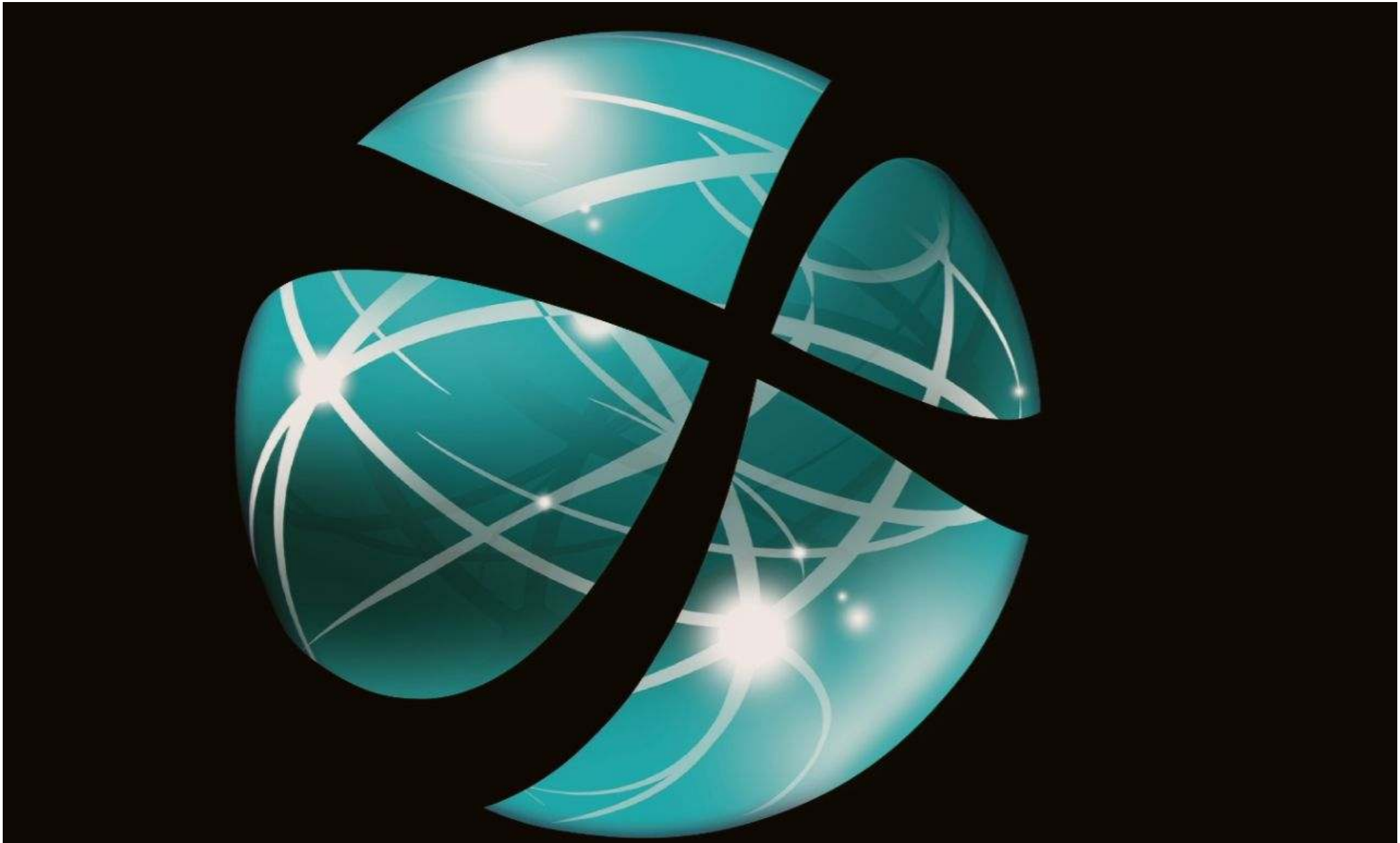
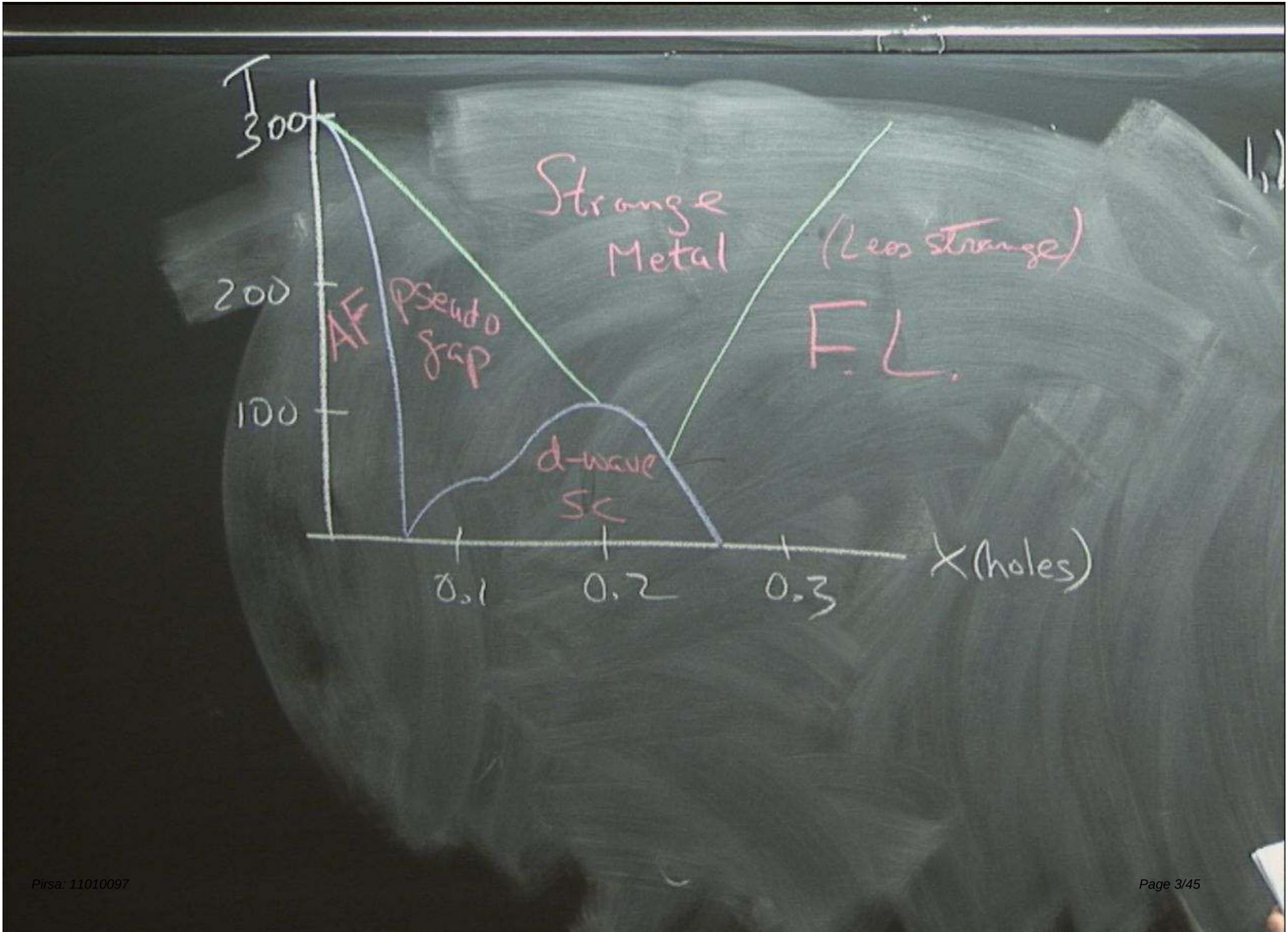
Title: Condensed Matter Review - Lecture 15

Date: Jan 21, 2011 10:15 AM

URL: http://pirsa.org/11010097

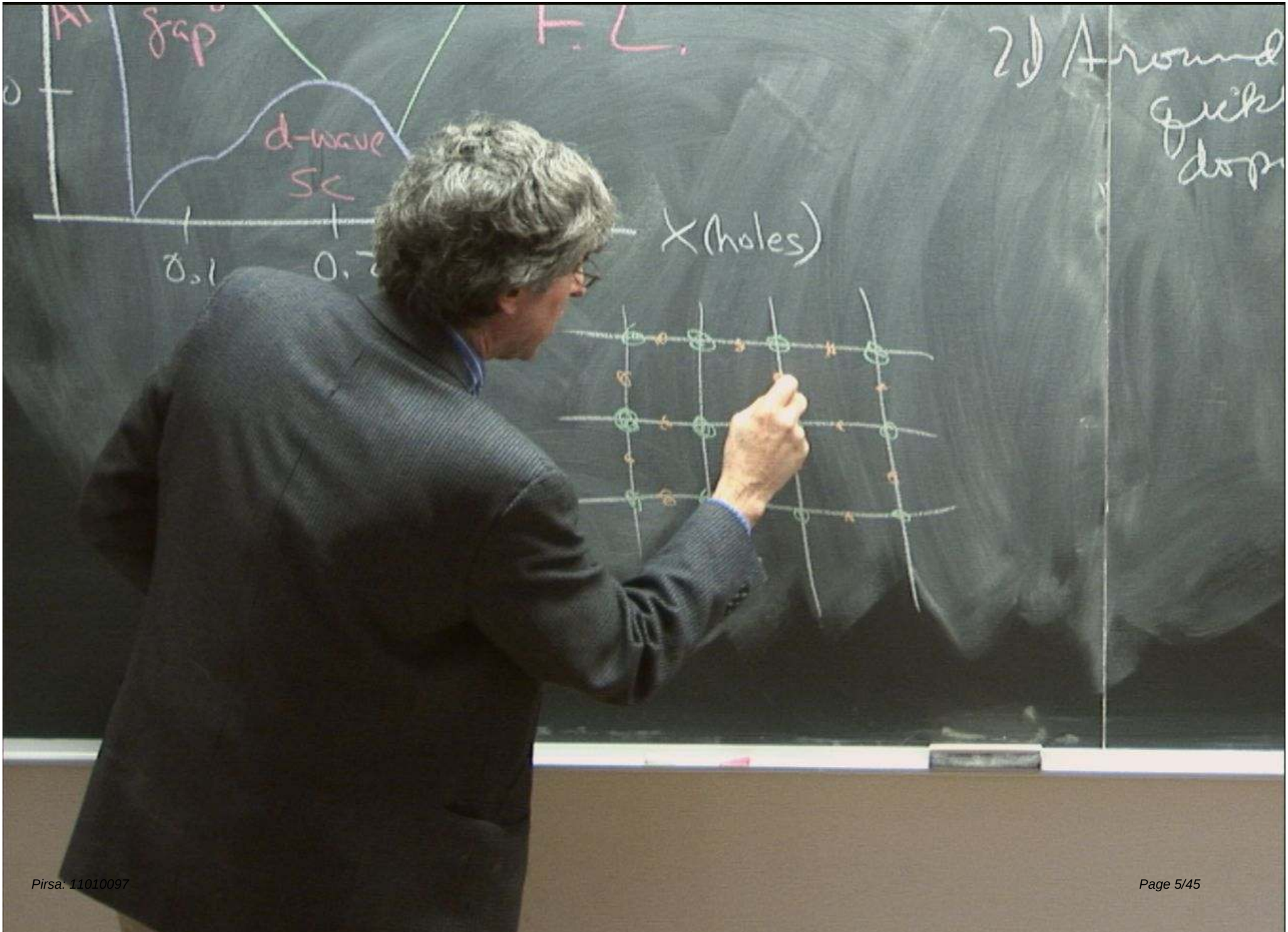
Abstract:


perimeter scholars
international


T
300
200
100
AF
Pseudo gap
Strange Metal
(Less Strange)
F.L.
d-wave sc
0.1
0.2
0.3
x (holes)

1.) T vs x ∈ fraction
of holes/cell x=0
→ 1 el/cell

2) Around x=0 AFM
quickly destroyed by
doping with holes


gap
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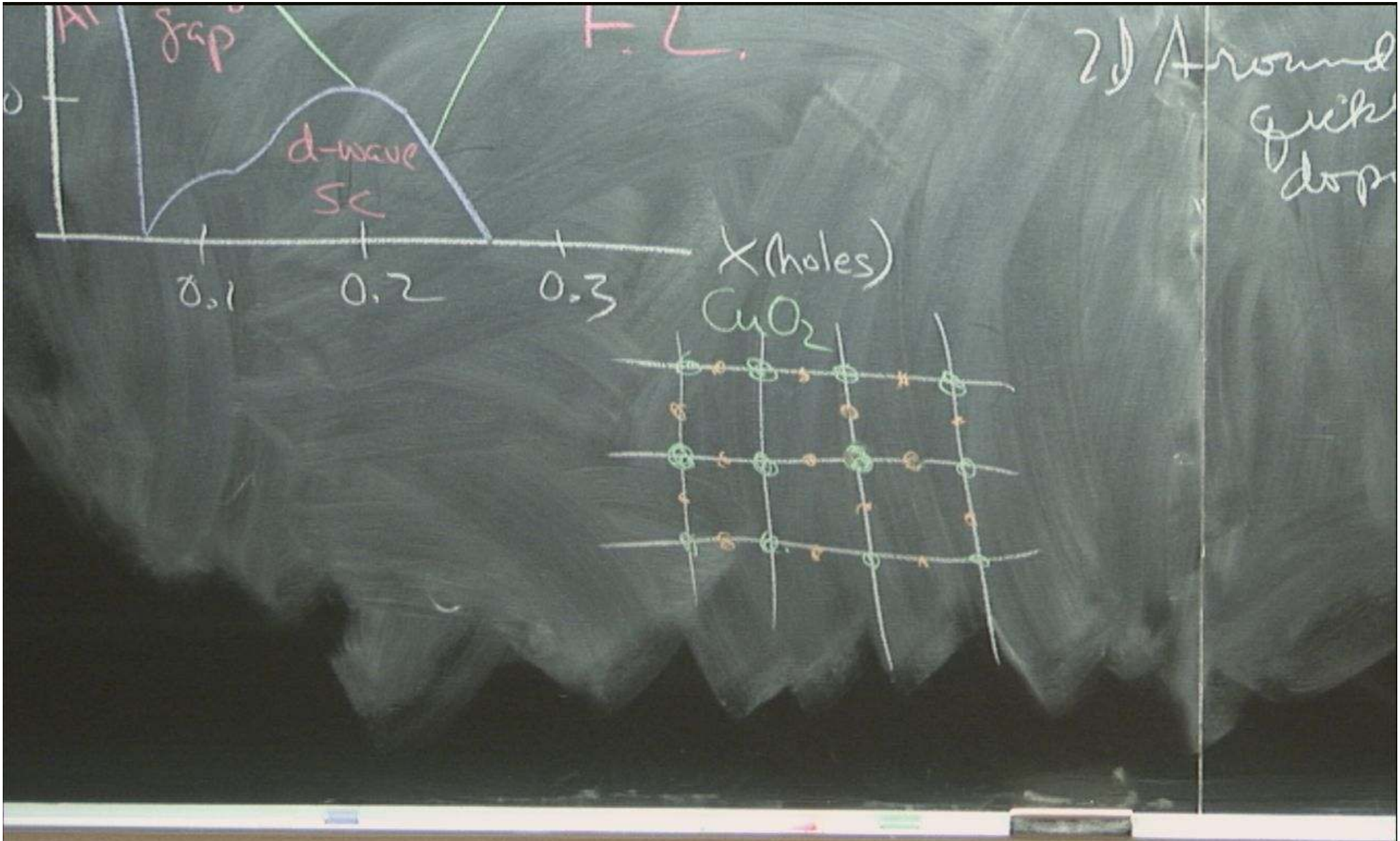
SC
0.1
x (holes)


AF
gap
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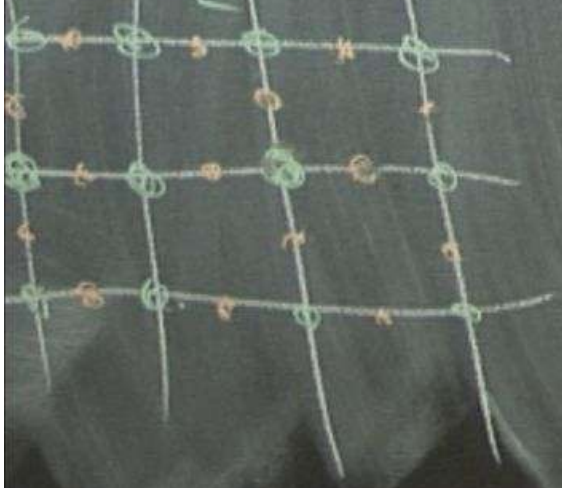
d-wave
SC
0.1
0.2
0.3
X (holes)
CuO_2
2) Around
quick
dop

2) Around x=0 AFM quickly destroyed by doping with holes

- x (holes)

CuO_2



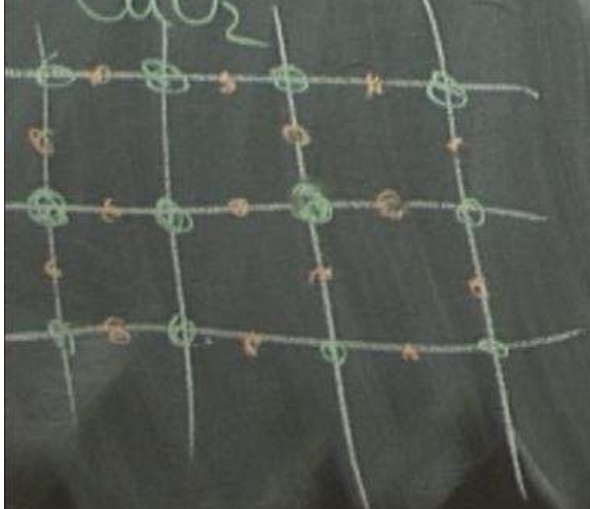
$YBaCuO_{6+x}$

...es strange)

L.

