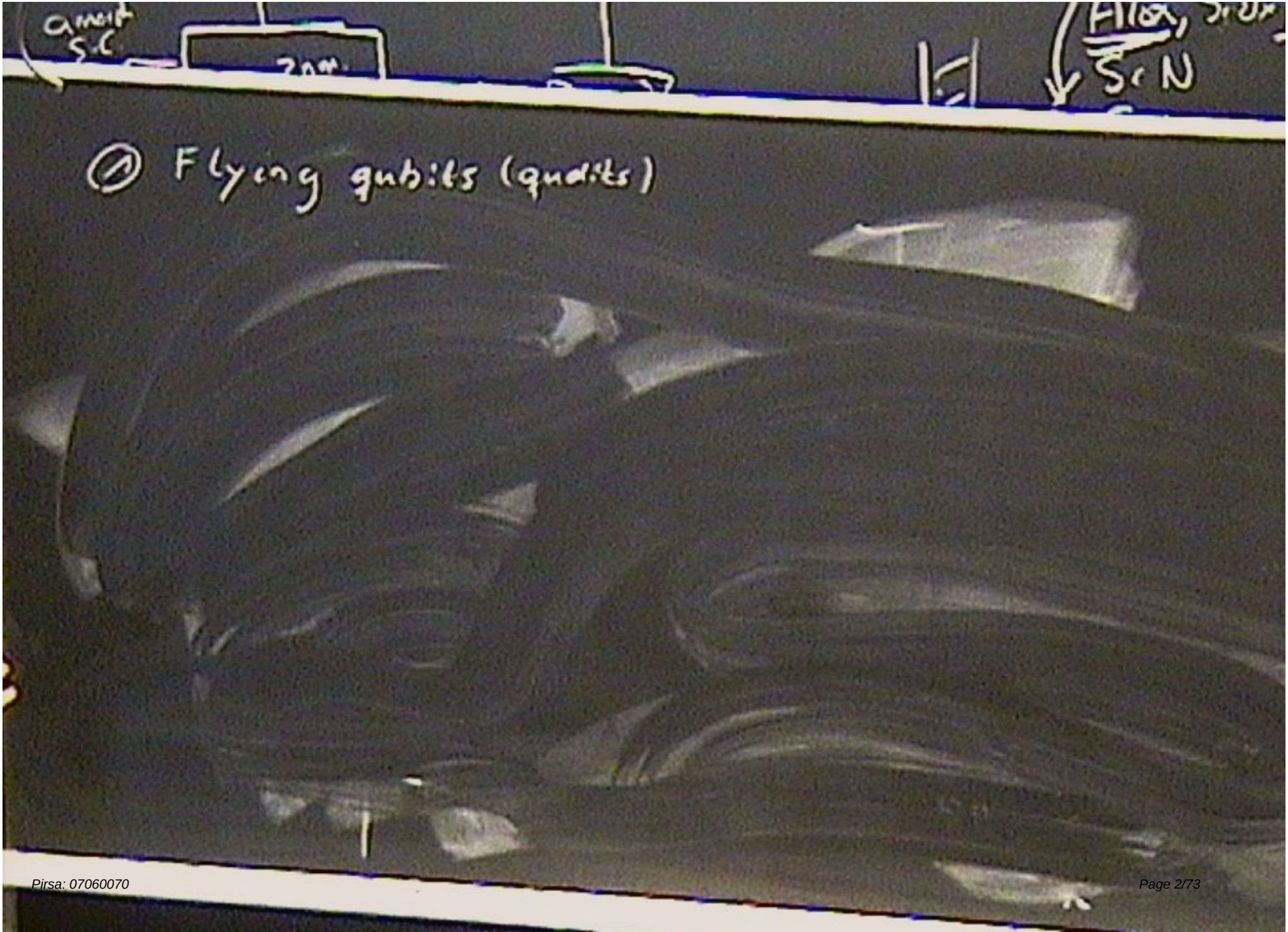
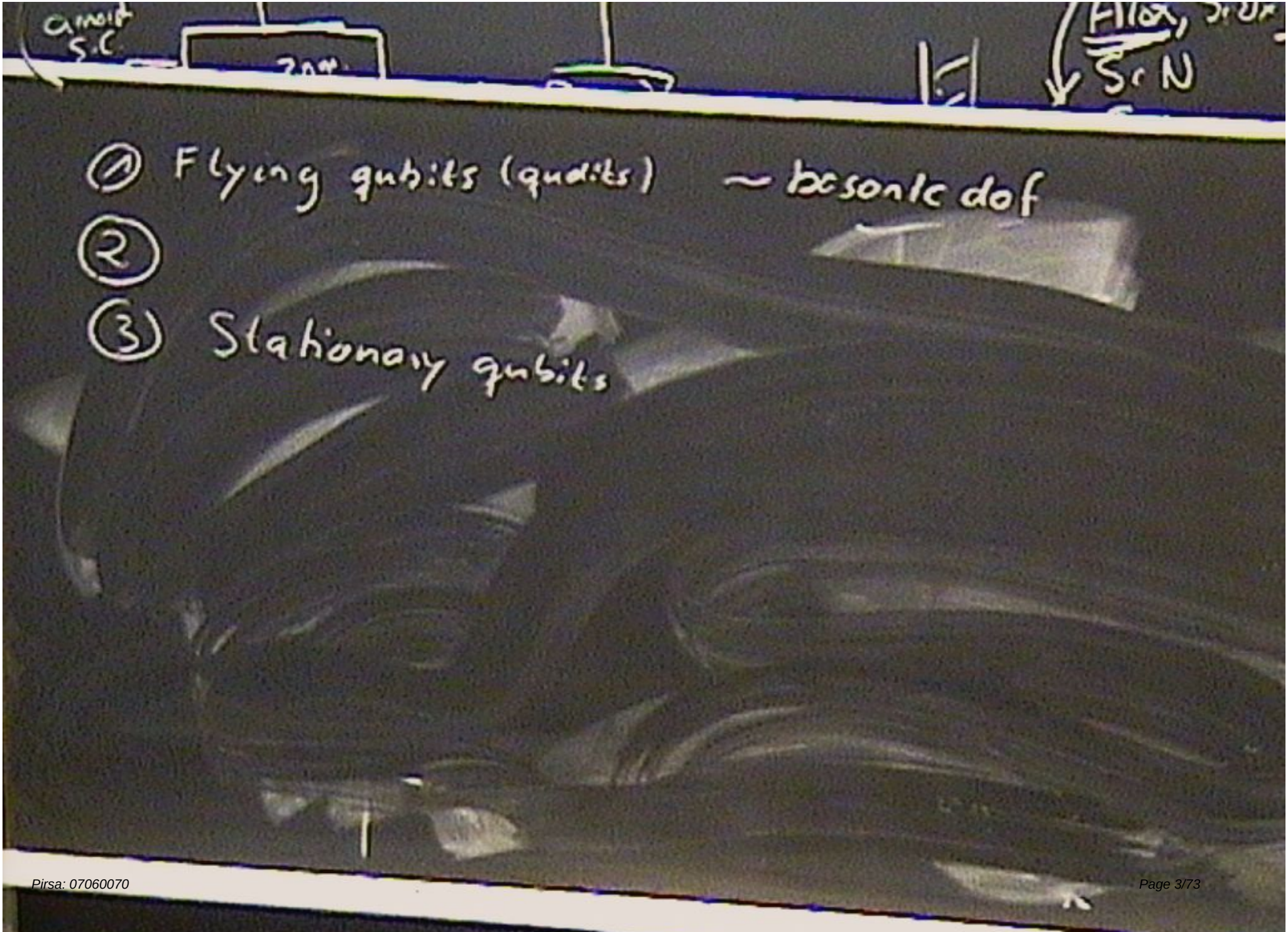
Title: Quantum Information meets Optics

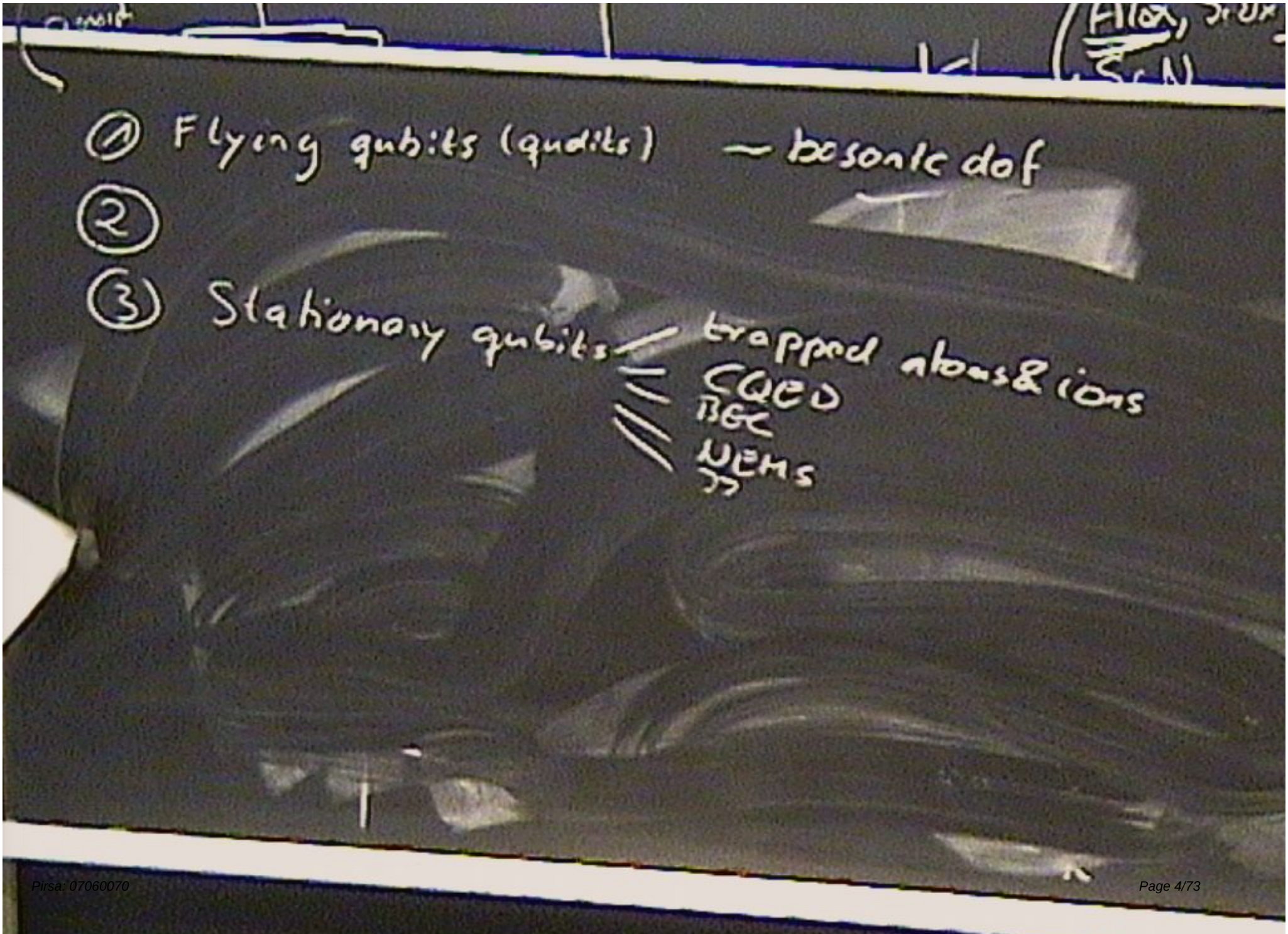
Date: Jun 25, 2007 05:00 PM

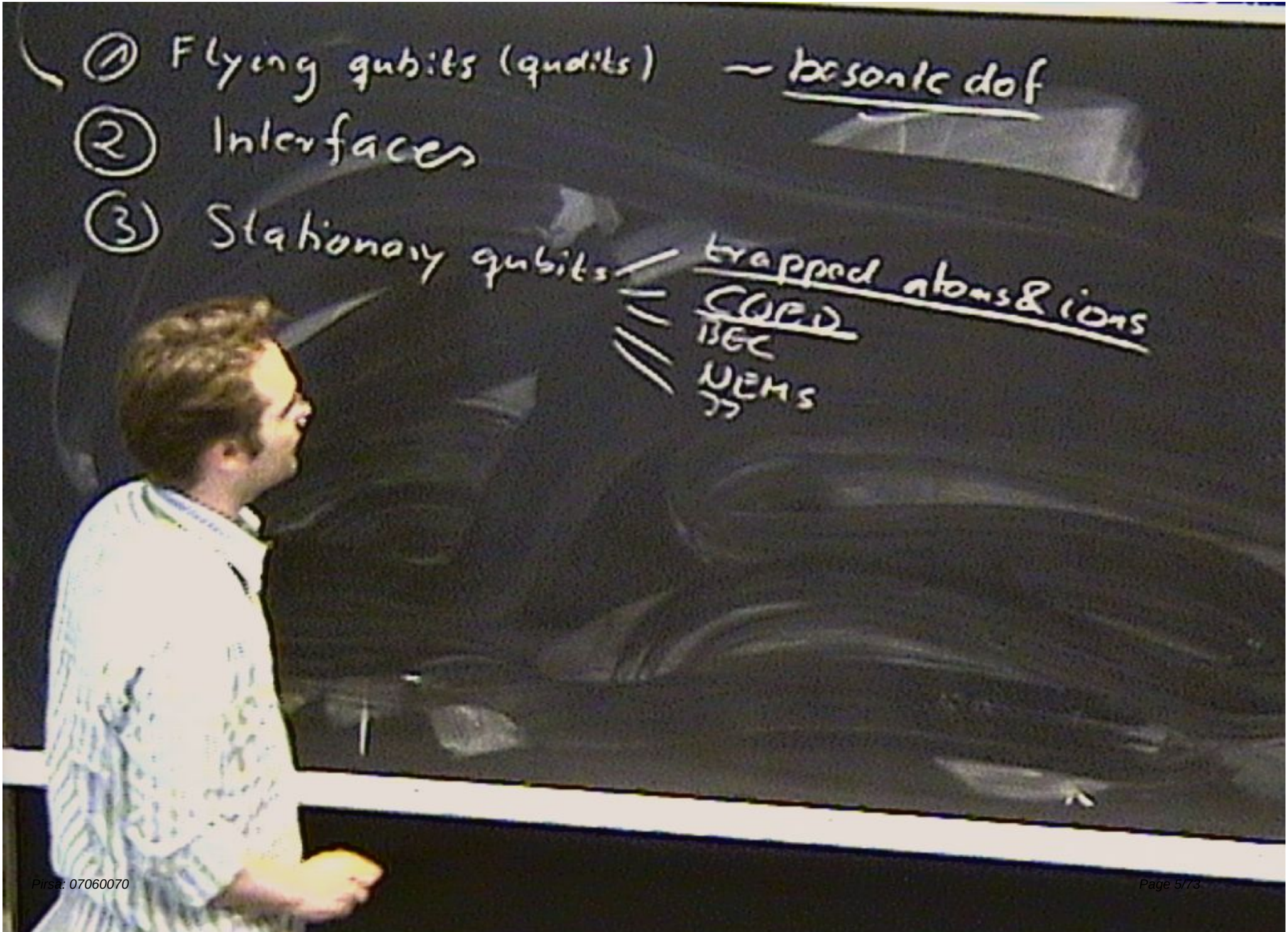
URL: http://pirsa.org/07060070

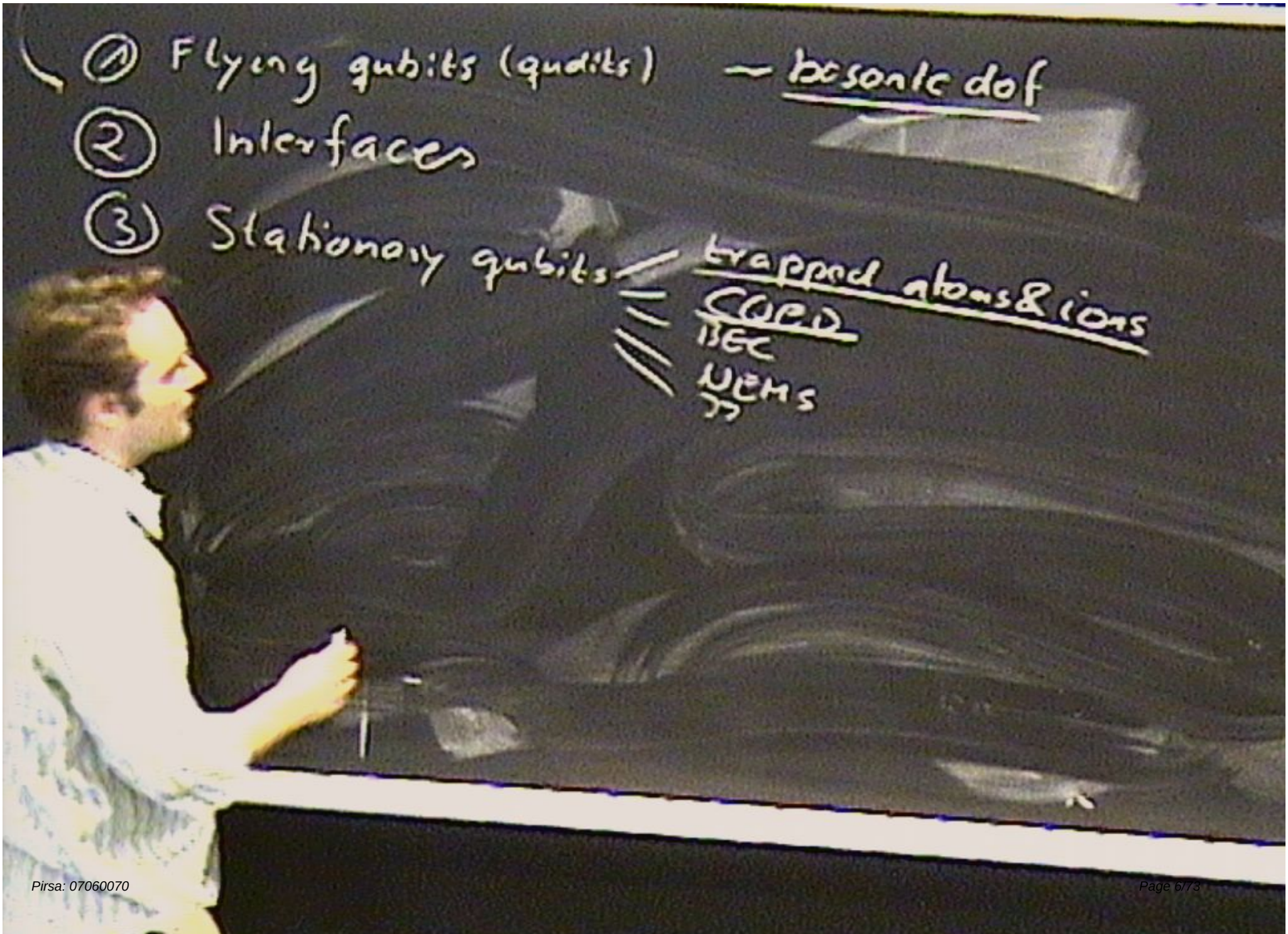
Abstract:

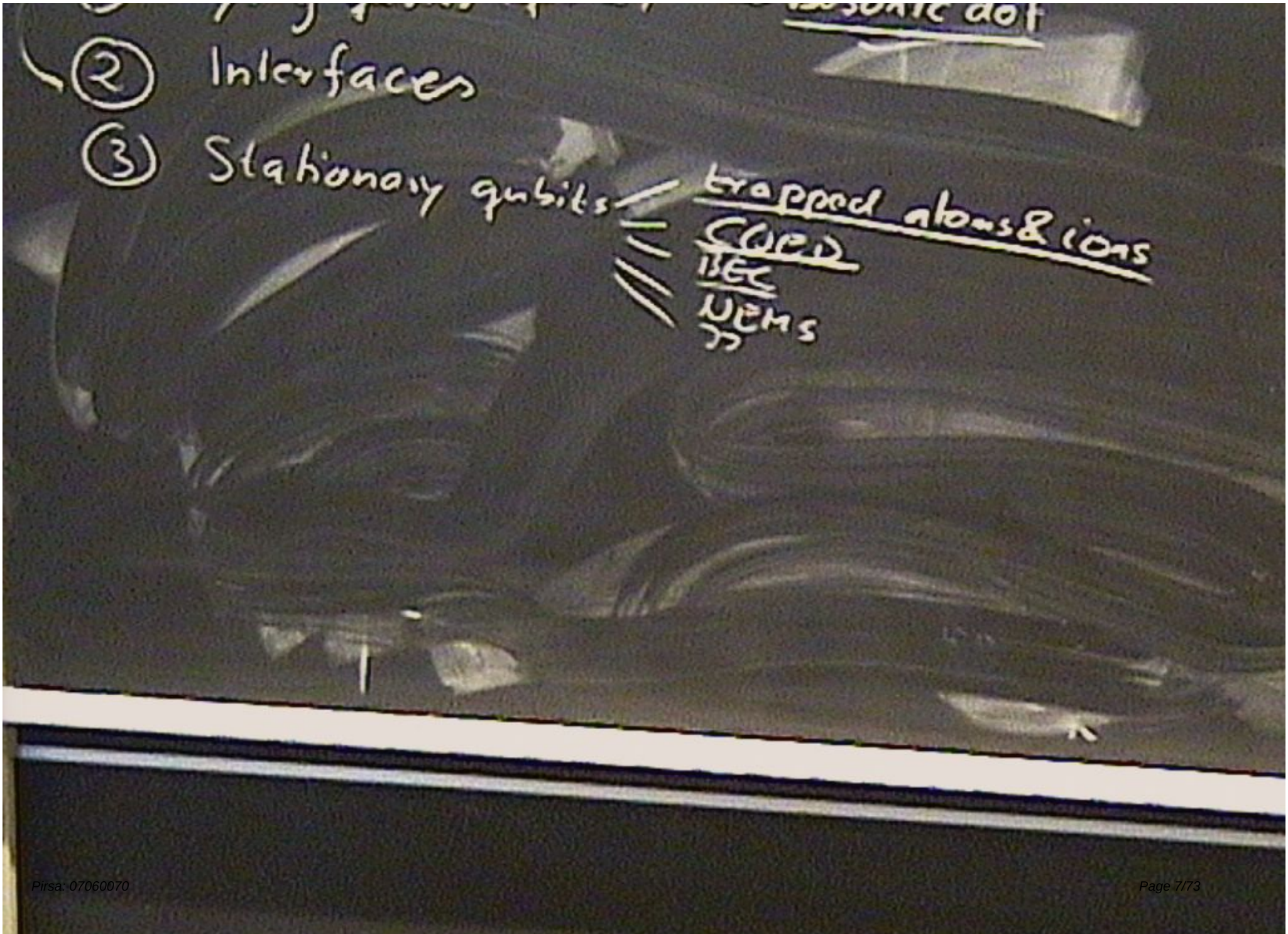

② Flying qubits (qudits)

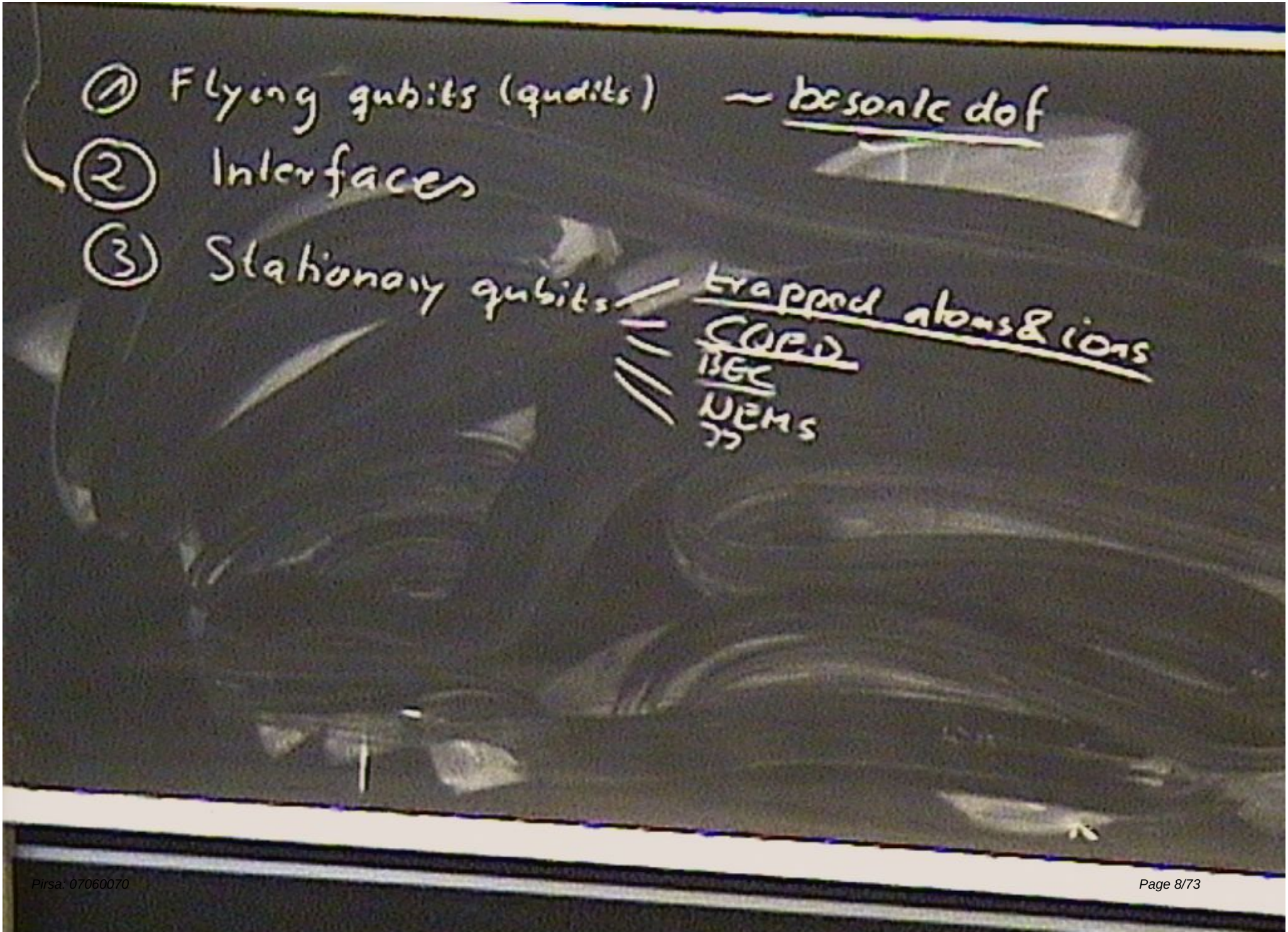

① Flying qubits (qudits) ~ bosonic dof
②
③ Stationary qubits

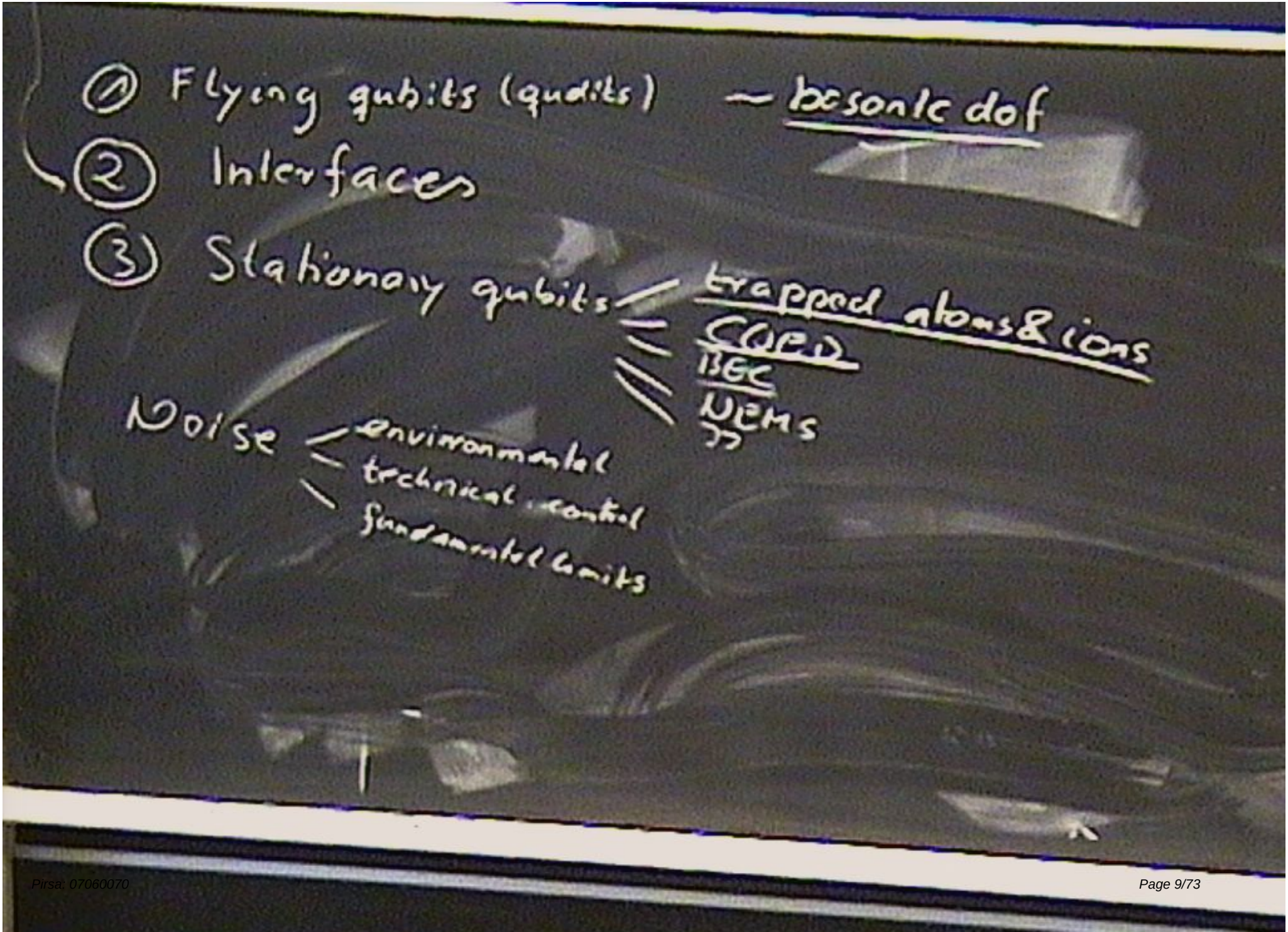

① Flying qubits (qudits) — bosonic dof
②
③ Stationary qubits — trapped atoms & ions
CQED
BEC
NEMS

