Title: Gauge/gravity duality and meta-stable SUSY breaking

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Abstract: TBA

Gauge/gravity duality and meta-stable SUSY breaking

Sebastián Franco
Princeton University

November 2007

Based on: hep-th/0610212: Argurio, Bertolini, Franco and Kachru

hep-th/0703236: Argurio, Bertolini, Franco and Kachru

Also: Fortsch.Phys.55:644-648,2007

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Outline

- Meta-stable SUSY breaking in field theory and string theory
- $SU(N_c)$ SQCD with massive flavors
- The model
- A mass term from a stringy instanton
- Stabilization of dynamical masses
- Gravity dual
- Type IIA T-dual

Meta-stable SUSY breaking

- Dynamical SUSY breaking (DSB) may be relevant in the description of Nature at the electroweak scale.

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  - Quite generic in field theory.
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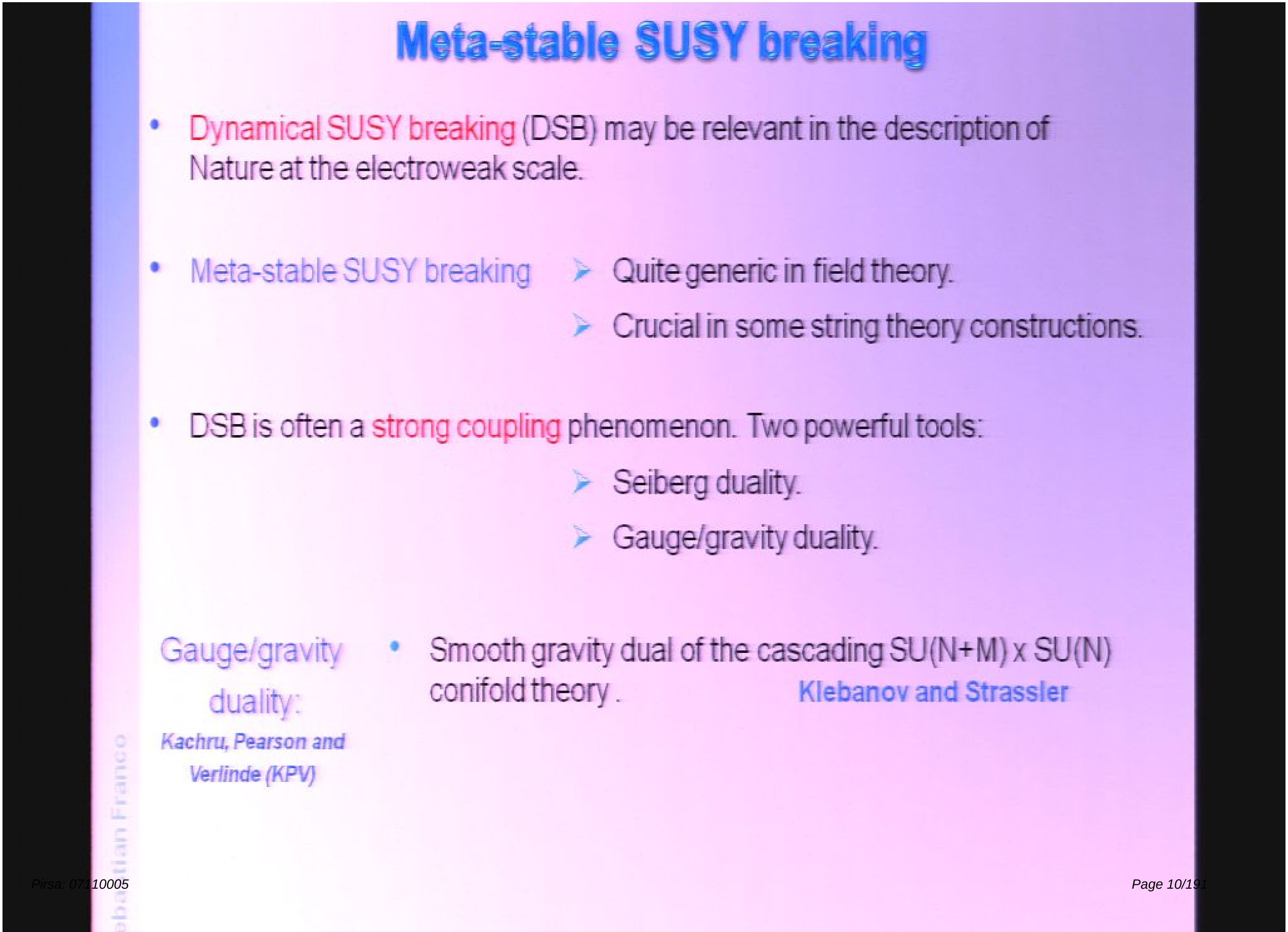
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- These states are important in KKLT and models of inflation