— X (holes)

CuO_2

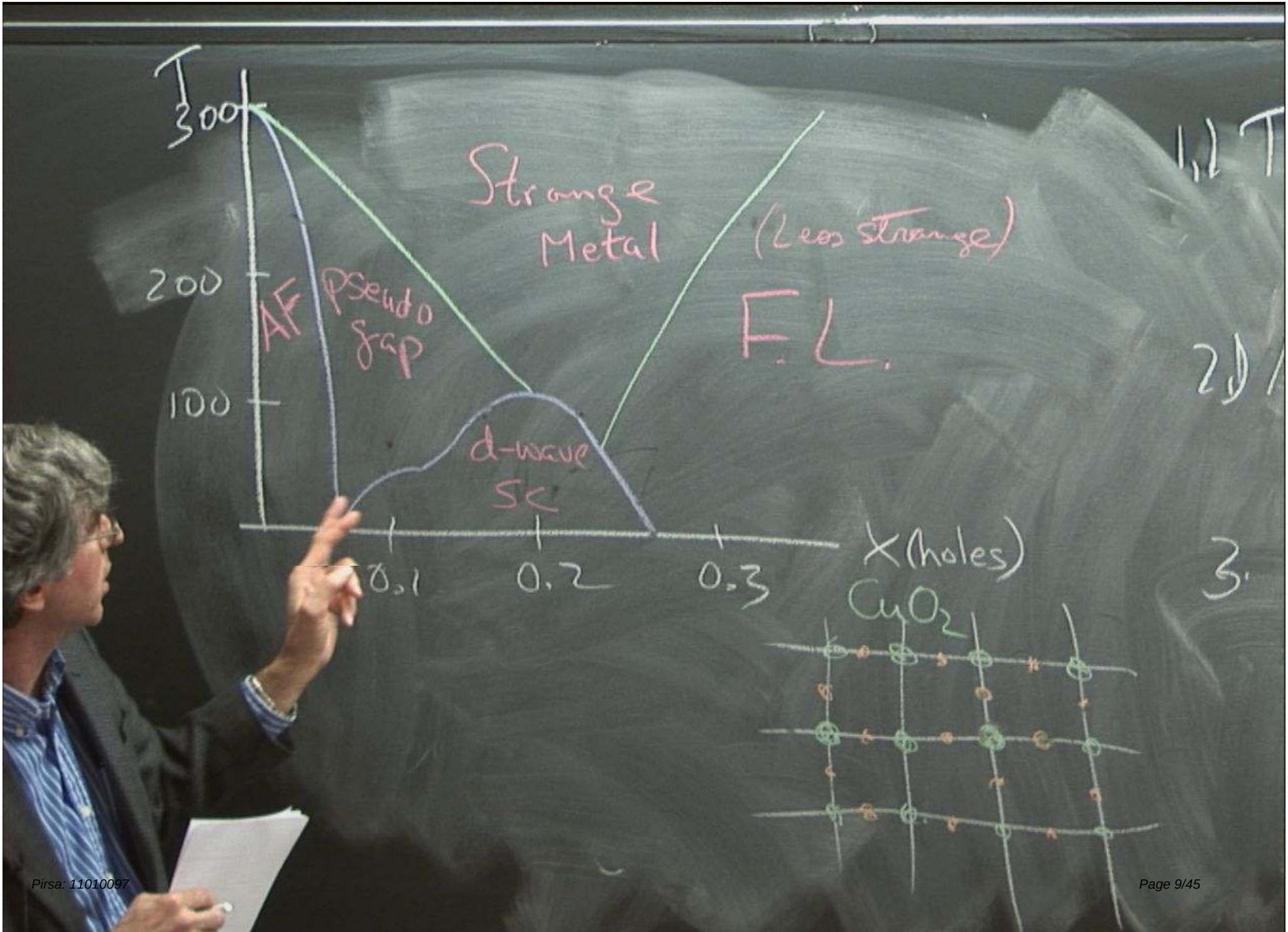


1.) T vs X ∈ fraction of holes/site X=0 → 1 el/site

2.) Around X=0 AFM quickly destroyed by doping with holes

3. D-wave SC

- $T_c > 0$ for some small X
- Optimal T_c
- T_c disappears at large X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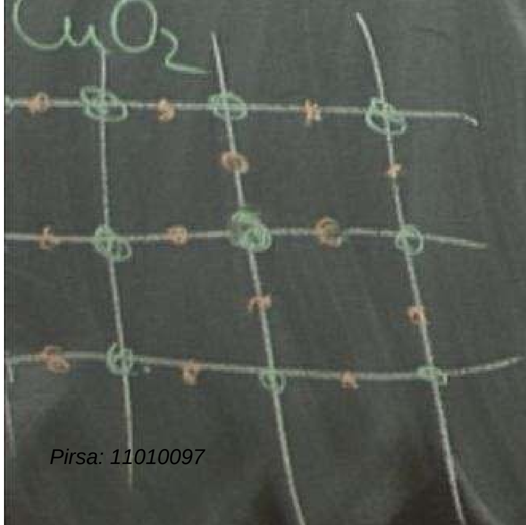
X (holes)



1.) T vs x ∈ fraction of holes/site x=0
→ 1 el/site

2.) Around x=0 AFM
quickly destroyed by
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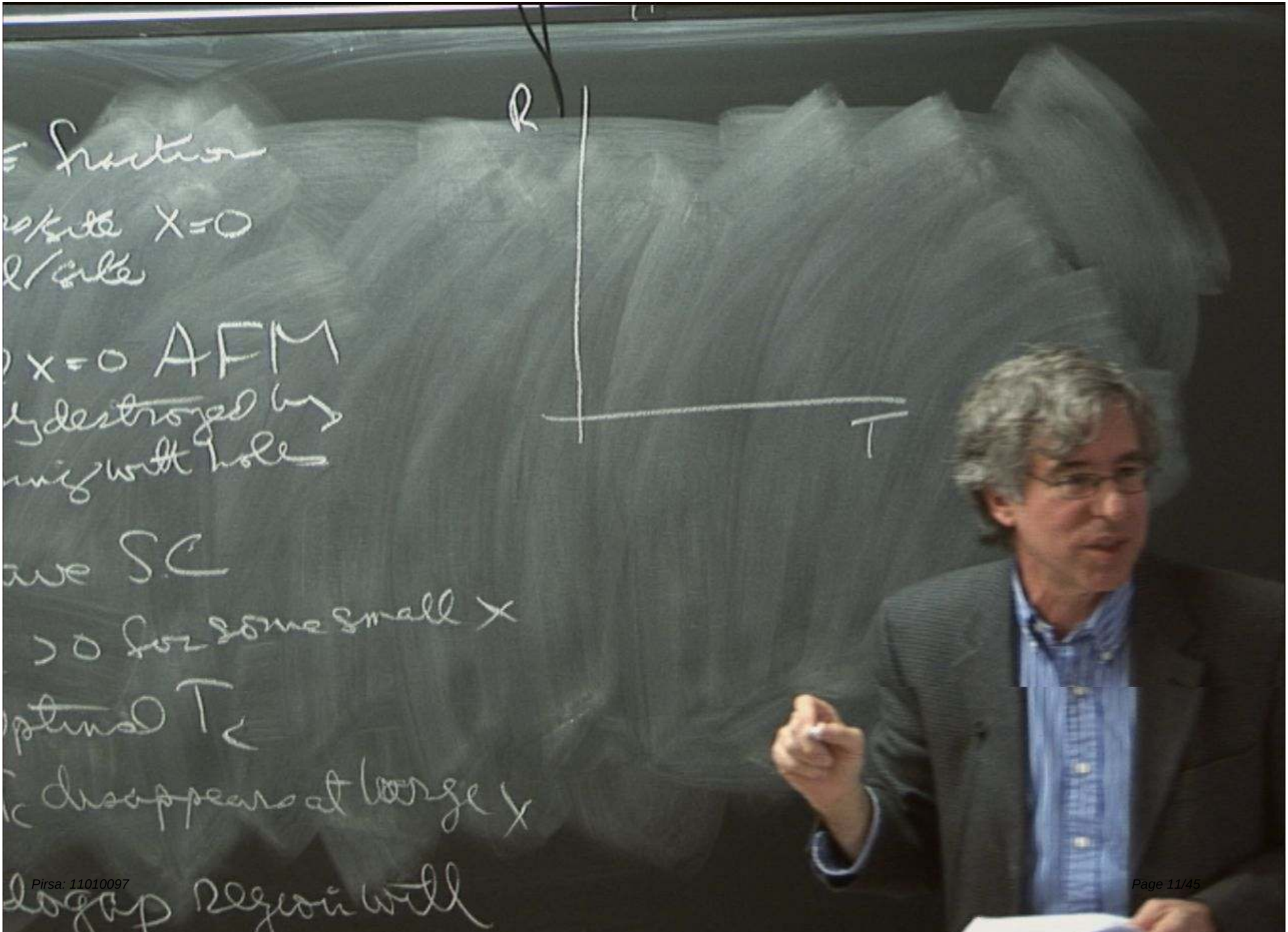
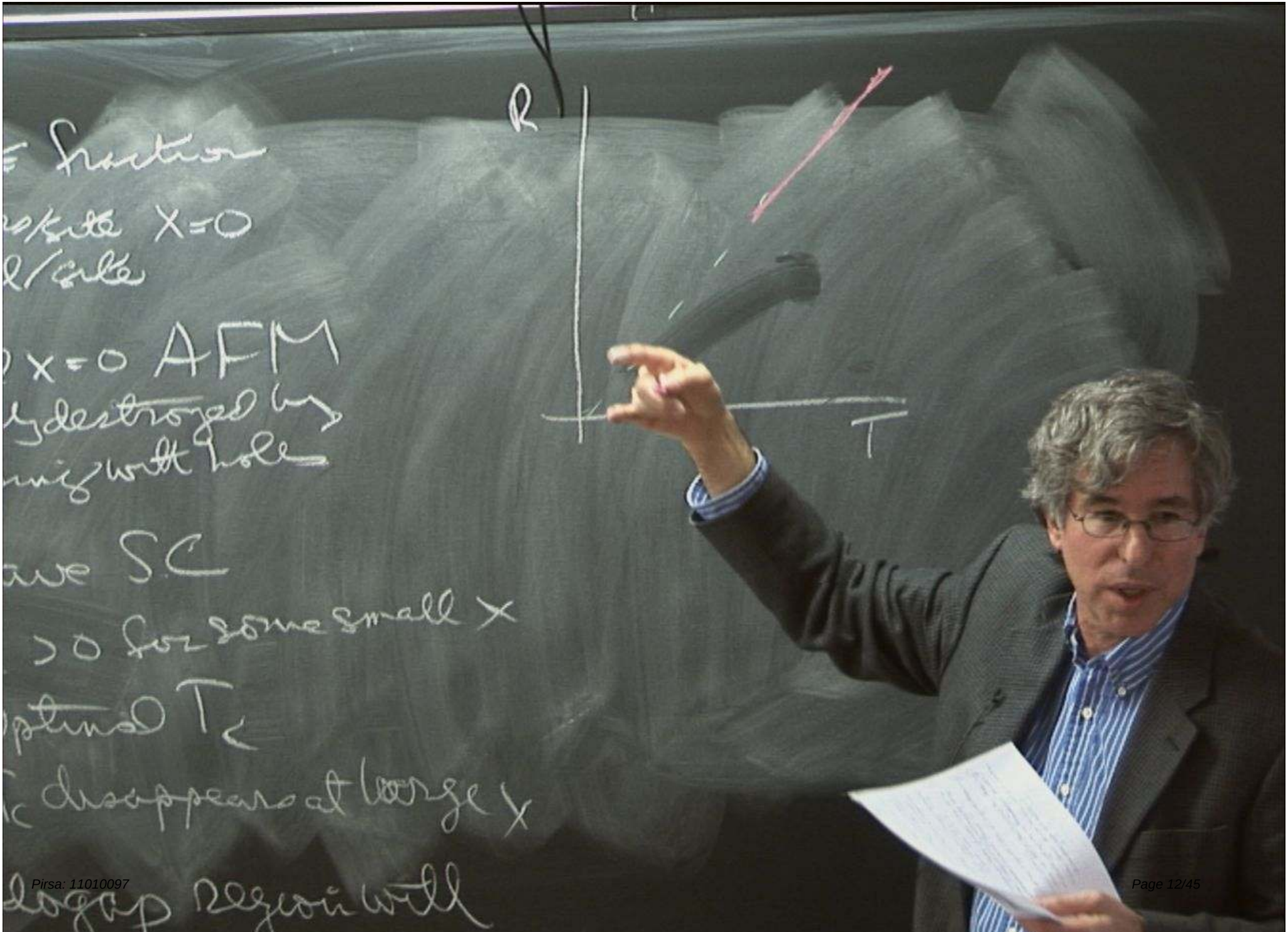
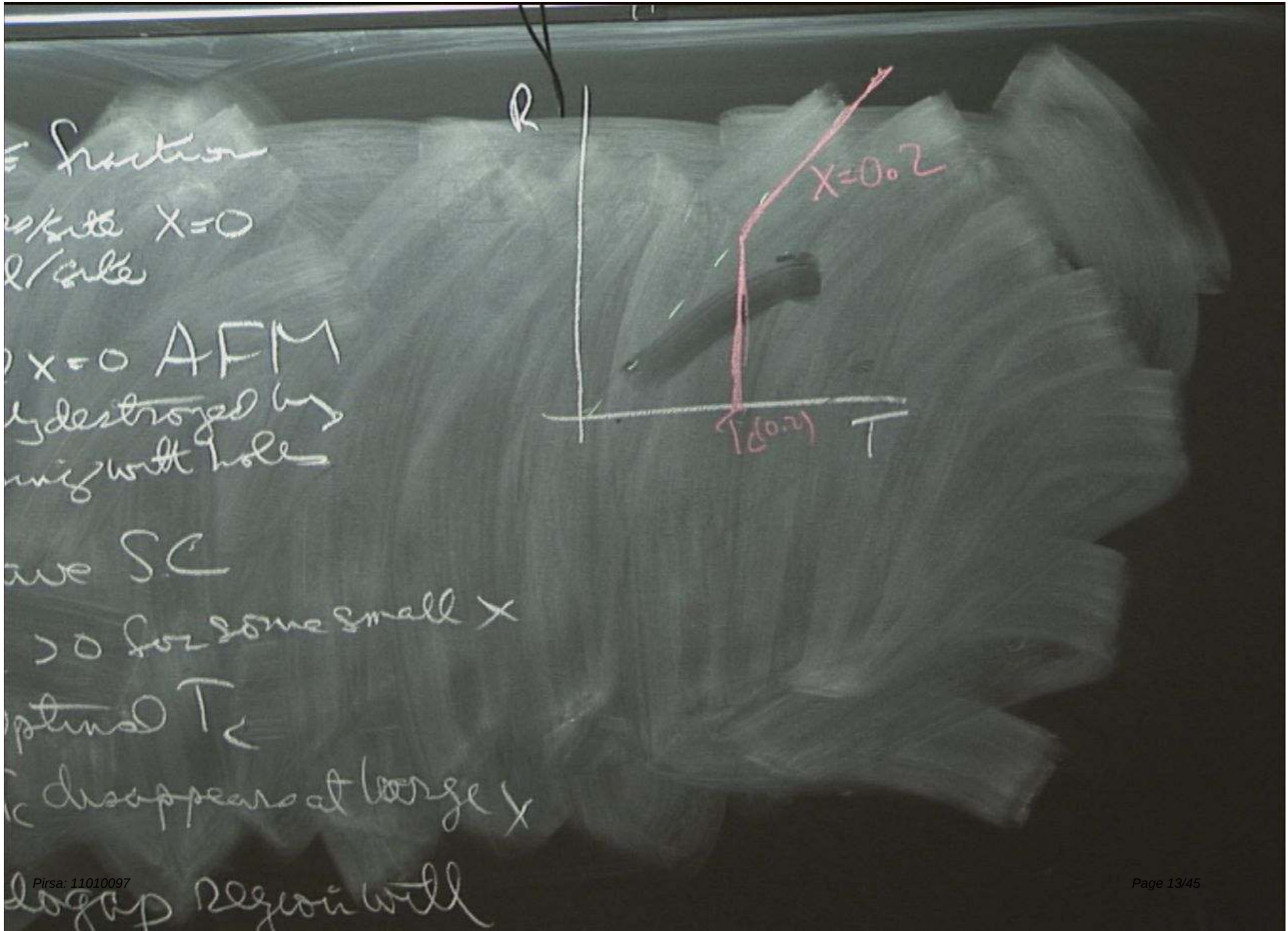
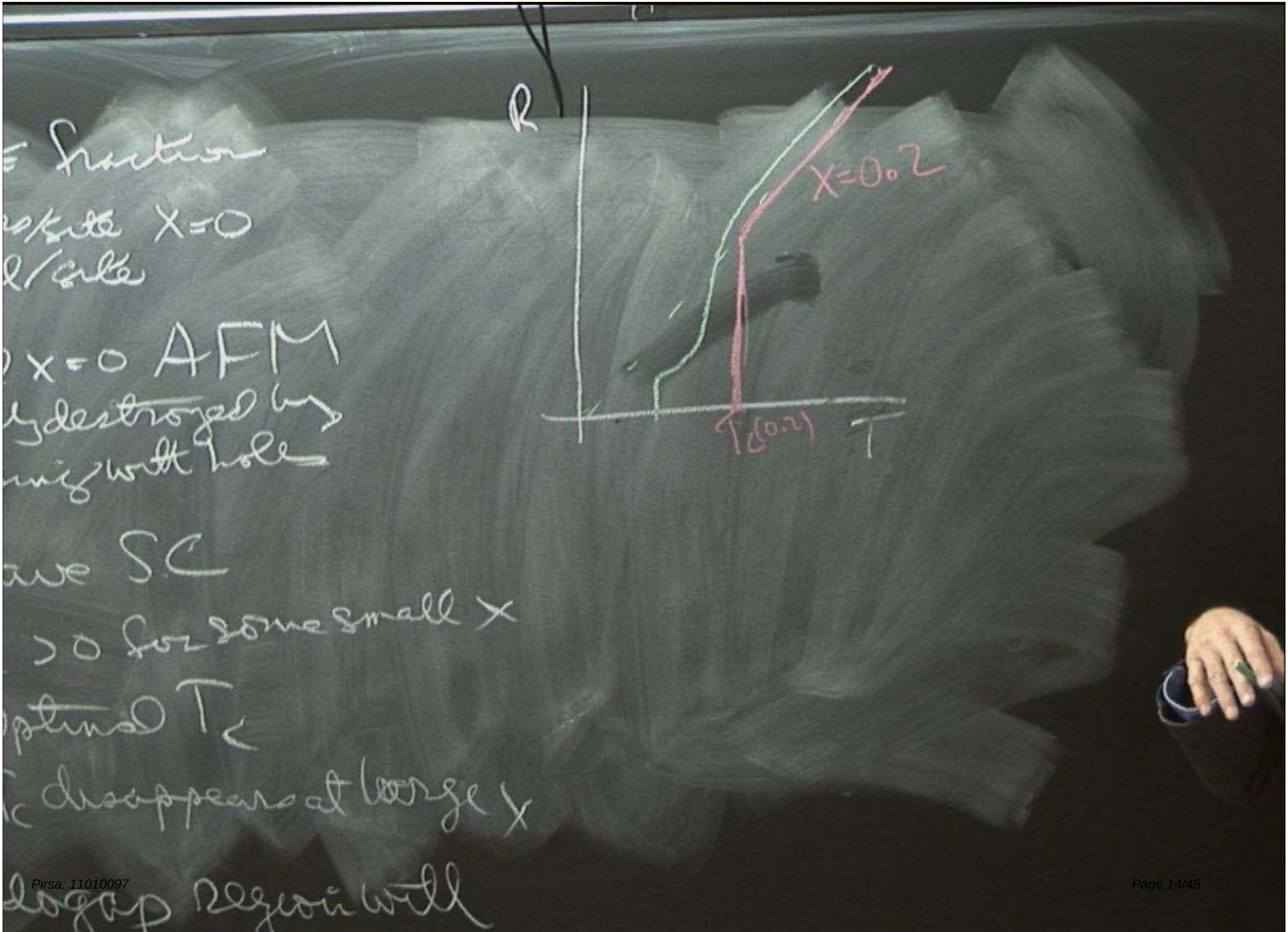
3. D-wave SC
- $T_c > 0$ for some small x
- Optimal T_c
- T_c disappears at large x