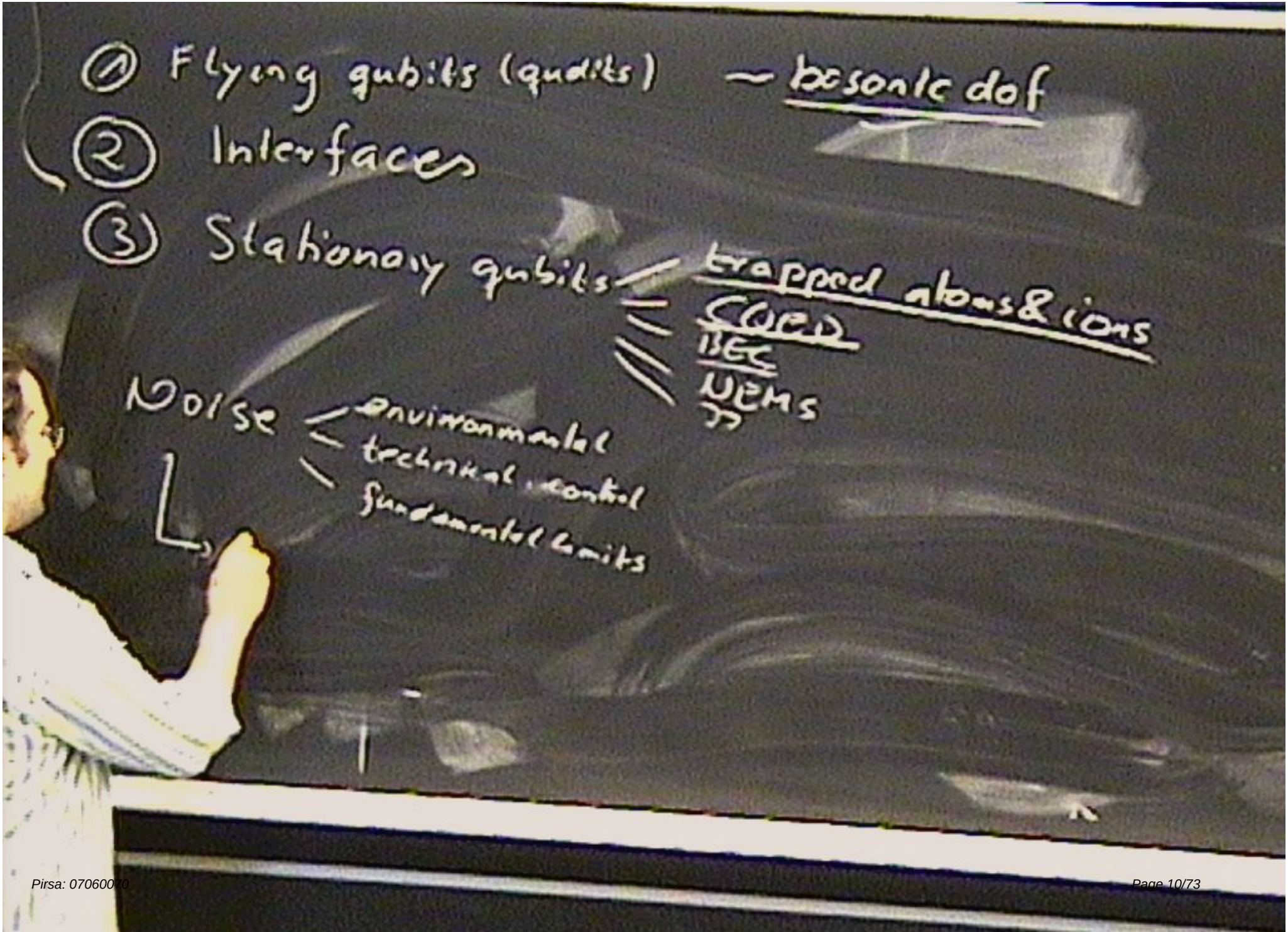

① Flying qubits (qudits) ~ bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
CQED
BEC
NEMs

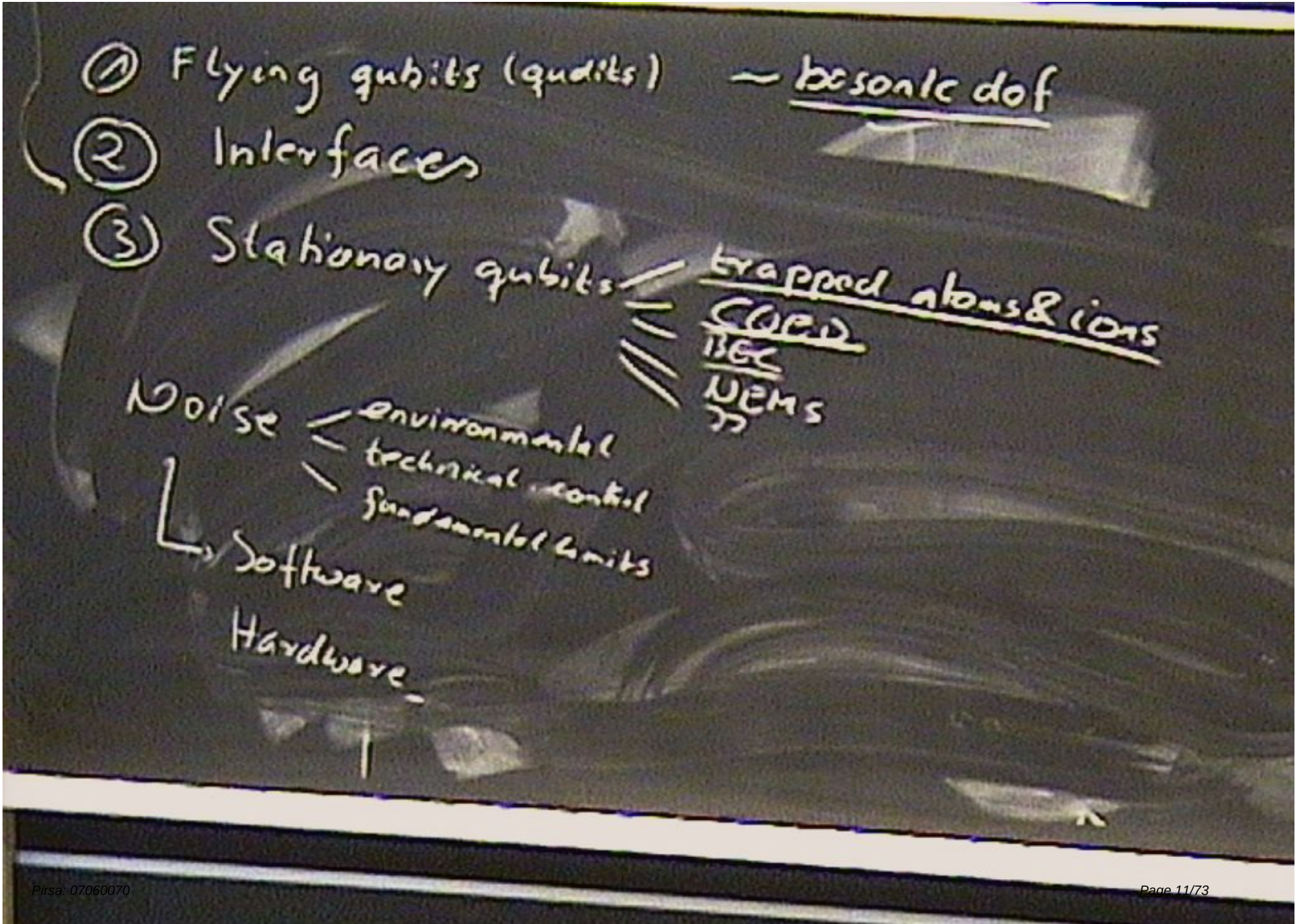

① Flying qubits (qudits) — bosonic dof
② Interfaces
③ Stationary qubits — trapped atoms & ions
CQED
BEC
NEMs

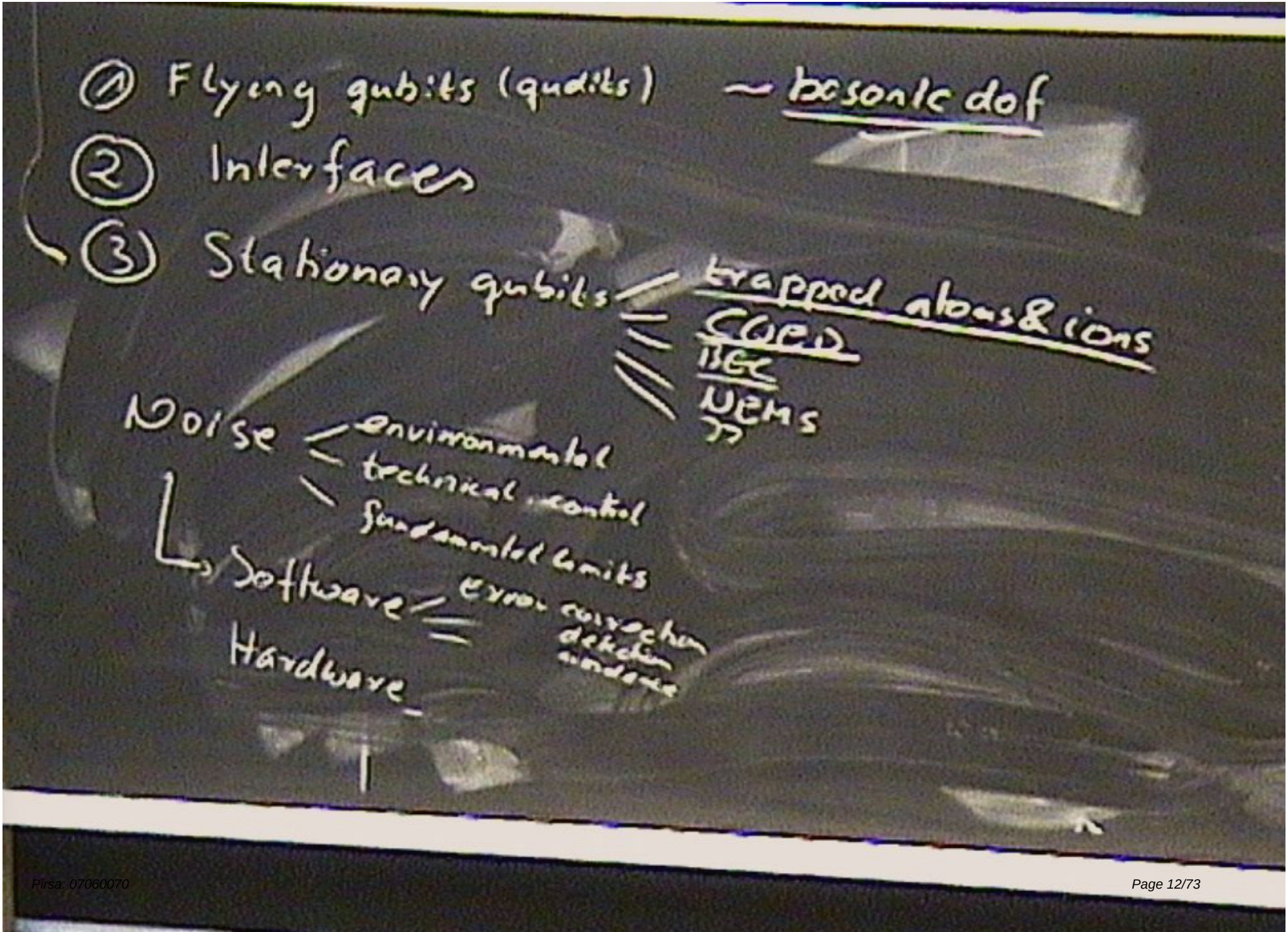

② Interfaces
③ Stationary qubits
trapped atoms & ions
CQED
NEMS

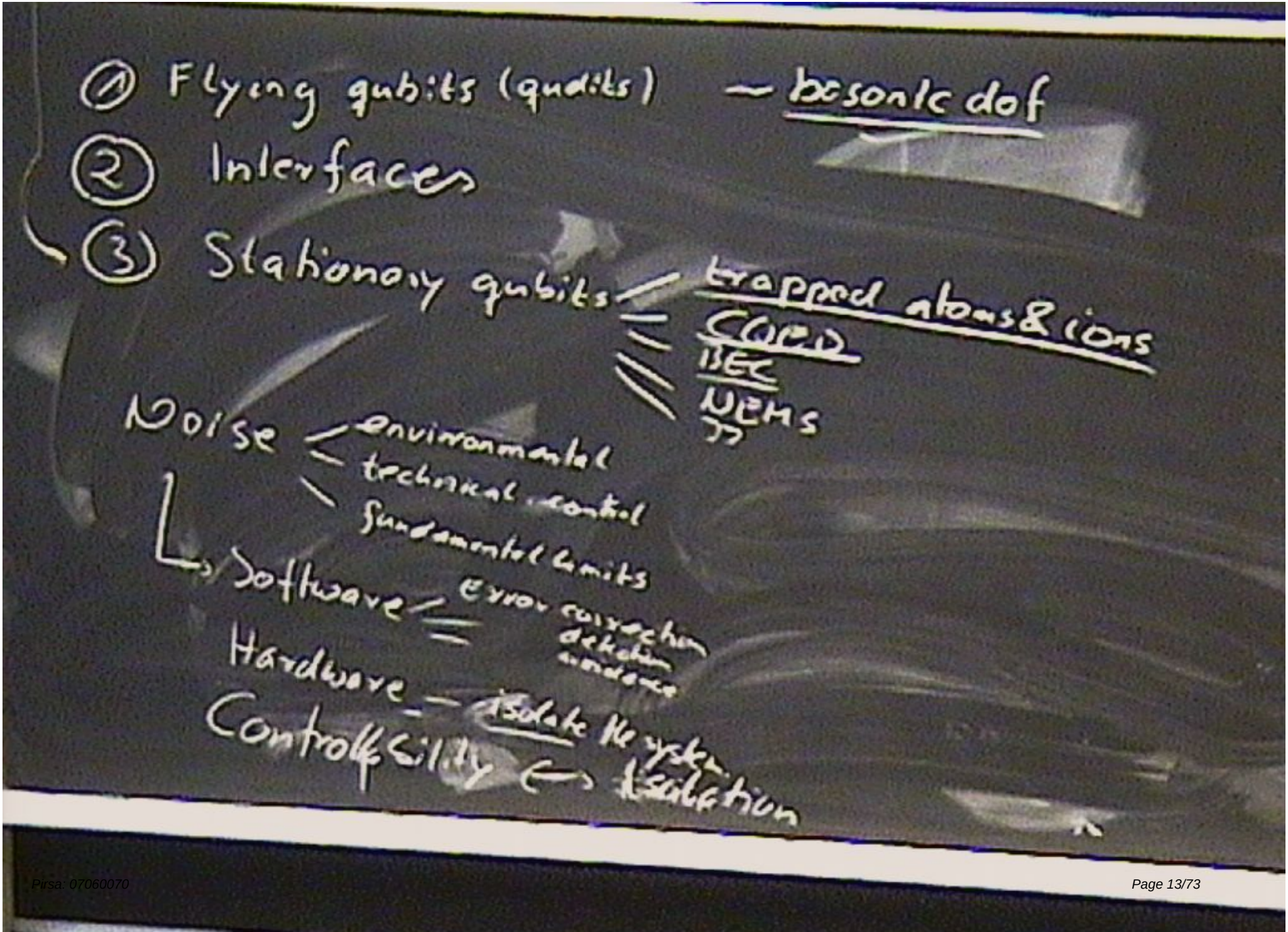

① Flying qubits (qudits) ~ bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
CQED
BEC
NEMS

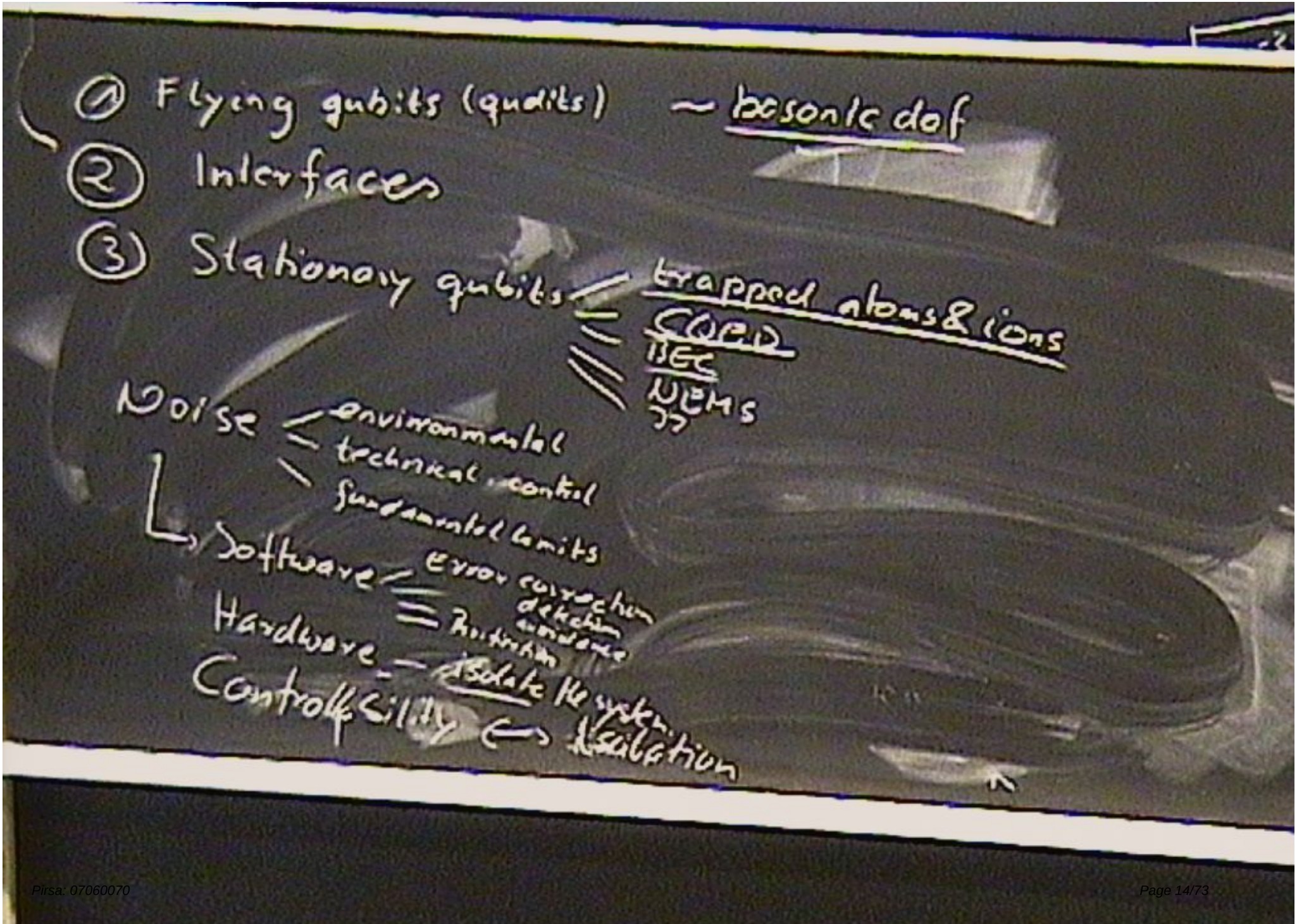

① Flying qubits (qudits) ~ bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
CQED
IBEC
NEMS
Noise
environmental
technical control
fundamental limits

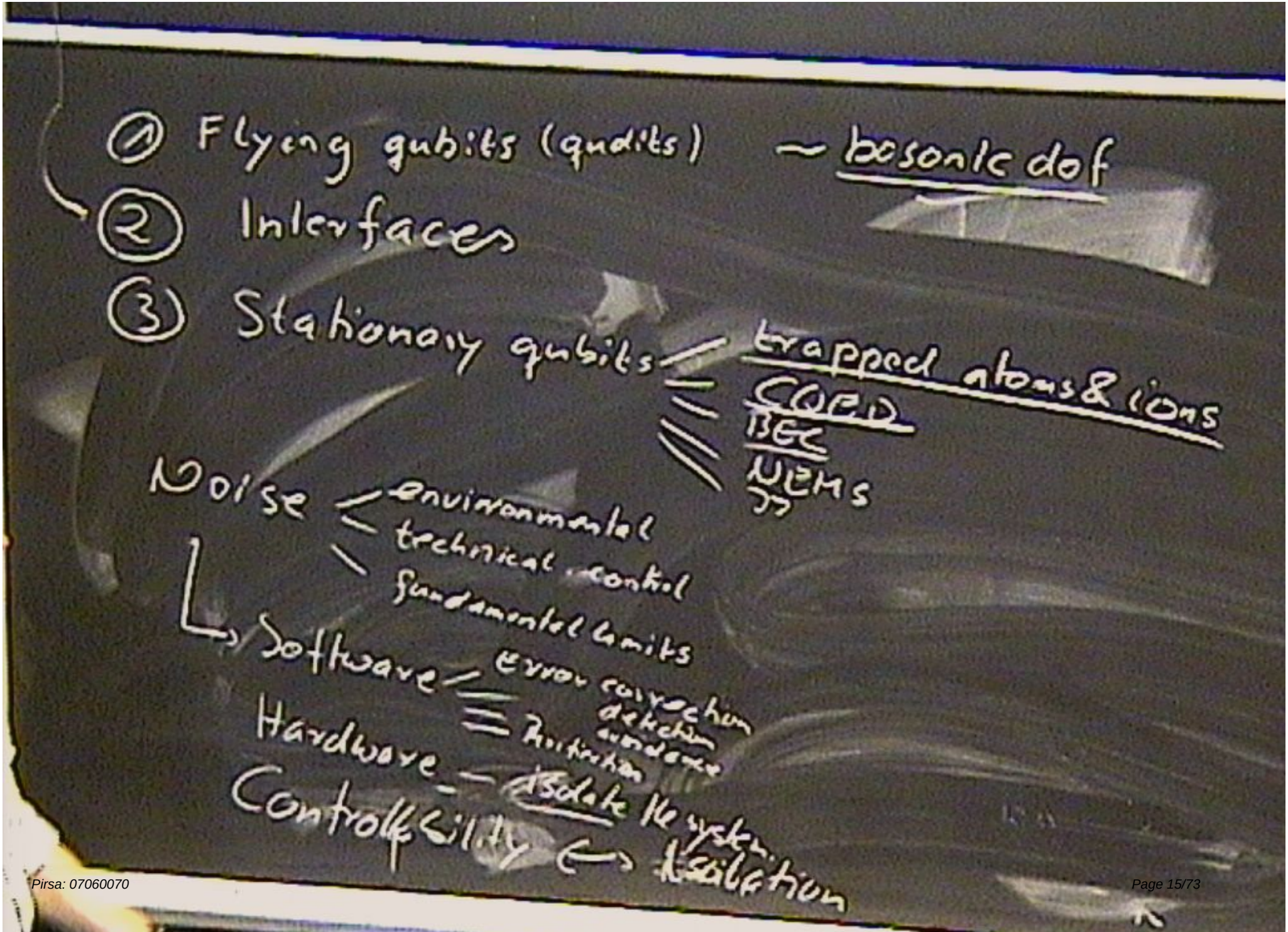

① Flying qubits (qudits) ~ bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
SQUID
BEC
NEMS
Noise
environmental
technical control
fundamental limits

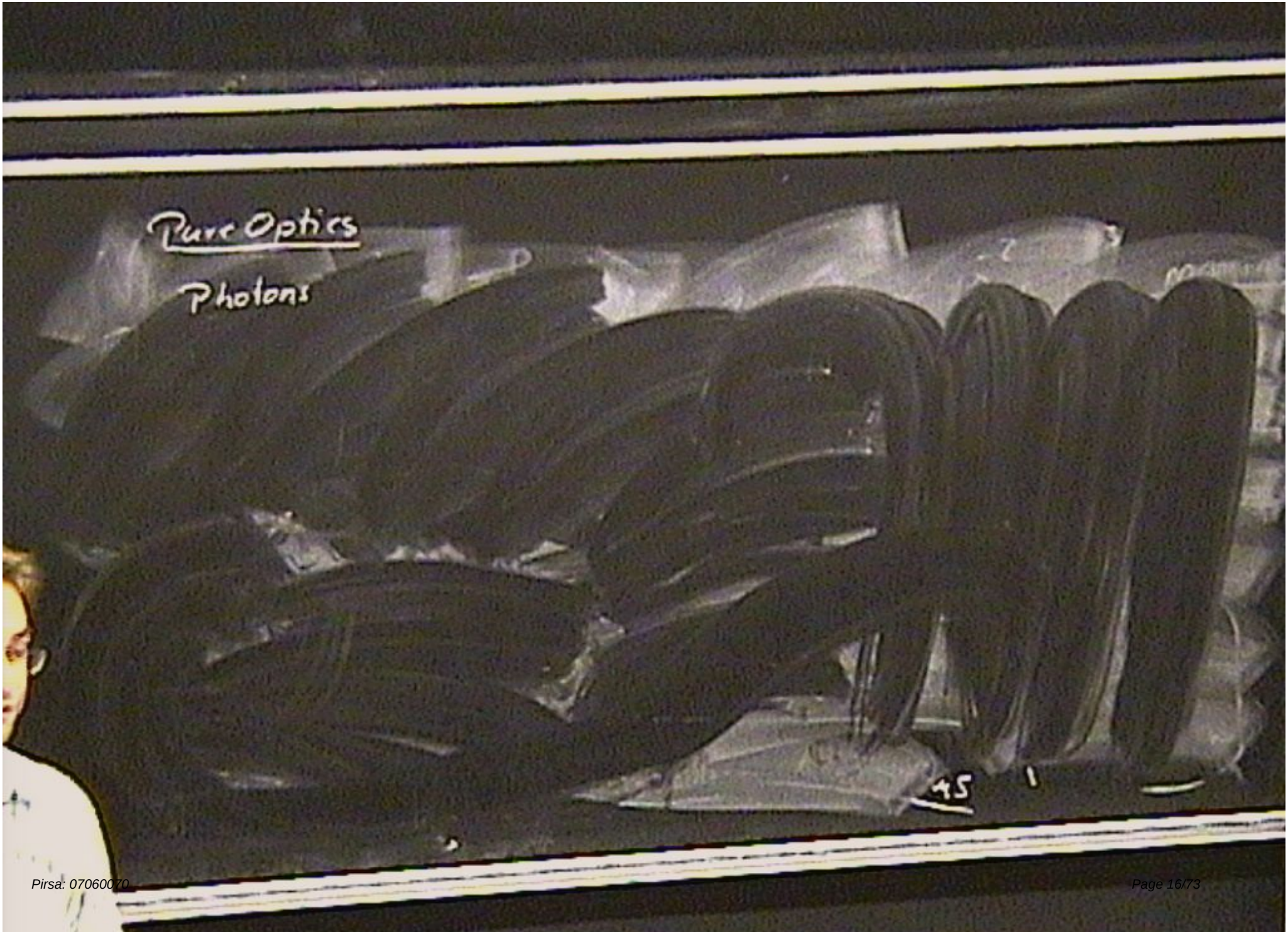

① Flying qubits (qudits) ~ bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
SQUID
BEC
NEMS
Noise
environmental
technical control
fundamental limits
Software
Hardware

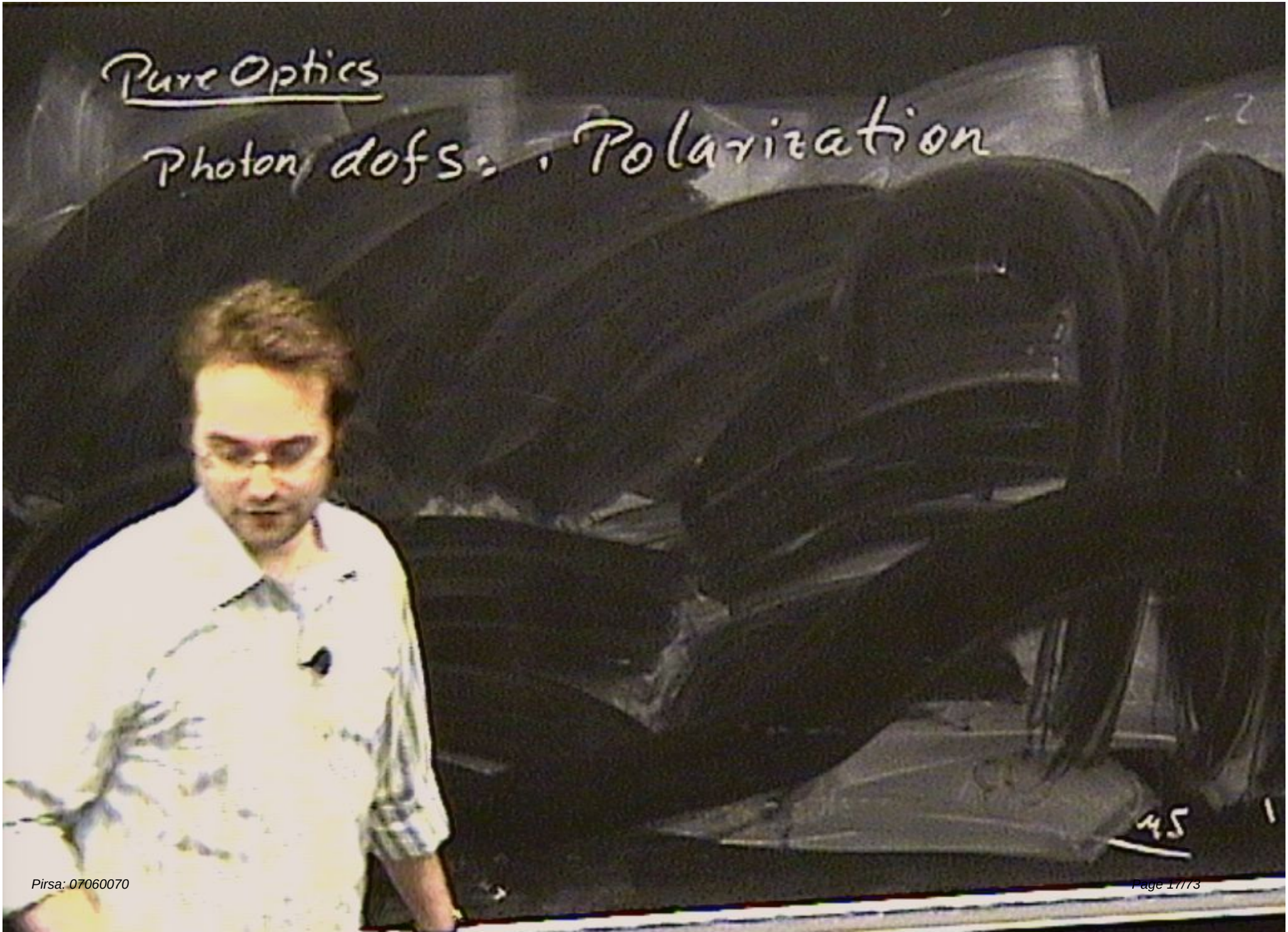

① Flying qubits (qudits) ~ bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
SQED
TSC
NEMS
Noise
environmental
technical control
fundamental limits
Software
error correction
detection
avoidance
Hardware

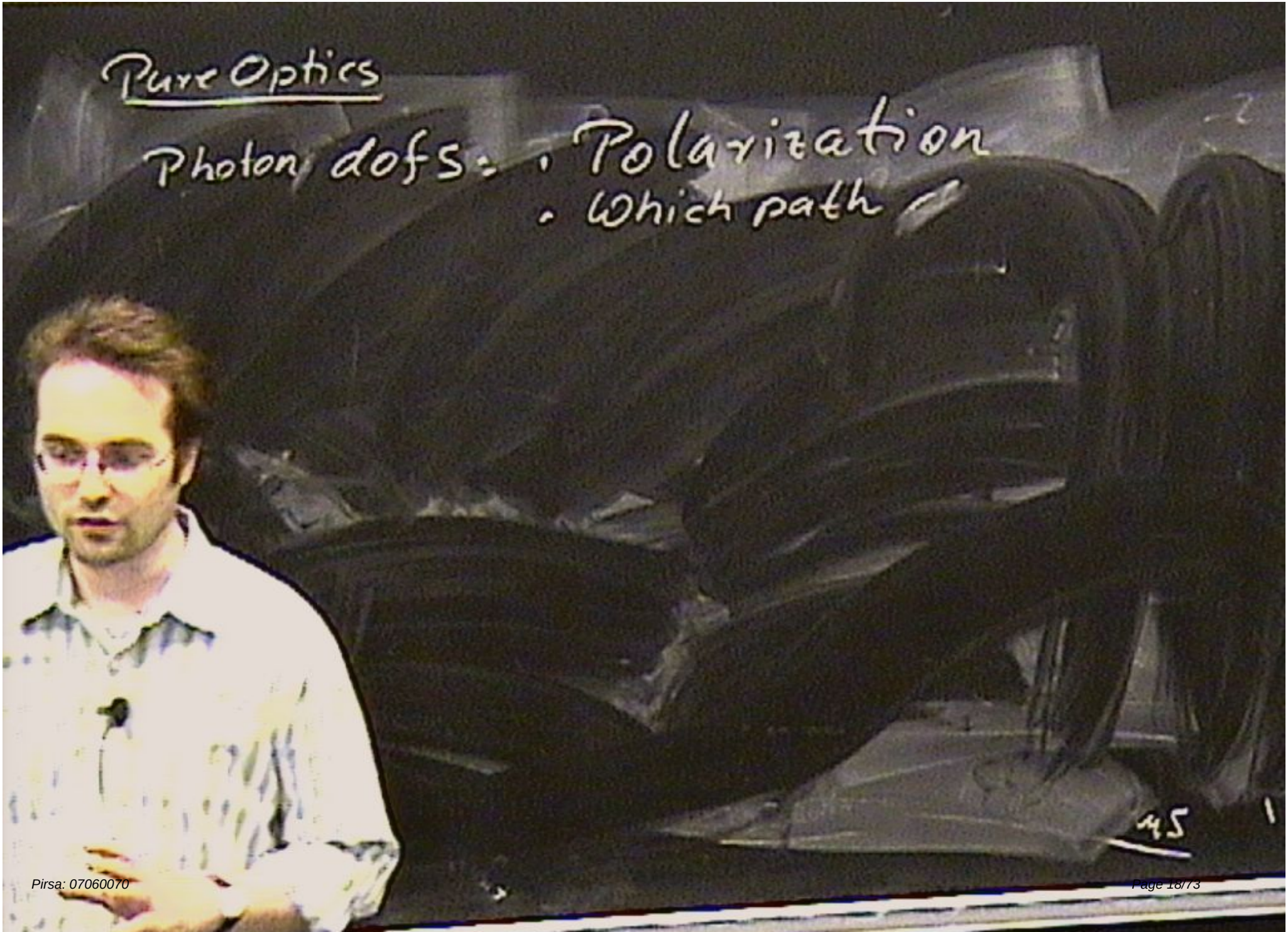

① Flying qubits (qudits) — bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
CQED
BEC
NEMS
Noise
environmental
technical control
fundamental limits
Software
error correction
detection
avoidance
Hardware
isolate
Controllability
isolation