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- Is there some relation between the two classes of meta-stable states?

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A simple FT model: $SU(N_c)$ with massive flavors

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- In this talk, we will argue that in some cases the answer is yes.

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- distance between non-SUSY and SUSY minima
- height of the barrier

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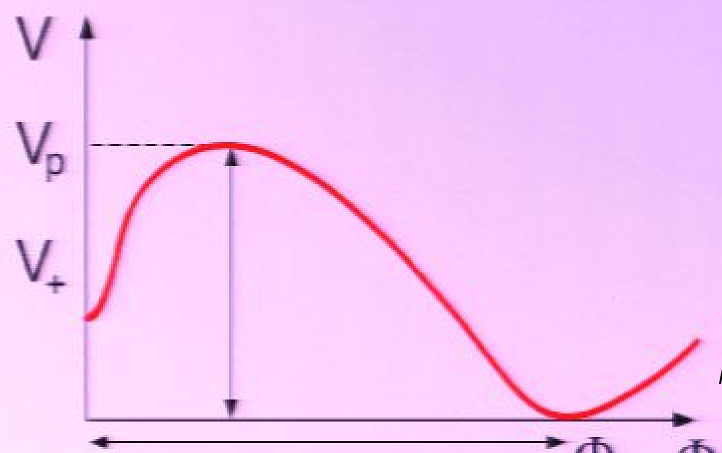

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$SU(N_c)$ with massive flavors

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This is the rank-condition mechanism

The model

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- There is a classical moduli space of SUSY breaking vacua with

$$\Phi = \begin{pmatrix} 0 & 0 \\ 0 & \Phi_0 \end{pmatrix} \qquad q = \begin{pmatrix} \varphi_0 \\ 0 \end{pmatrix} \qquad \tilde{q}^T = \begin{pmatrix} \tilde{\varphi}_0 \\ 0 \end{pmatrix} \qquad \tilde{\varphi}_0 \varphi_0 = \mu^2 \mathbf{1_N}$$

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- All pseudomoduli (classically flat directions not corresponding to Goldstone directions) become massive due to the one-loop effective potential:

$$V_{eff}^{(1)} = \frac{1}{64\pi^2} \mathrm{STr}\, \mathcal{M}^4 \log \frac{\mathcal{M}^2}{\Lambda^2} \equiv \frac{1}{64\pi^2} \left(\mathrm{Tr}\, m_B^4 \log \frac{m_B^2}{\Lambda^2} - \mathrm{Tr}\, m_F^4 \log \frac{m_F^2}{\Lambda^2} \right)$$

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- The point of maximal unbroken global symmetry is a meta-stable SUSY breaking minimum

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- The theory has $N_f - N_c$ SUSY minima at:

$$\langle h\Phi \rangle = \Lambda \epsilon^{\frac{2N}{N_f - N}} \mathbf{1}_{\mathbf{N_f}} = \mu \epsilon^{-\frac{\mathbf{N_f - 3N}}{\mathbf{N_f - N}}} \mathbf{1}_{\mathbf{N_f}} \qquad \epsilon = \mu/\Lambda \qquad \text{(b)}$$