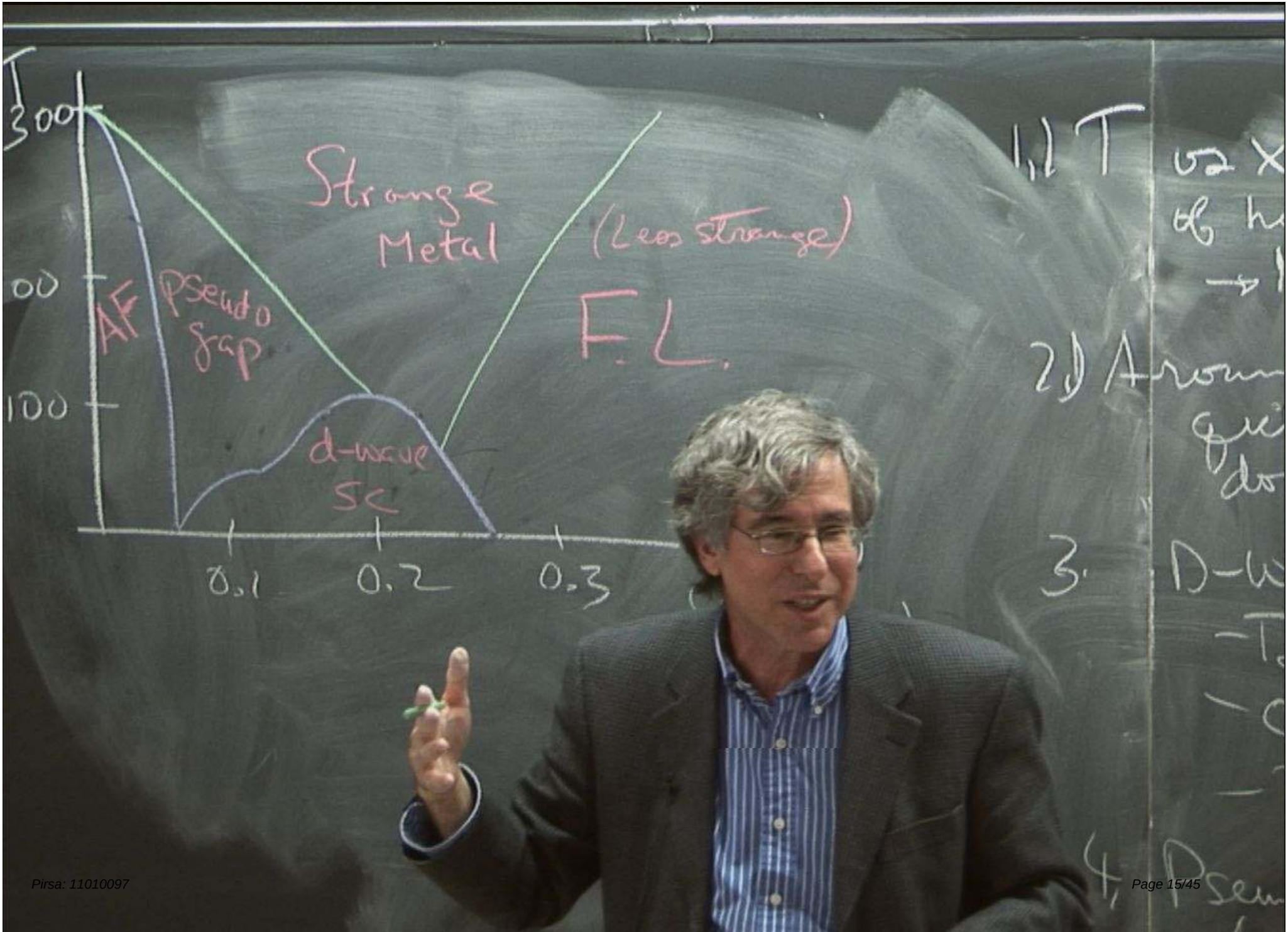
4. Pseudogap region with


R
T
AFM
SC


R
T
AFM
SC


R
X=0.2
T


R
X=0.2
T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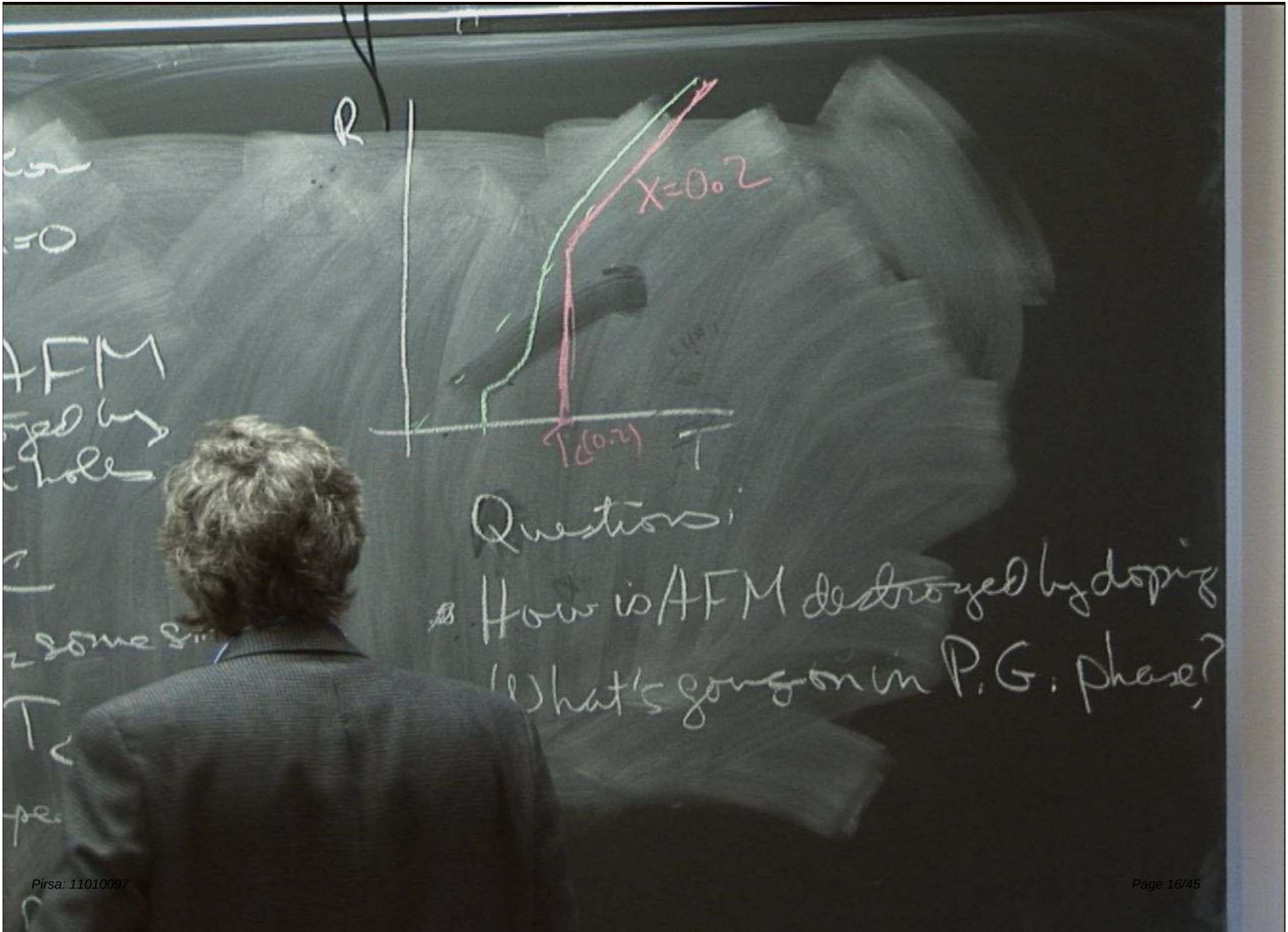
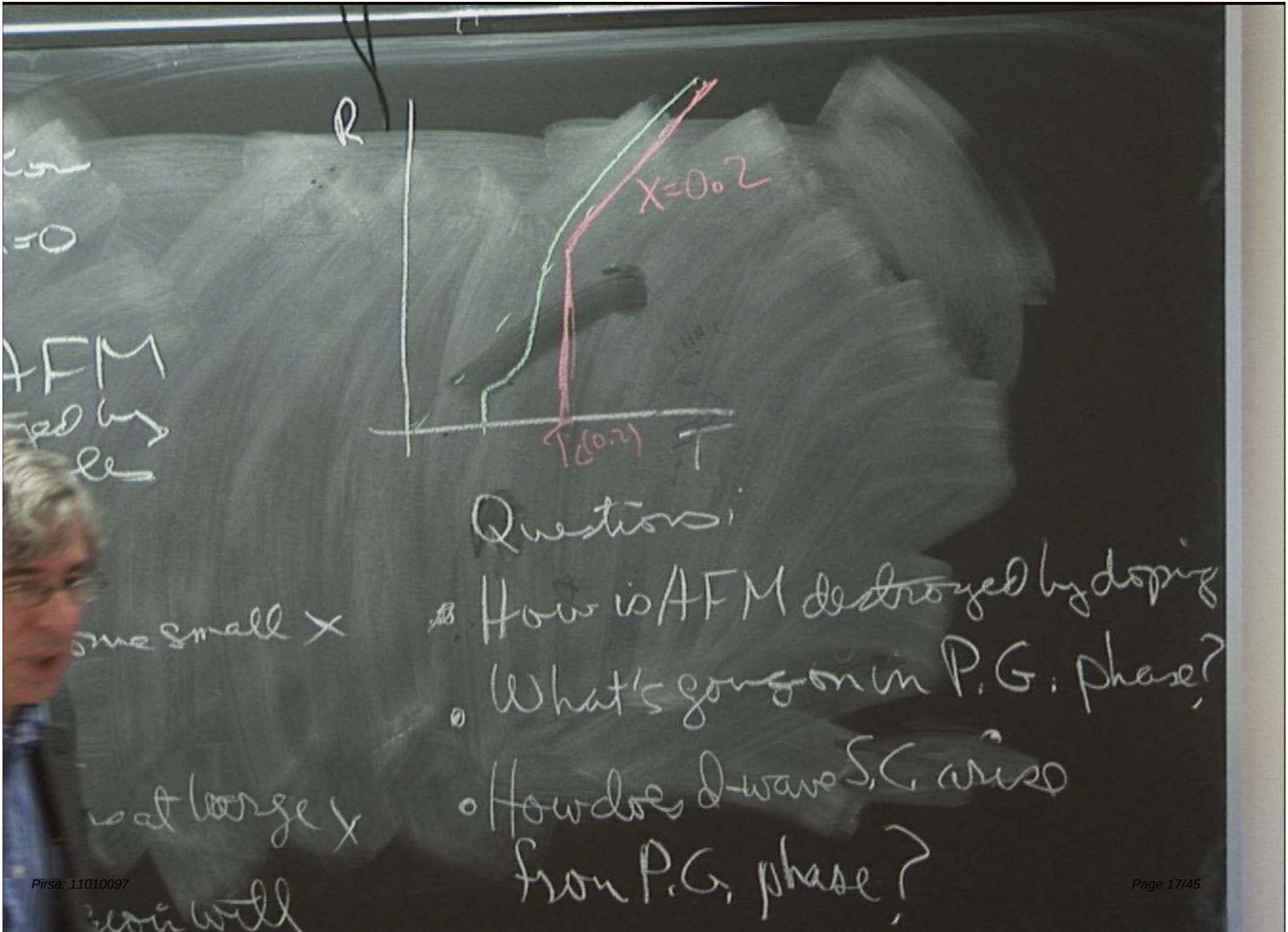
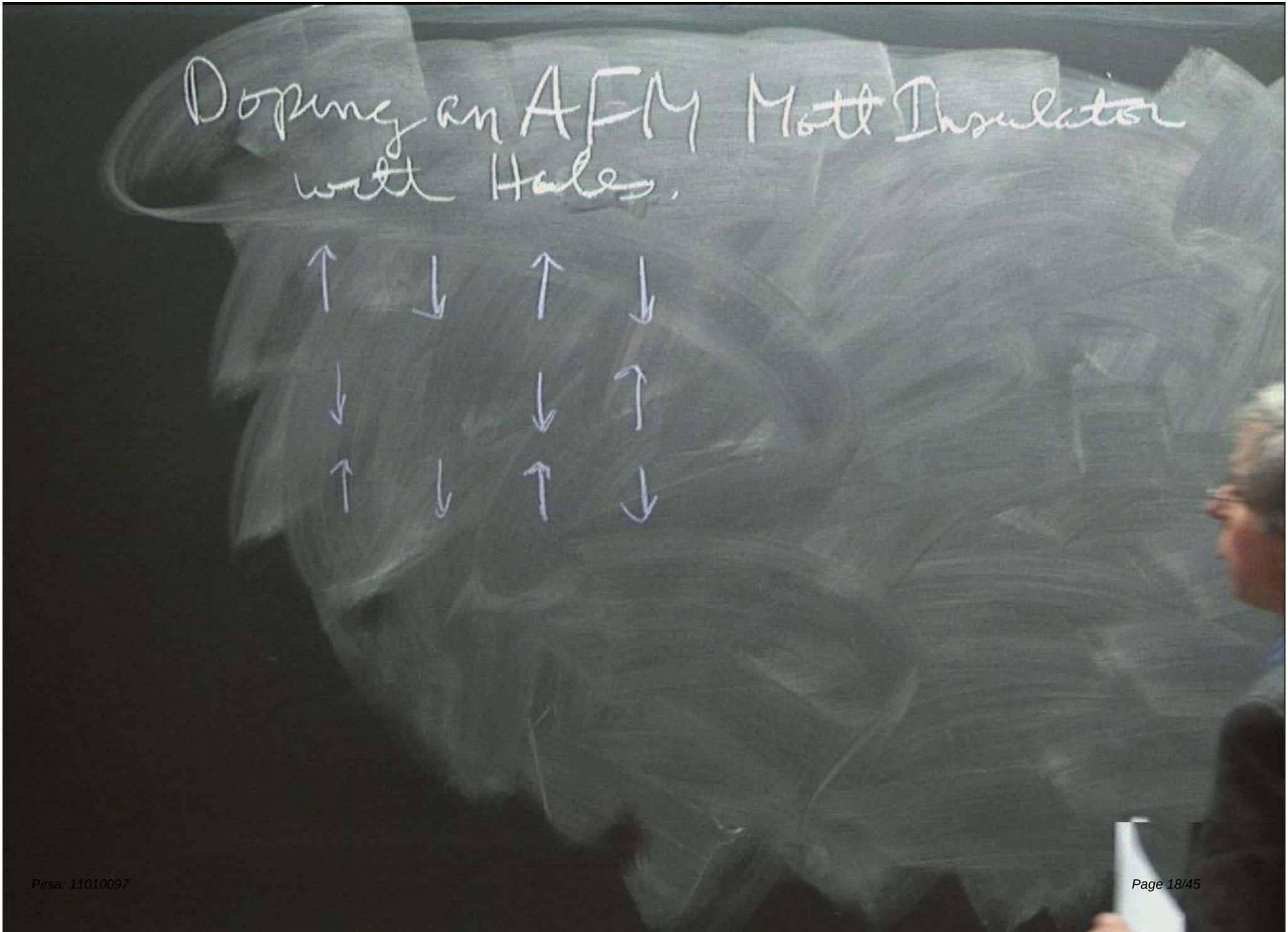
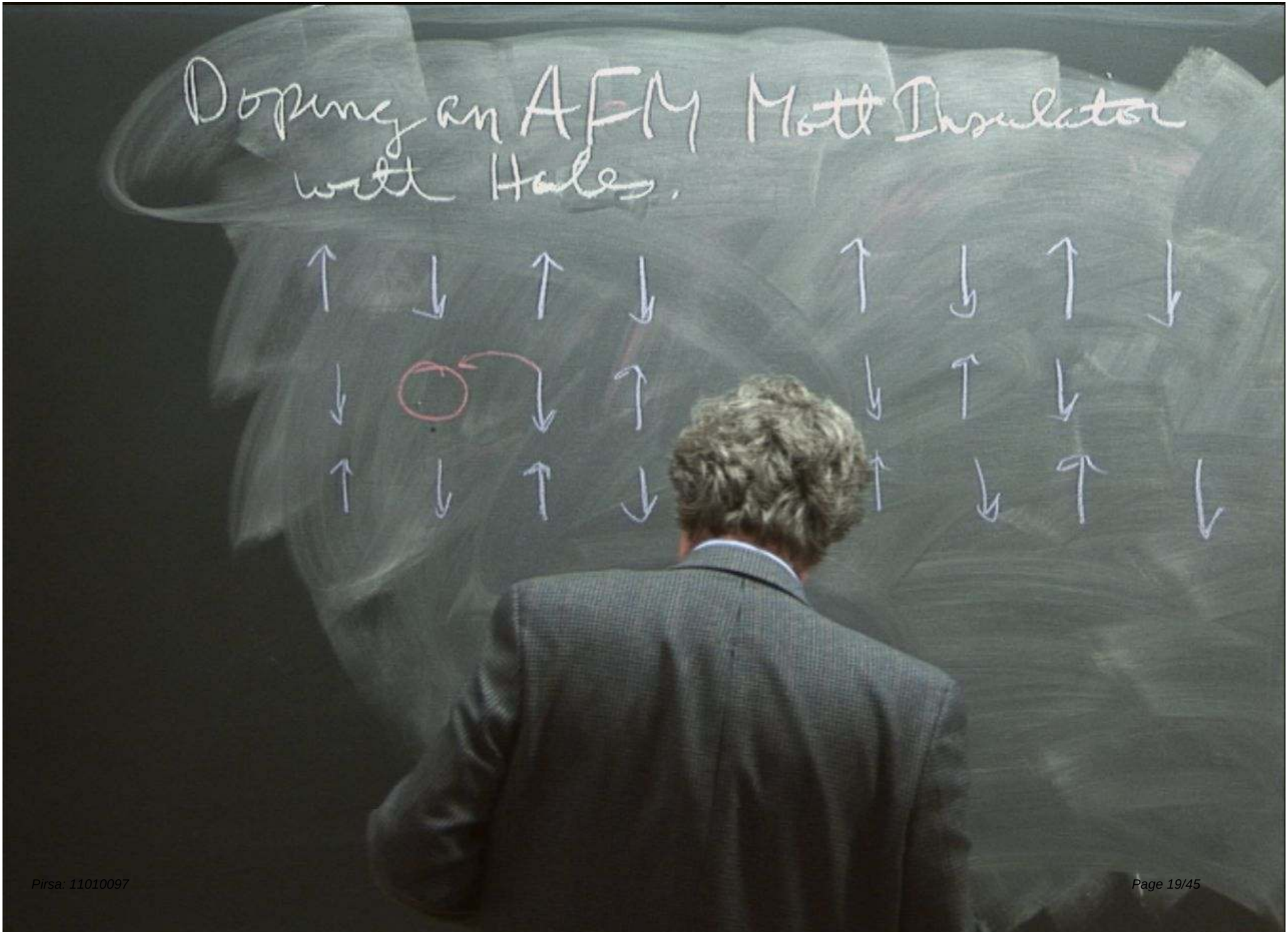
1.) T vs x
2.) Aroun
3. D-W
4. Pseu