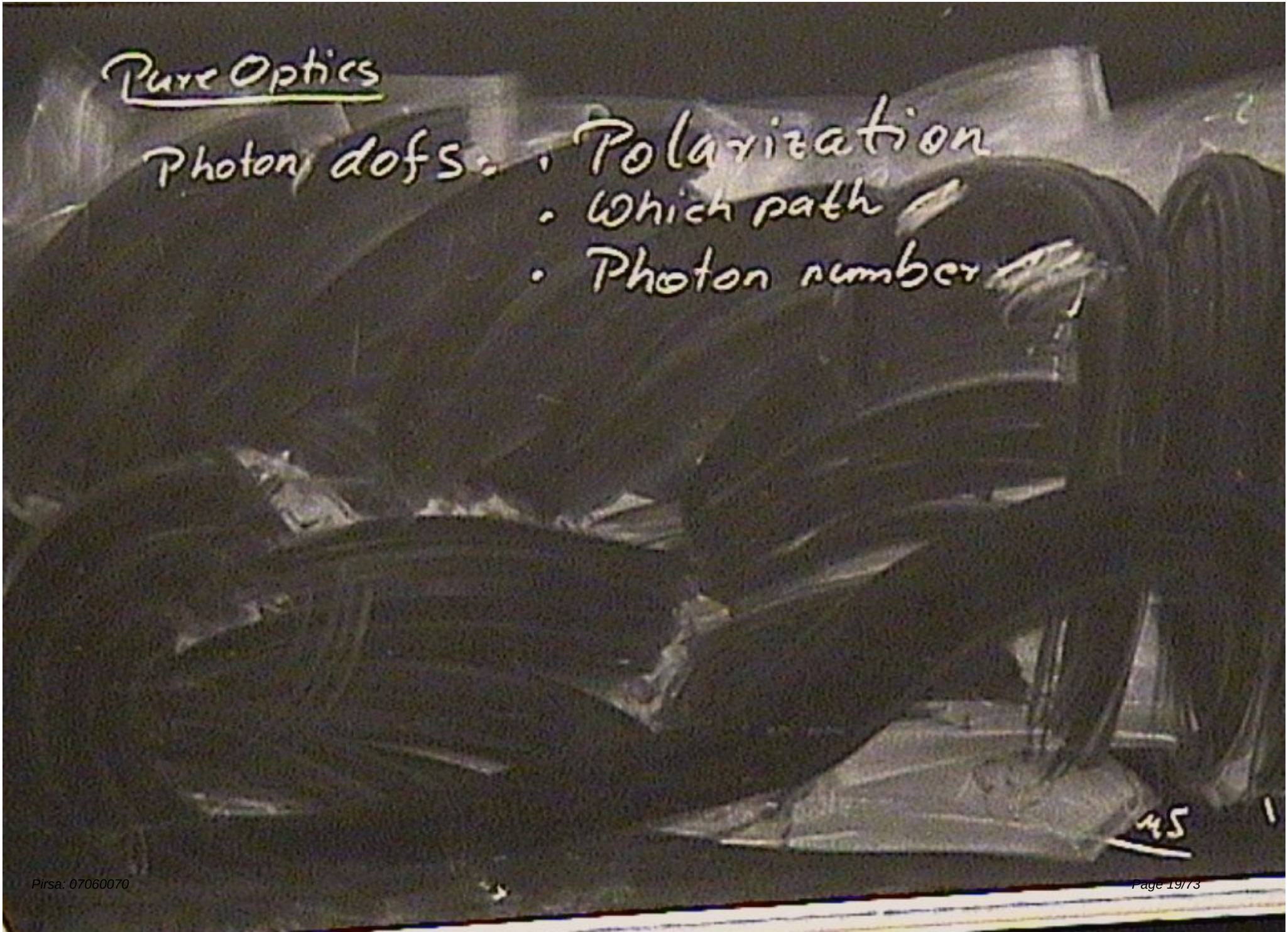

① Flying qubits (qudits) ~ bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
SQED
BEC
NEMS
Noise
environmental
technical control
fundamental limits
Software
error correction
detection
avoidance
Hardware
Controllability
isolation

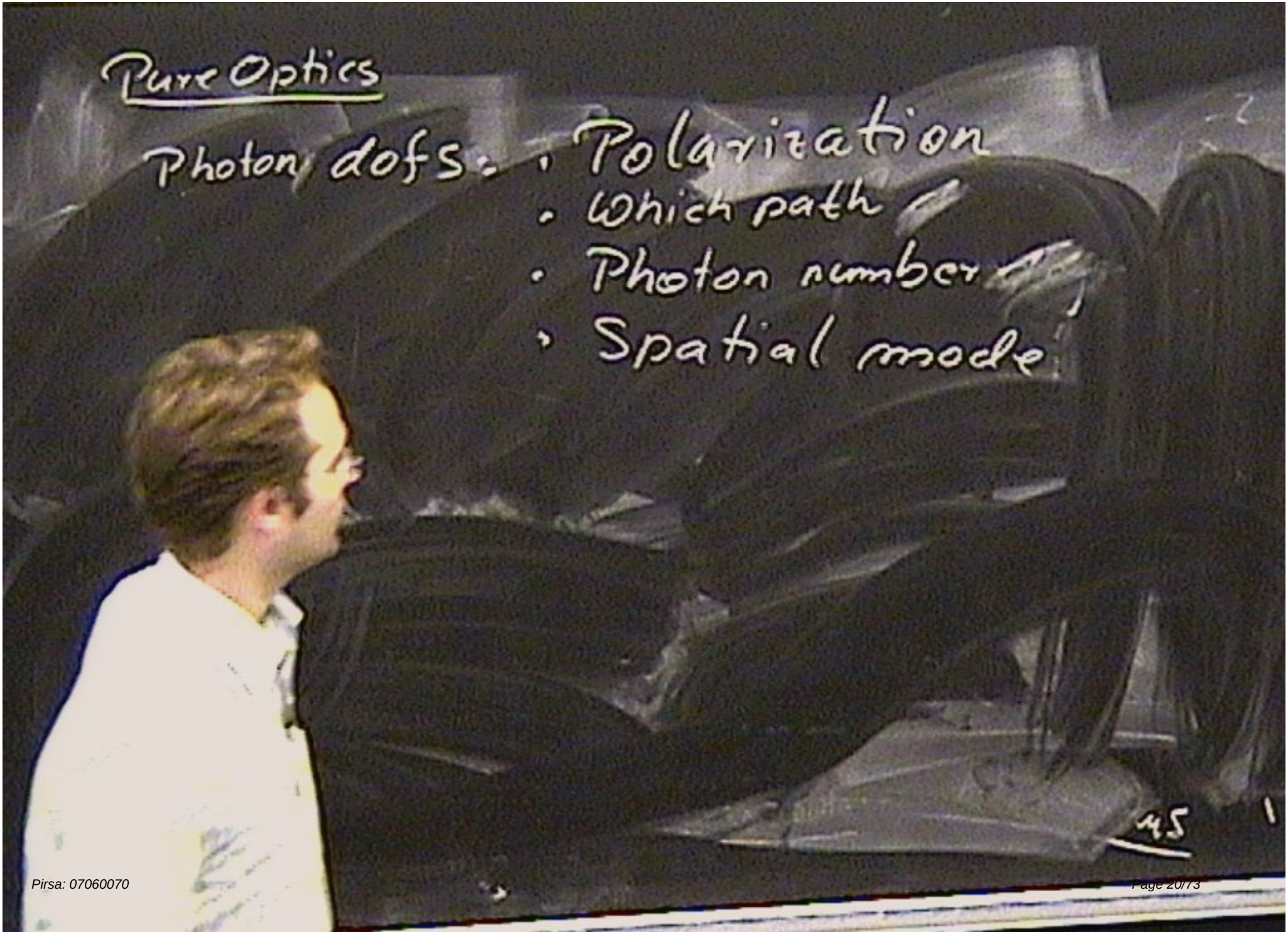

① Flying qubits (qudits) ~ bosonic dof
② Interfaces
③ Stationary qubits
trapped atoms & ions
CQED
BEC
NEMS
Noise
environmental
technical control
fundamental limits
Software
error correction
detection
Hardware
Controllability
isolation

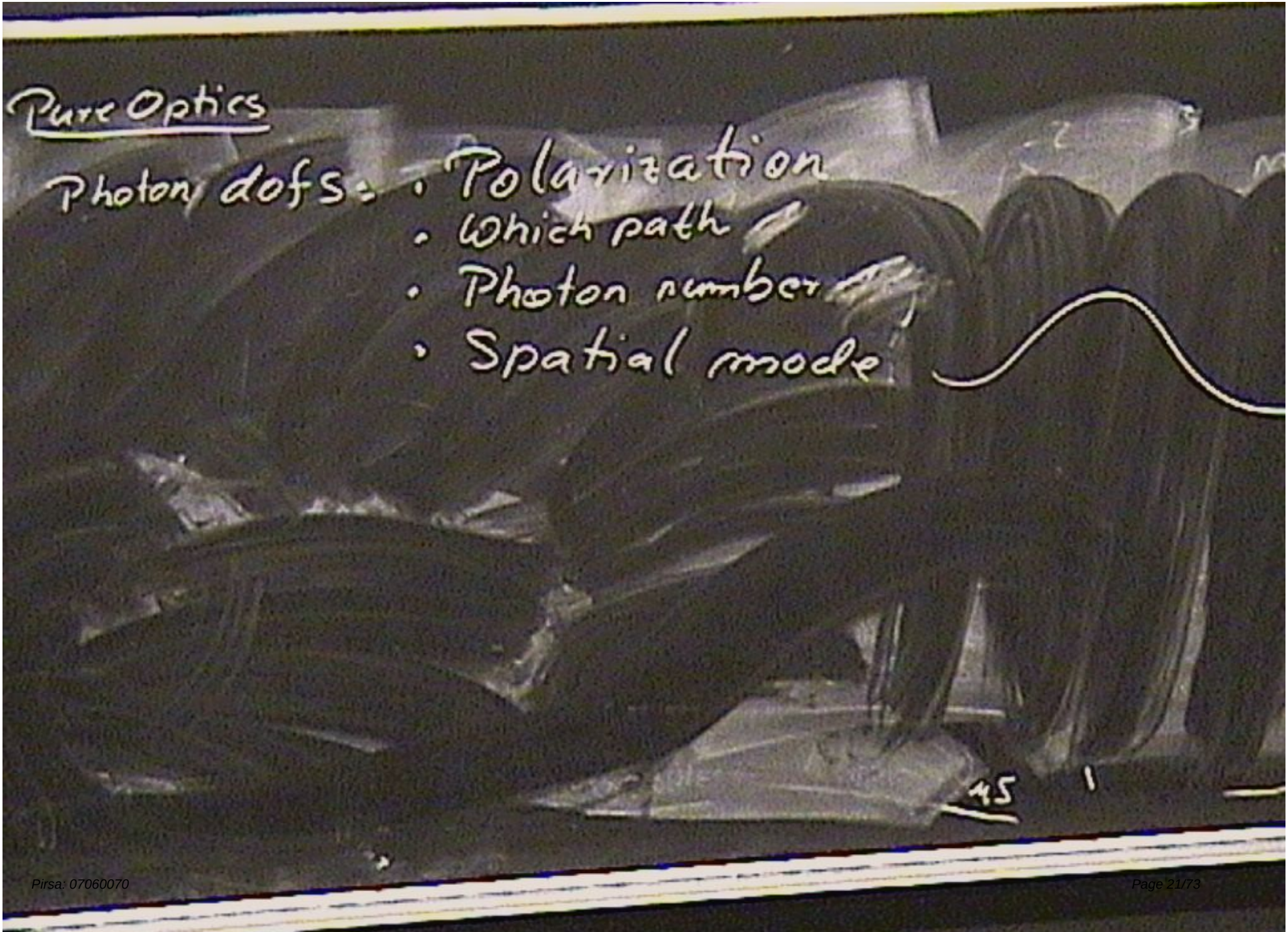

Pure Optics
Photons

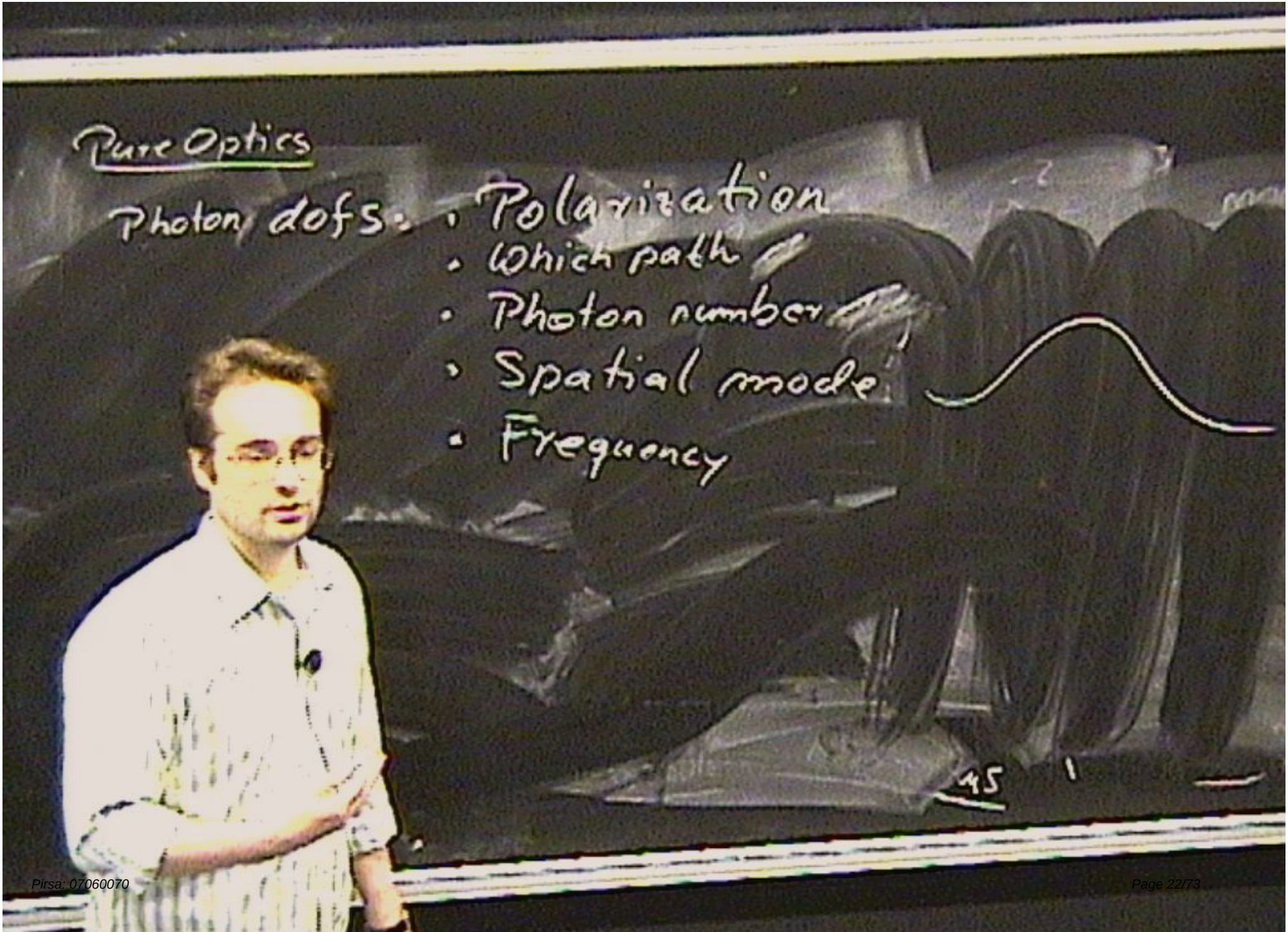

Pure Optics
Photon dofs: . Polarization
45

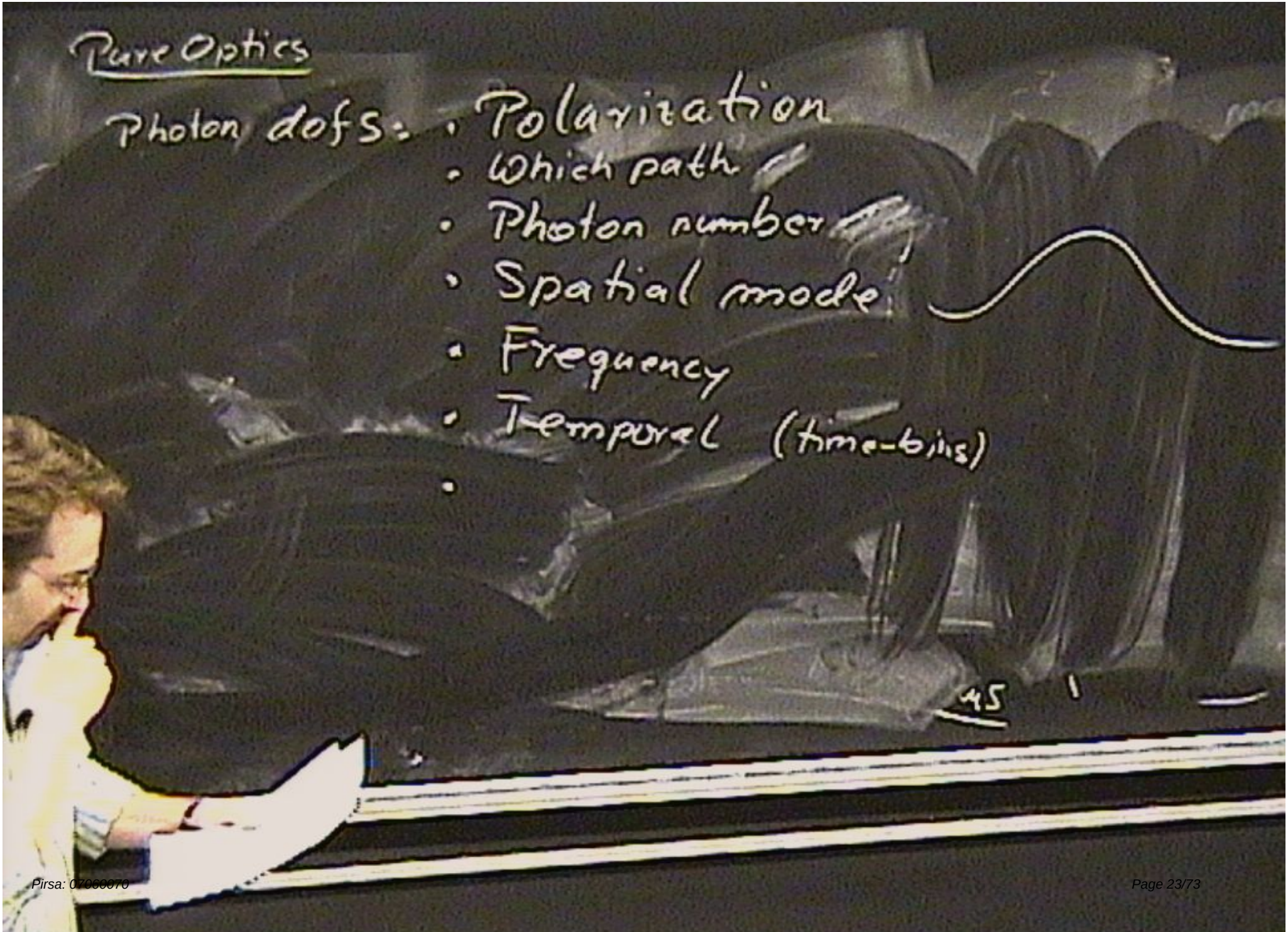

Pure Optics
Photon dofs: . Polarization
. Which path

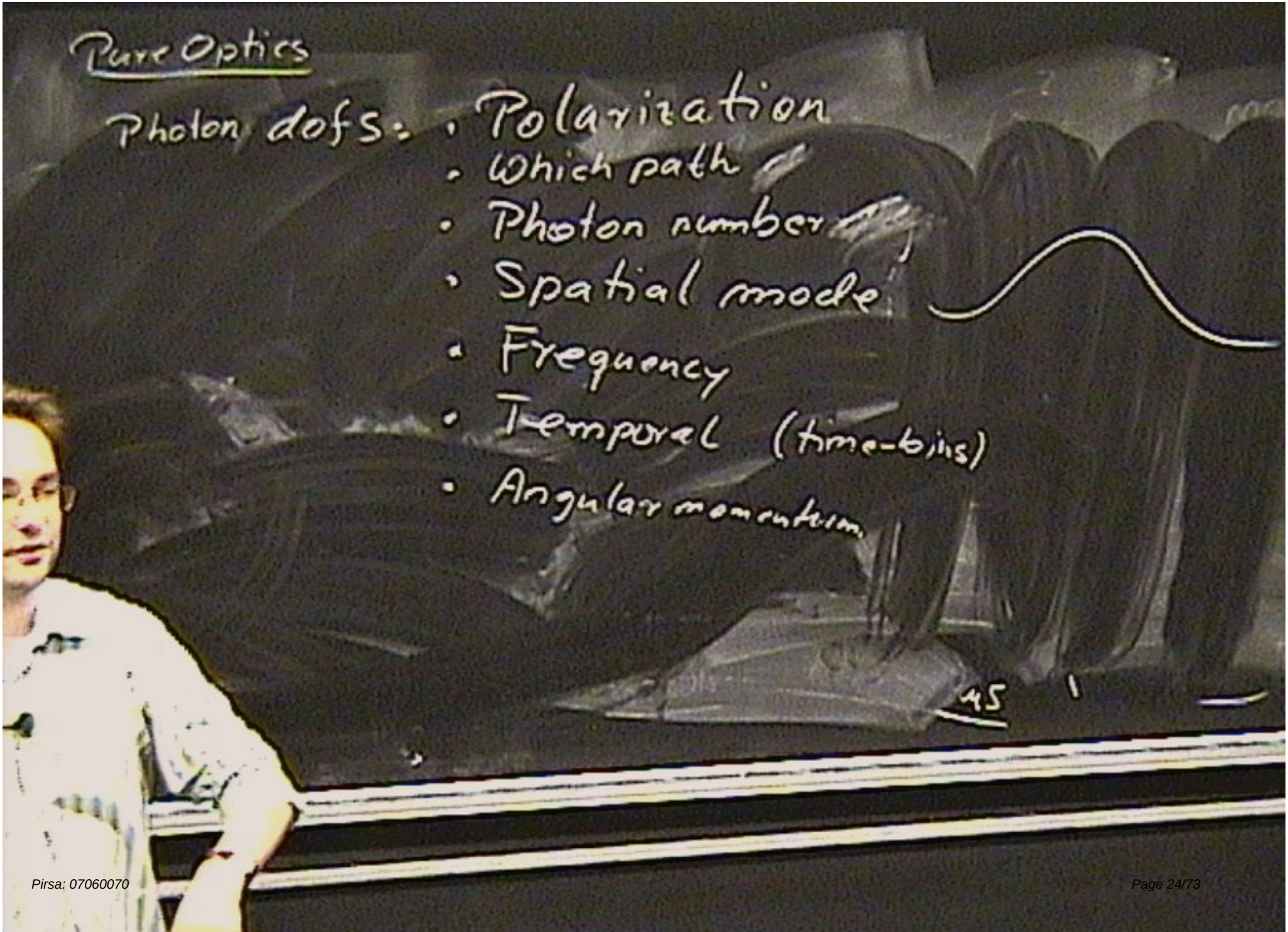

Pure Optics
Photon dofs: . Polarization
. Which path
. Photon number

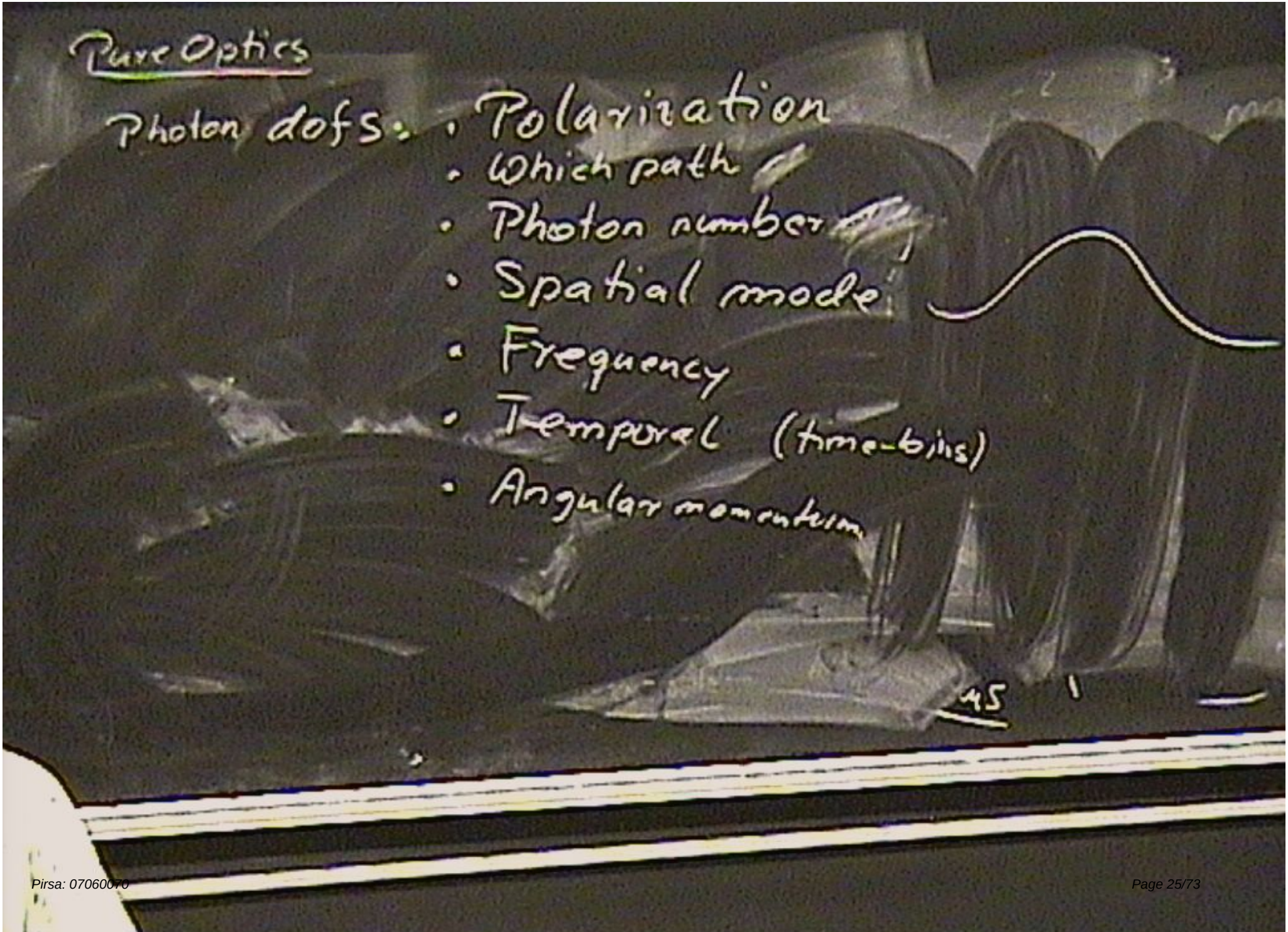

Pure Optics
Photon dofs:
. Polarization
. Which path
. Photon number
. Spatial mode
45

