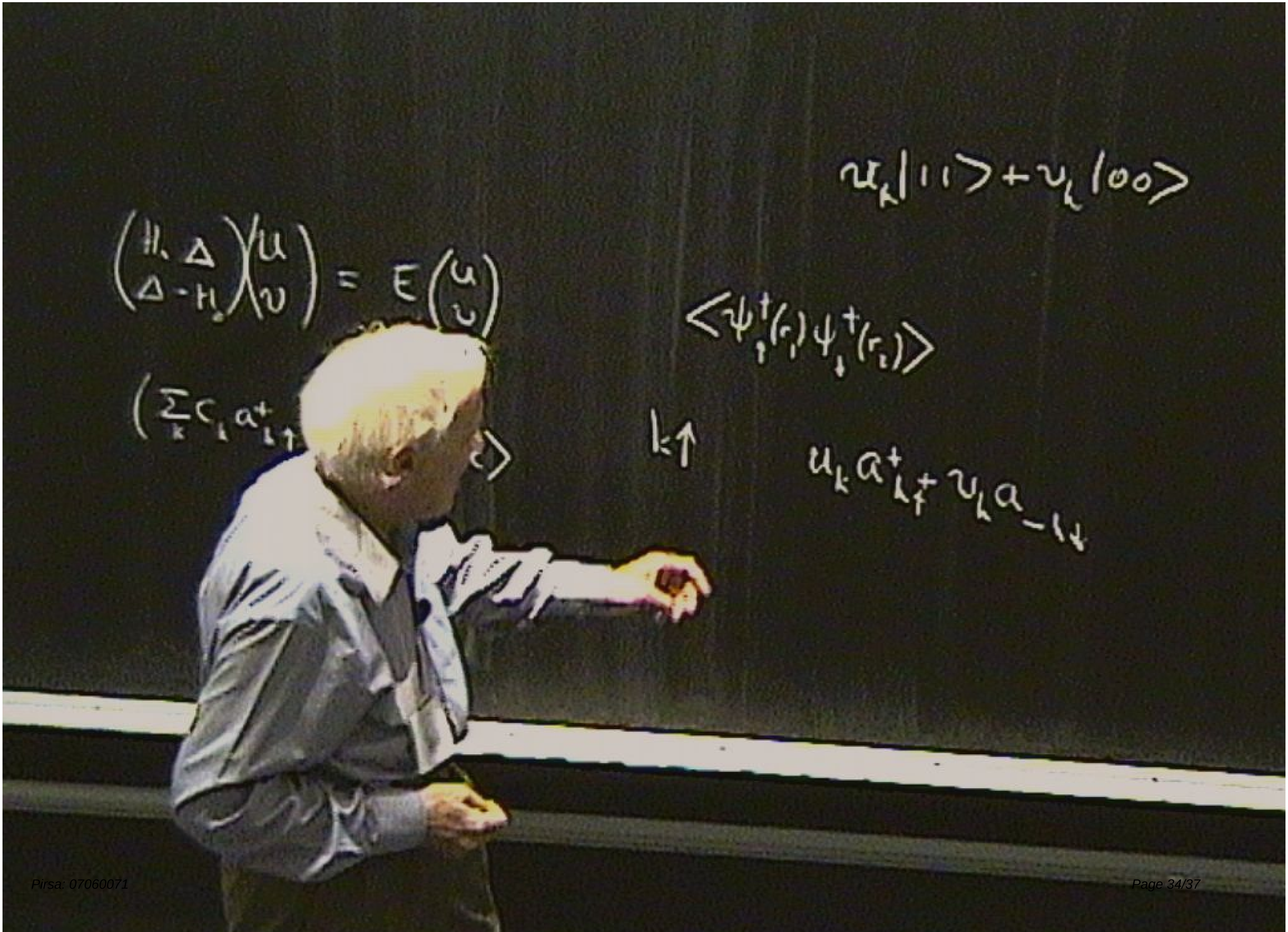
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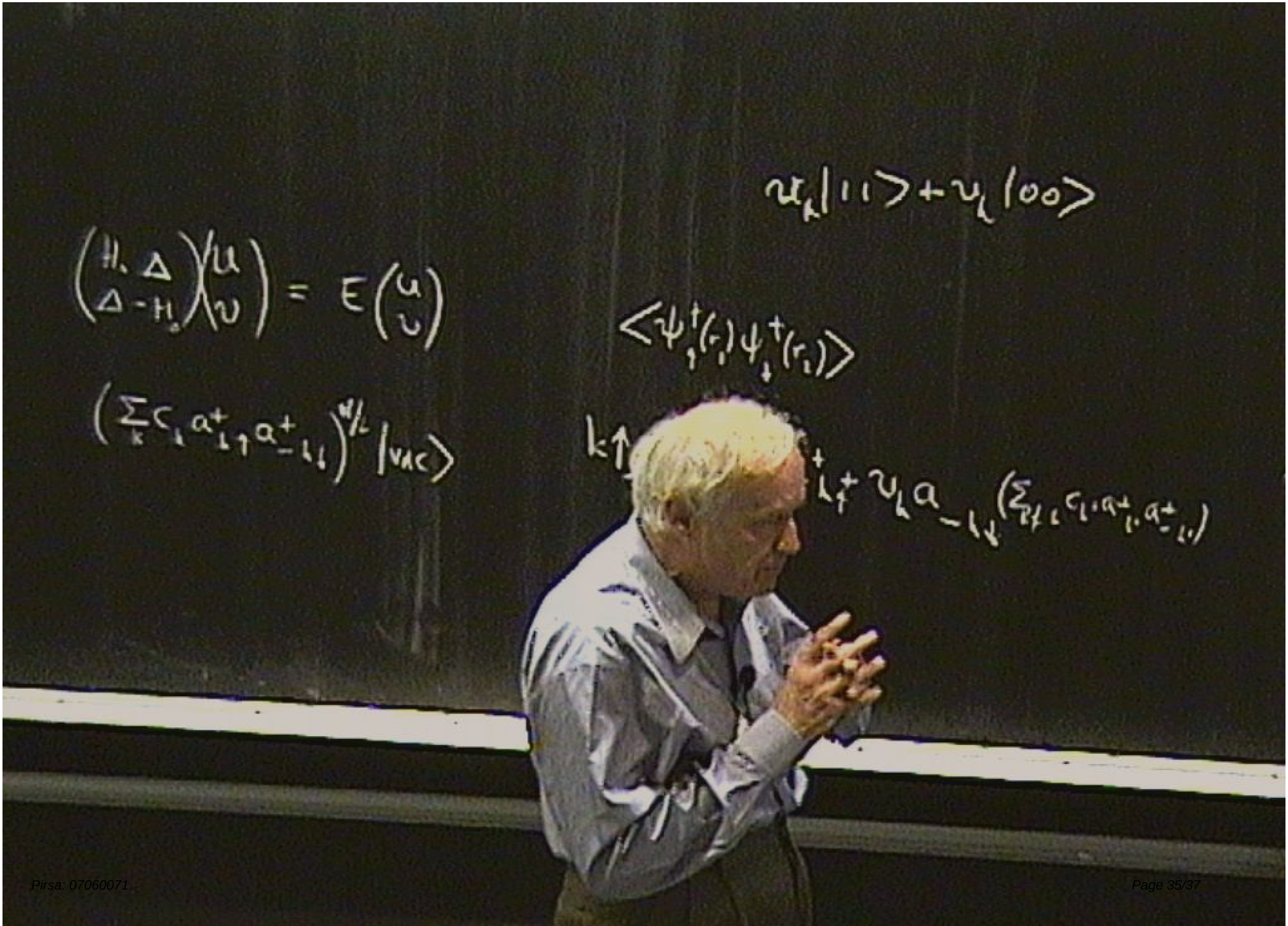
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$$\left(\sum_k c_k a^+_{k\uparrow} a^+_{-k\downarrow}\right)^{N/2} |vac\rangle$$

$$u_k|11\rangle + v_k|00\rangle$$

$$\langle \psi^+_\uparrow(r_1)\psi^+_\downarrow(r_2)\rangle$$

$k\uparrow$

$$u_k a^+_{k\uparrow} + v_k a_{-k\downarrow}\left(\sum_{l\neq k} c_l a^+_{l\uparrow} a^+_{-l\downarrow}\right)$$

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