R
X=0.2
T
Questions:
How is AFM destroyed by doping
What's going on in P.G. phase?


R
X=0.2
T_c(0.2)
T
Questions:
How is AFM destroyed by doping
What's going on in P.G. phase?
How does d-wave S.C. arise from P.G. phase?


Doping an AFM Mott Insulator
with Holes.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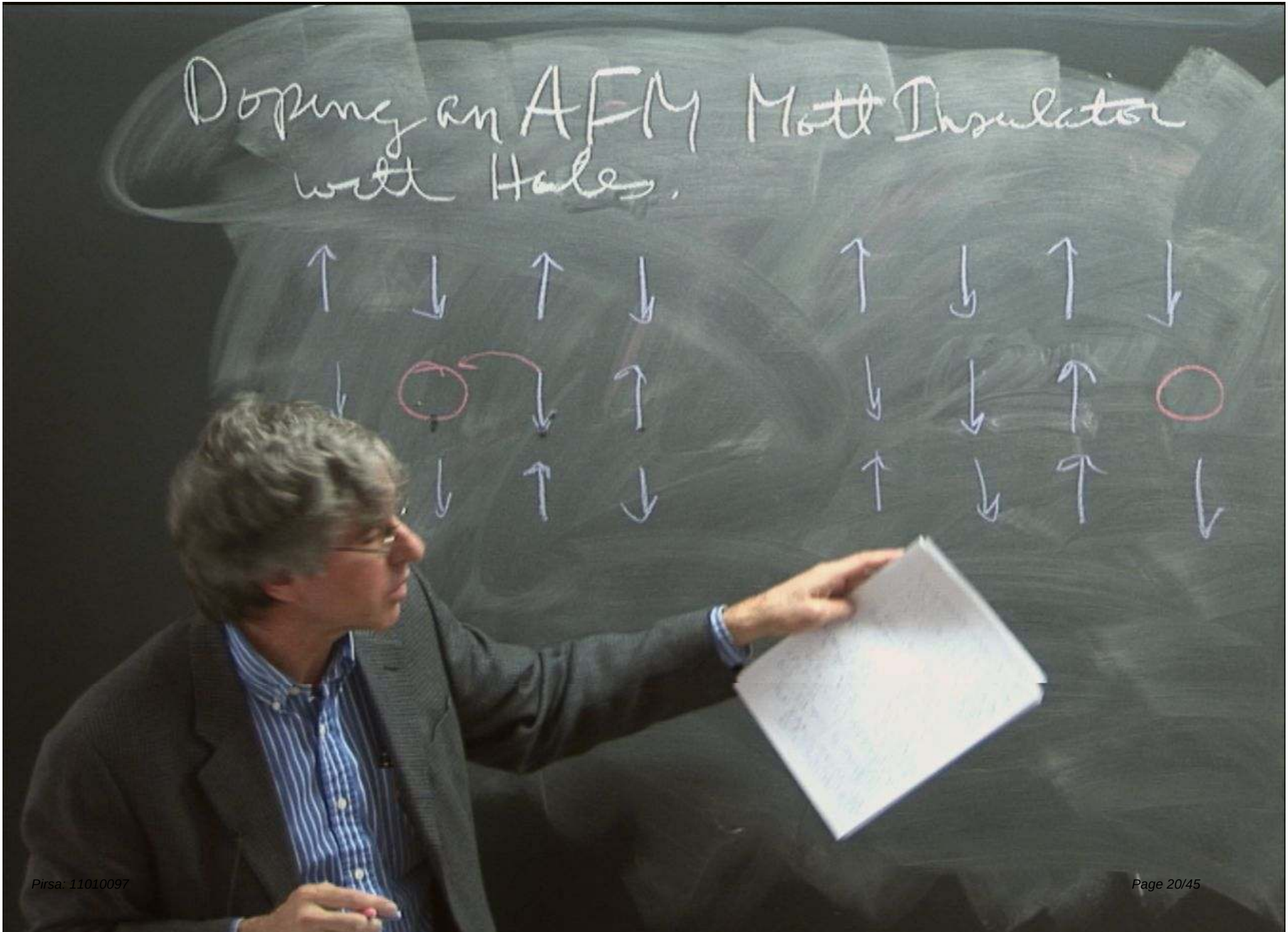
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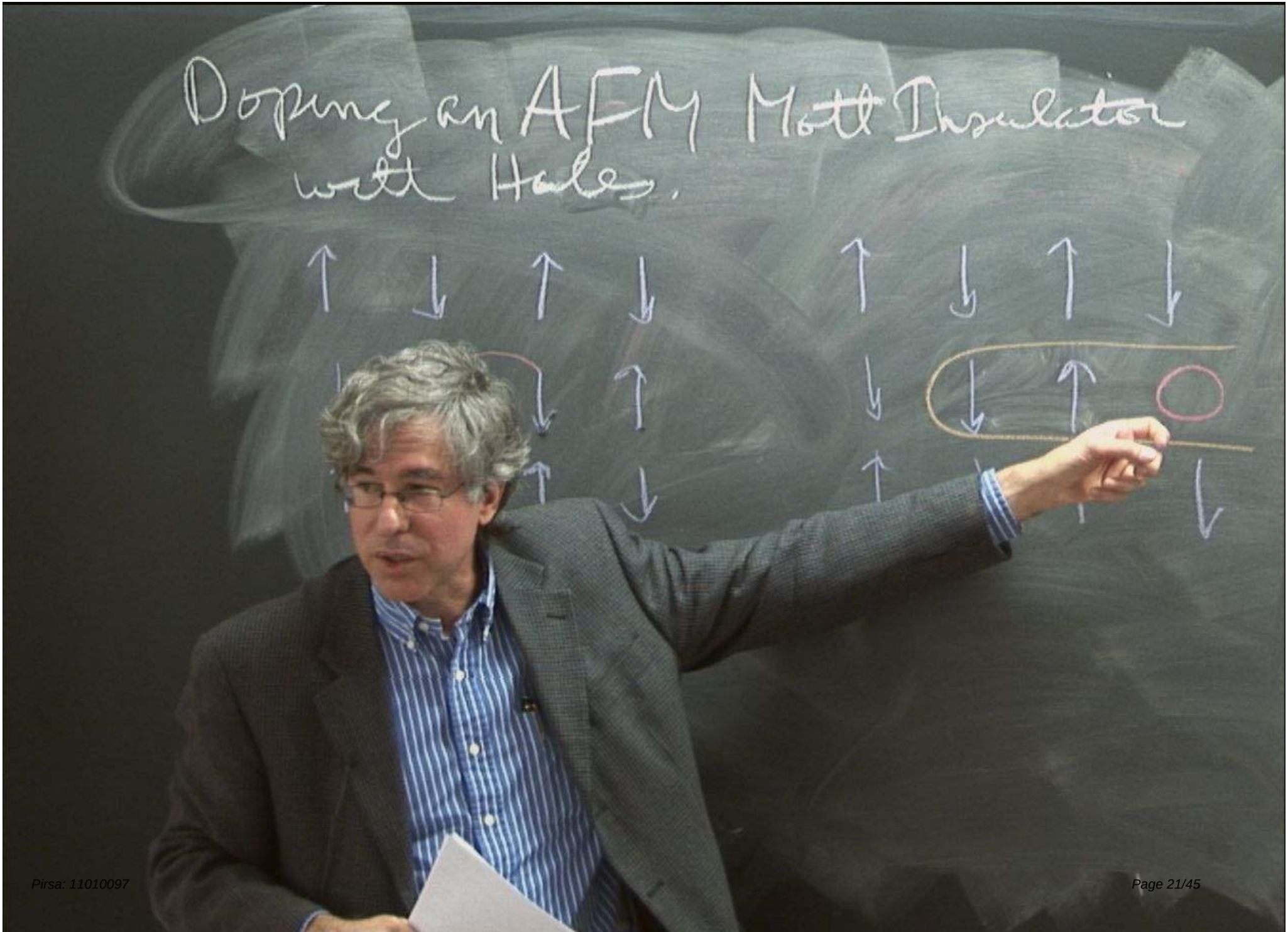
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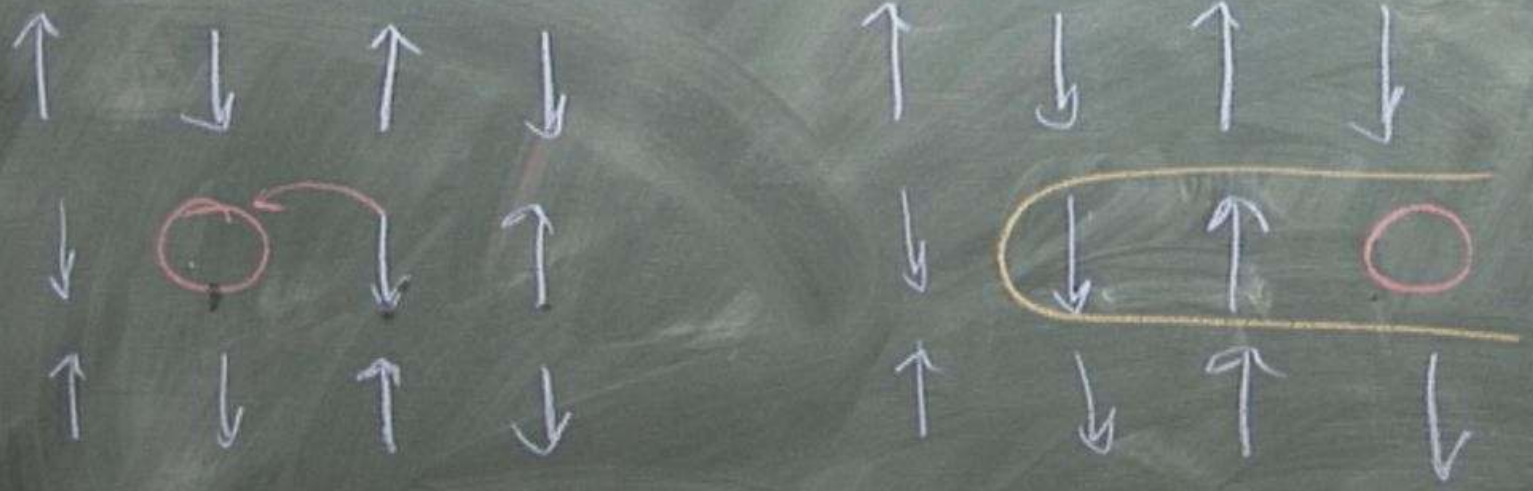
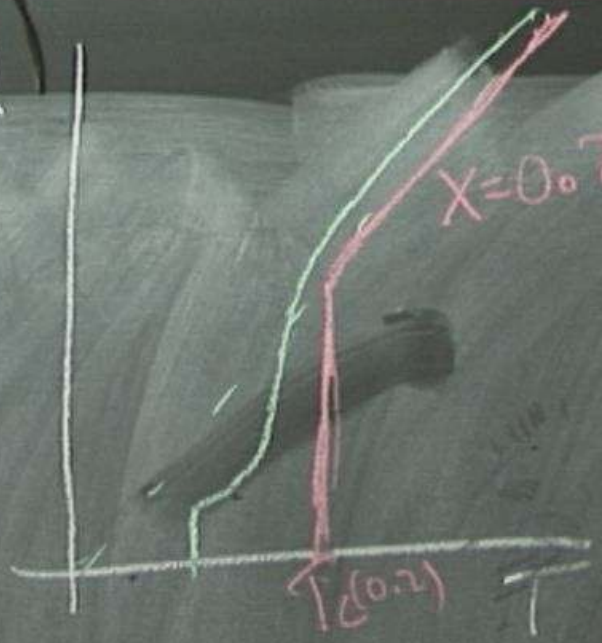


nce Bond State

Anderson 1973,

ekas + PWA 1974



Questions:

- How is AFM destroyed by dop
- What's going on in P.G. phas
- How does d-wave S.C. arise from P.G. phase?