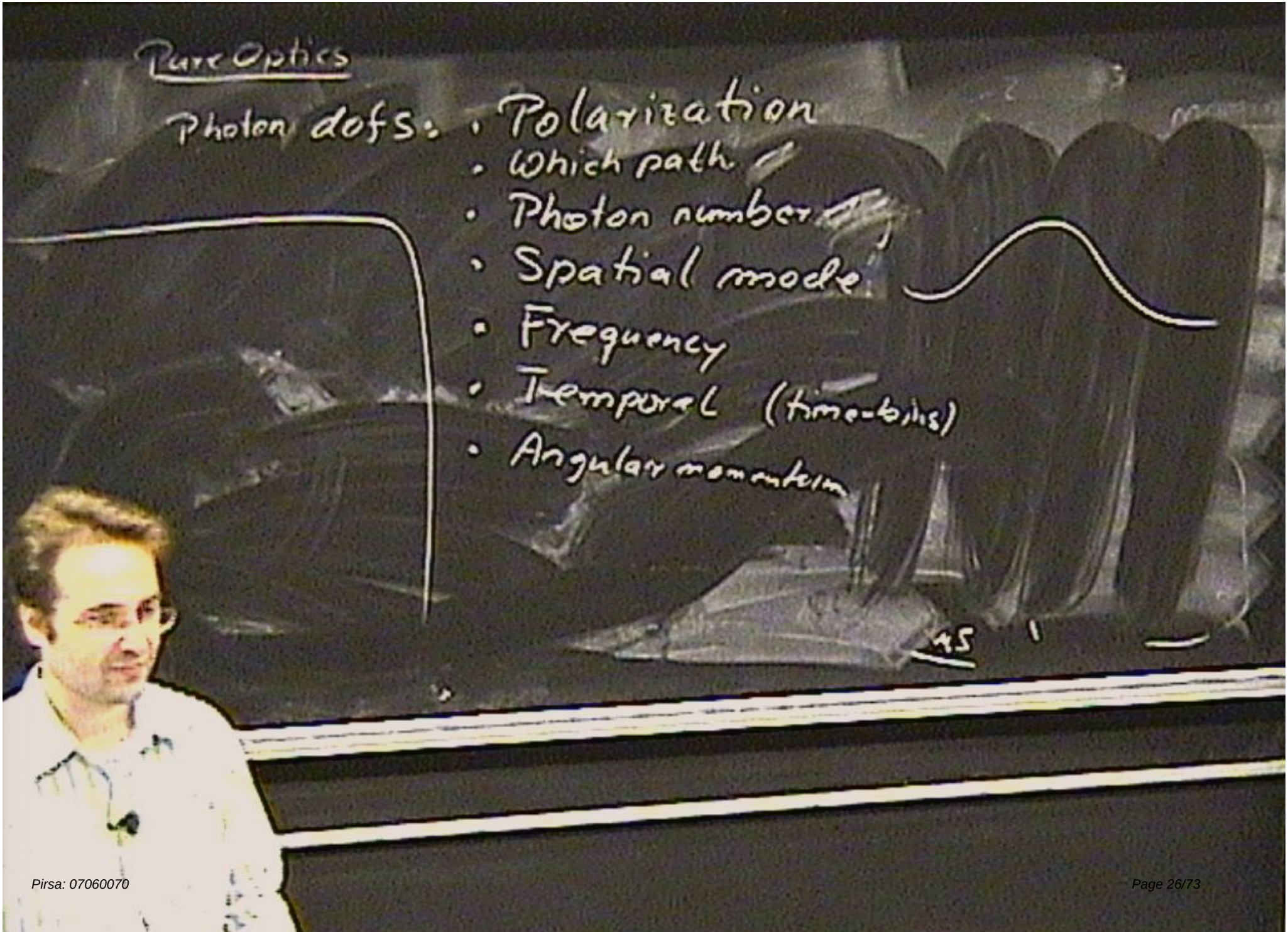

Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
45

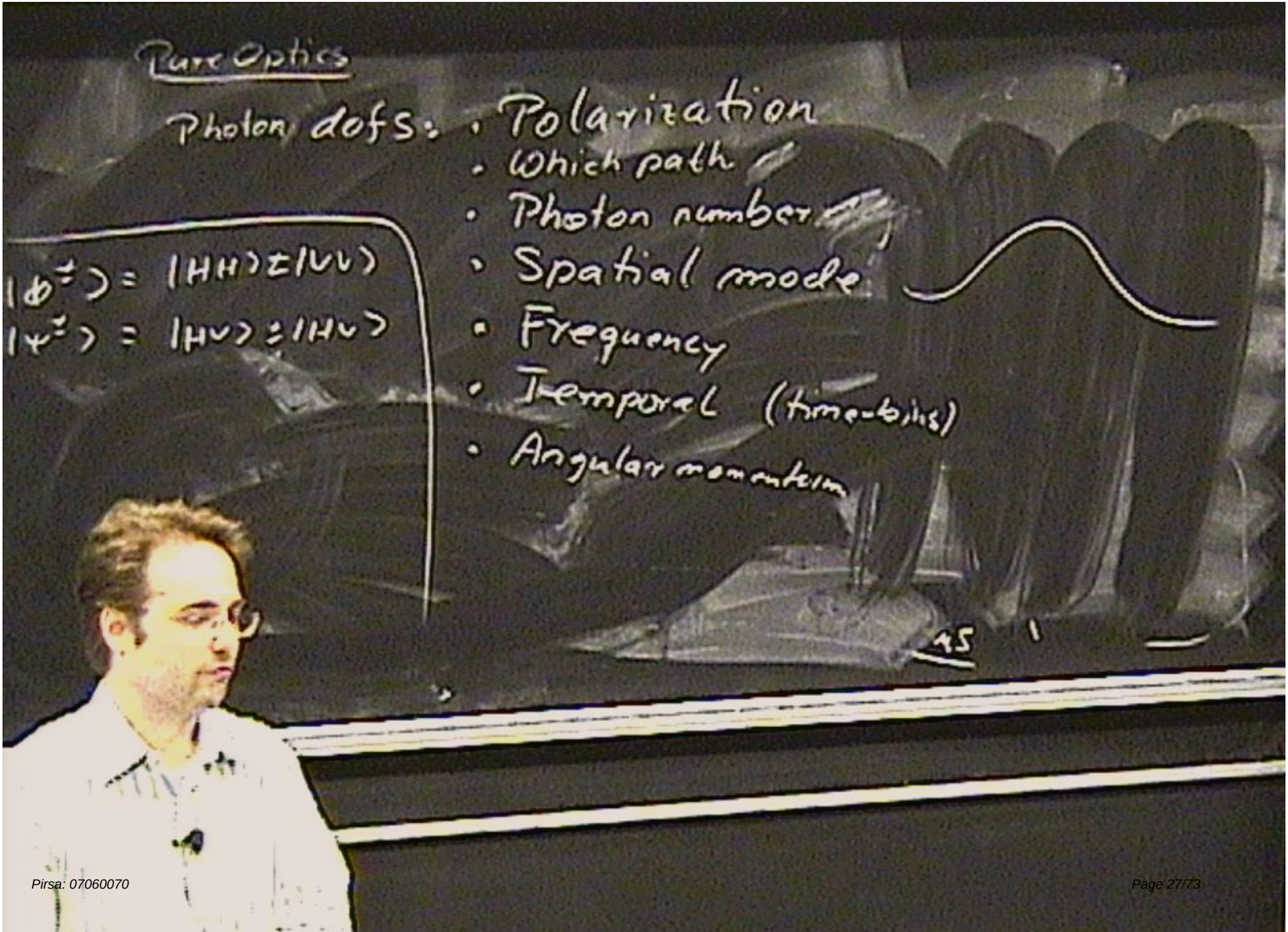

Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
• Frequency
45

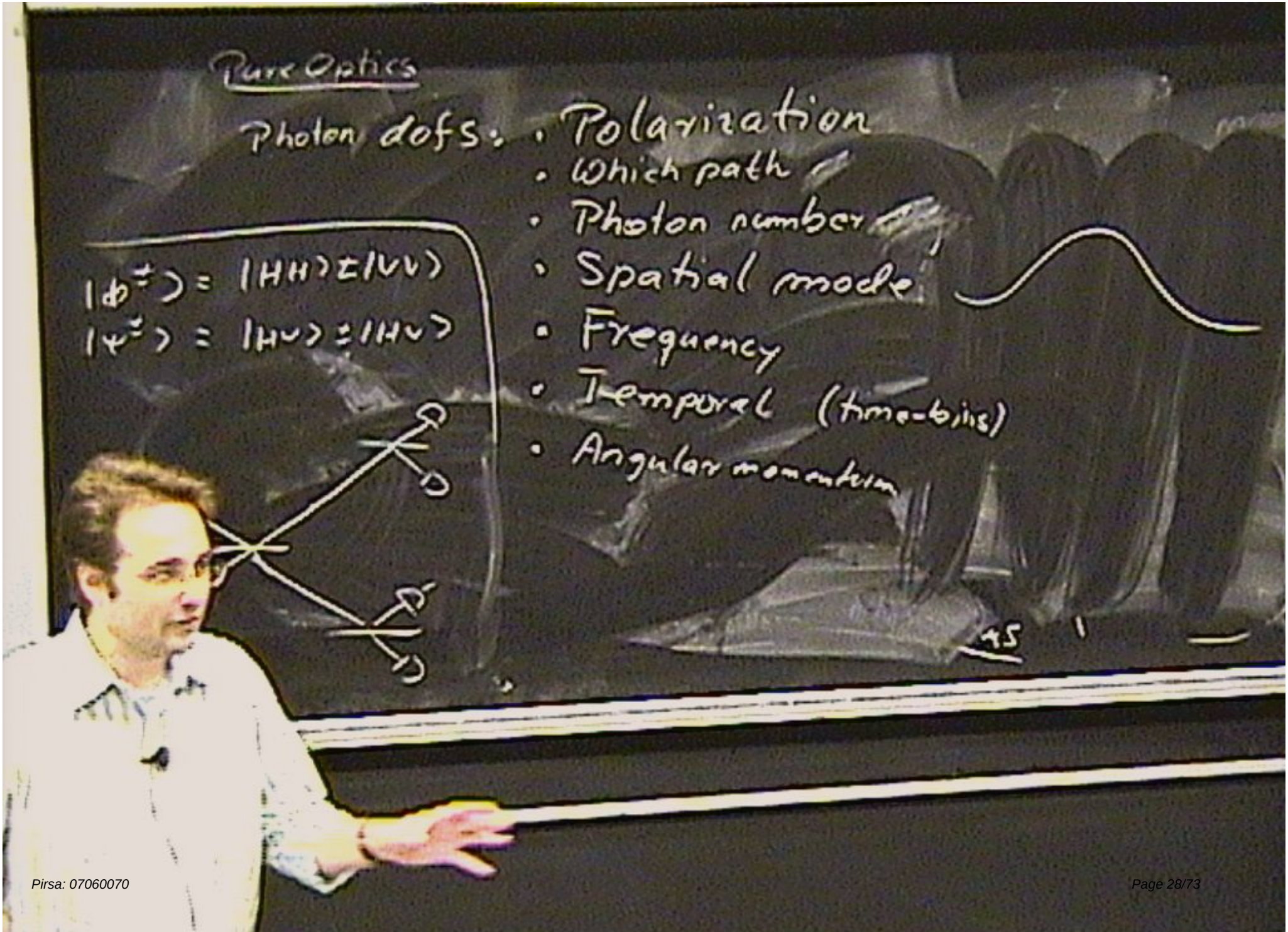

Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
• Frequency
• Temporal (time-bins)
•
45

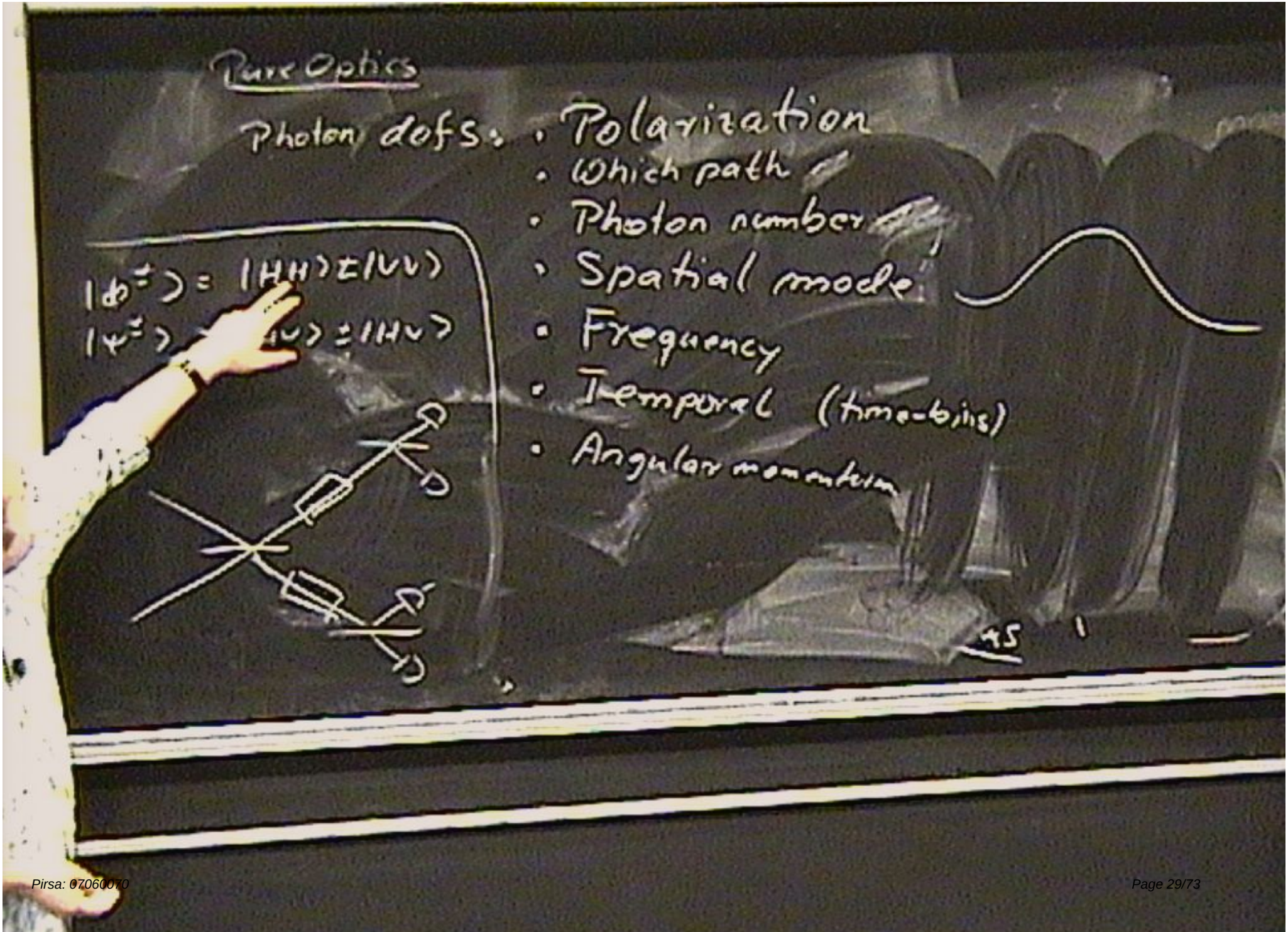

Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
• Frequency
• Temporal (time-bins)
• Angular momentum
45


Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
• Frequency
• Temporal (time-bins)
• Angular momentum
45


Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
• Frequency
• Temporal (time-bins)
• Angular momentum
45


Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
• Frequency
• Temporal (time-bins)
• Angular momentum
$|\Phi^{\pm}\rangle = |HH\rangle \pm |VV\rangle$
$|\Psi^{\pm}\rangle = |HV\rangle \pm |HV\rangle$
45


Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
• Frequency
• Temporal (time-bins)
• Angular momentum
$|\phi^{\pm}\rangle = |HH\rangle \pm |VV\rangle$
$|\psi^{\pm}\rangle = |HV\rangle \pm |HV\rangle$
45

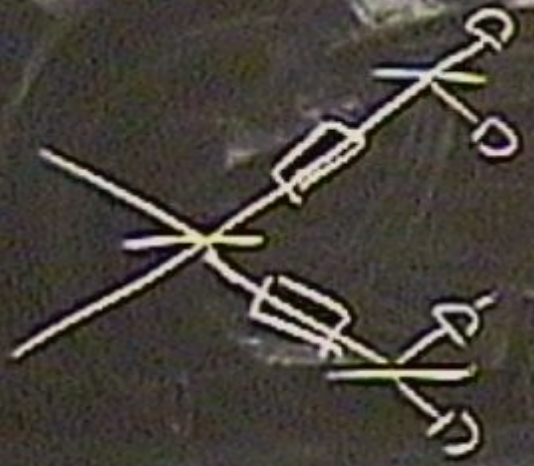

Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spatial mode
• Frequency
• Temporal (time-bins)
• Angular momentum
|Φ±⟩ = |HH⟩ ± |VV⟩
|Ψ±⟩ = |HV⟩ ± |HV⟩
45

Pure Optics

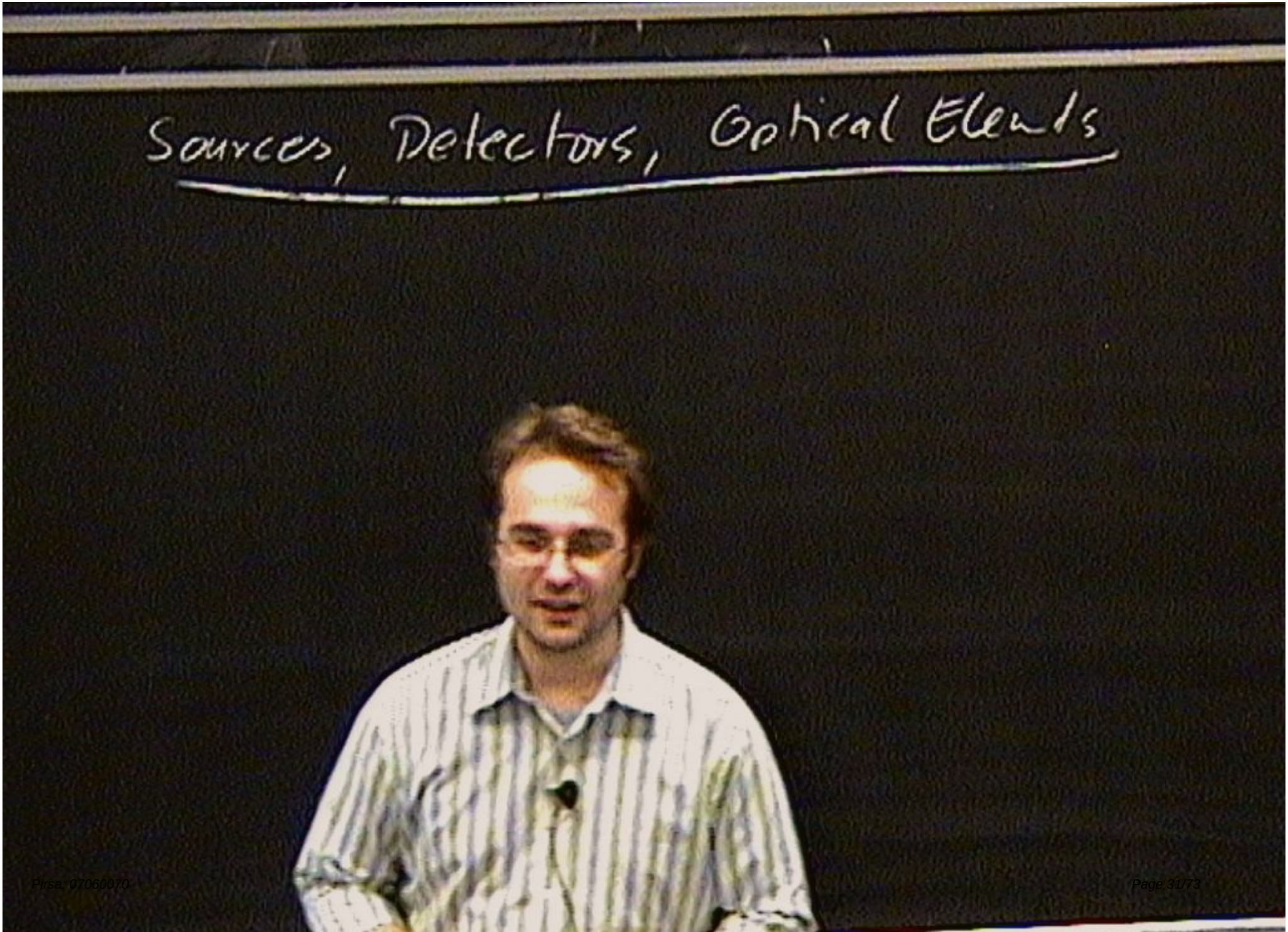
Photon dofs:
- Polarization
- Which path
- Photon number
- Spatial mode
- Frequency
- Temporal (time-bins)
- Angular momentum

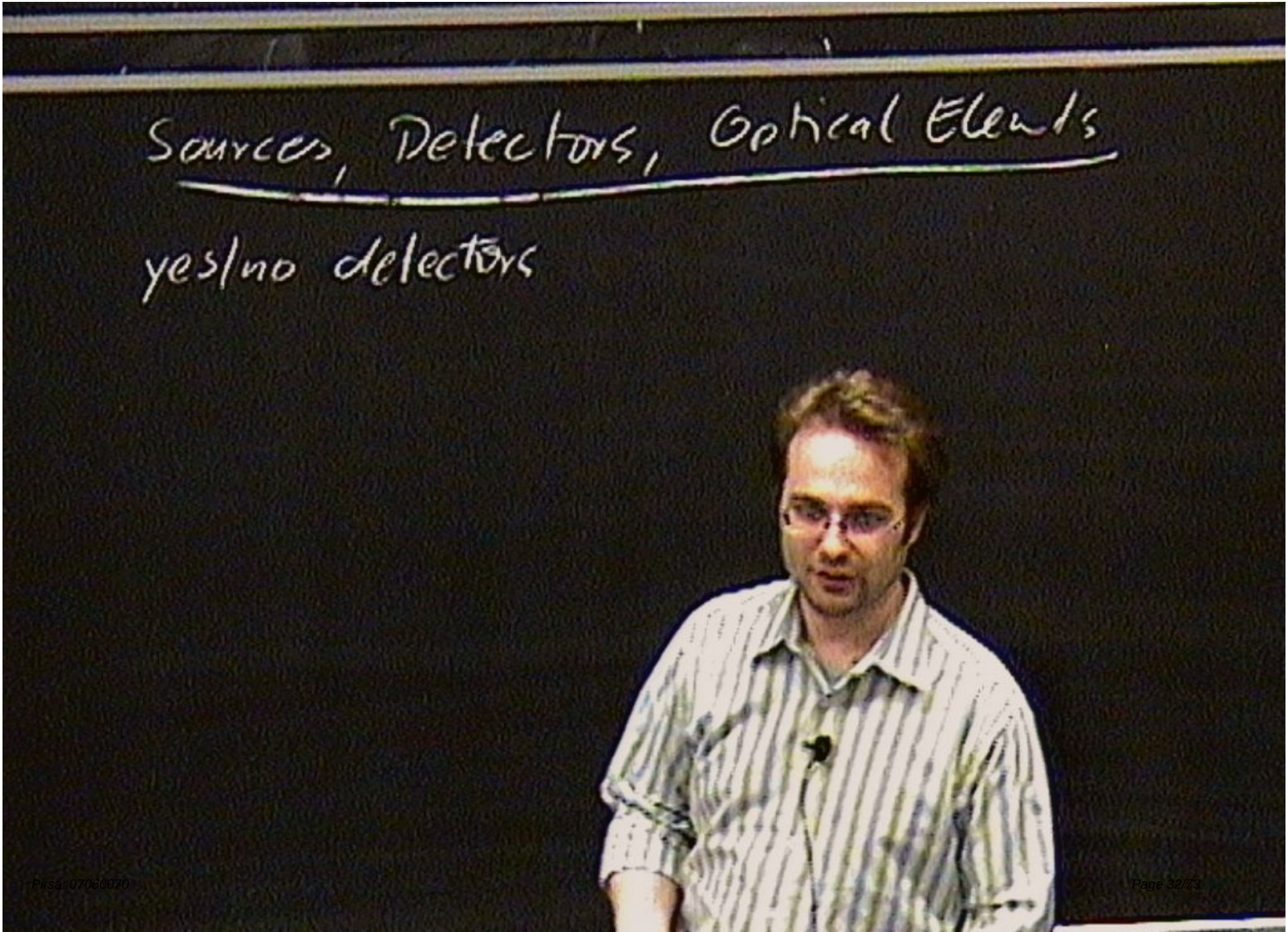
$|\phi^{\pm}\rangle = |HH\rangle \pm |VV\rangle$

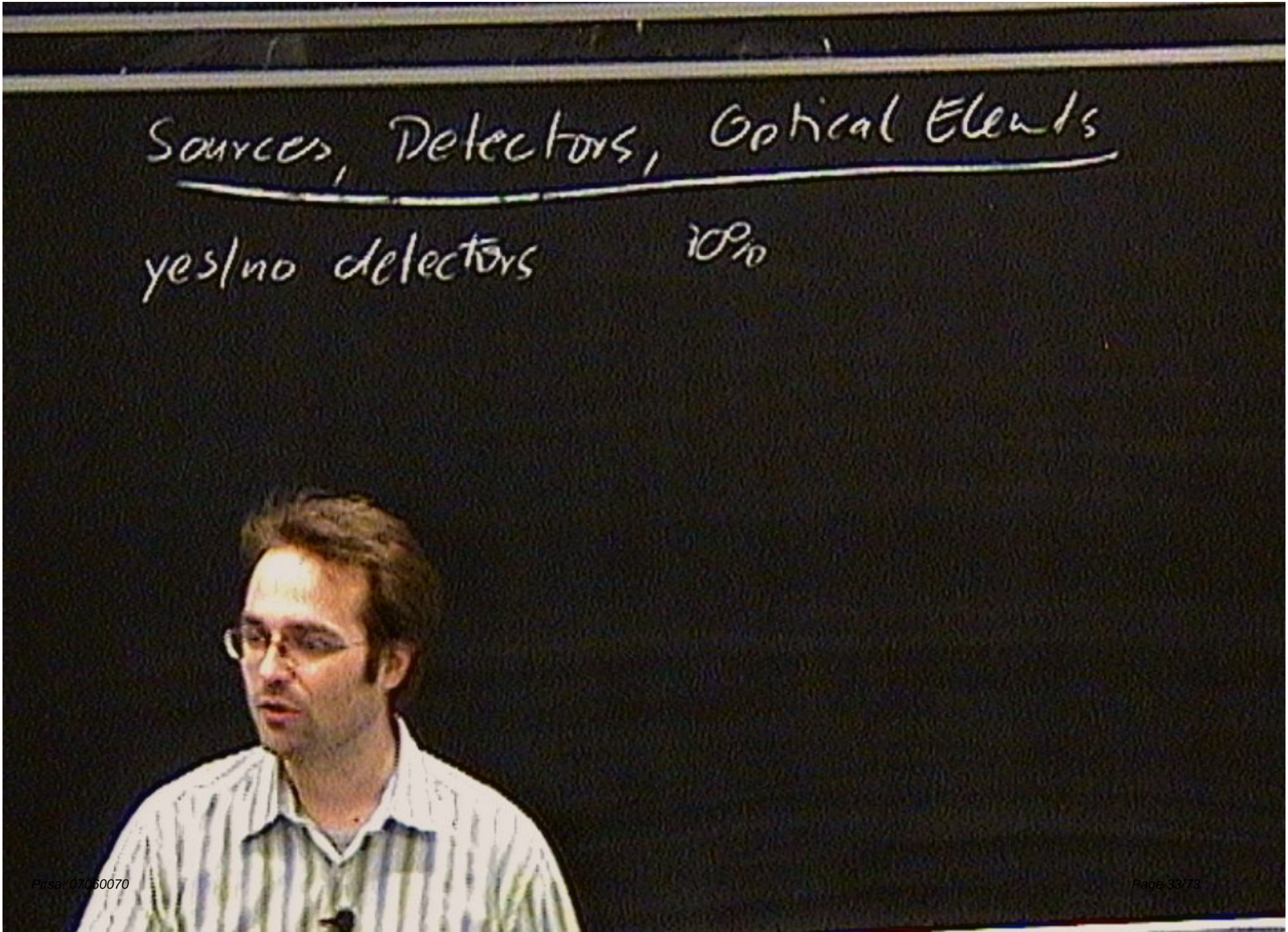
$|\psi^{\pm}\rangle = |HV\rangle \pm |HV\rangle$