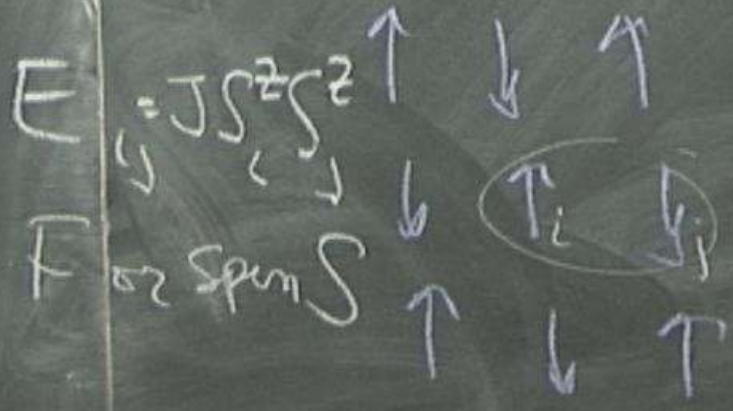
Valence Bond States

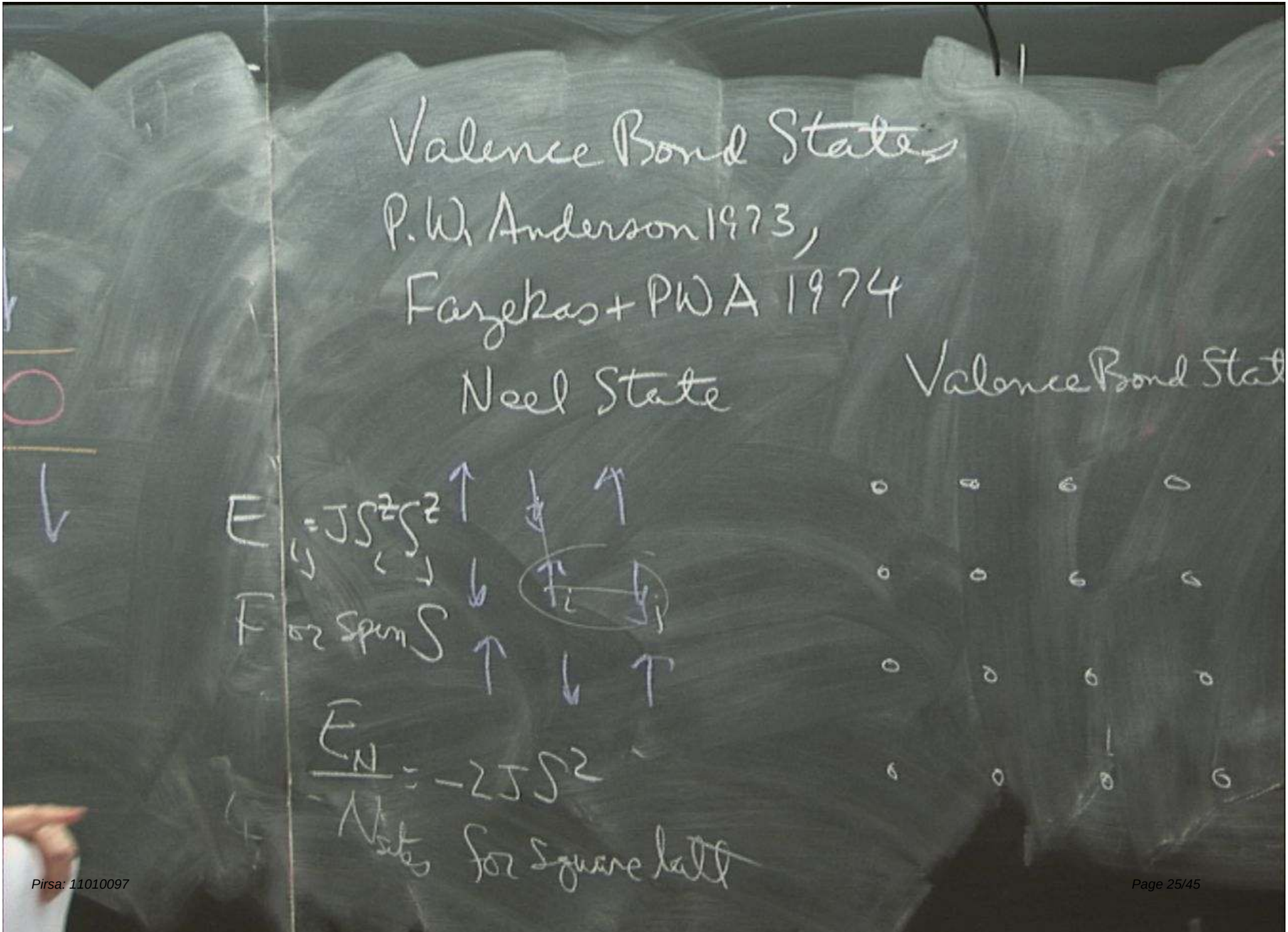
P.W. Anderson 1973,

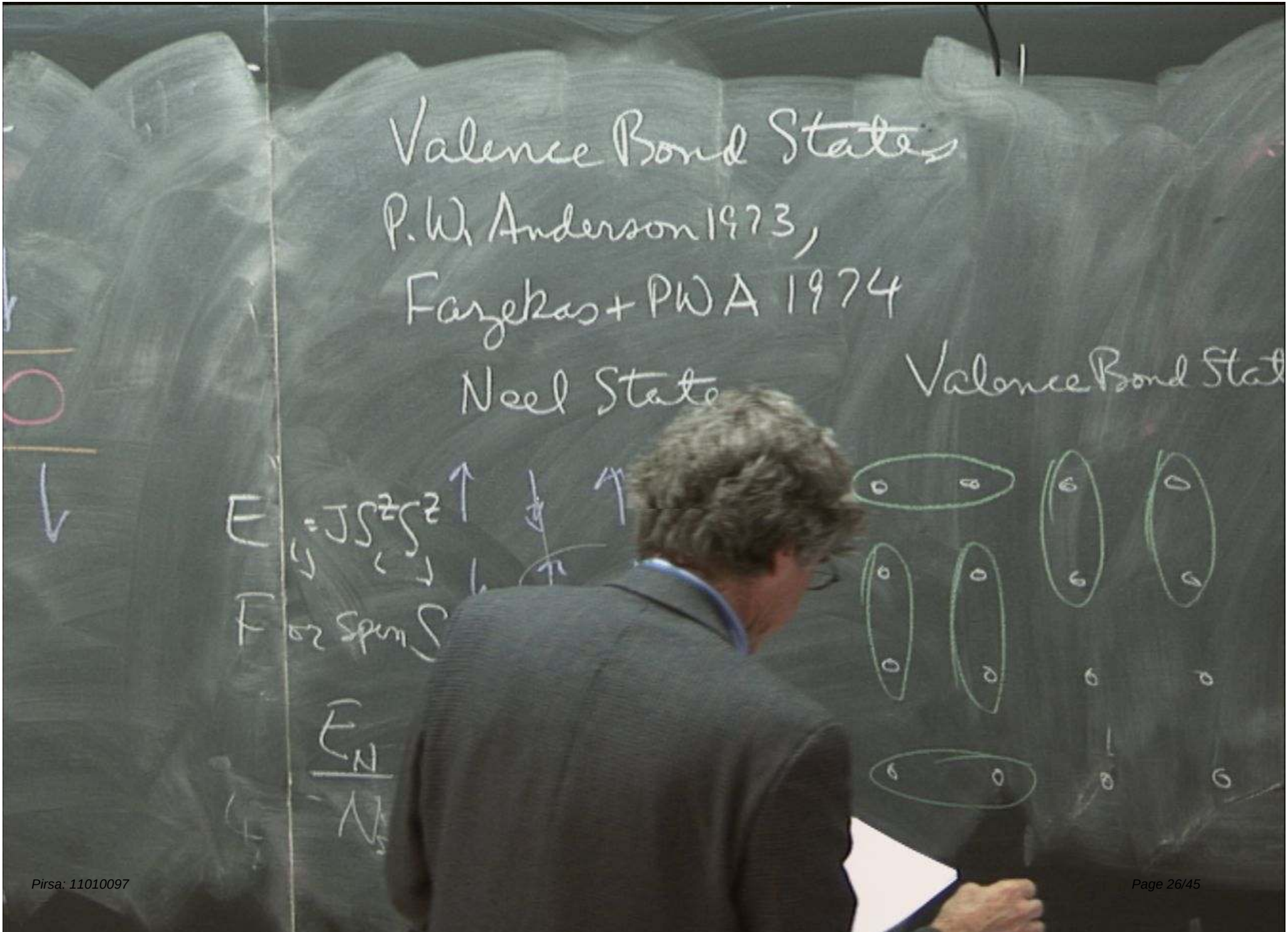
Fazekas + PWA 1974

Neel State

Valence Bond Stat




Valence Bond States
P.W. Anderson 1973,
Fazekas + PWA 1974
Neel State
Valence Bond Stat
$E = -JS^z S^z$
For Spin S
$\frac{E_N}{N} = -zJS^2$
Notes for Square latt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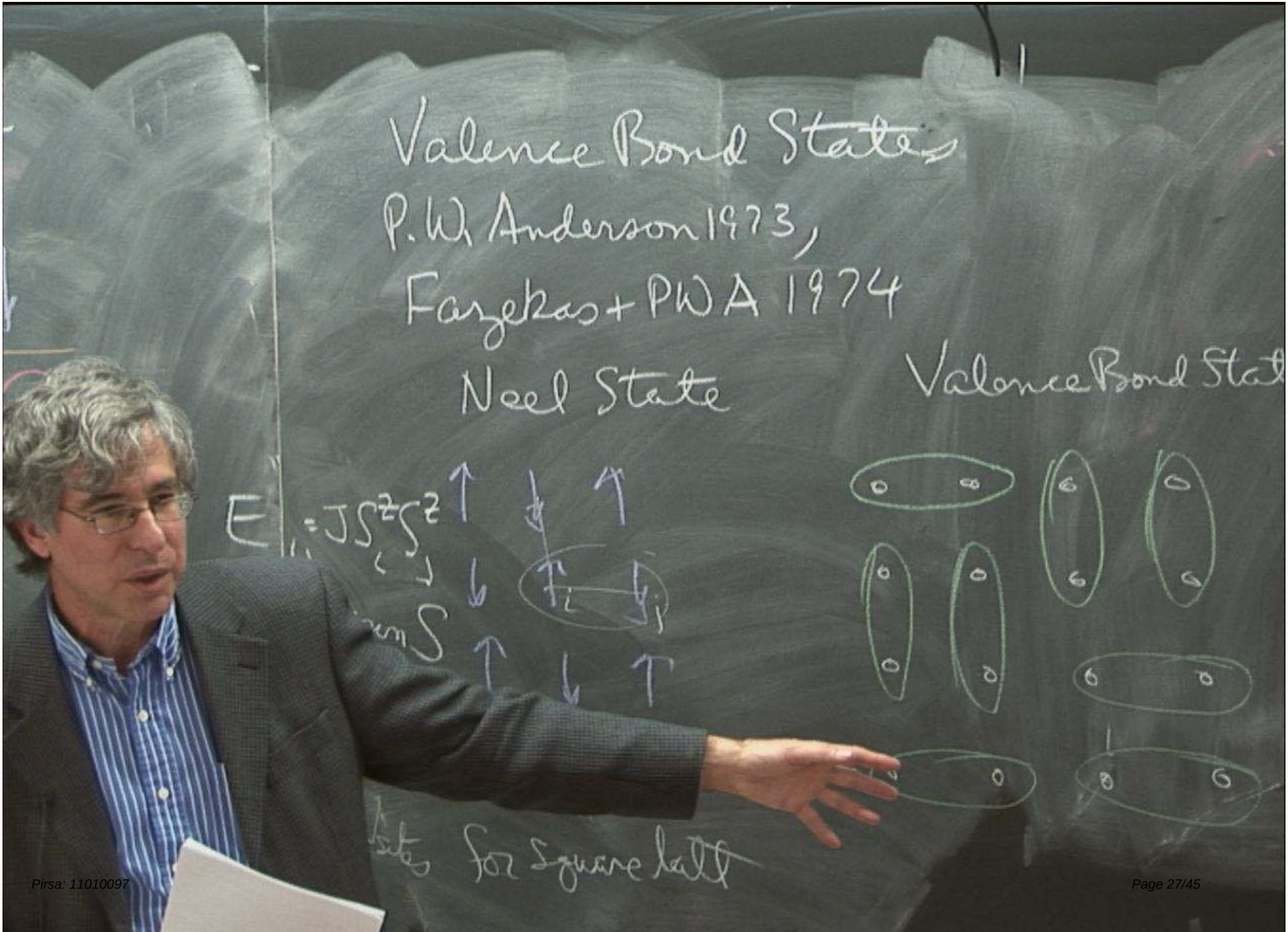
Valence Bond State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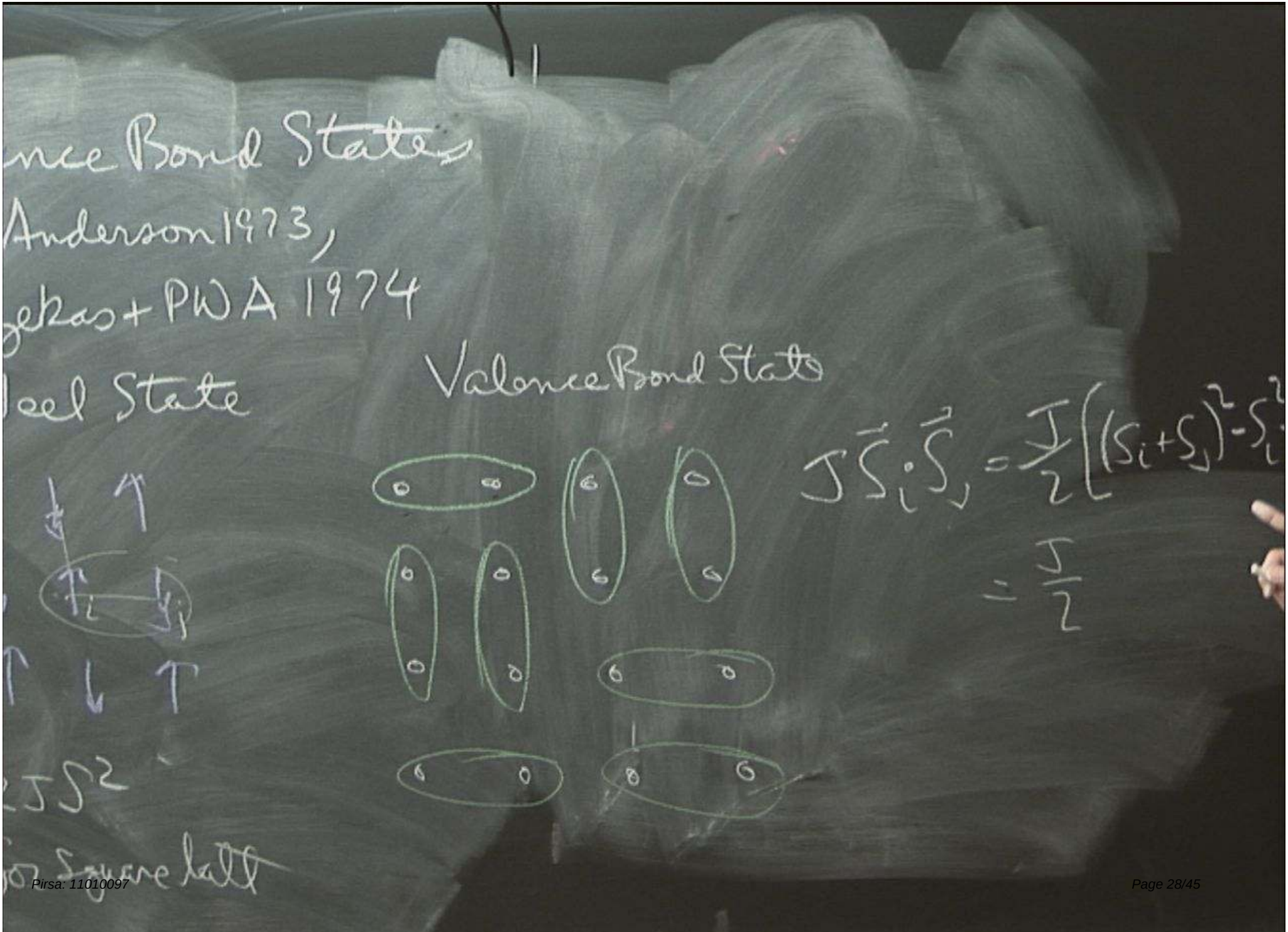
nce Bond States
Anderson 1973,
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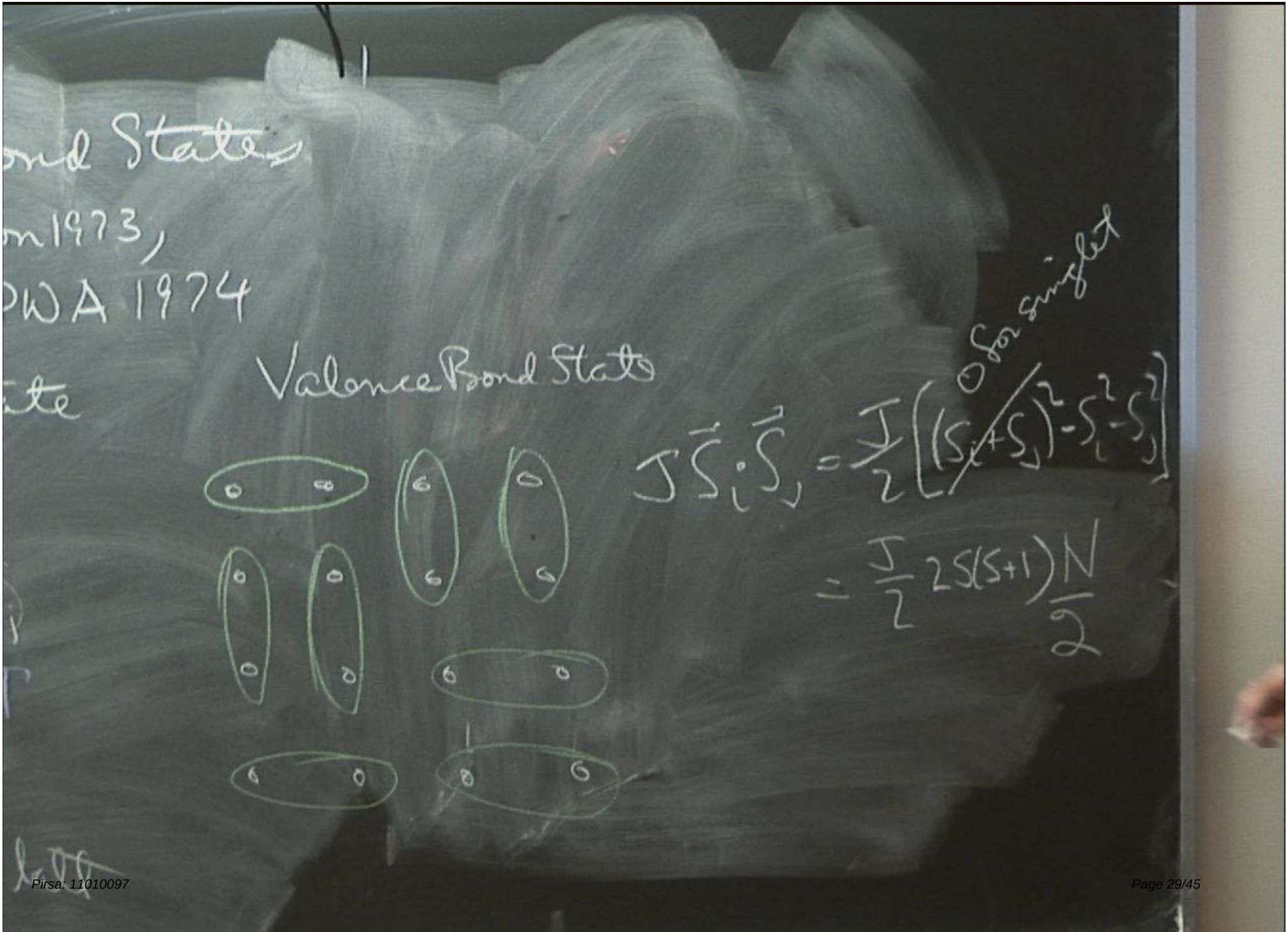
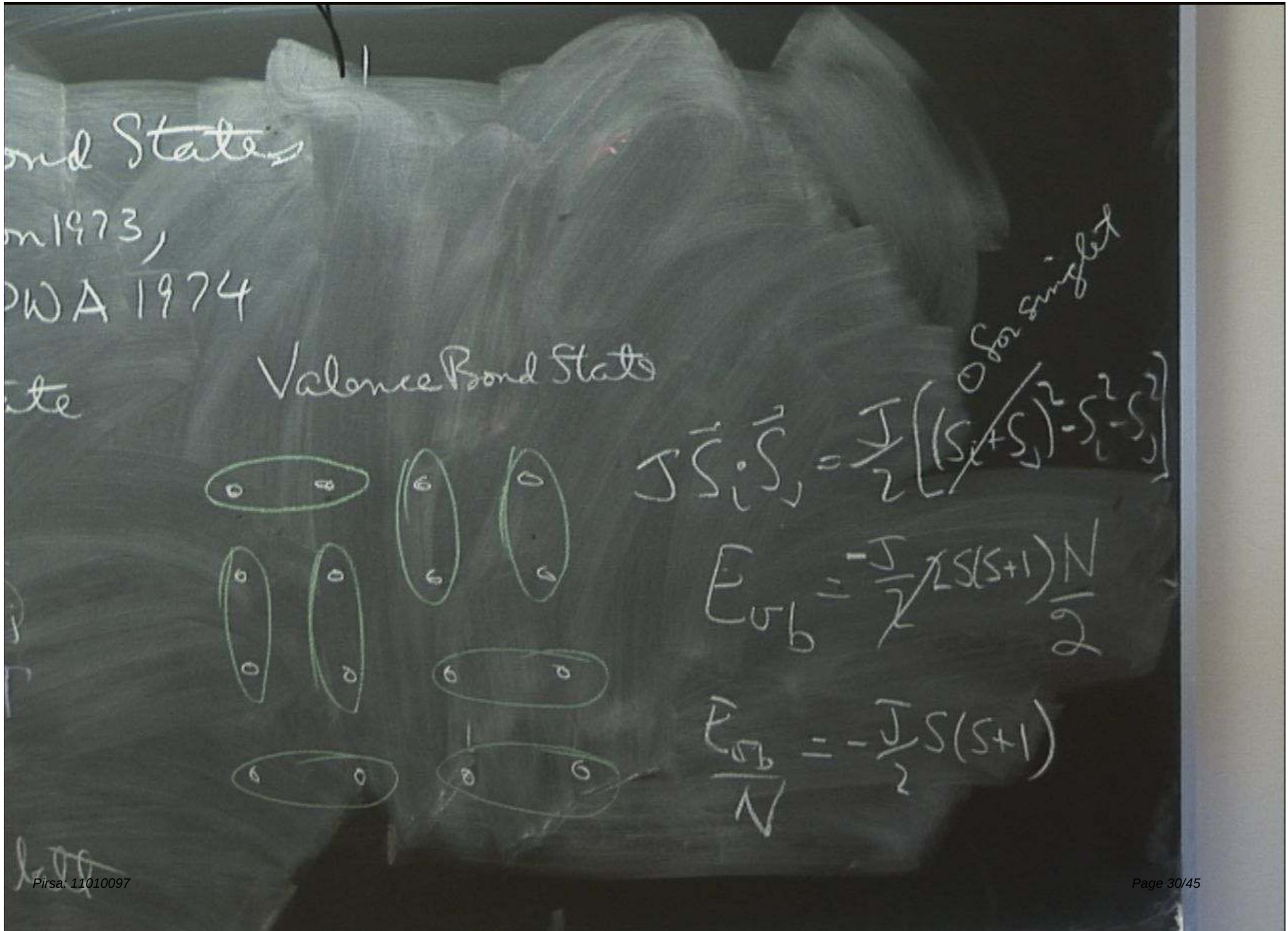
eel State
Valence Bond State
$J\vec{S}_i\cdot\vec{S}_j = \frac{J}{2}\left[(S_i+S_j)^2 - S_i^2\right.$
$= \frac{J}{2}$
$2JS^2$
or Square latt


ond States
m 1973,
PWA 1974
ite
Valence Bond State
$J\vec{S}_i\cdot\vec{S}_j = \frac{J}{2}\left[(S_i+S_j)^2 - S_i^2 - S_j^2\right]$
0 for singlet
$= \frac{J}{2} 2S(S+1)\frac{N}{2}$


ond States
m 1973,
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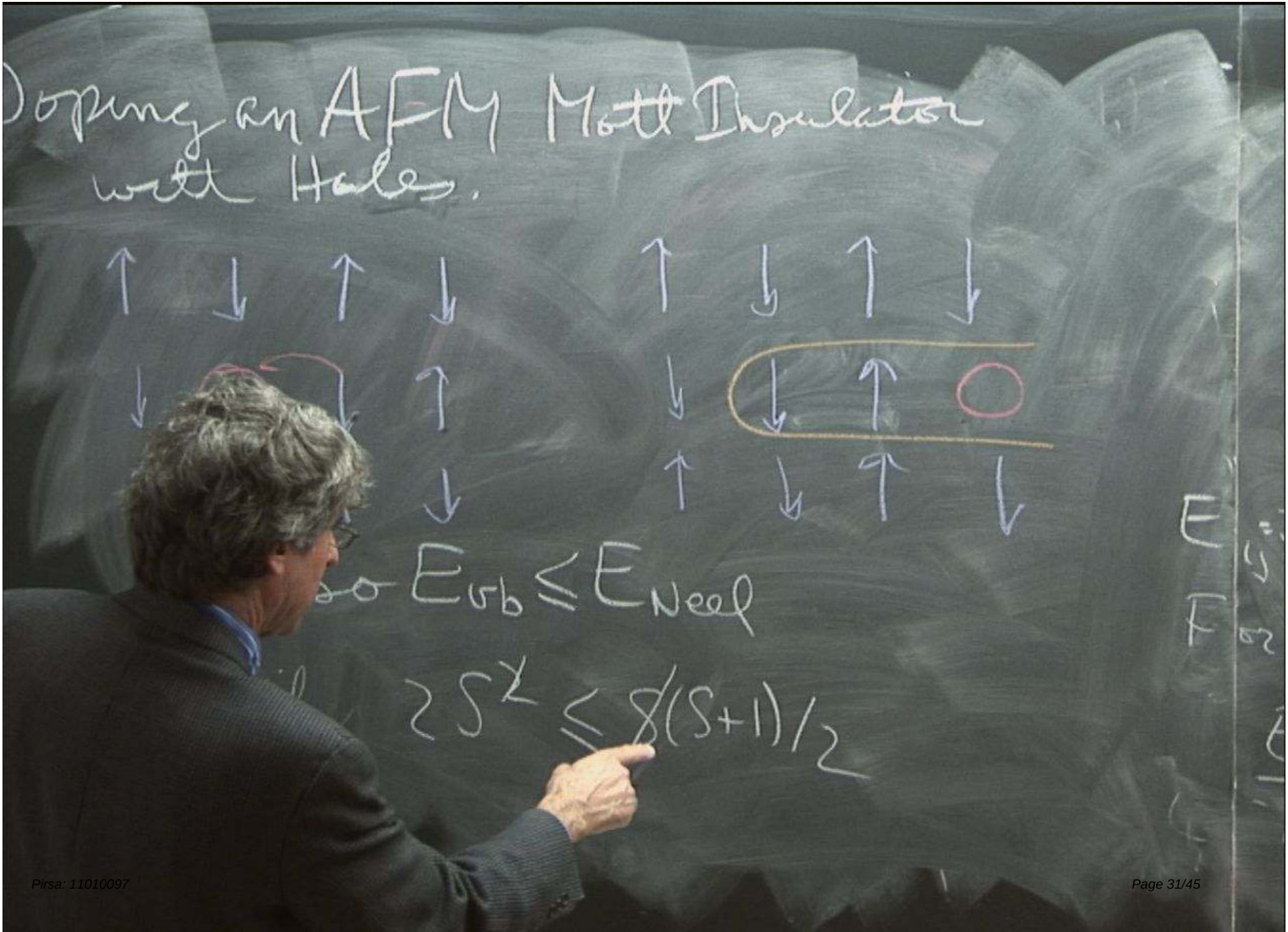
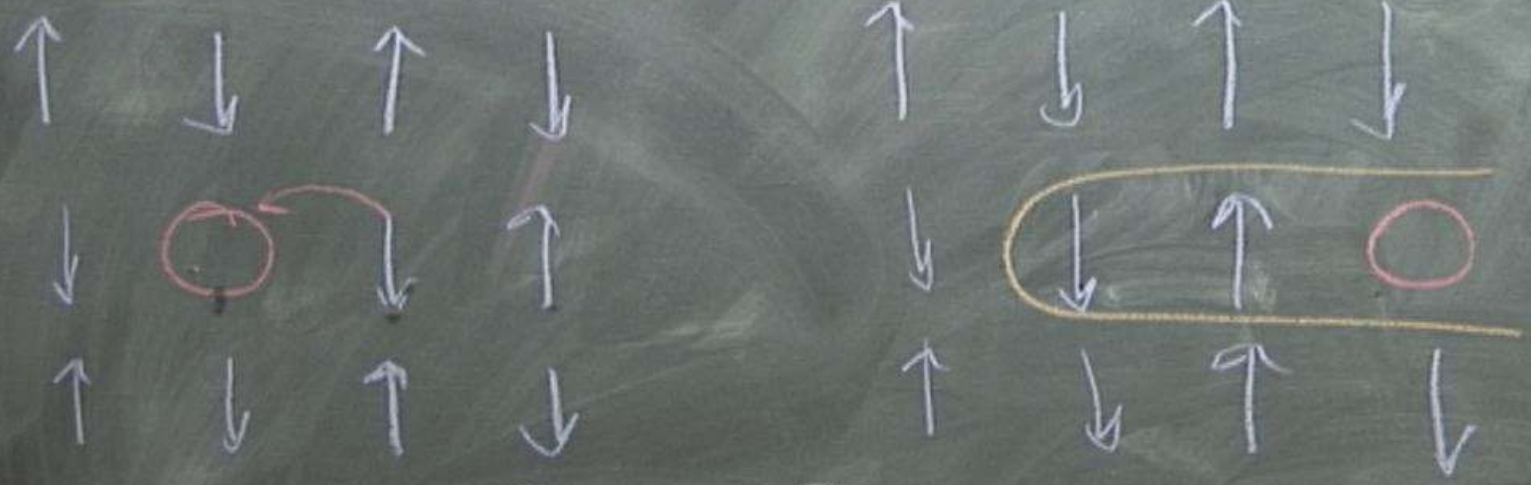
$J\vec{S}_i\cdot\vec{S}_j = \frac{J}{2}\left[(\vec{S}_i+\vec{S}_j)^2 - \vec{S}_i^2 - \vec{S}_j^2\right]$
0 for singlet
$E_{VB} = -\frac{J}{2}z\,S(S+1)\frac{N}{2}$
$\frac{E_{VB}}{N} = -\frac{J}{2}z\,S(S+1)$


Doping an AFM Mott Insulator
with Holes.
$E_{Gb} \leq E_{Neel}$
$2S^z \leq S(S+1)/2$

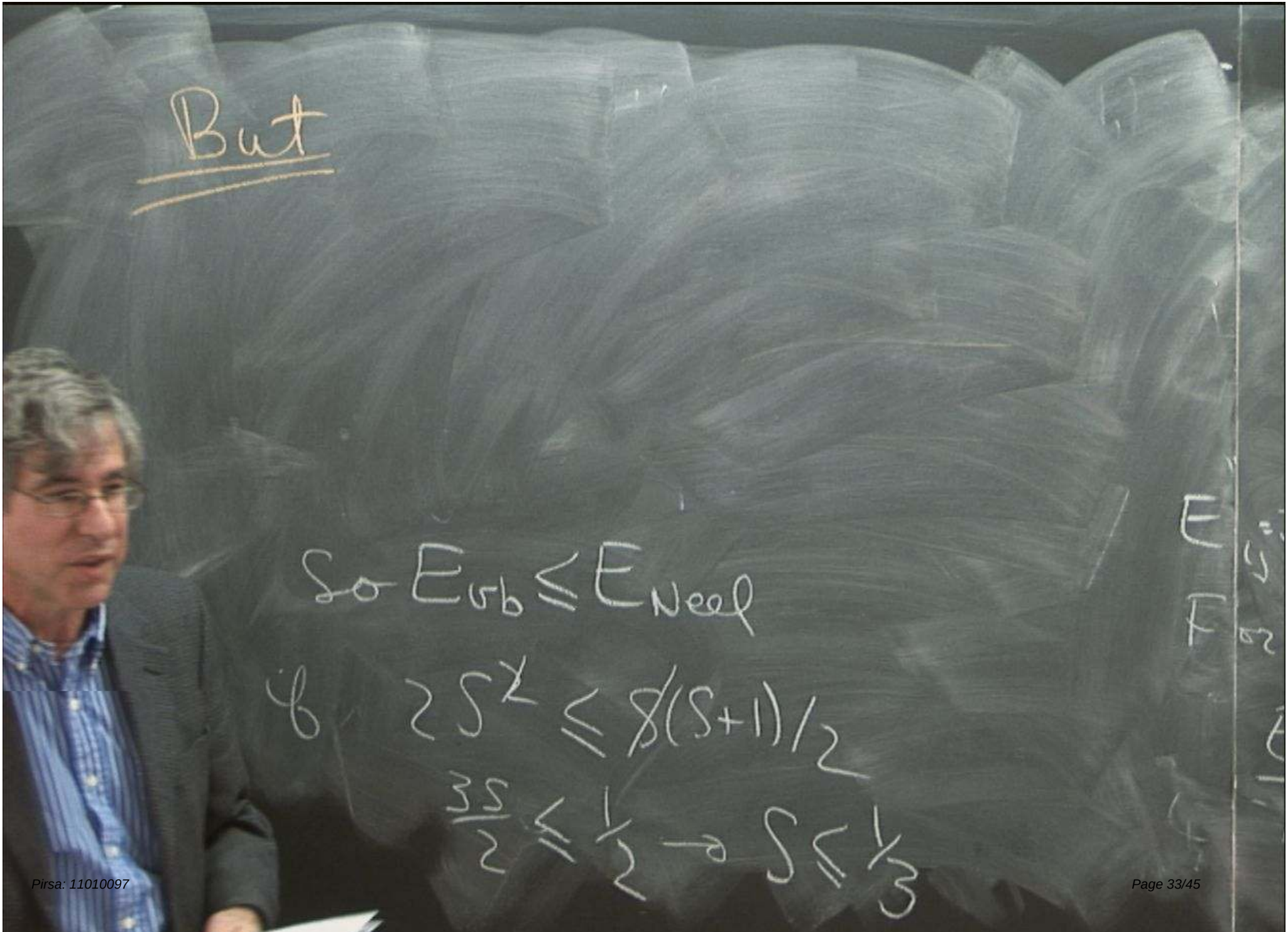
Doping an AFM Mott Insulator with Holes.



So $E_{Gb} \leq E_{Neel}$

$6 \cdot 2S^2 \leq 8(S+1)/2$

$\frac{3}{2} S^2 \leq \frac{1}{2} S(S+1) \rightarrow S \leq \frac{1}{3}$


But
So $E_{GS} \leq E_{Neel}$
$-6 \cdot 2S^2 \leq -8(S+1)/2$
$\frac{3}{2} \leq \frac{1}{2} \rightarrow S \leq \frac{1}{3}$

But - Frustration

(e.g. 2nd neighbor AF ints

So $E_{vb} \leq E_{Neel}$

if $2S^{\cancel{2}} \leq \cancel{S}(S+1)/2$

$\frac{3S}{2} \leq \frac{1}{2} \rightarrow S \leq \frac{1}{3}$

But - Frustration
(e.g. 2nd neighbor AF int)