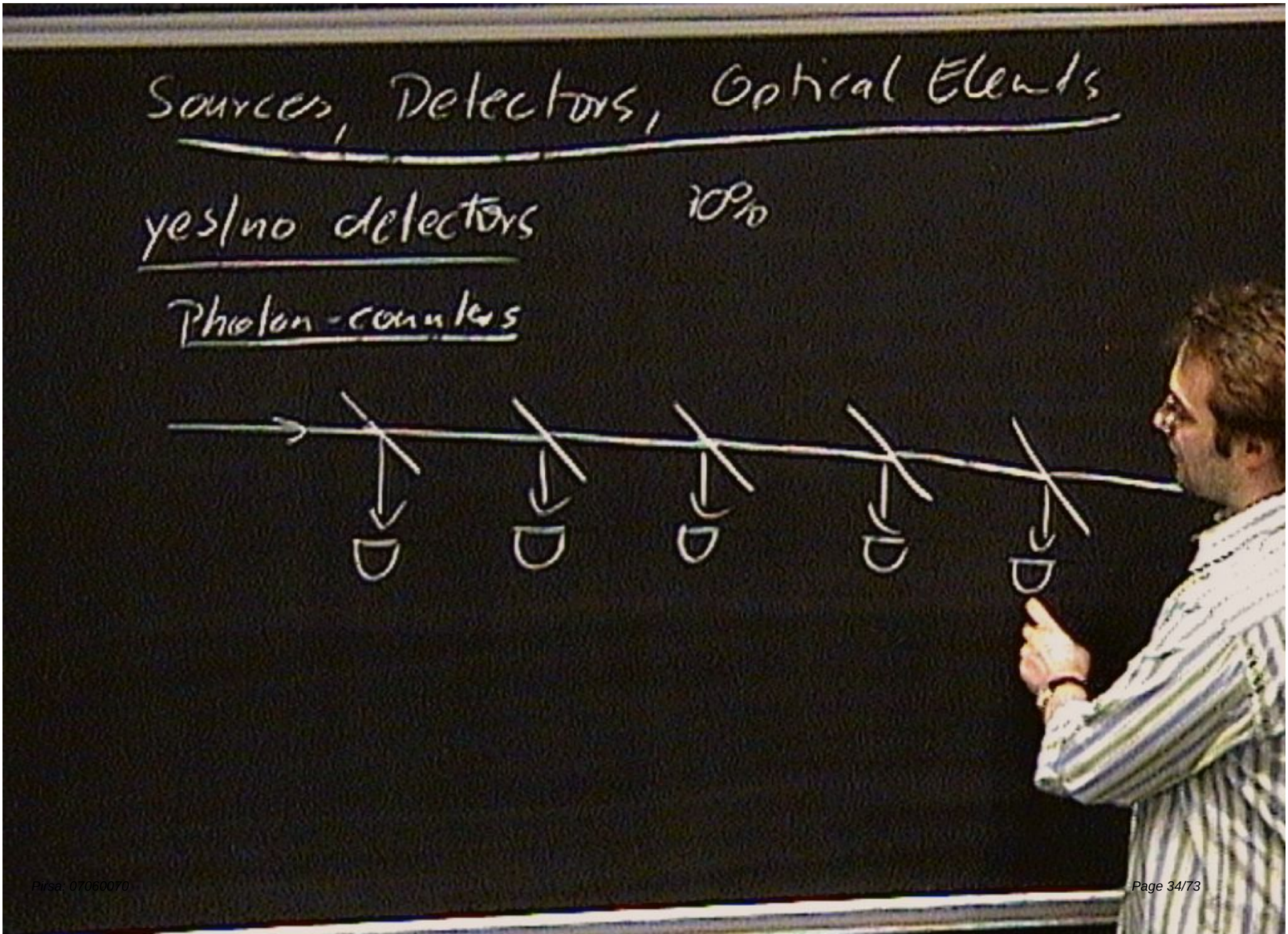


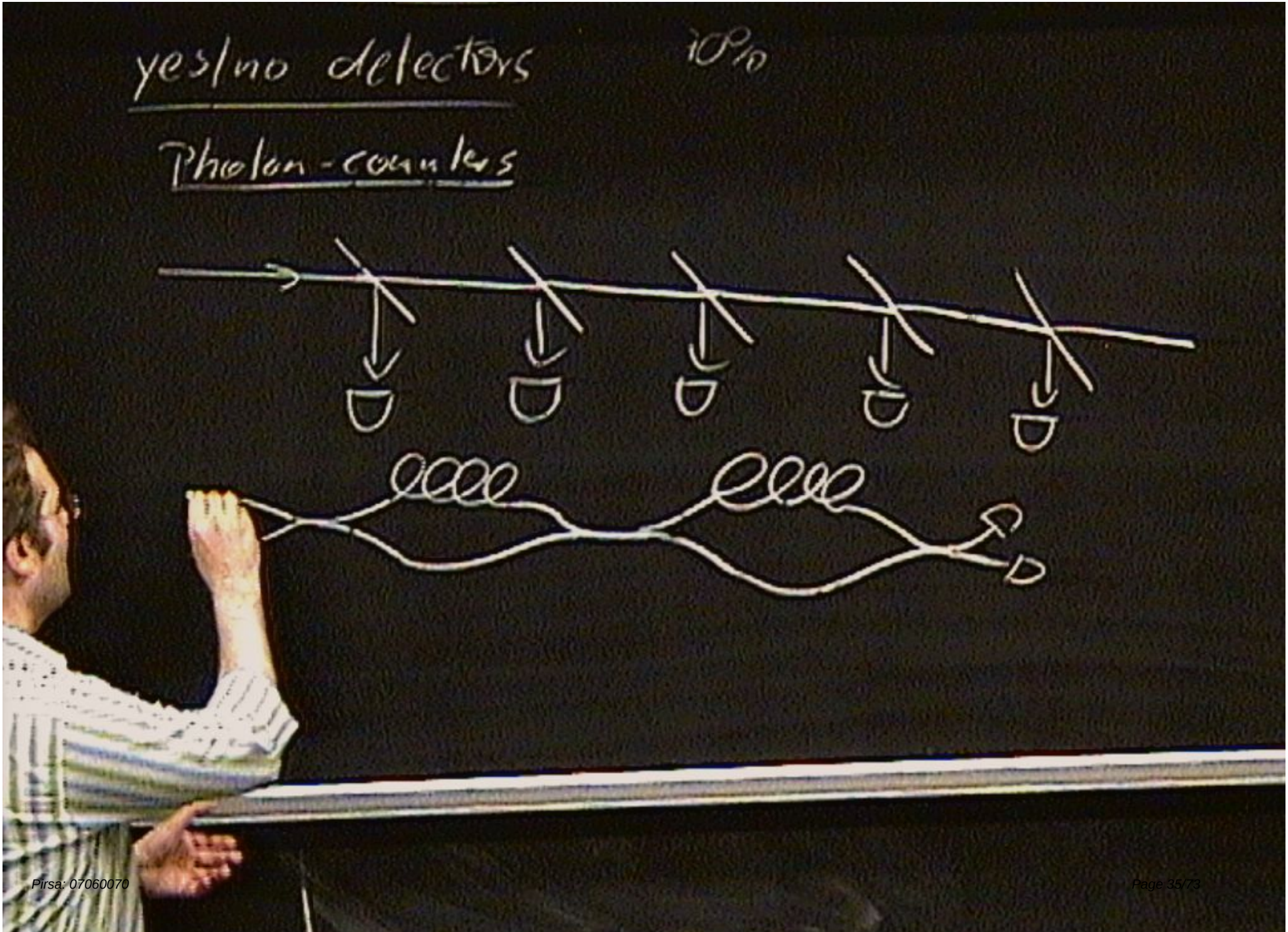
45°


Sources, Detectors, Optical Elements


Sources, Detectors, Optical Elements
yes/no detectors

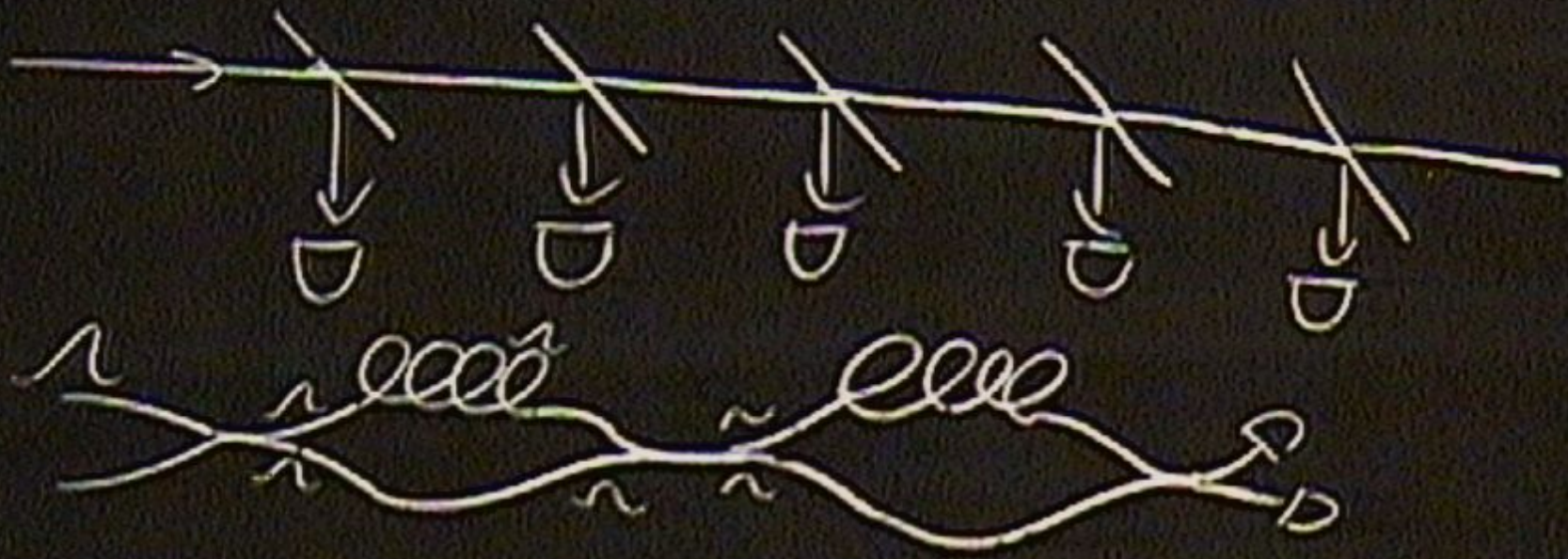

Sources, Detectors, Optical Elements
yes/no detectors 100%

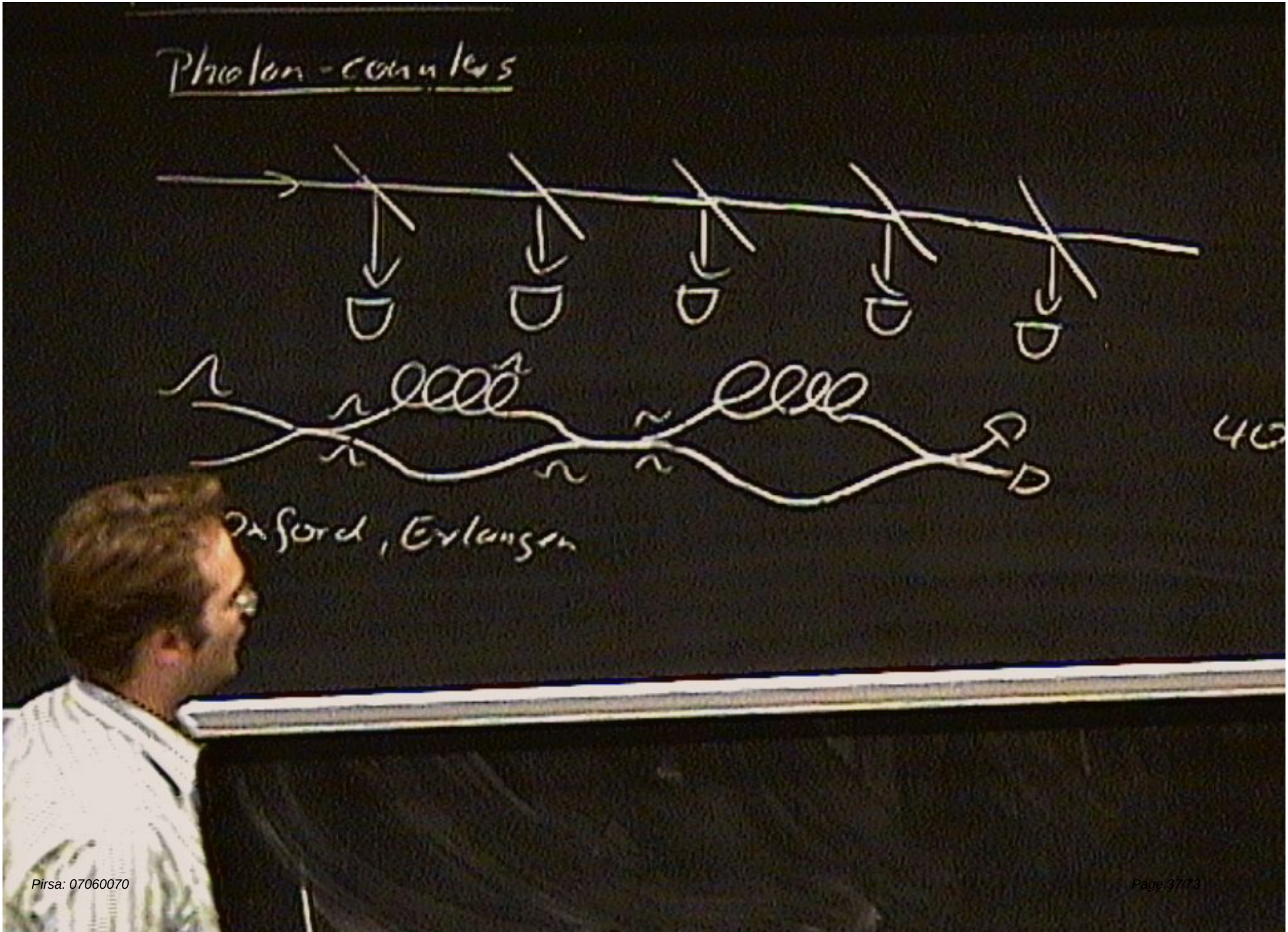

Sources, Detectors, Optical Elements
yes/no detectors
100%
Photon-counters

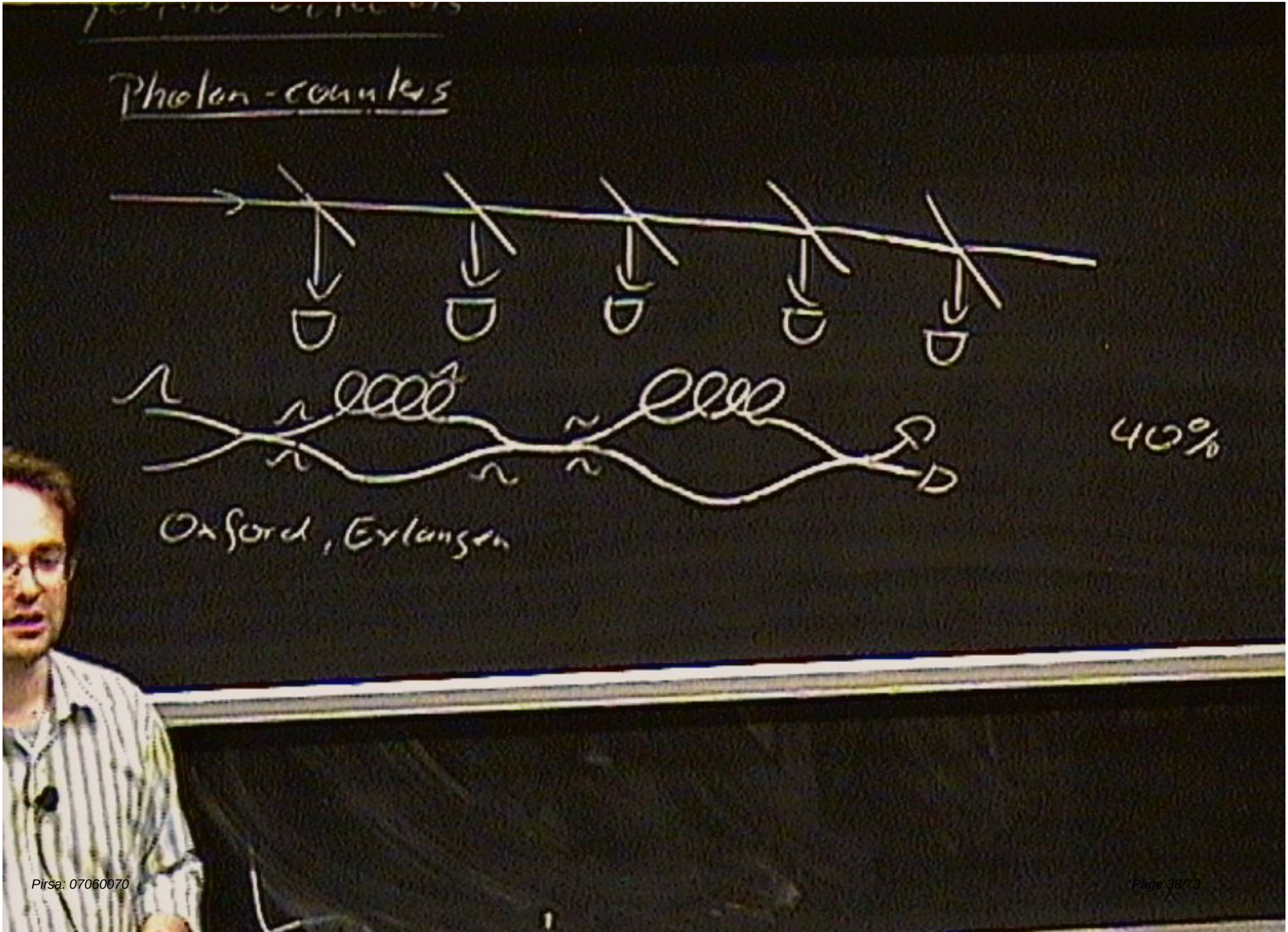

yes/no detectors
100%
Photon-counters

yes/no detectors

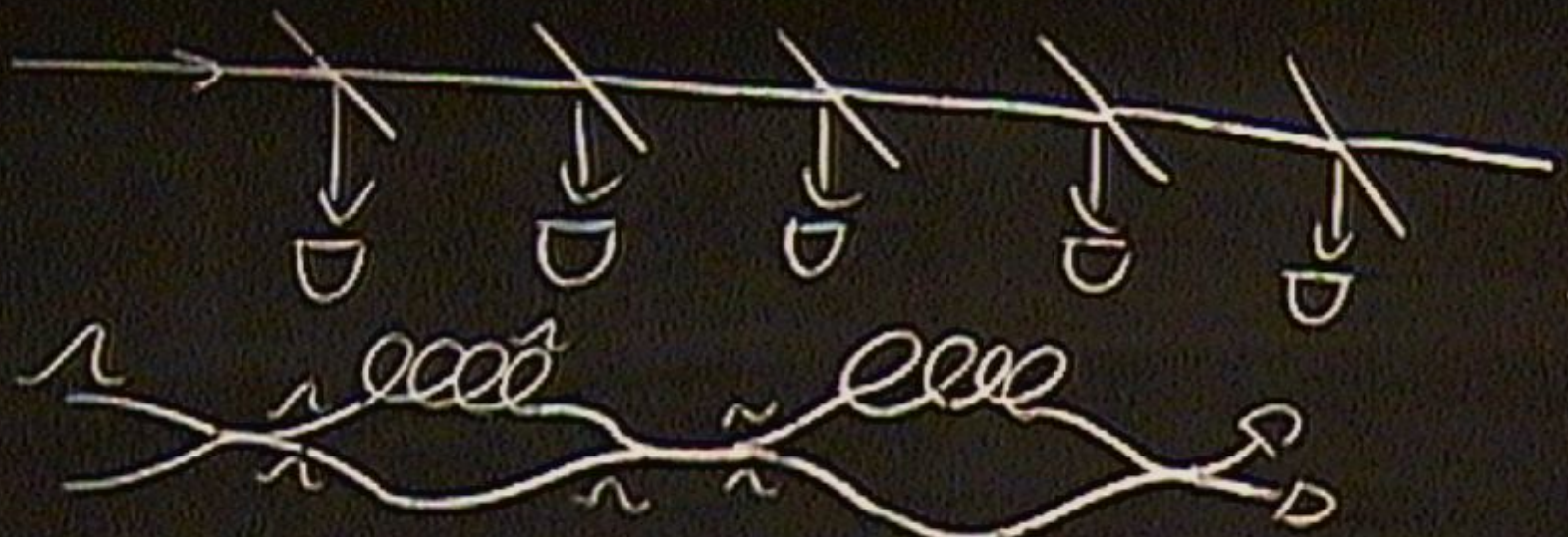
Photon-counters




Photon - couplings
Oxford, Erlangen

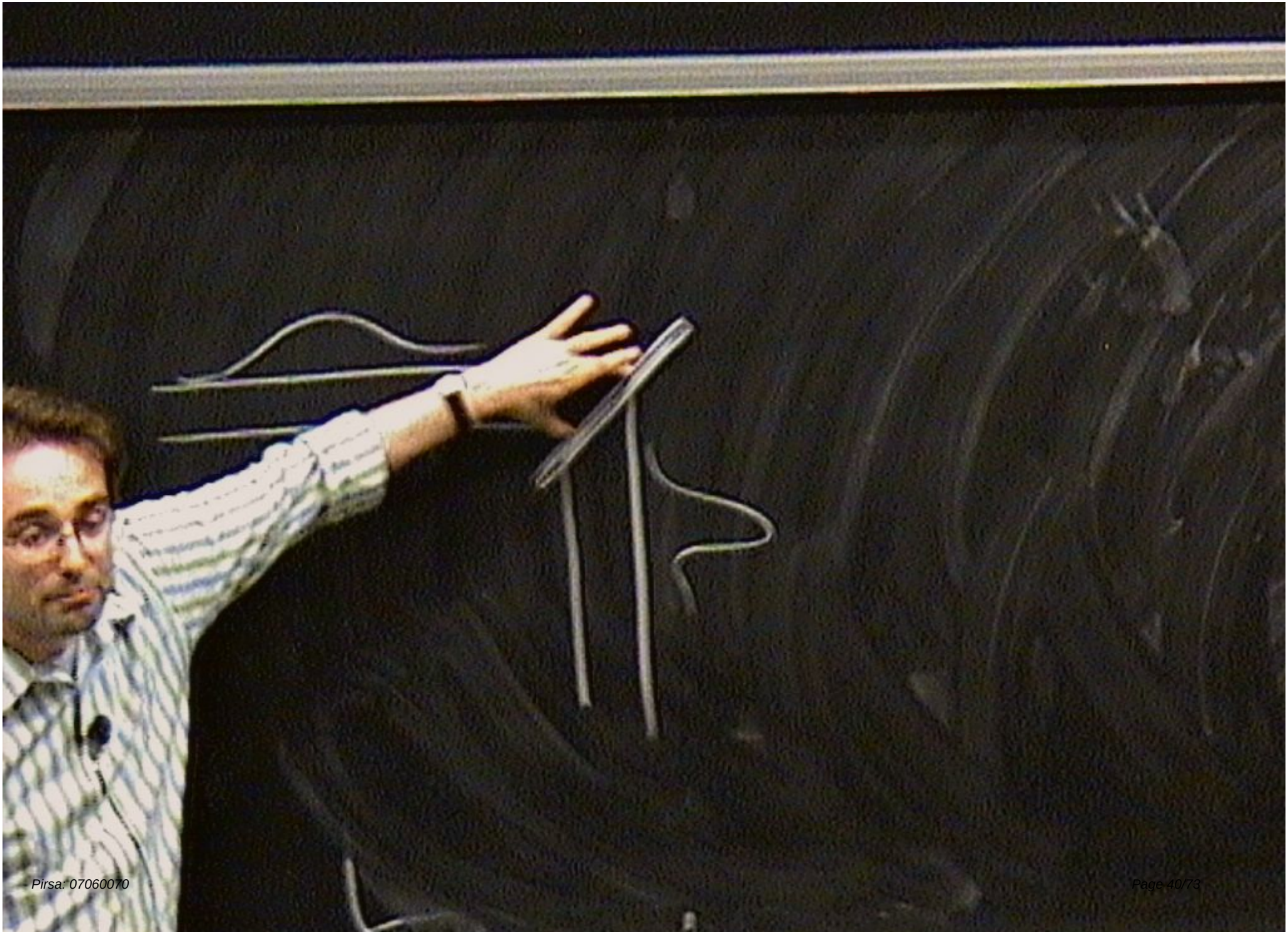

Photon-counters
40%
Oxford, Erlangen

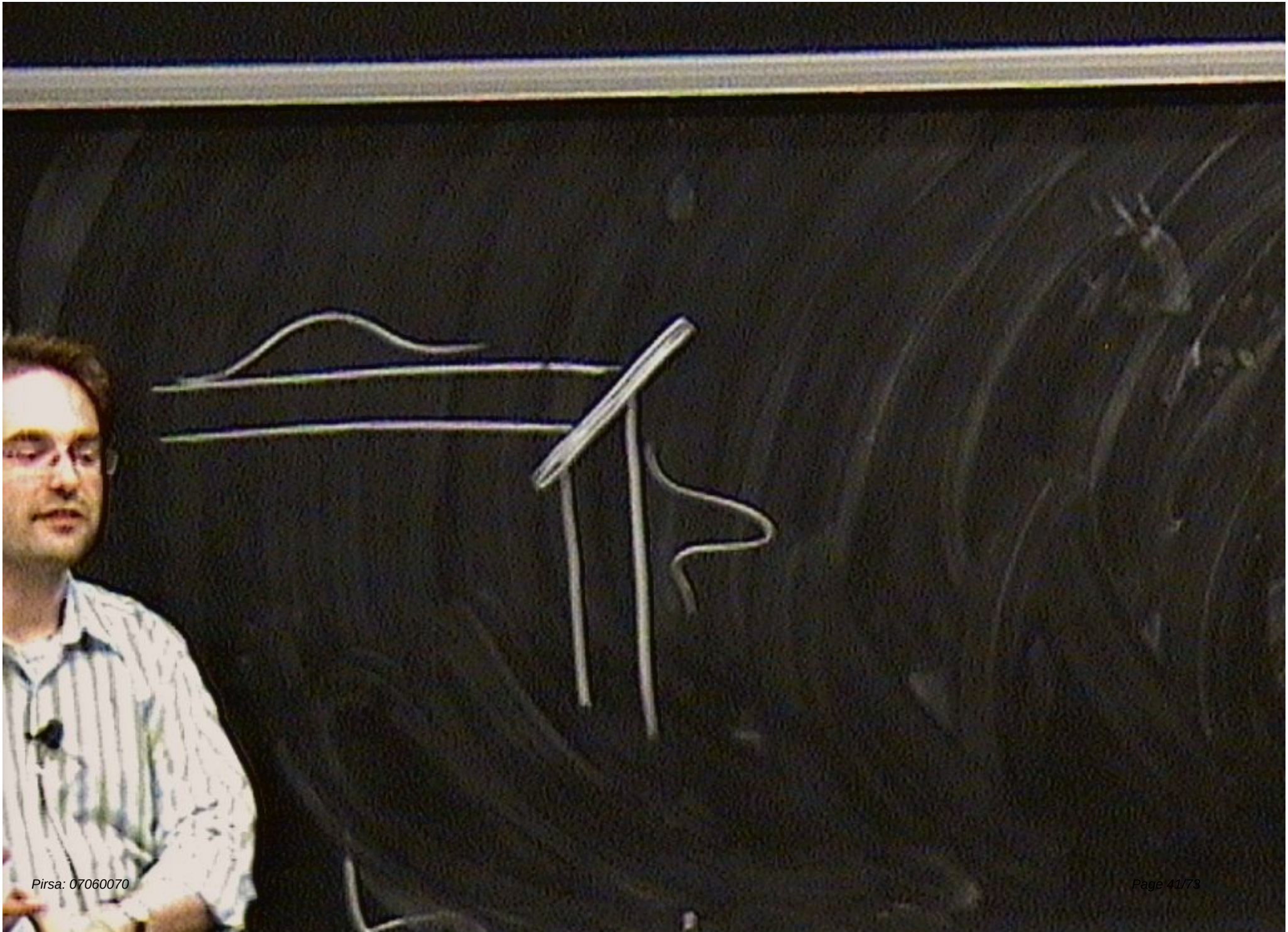
Photon-counters

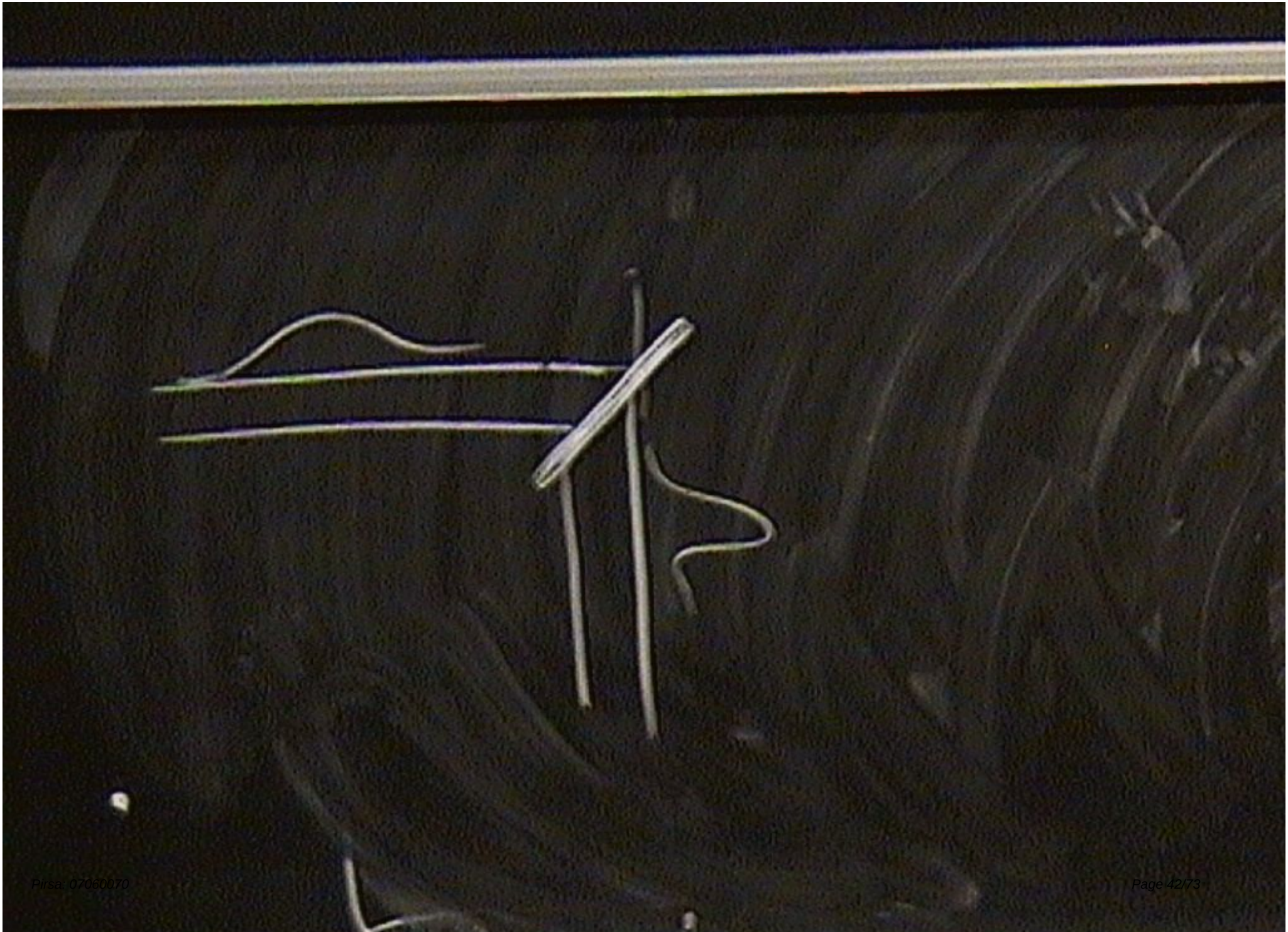


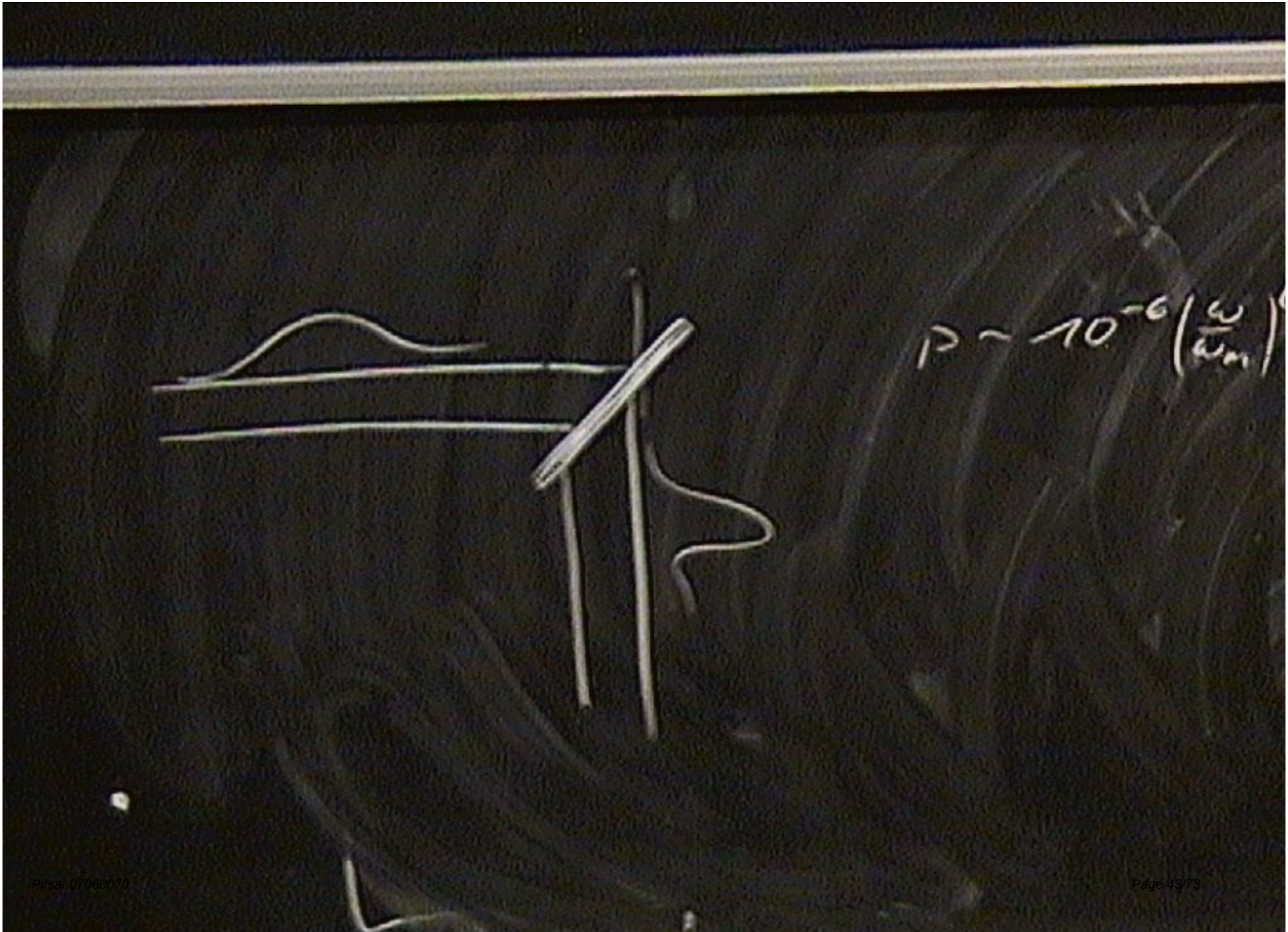
40%

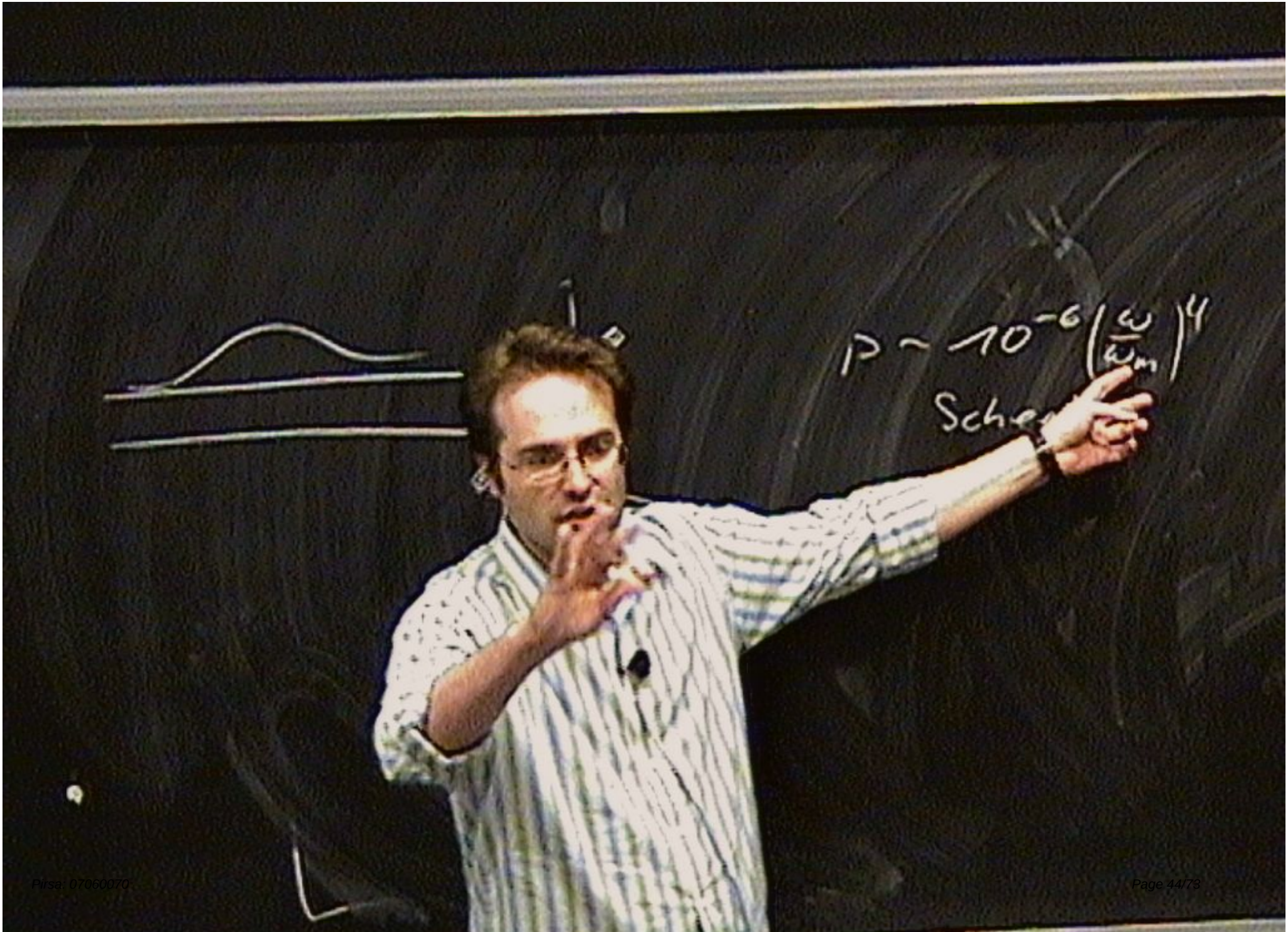
Oxford, Erlangen