- Quantum Effects

So $E_{GS} \leq E_{Neel}$

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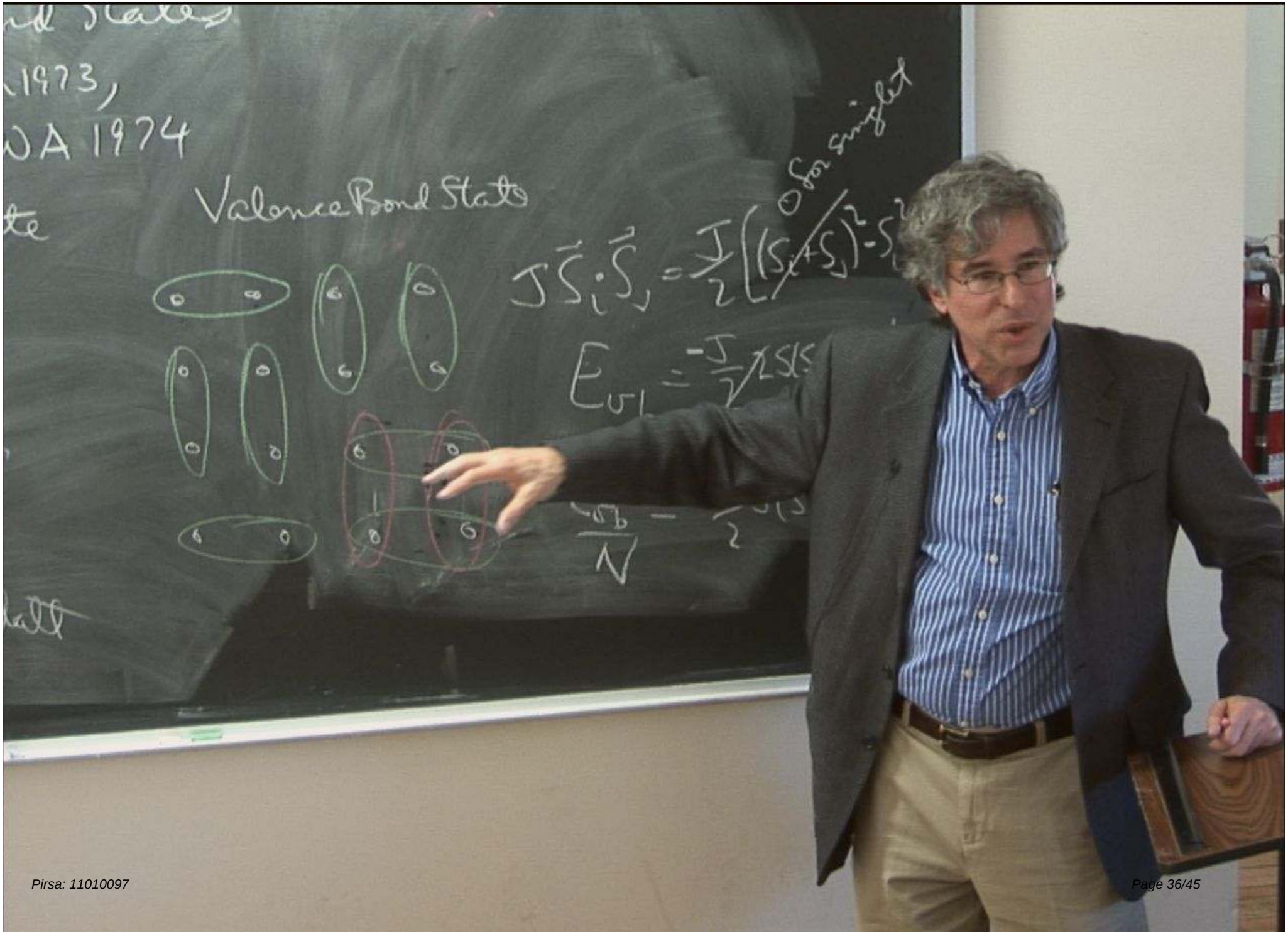
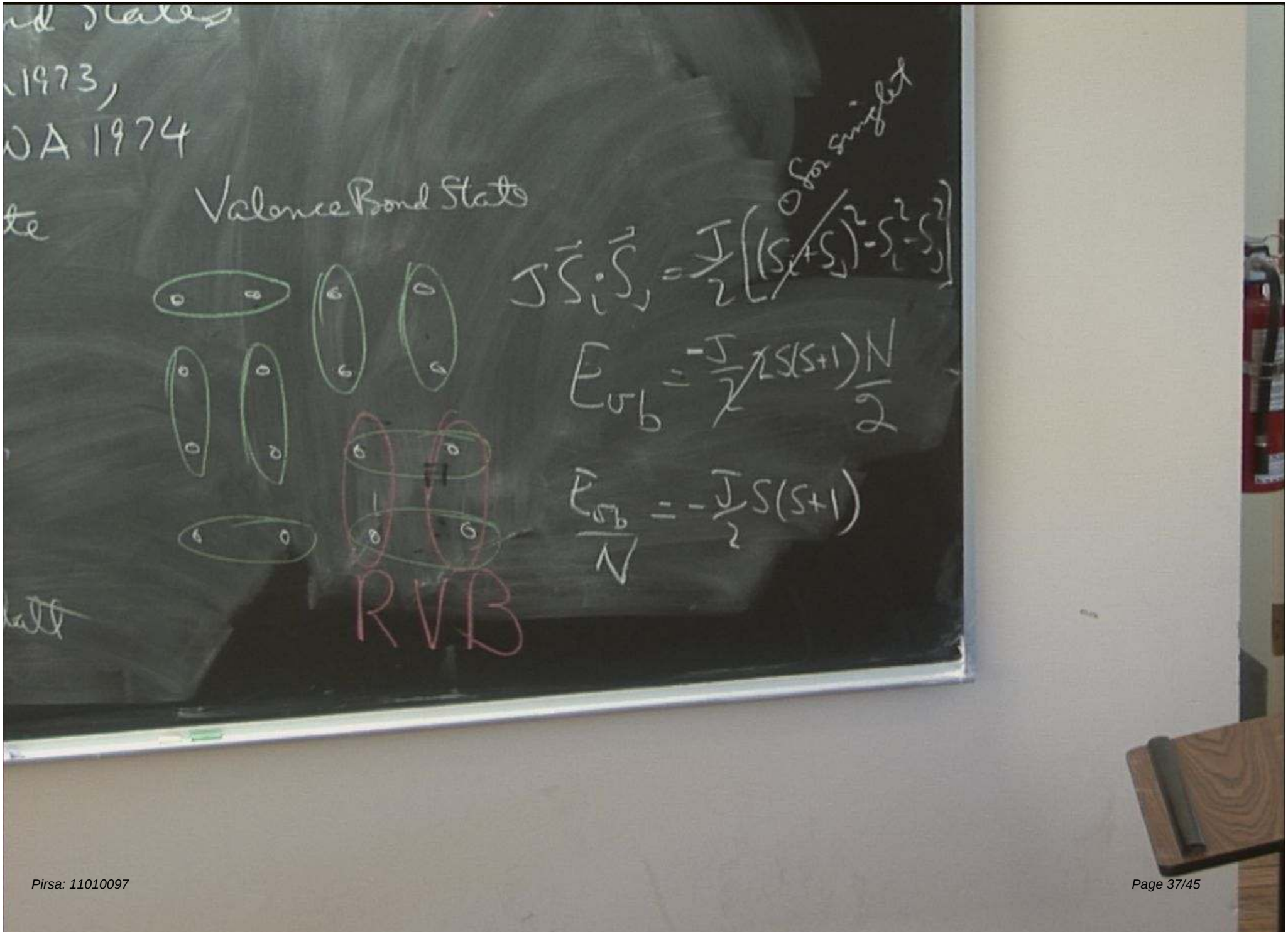

1973,
OA 1974
Valence Bond State
of a singlet


1973,
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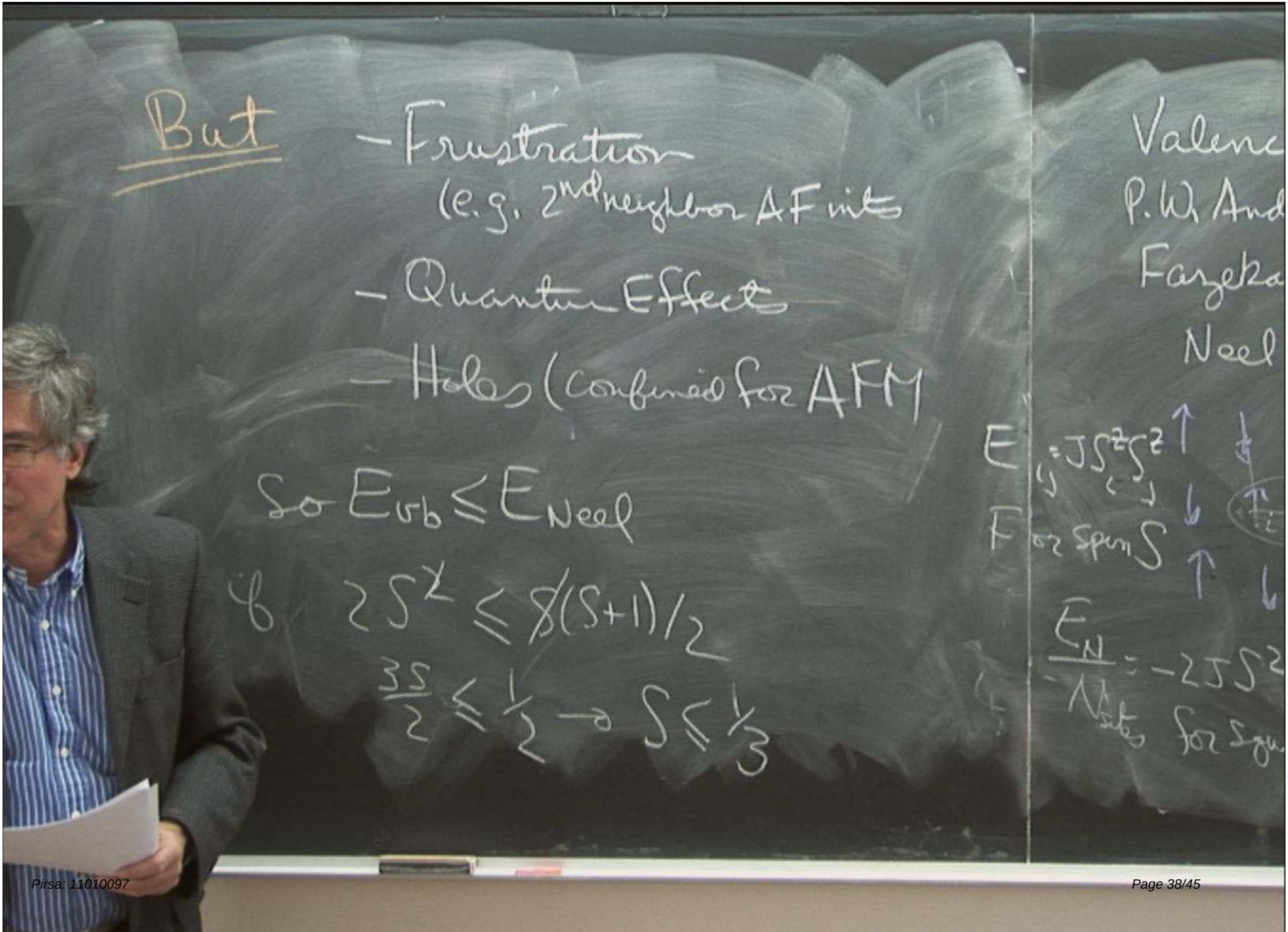
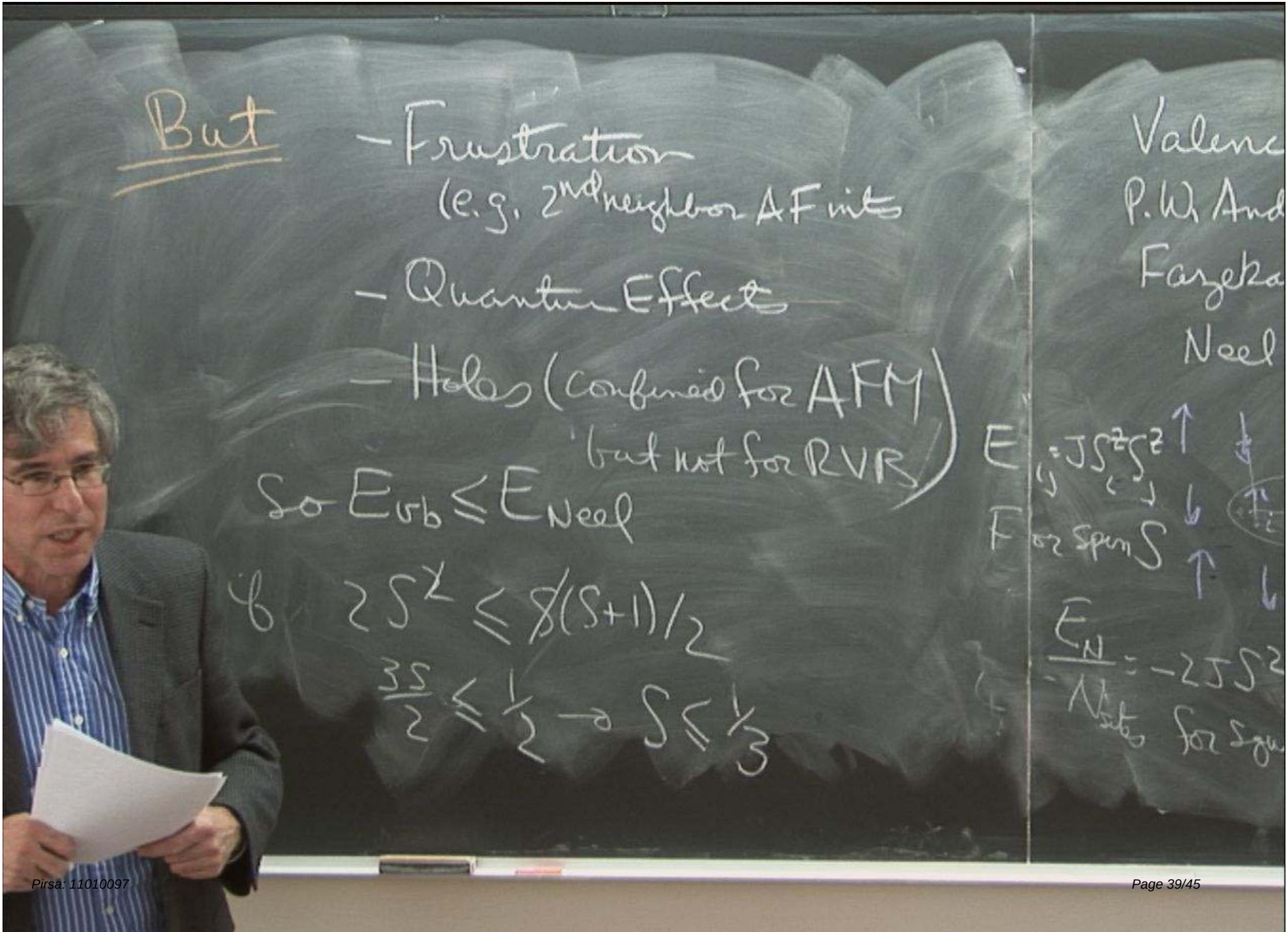
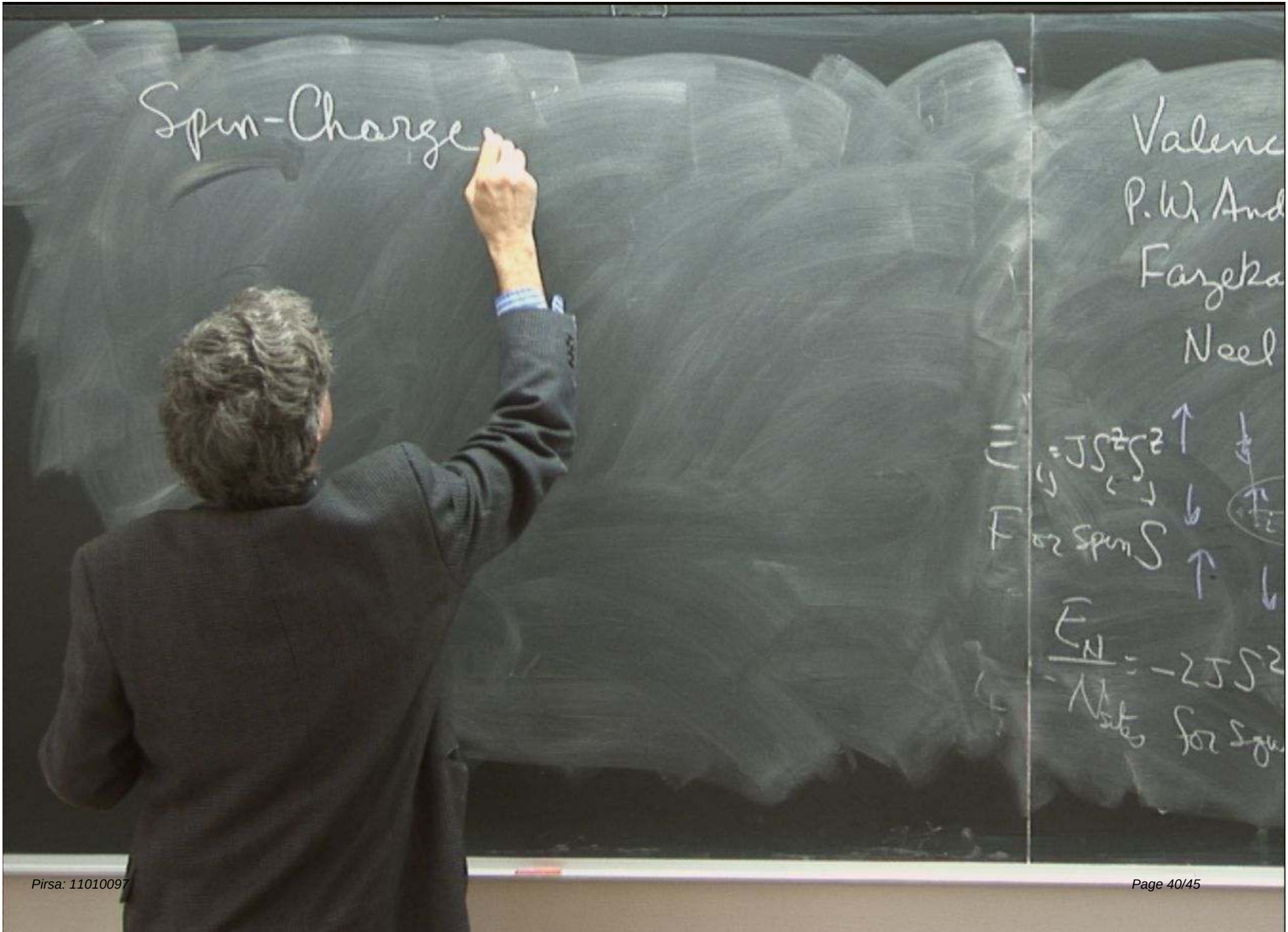
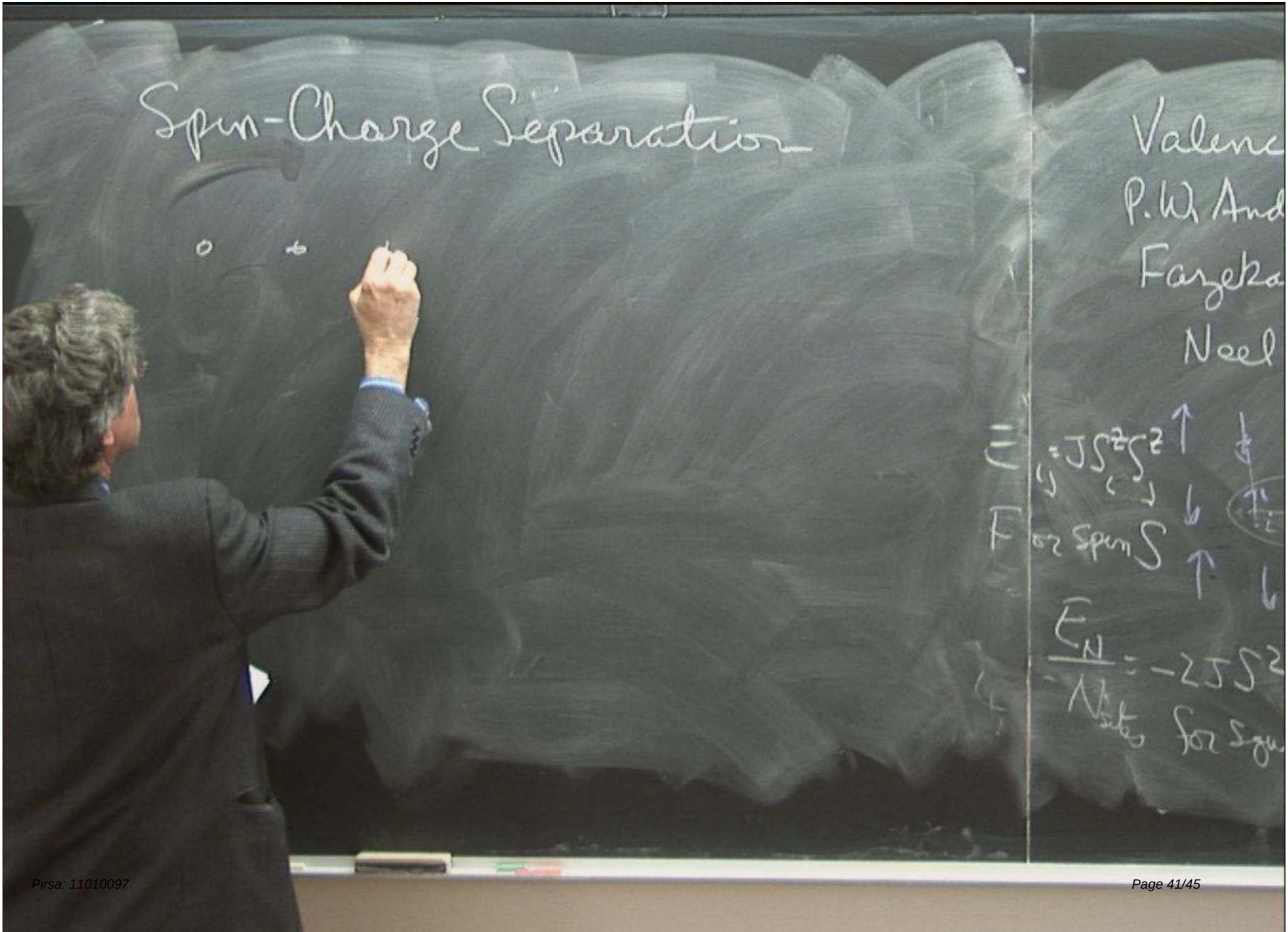
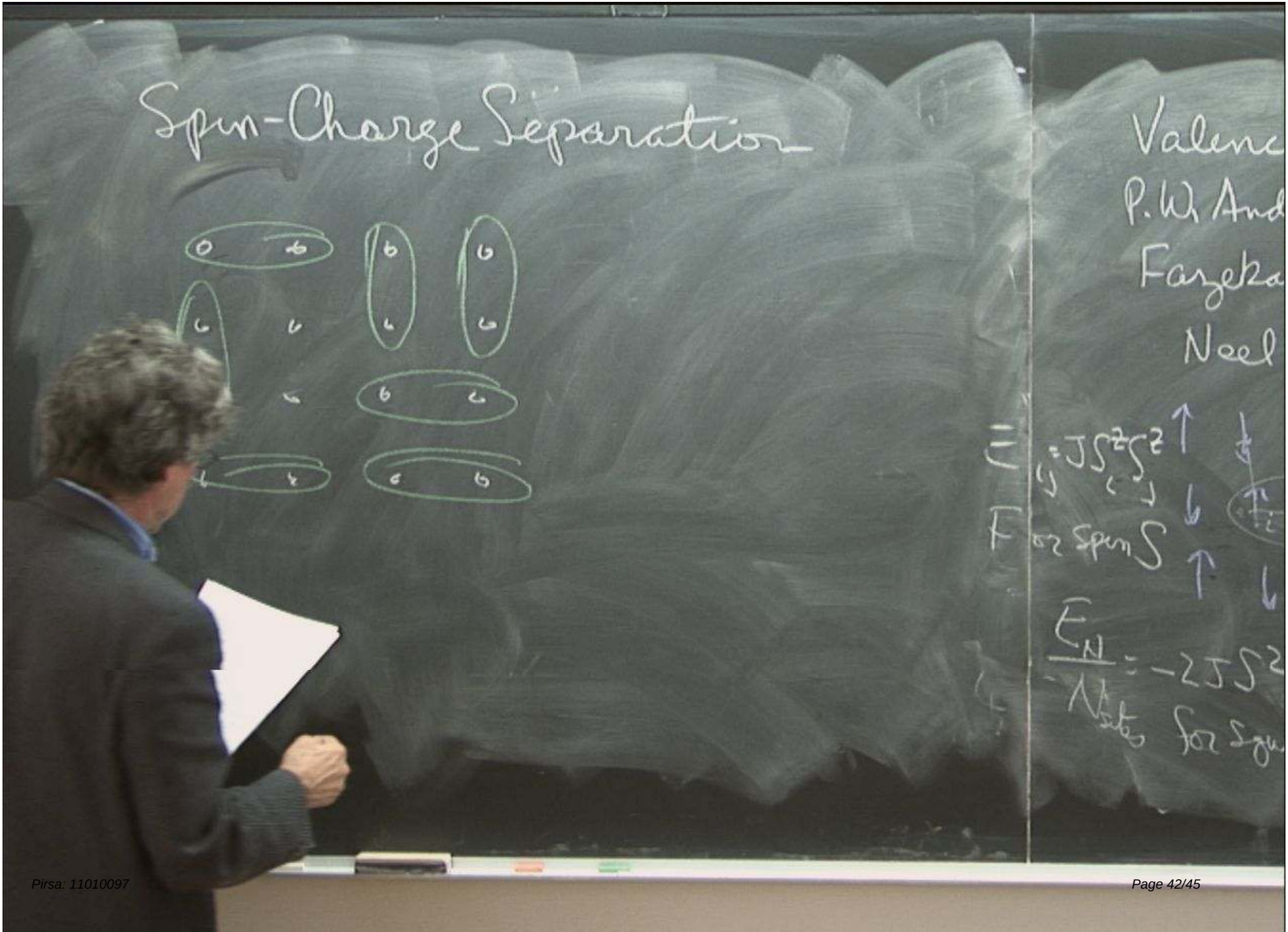
$J\vec{S}_i\cdot\vec{S}_j = \frac{J}{2}\left[(\vec{S}_i+\vec{S}_j)^2 - S_i^2 - S_j^2\right]$
of a singlet
$E_{VB} = -\frac{J}{2}z\,S(S+1)\frac{N}{2}$
$\frac{E_{VB}}{N} = -\frac{J}{2}S(S+1)$
RVB


But
- Frustration
(e.g. 2nd neighbor AF ints
- Quantum Effects
- Holes (confined for AFM
So $E_{vb} \leq E_{Neel}$
if $2S^2 \leq S(S+1)/2$
$\frac{3S}{2} \leq \frac{1}{2} \rightarrow S \leq \frac{1}{3}$
Valenc
P.W. And
Fazeka
Neel
$E_{ij} = JS_i^z S_j^z$
For spin S
$\frac{E_N}{N_{sites}} = -2JS^2$
for Squ


But
- Frustration
(e.g. 2nd neighbor AF int
- Quantum Effects
- Holes (confined for AFM
but not for RVB)
So $E_{Gb} \leq E_{Neel}$
$\frac{3S}{2} \leq \frac{1}{2} \rightarrow S \leq \frac{1}{3}$
Valenc
P.W. And
Fazeka
Neel
$E_N = -2JS^2$


Spin-Charge
Valenc
P.W. And
Fazeka
Neel
For spin S


Spin-Charge Separation
Valenc
P.W. And
Fazeka
Neel
For spin S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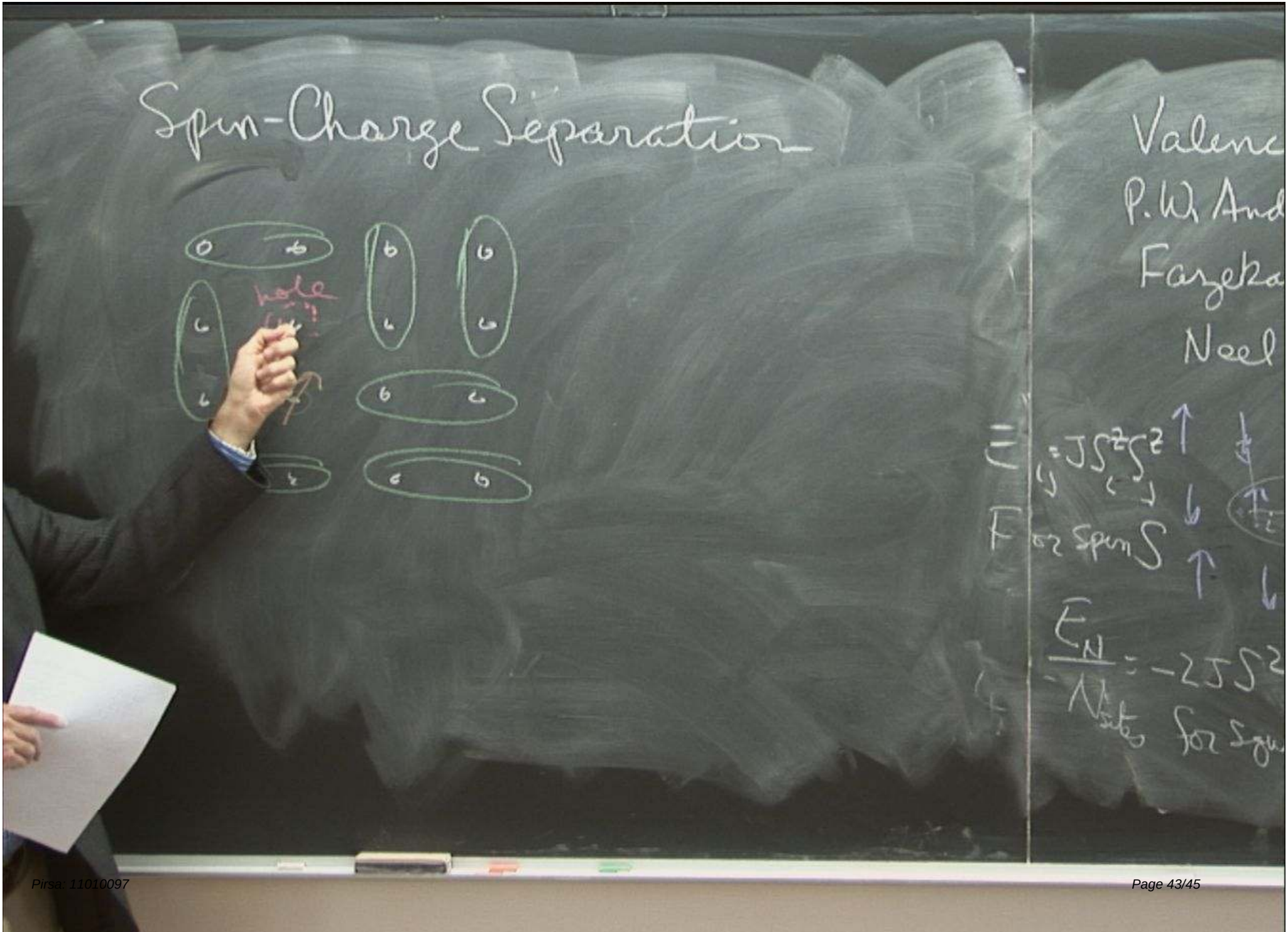
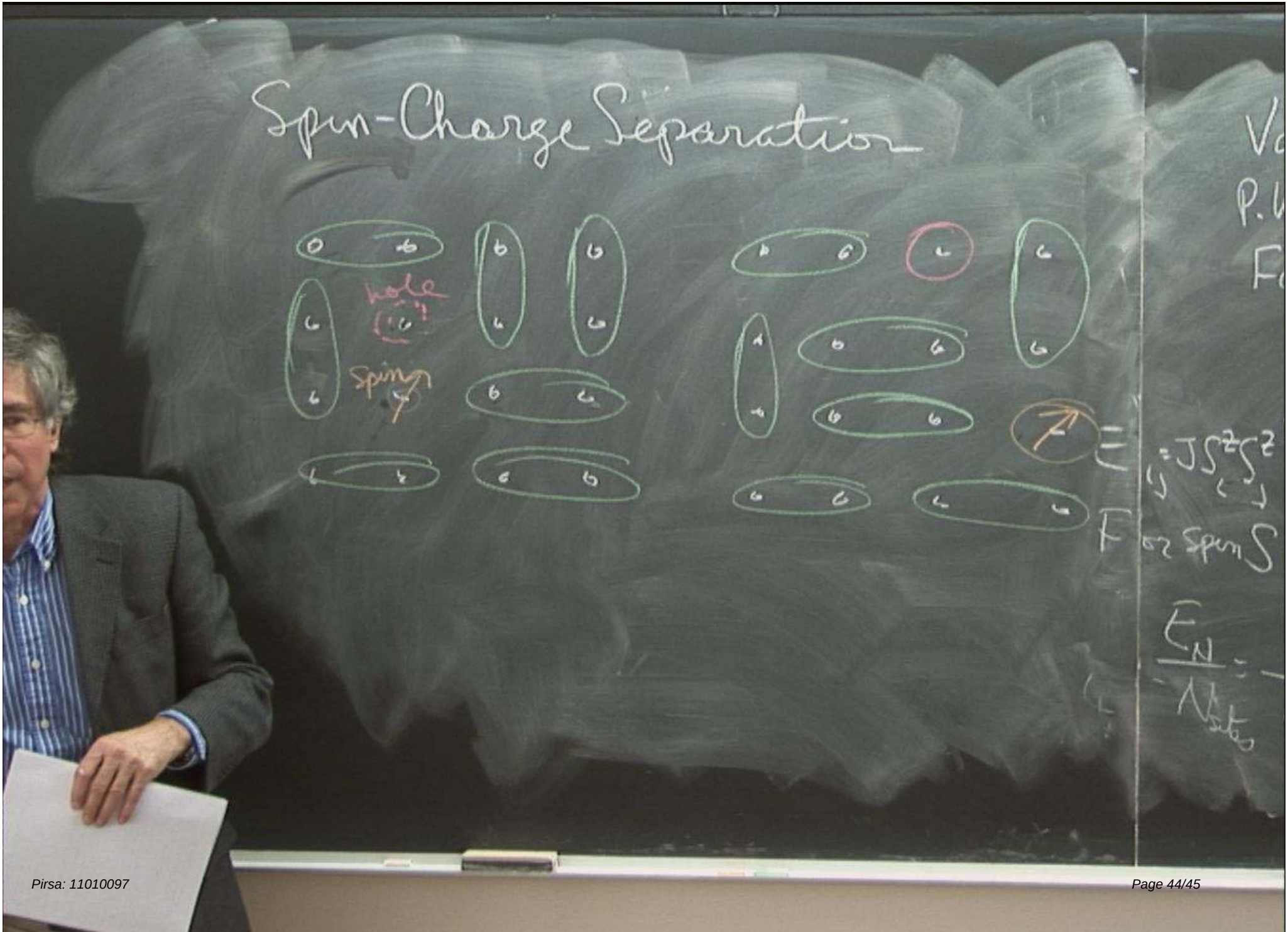
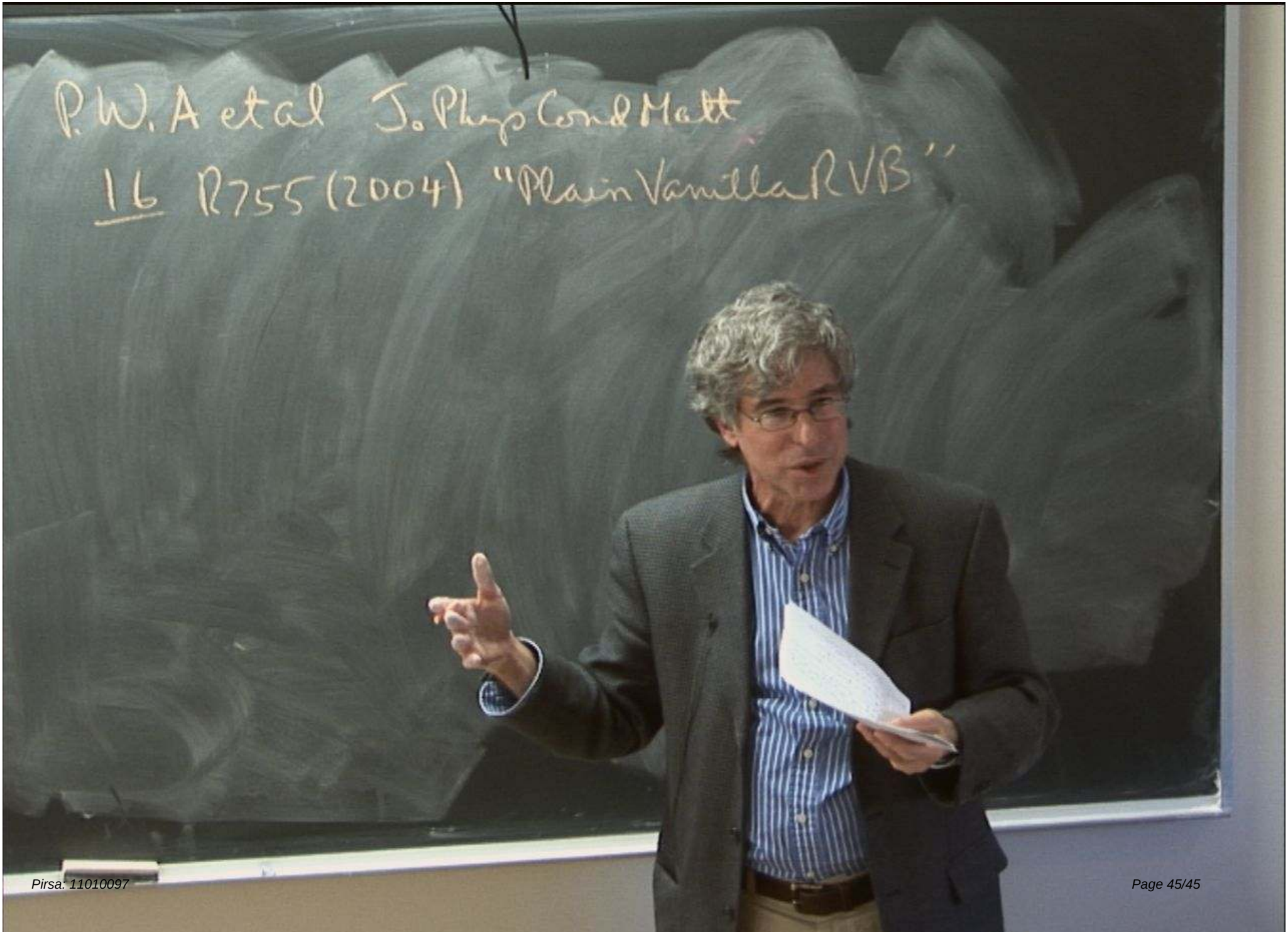

Spin-Charge Separation
hole
Valenc
P.W. And
Fazeka
Neel
For spin S


Spin-Charge Separation
hole
spinon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16 R755 (2004) "Plain Vanilla RVB"