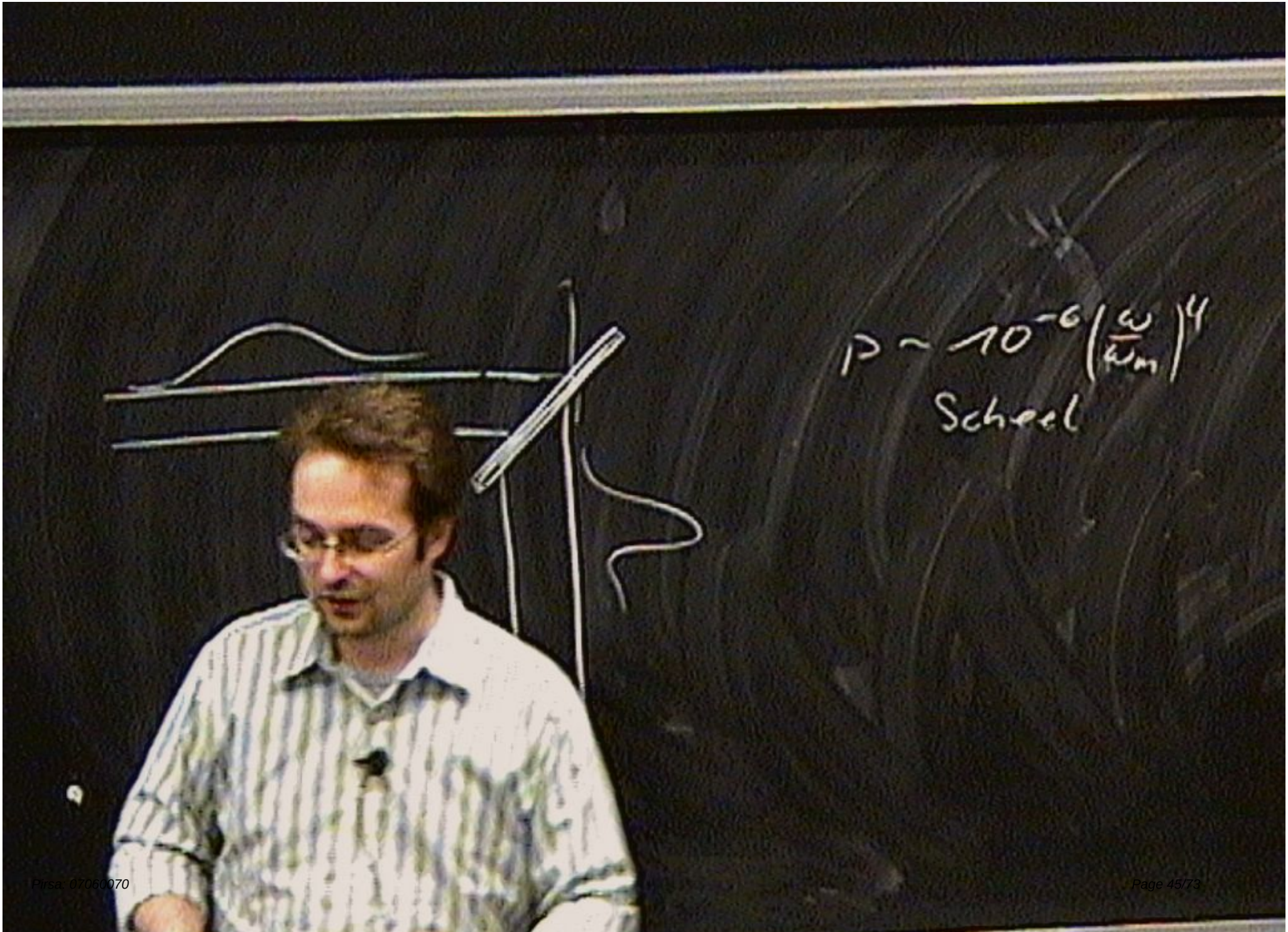






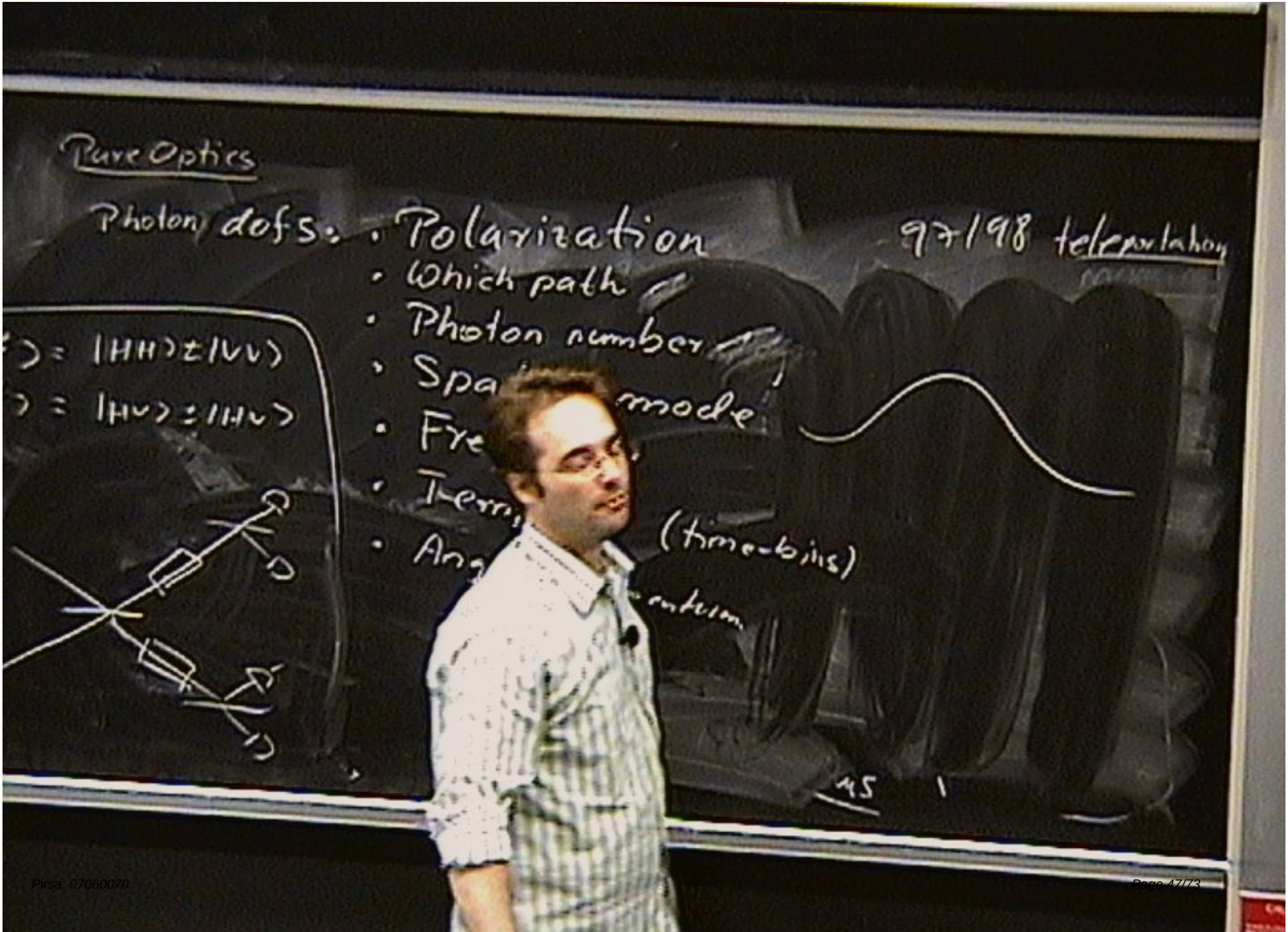

$P \sim 10^{-6} \left(\frac{\omega}{\omega_m}\right)^2$


P ~ 10^-6 (ω/ω_m)^4


$P \sim 10^{-6}\left(\frac{\omega}{\omega_m}\right)^4$
Scheel

$P \sim 10^{-6} \left(\frac{\omega}{\omega_m}\right)^4$

Scheel


Pure Optics
Photon dofs:
• Polarization
• Which path
• Photon number
• Spa
• Fre
• Ter
• Ang
(time-bins)
97/198 teleportation
|HH⟩±|VV⟩
|HV⟩±|HV⟩
D
D
45

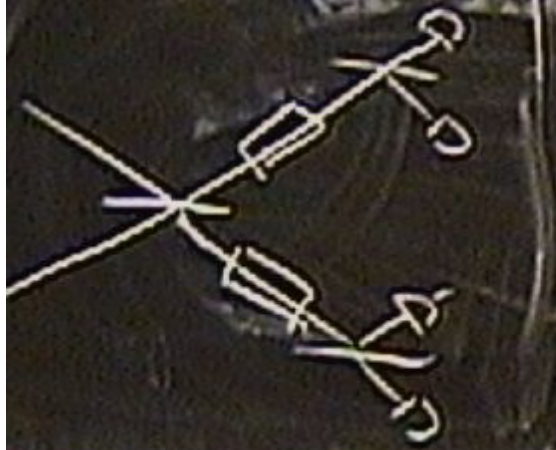
Pure Optics

Photony dofs:
- Polarization
- Which path
- Photon number
- Spatial mode
- Frequency
- Temporal (time-bins)
- Angular momentum

97/98 telecom lab

$\rangle = |HH\rangle \pm |VV\rangle$

$\rangle = |HV\rangle \pm |HV\rangle$



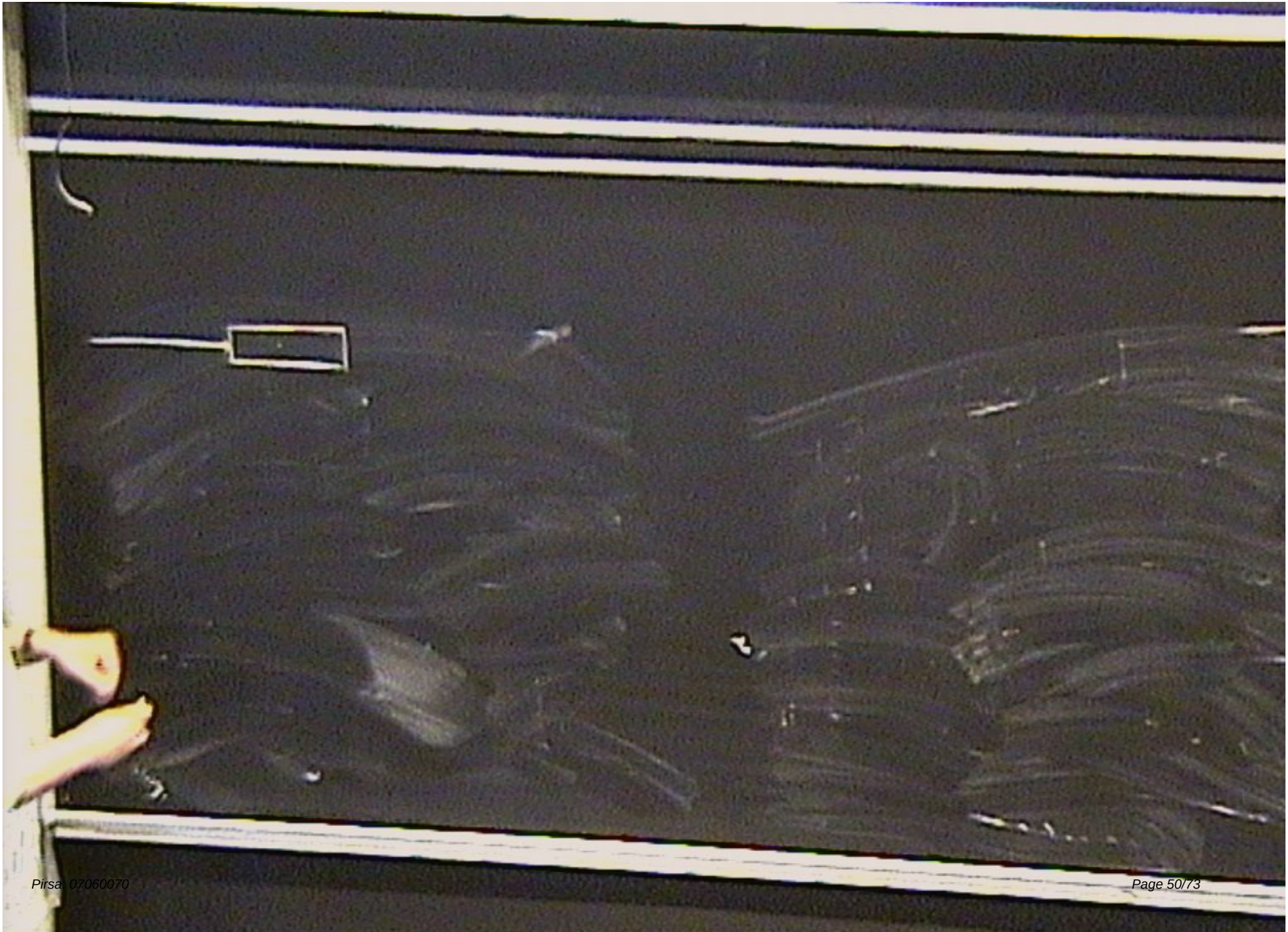
45 1

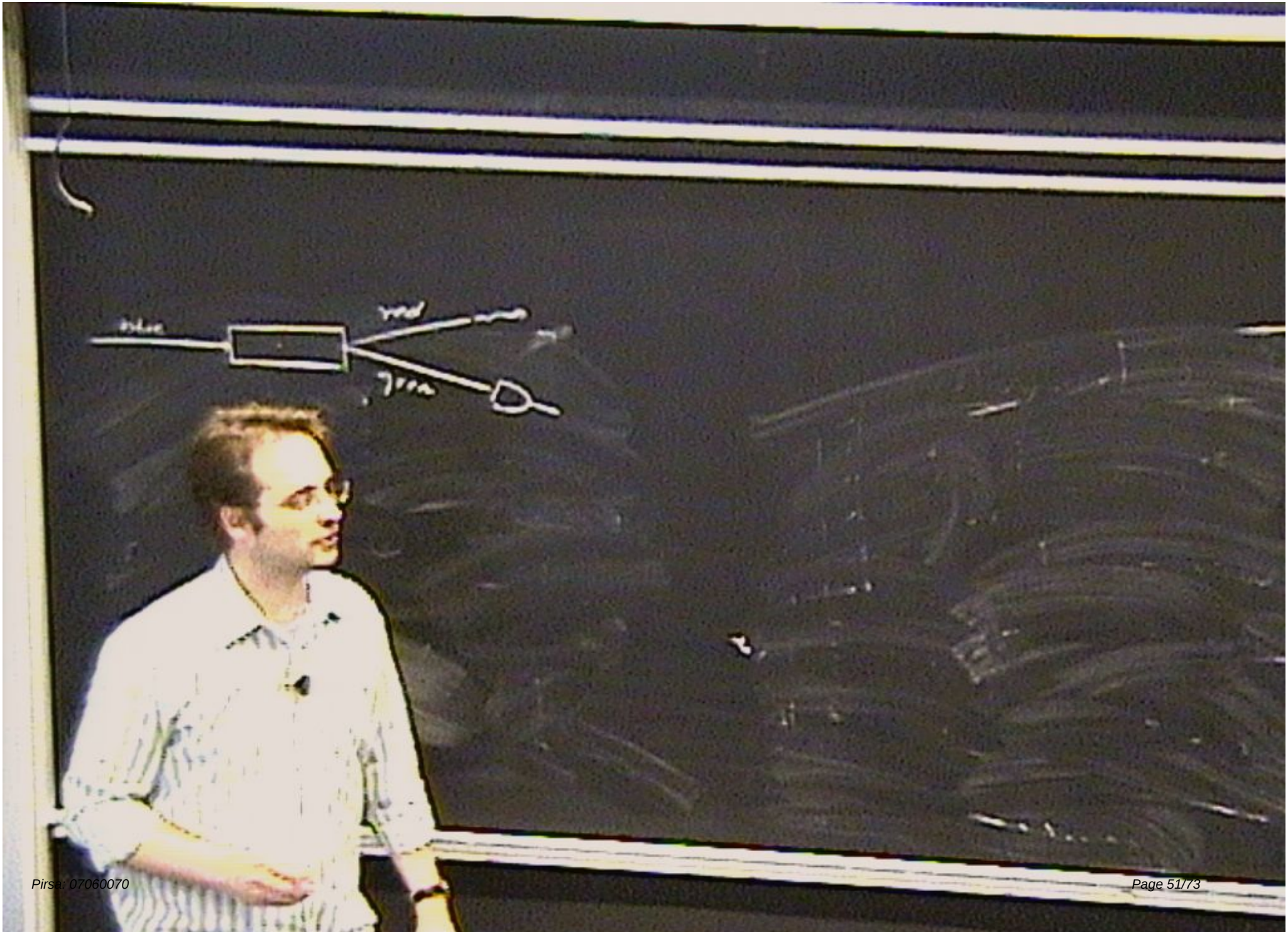
$P \sim 10^{-6} \left(\frac{\psi}{M_{Pl}}\right)^4$

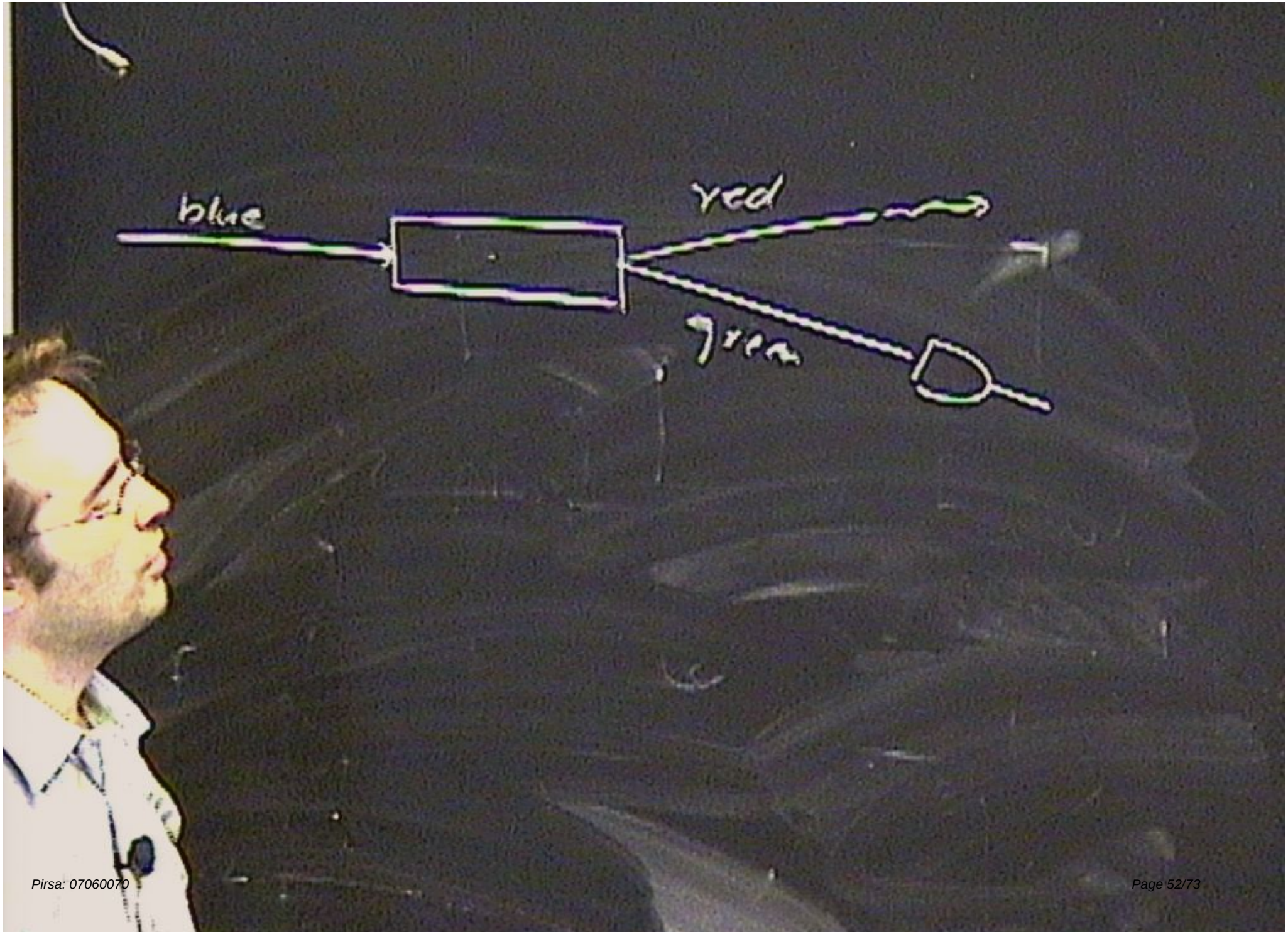
Scheel

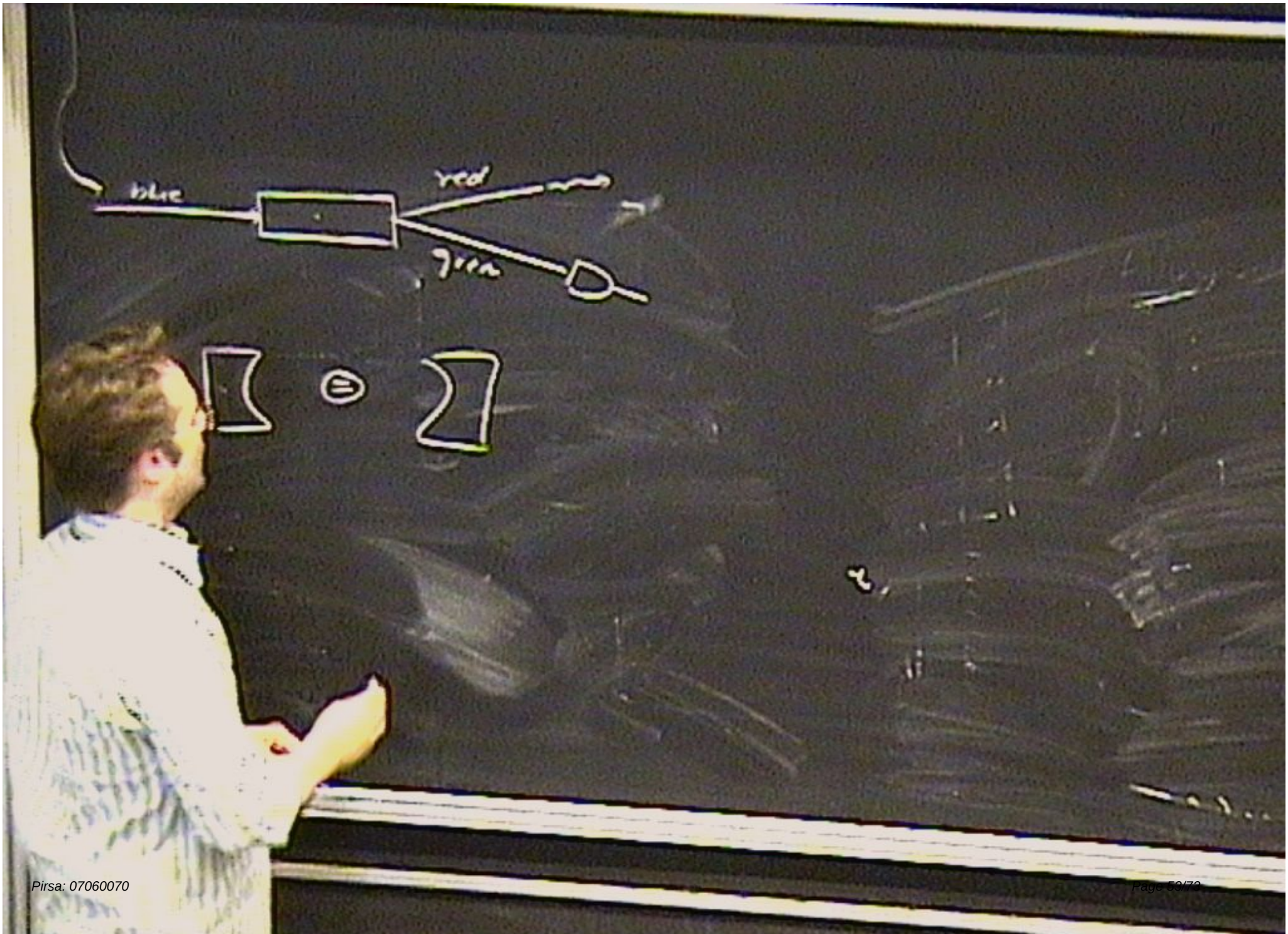
$X = (a + a^\dagger)/\sqrt{2}$

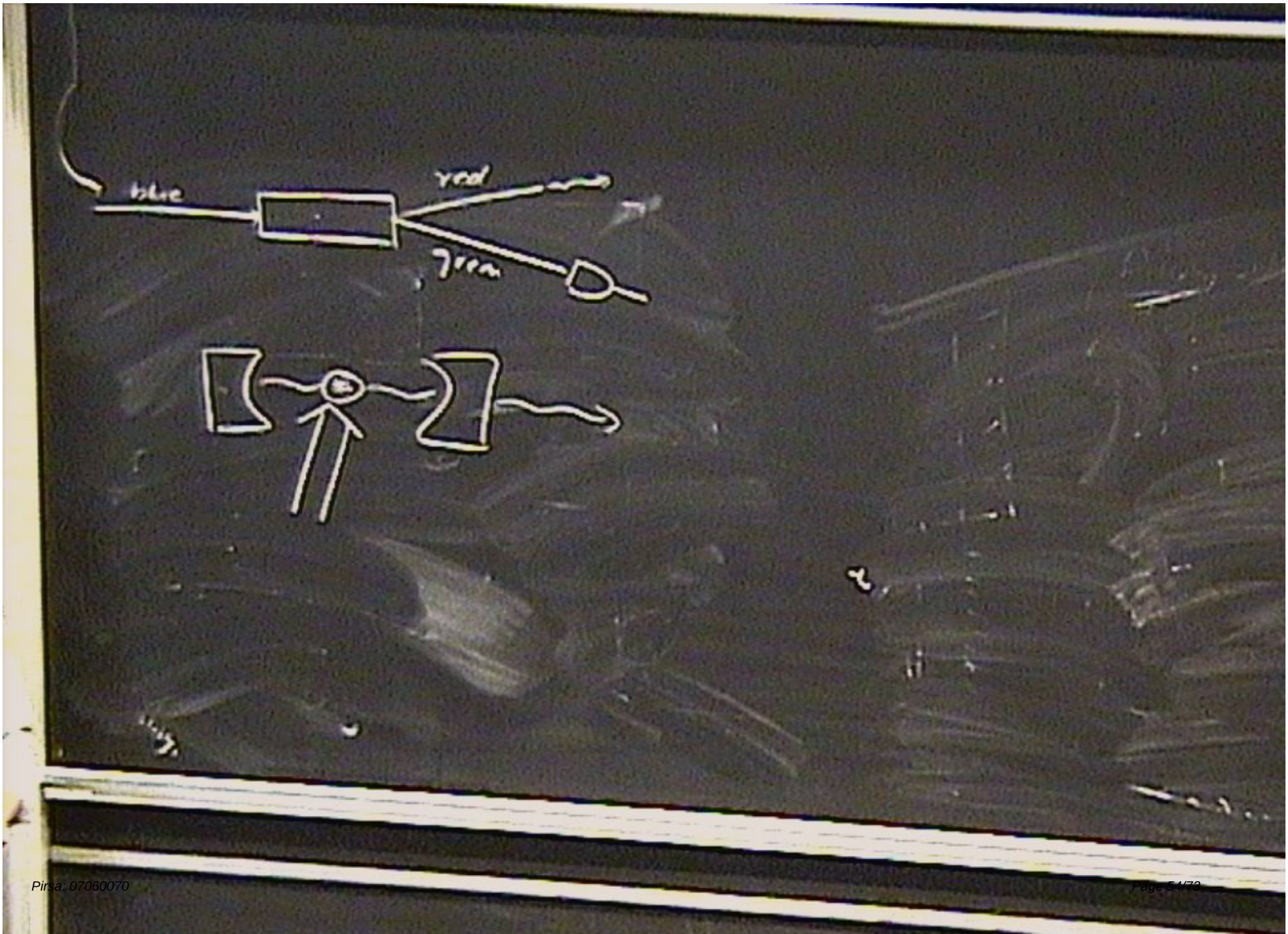
$P = i(a - a^\dagger)/\sqrt{2}$

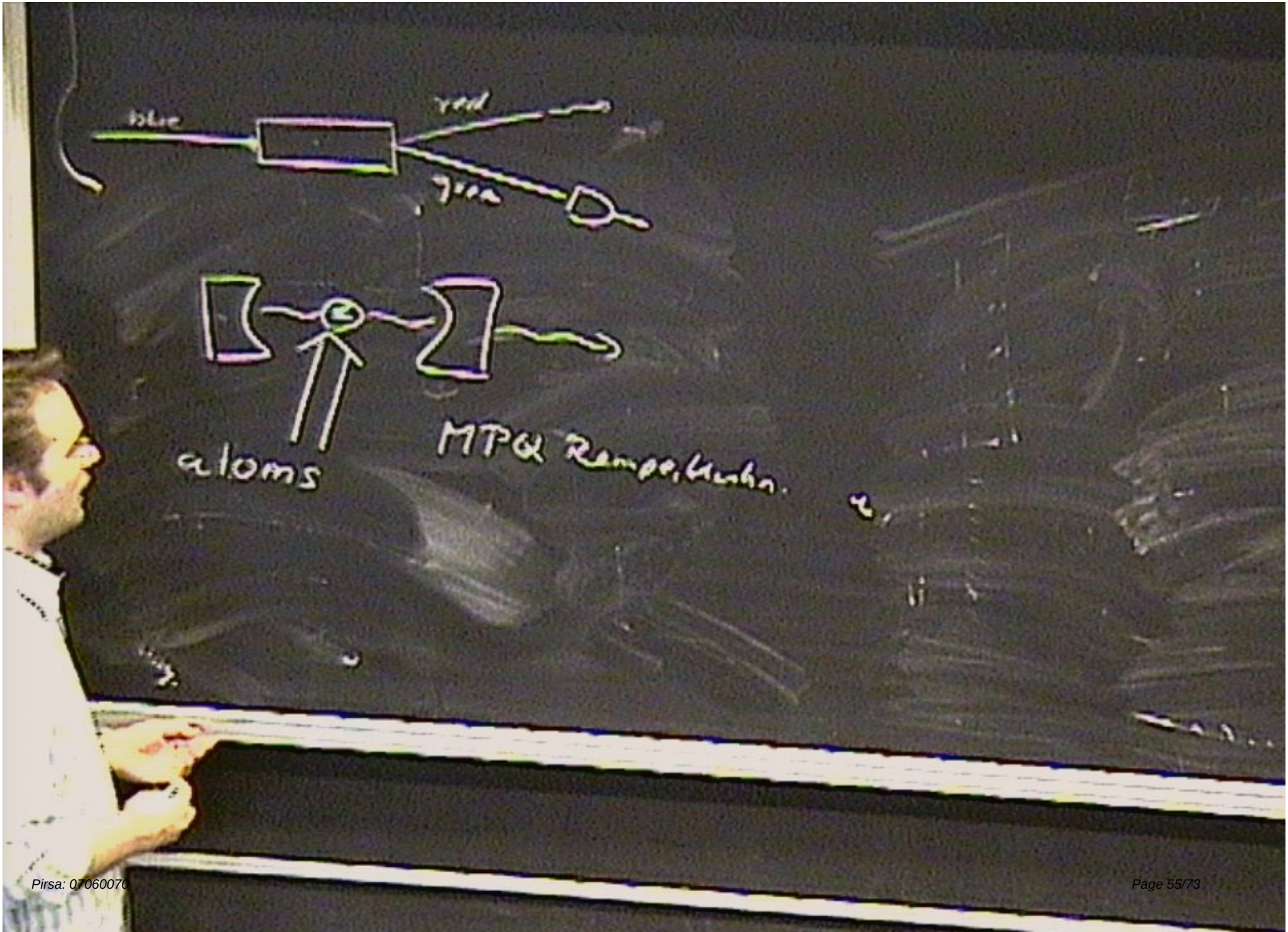


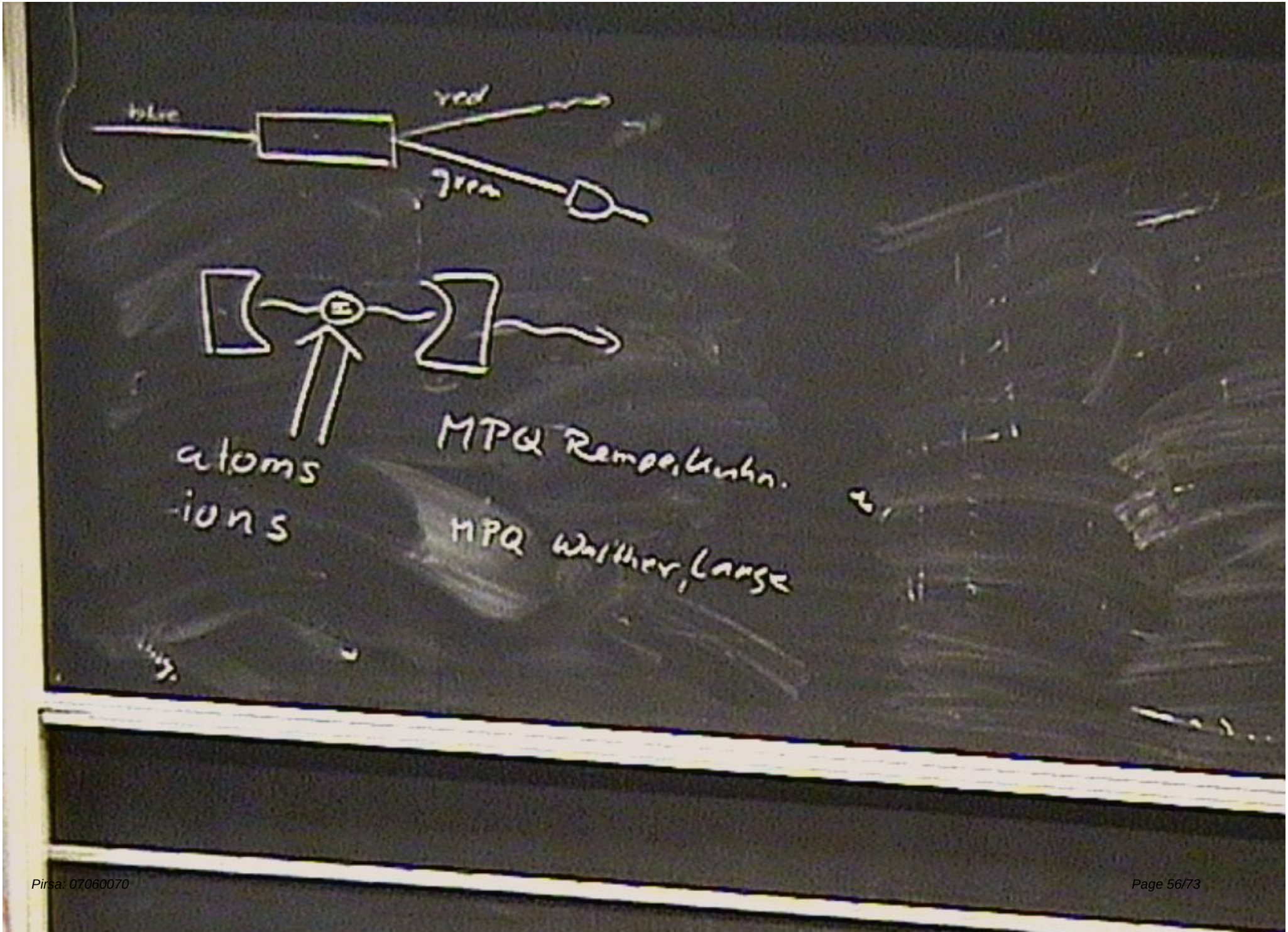


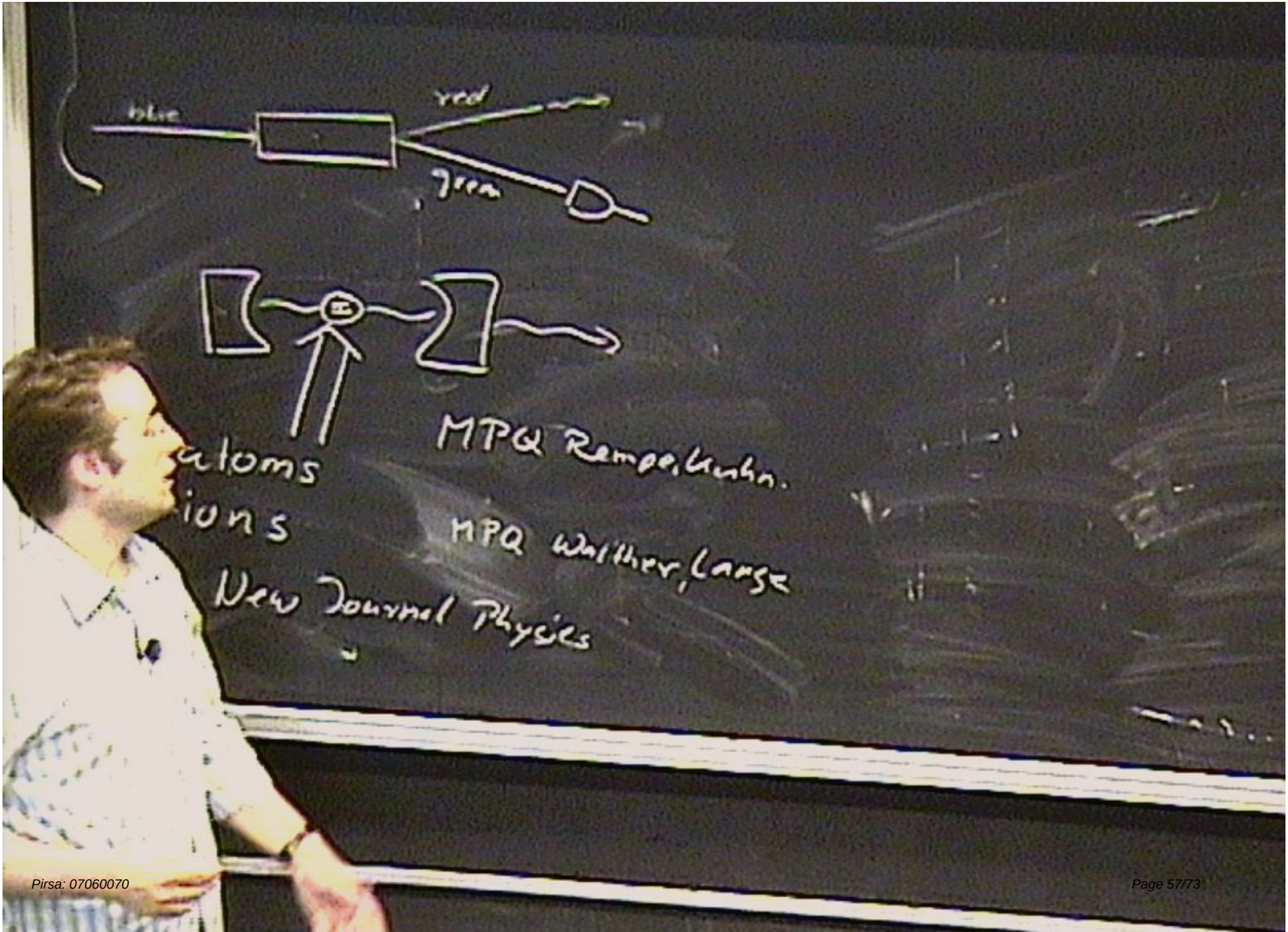

blue
red
green


blue
red


blue
red
green


blue
red
atoms


blue
red
green
atoms
ions
MPQ Rempe, Kuhn.
MPQ Walther, Large

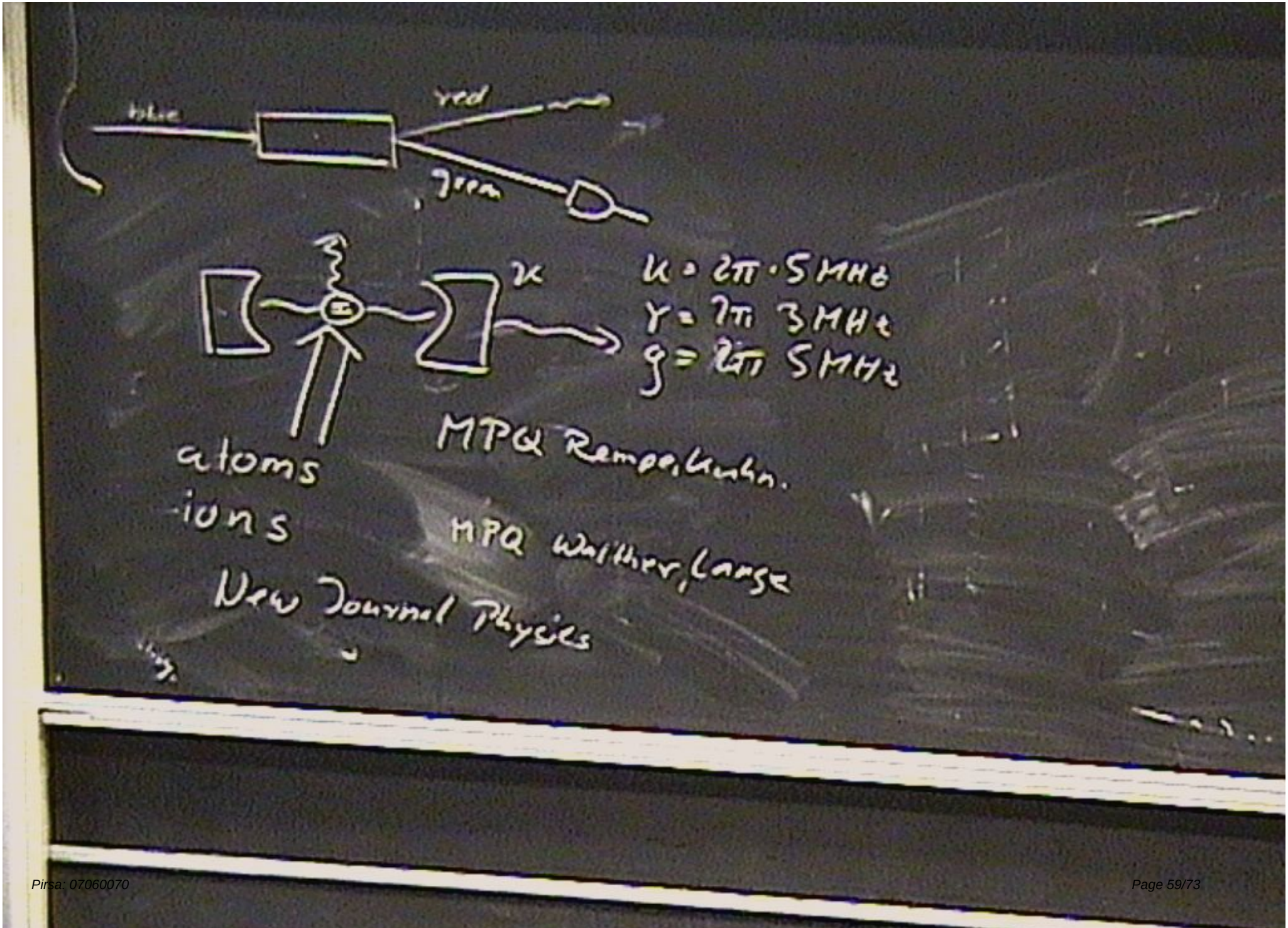

blue
red
green
MPQ Rempe, Kuhn.
atoms
ions
MPQ Walther, Lange
New Journal Physics

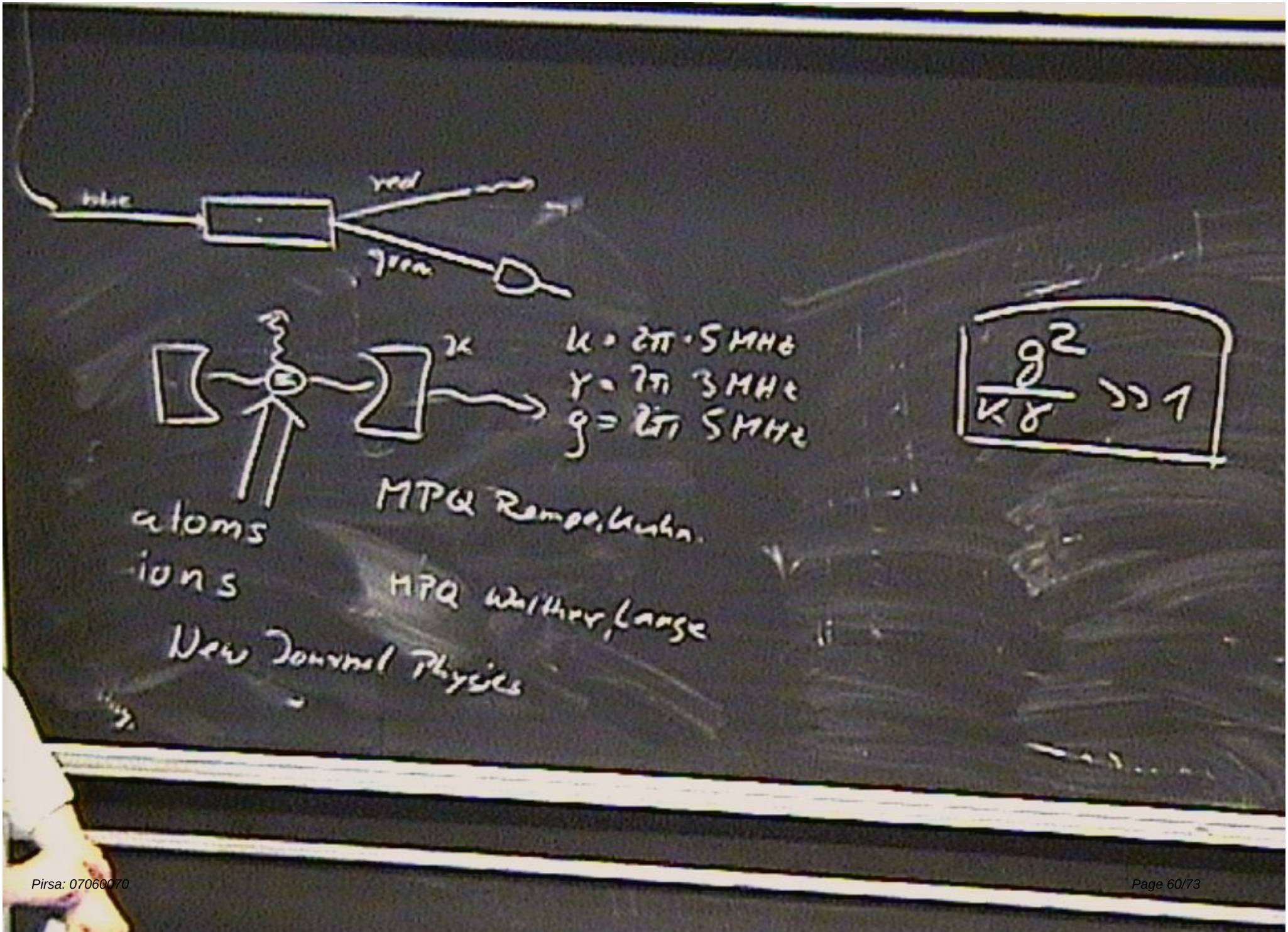
atoms
ions

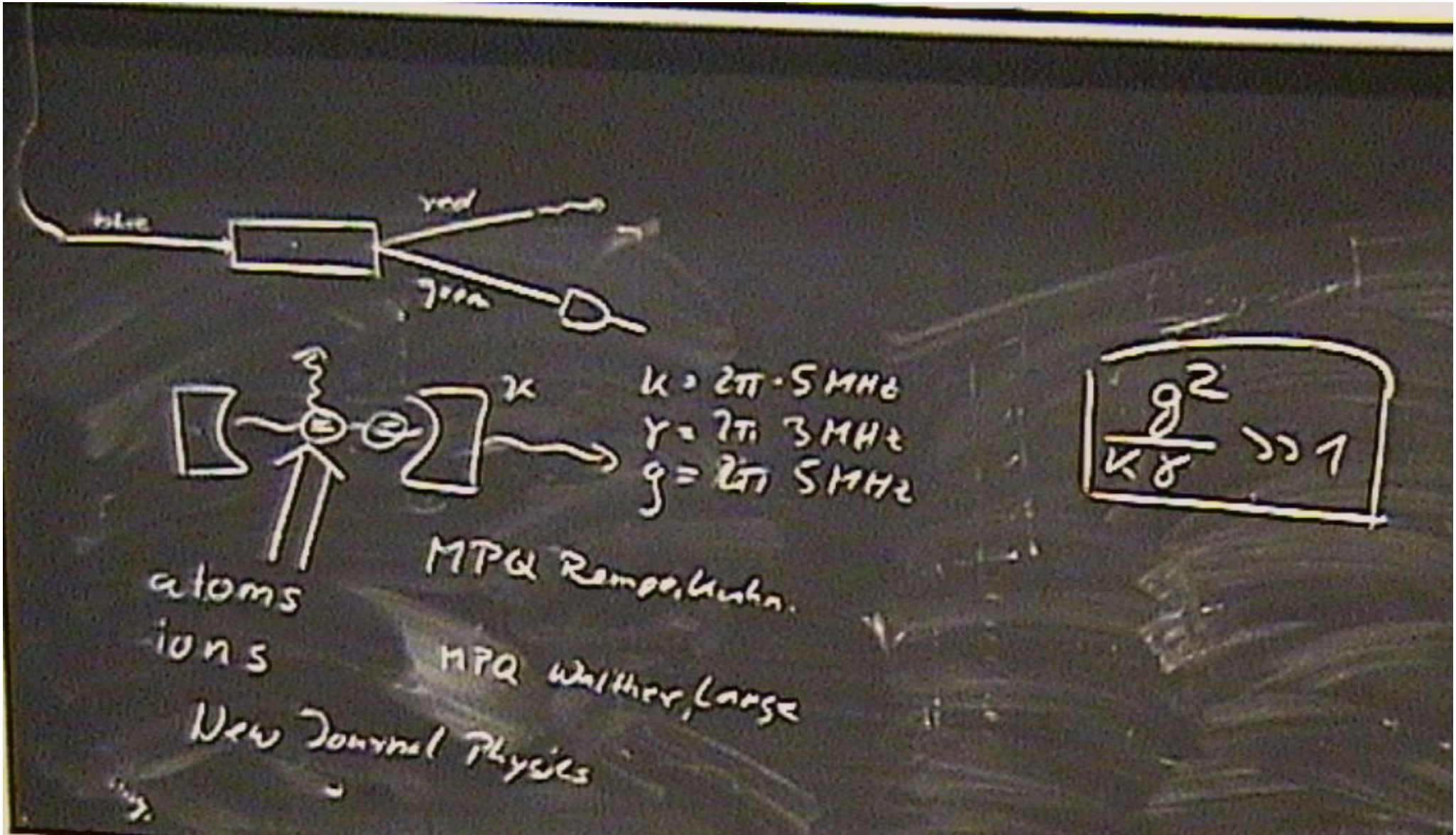
MPQ Rempe, Kuhn.

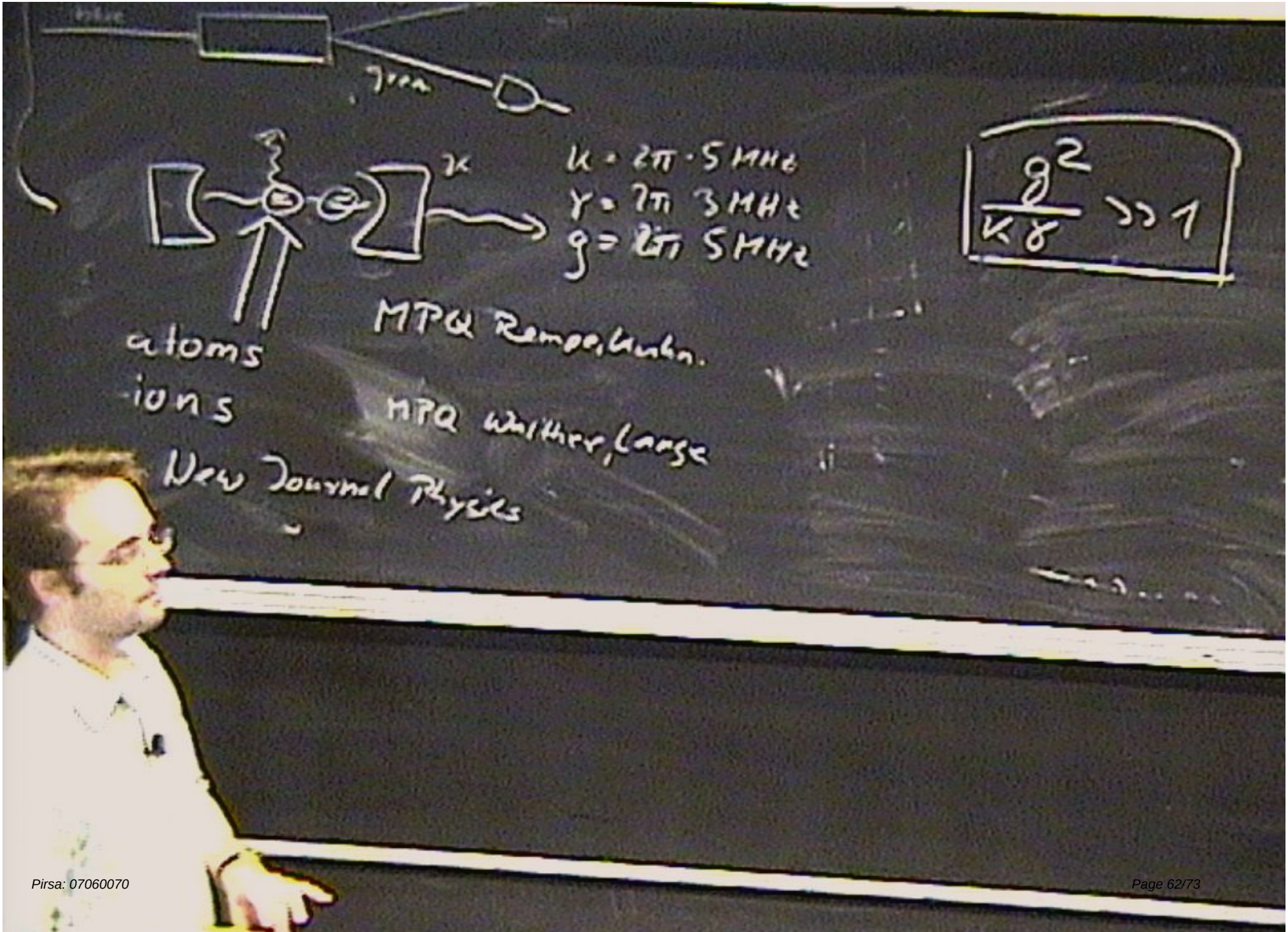
MPQ Walther, Lange

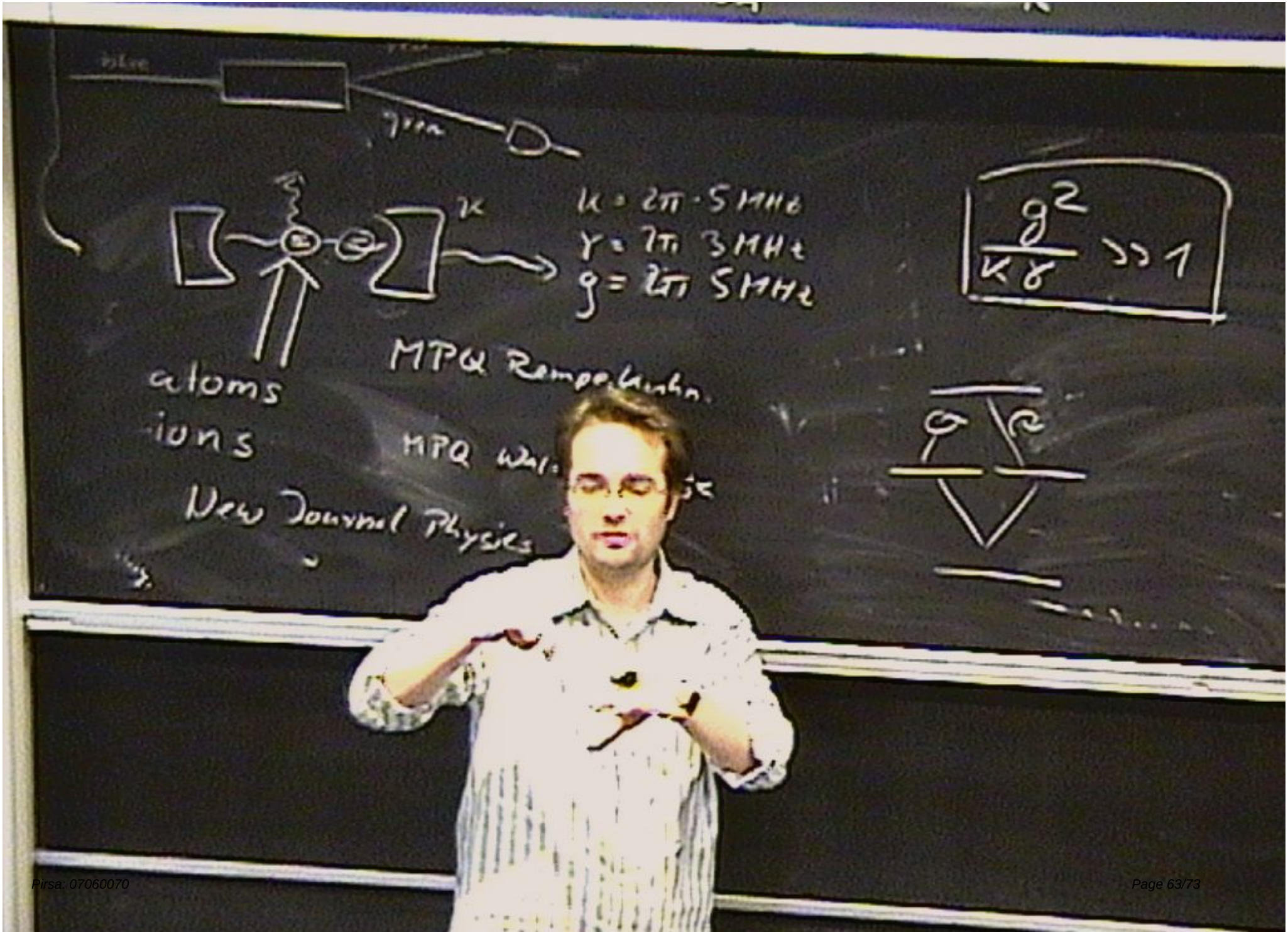
New Journal Physics

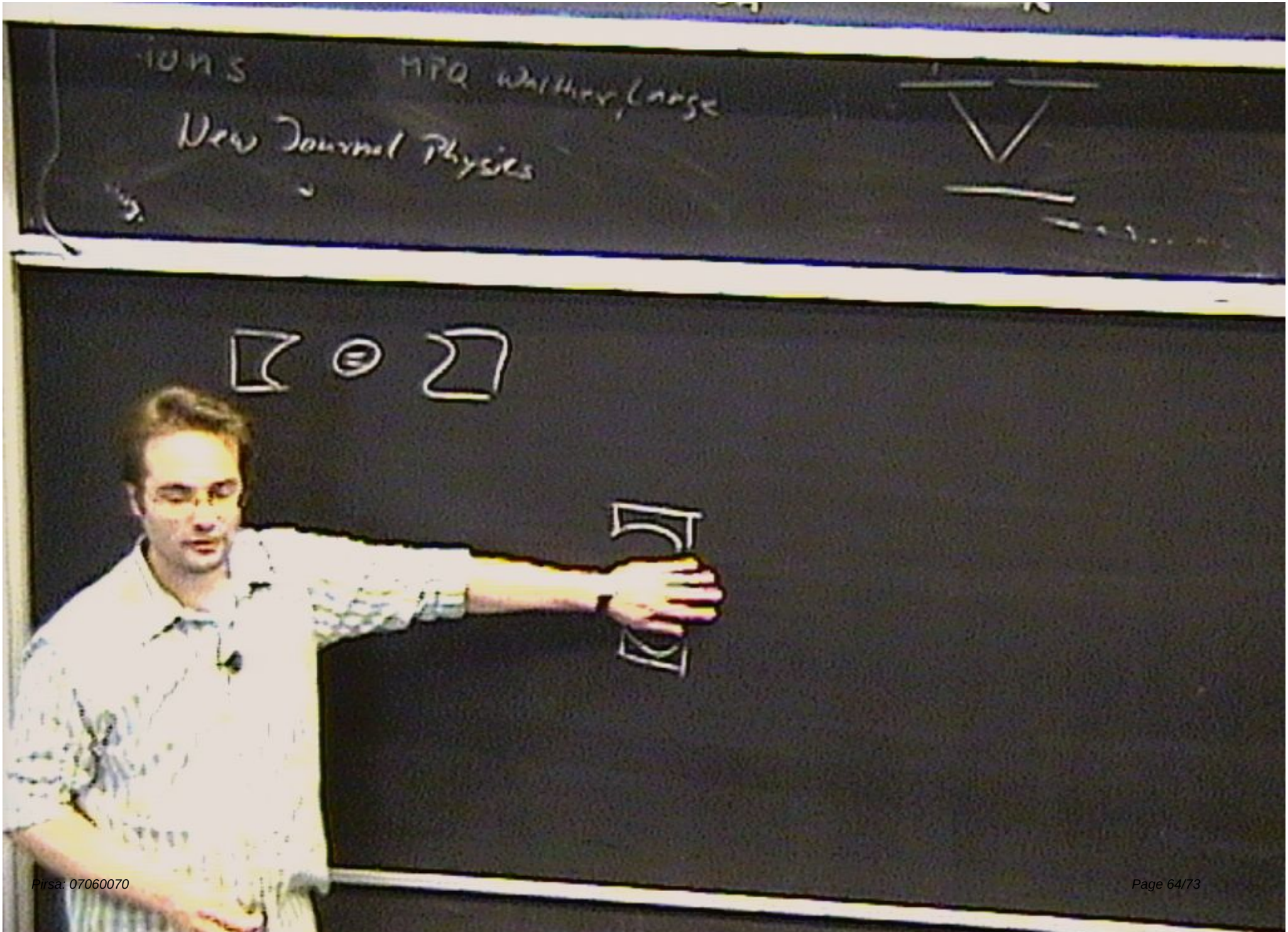

blue
red
green
2κ
κ = 2π · 5 MHz
γ = 2π 3 MHz
g = 2π 5 MHz
atoms
ions
MPQ Ramsey, Kuhn.
MPQ Walther, Lange
New Journal Physics

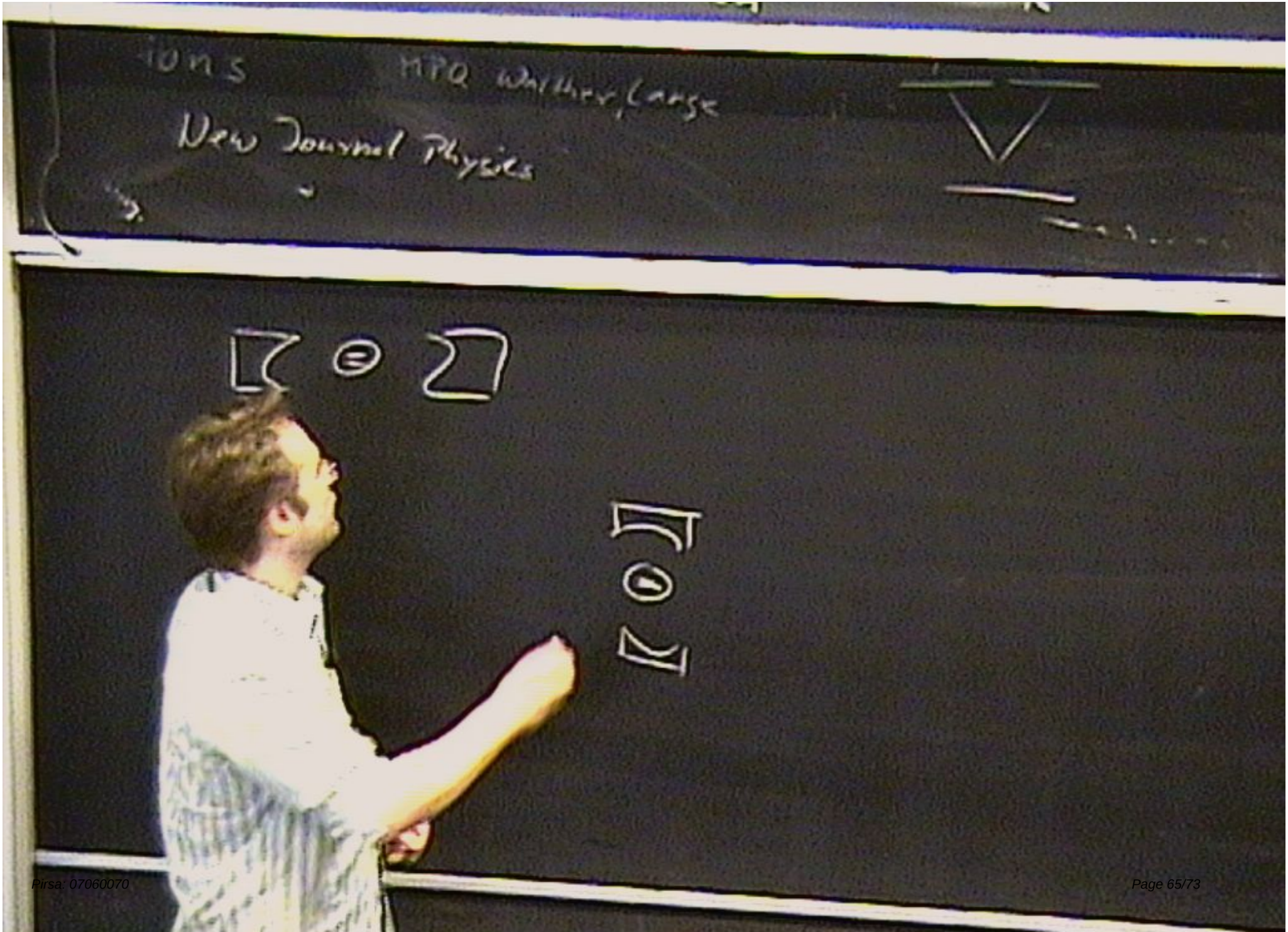

blue
red
green
2κ
κ = 2π · 5 MHz
γ = 2π 3 MHz
g = 2π 5 MHz
$\frac{g^2}{\kappa\gamma} \gg 1$
atoms
ions
MPQ Rempe, Kuhn.
MPQ Walther, Lange
New Journal Physics

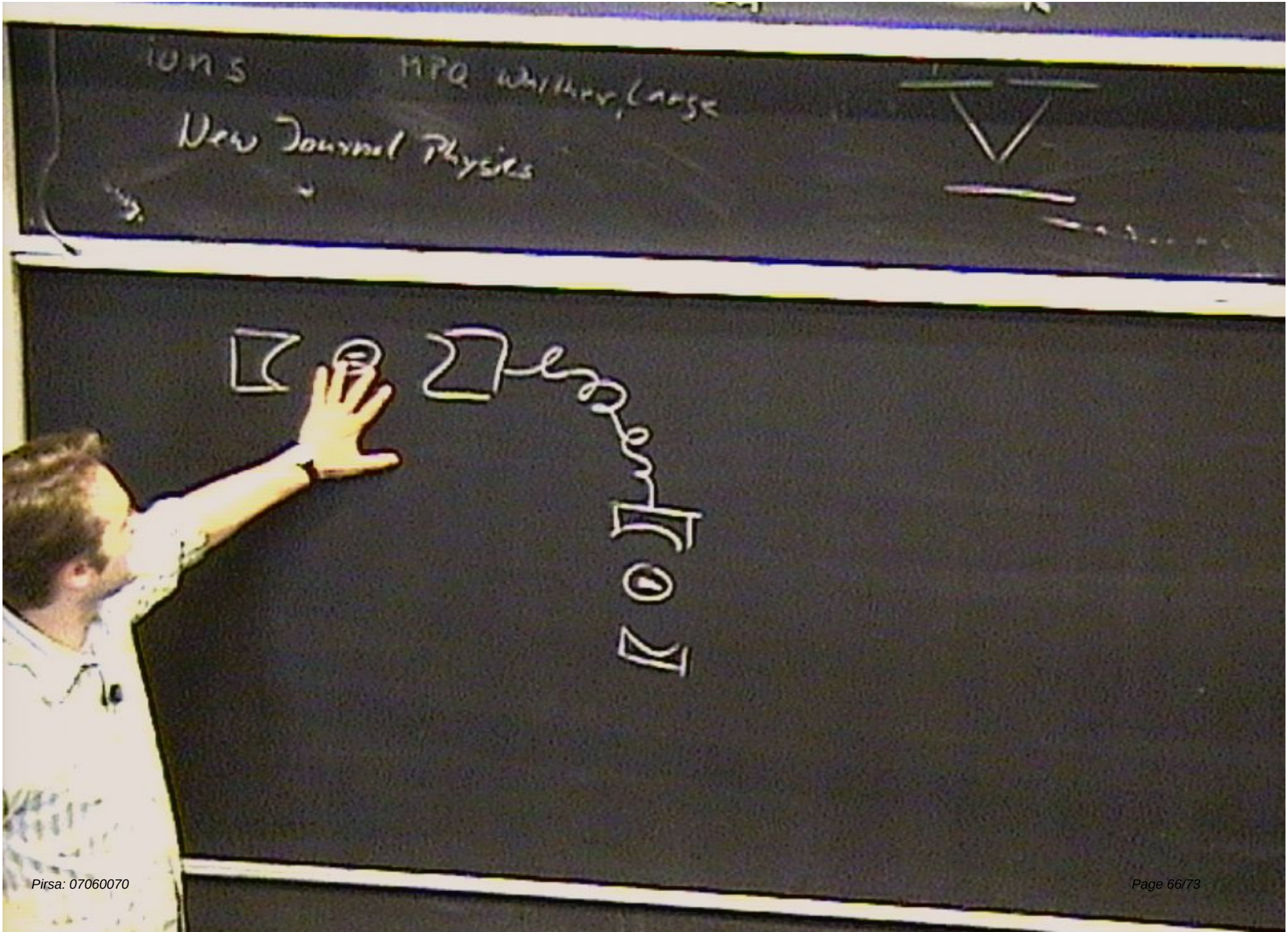

blue
red
κ
$\kappa = 2\pi \cdot 5\,MHz$
$\gamma = 2\pi\ 3\,MHz$
$g = 2\pi\ 5\,MHz$
$\frac{g^2}{\kappa\gamma} \gg 1$
atoms
ions
MPQ Rempe, Kuhn.
MPQ Walther, Large
New Journal Physics

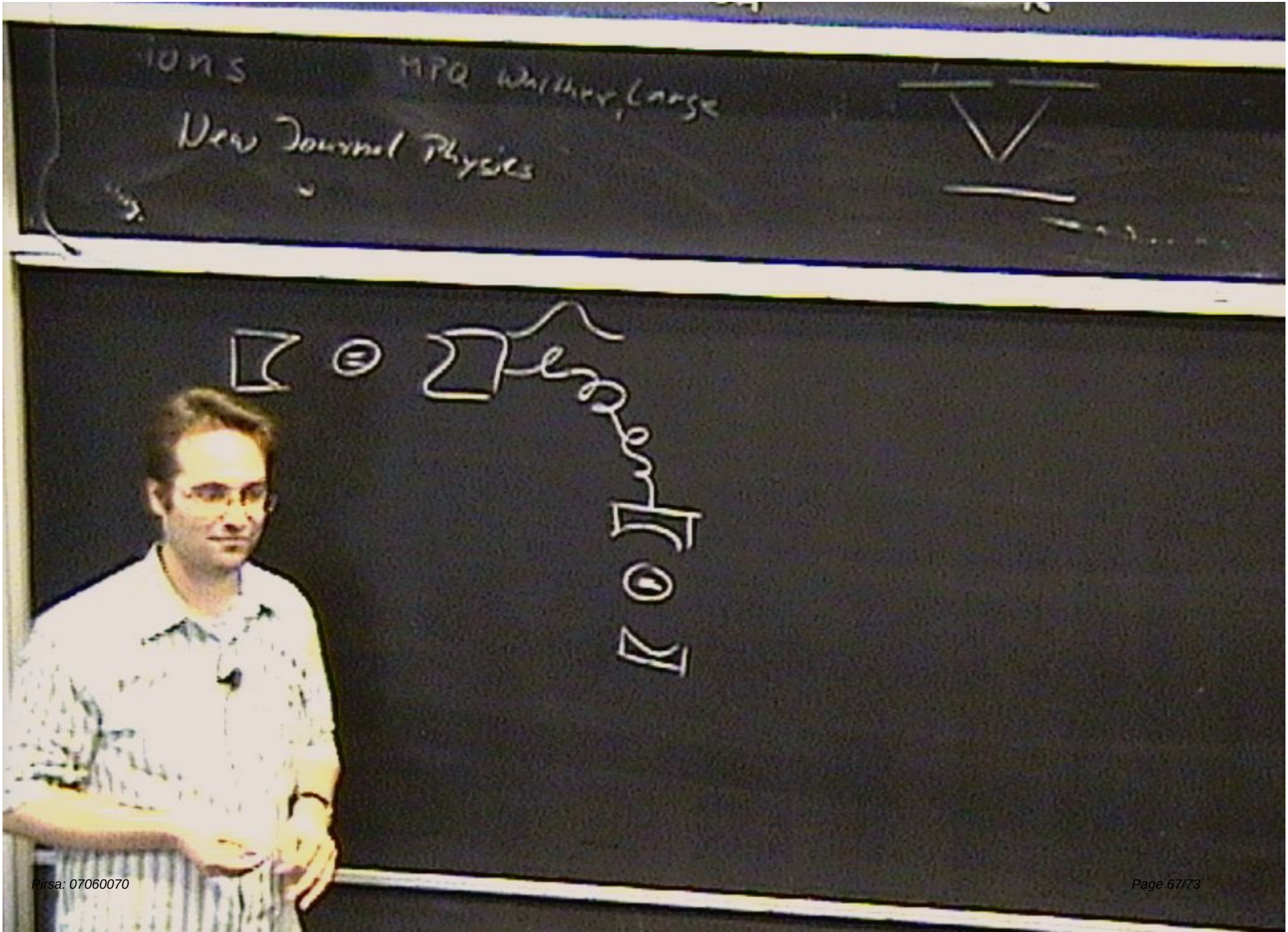

atoms
ions
MPQ Rempe, Kuhn.
MPQ Walther, Longe
New Journal Physics

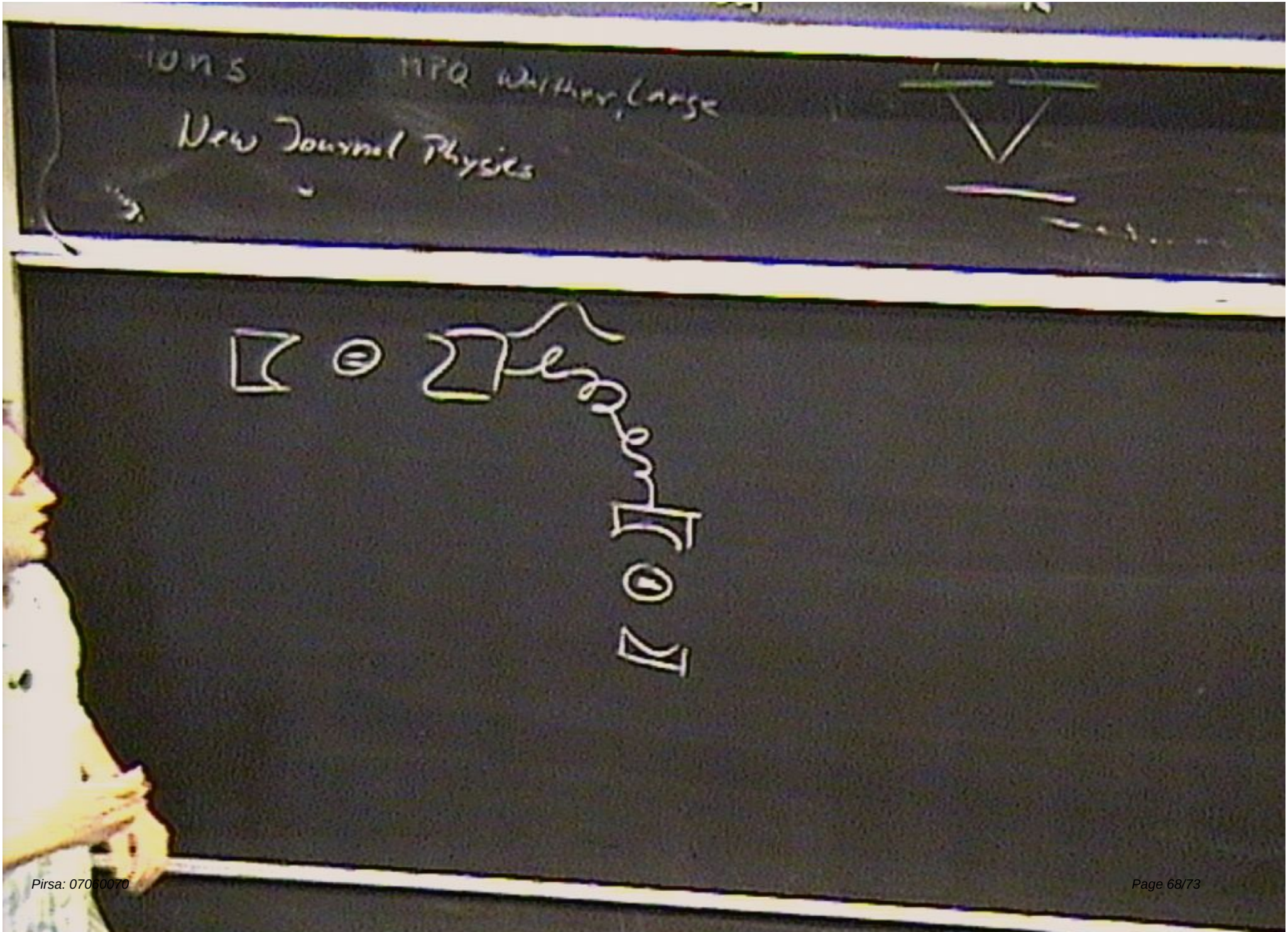

$\kappa = 2\pi \cdot 5\,\mathrm{MHz}$
$\gamma = 2\pi\ 3\,\mathrm{MHz}$
$g = 2\pi\ 5\,\mathrm{MHz}$
$\frac{g^2}{\kappa\gamma} \gg 1$
atoms
ions
MPQ
New Journal Physics

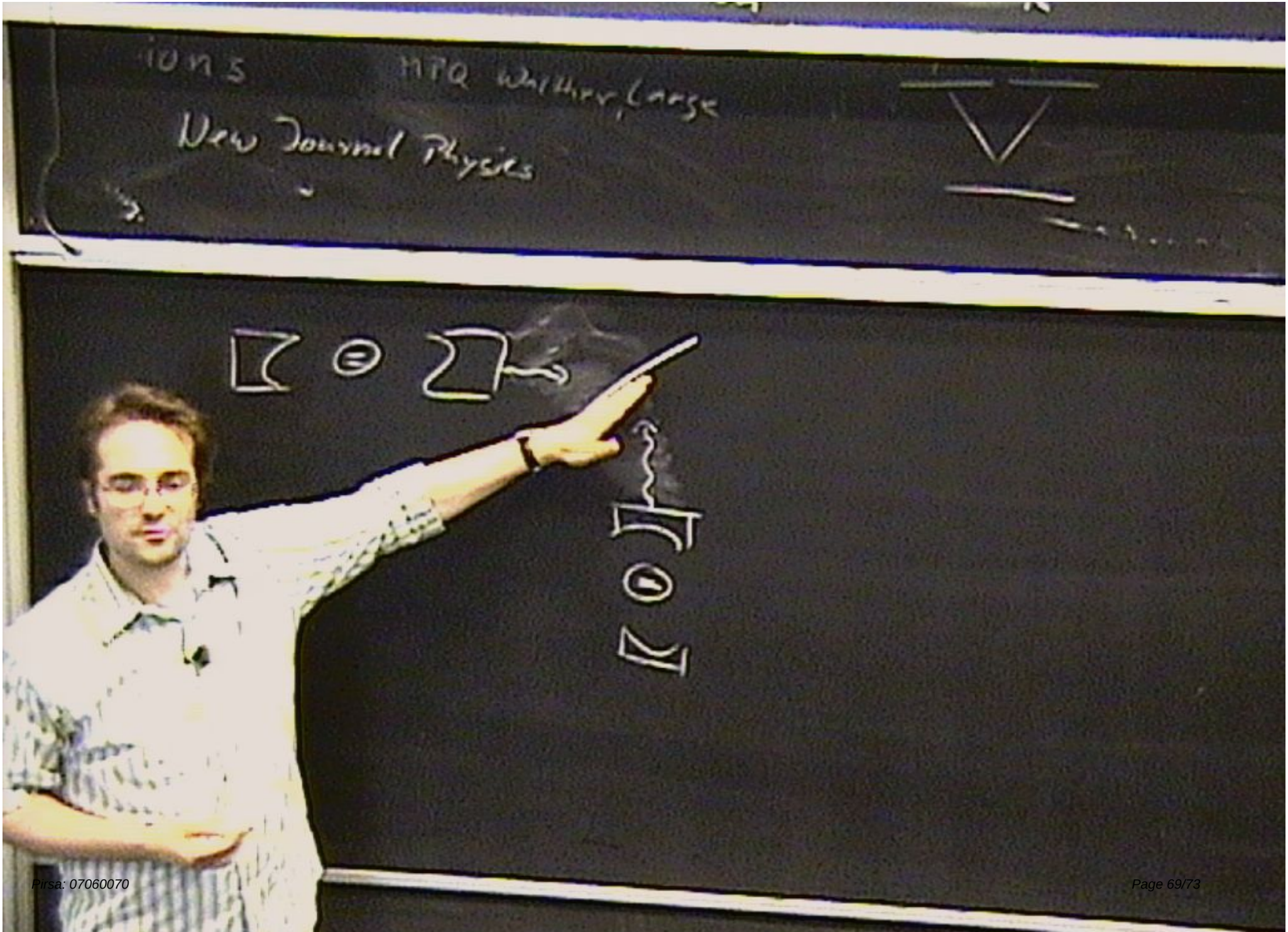

ions
MPQ Walther, Large
New Journal Physics

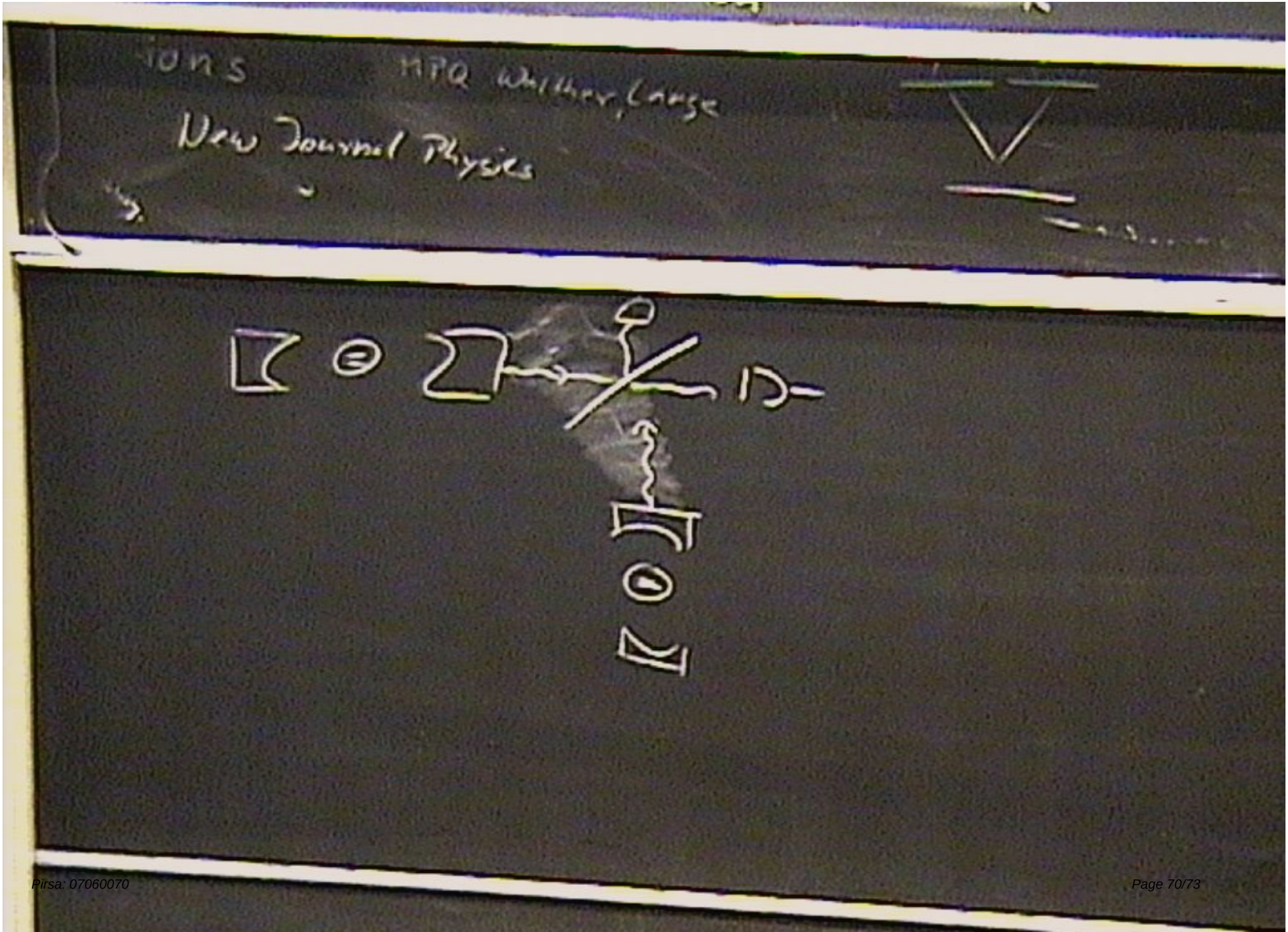

ions
MPQ
New Journal Physics

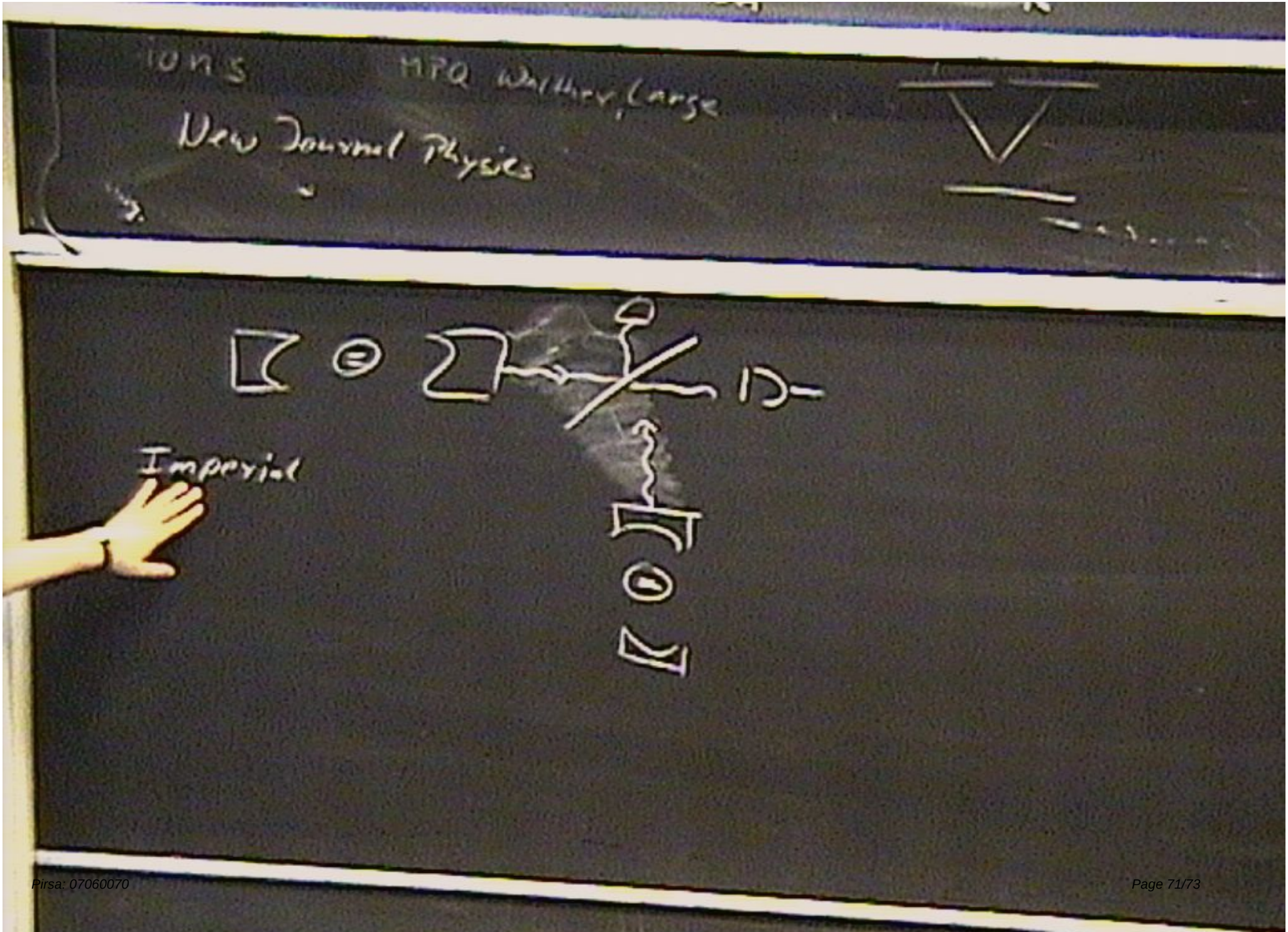

IONS
MPQ
New Journal Physics


ions
MPQ Walther, Large
New Journal Physics


IONS
MPQ Walther, Cirac
New Journal Physics

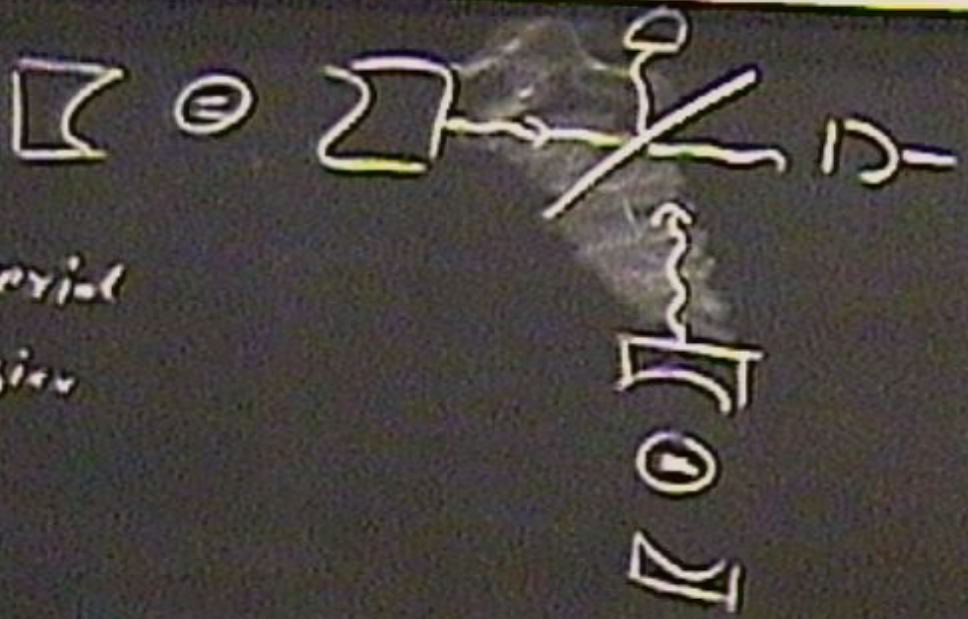

ions
MTQ Whitney, Large
New Journal Physics


ions
MPQ Whitaker, Lange
New Journal Physics


ions
MPQ Walther, Large
New Journal Physics
Imperial

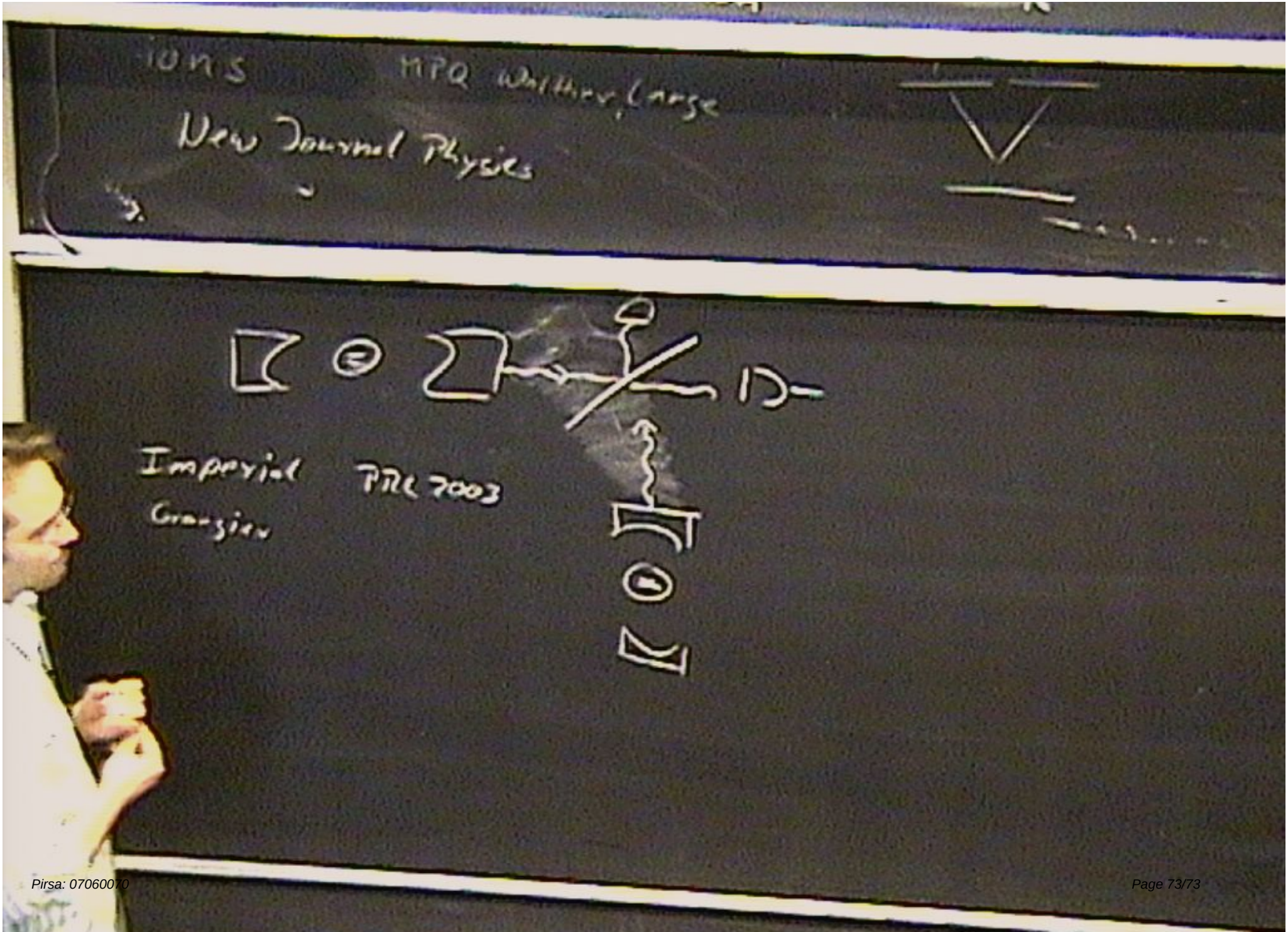
ions MPQ Walther, Lange

New Journal Physics



Imperial

Grangier


IONS
MPQ Walther, Large
New Journal Physics
Imperial
Pile 7003
Georgia