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- The distance in field space and the potential barrier between (a) and (b) guarantee that the SUSY breaking minimum (a) is parametrically long-lived

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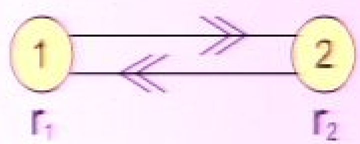

$$W = h\epsilon^{ij}\epsilon^{kl}A_iB_kA_jB_l$$

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Fractional branes

- We want to consider ranks: $(N_c, N_c, N_c, 1, 0, 0)$

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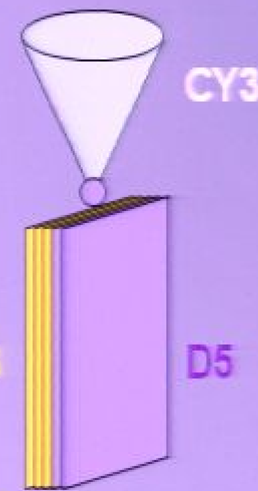

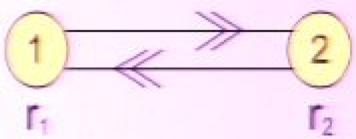

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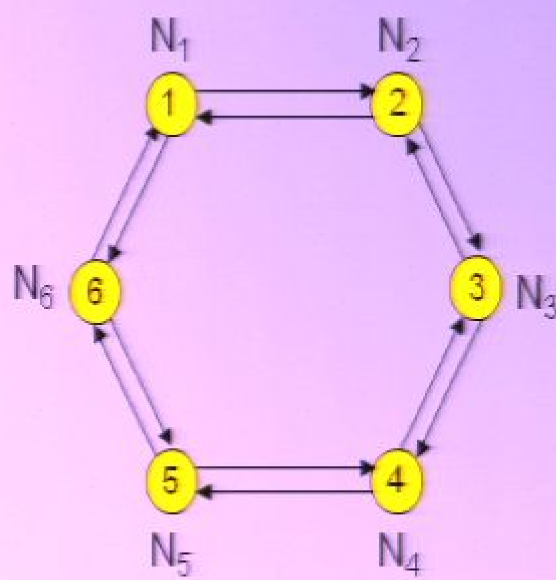
Z_3 orbifold



- Both the conifold and its orbifold are non-chiral. The ranks can be arbitrary.

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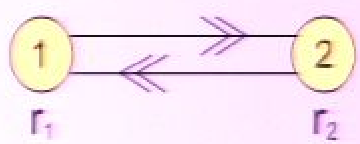

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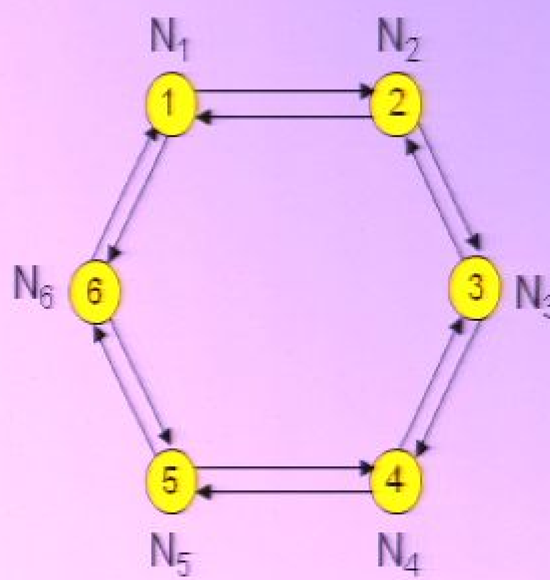

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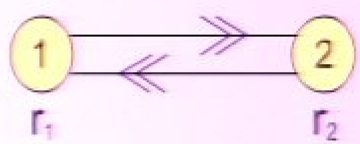
The model

- We engineer our gauge theory in string theory by considering (fractional) D3-branes at the tip of a Z_n orbifold of the conifold.



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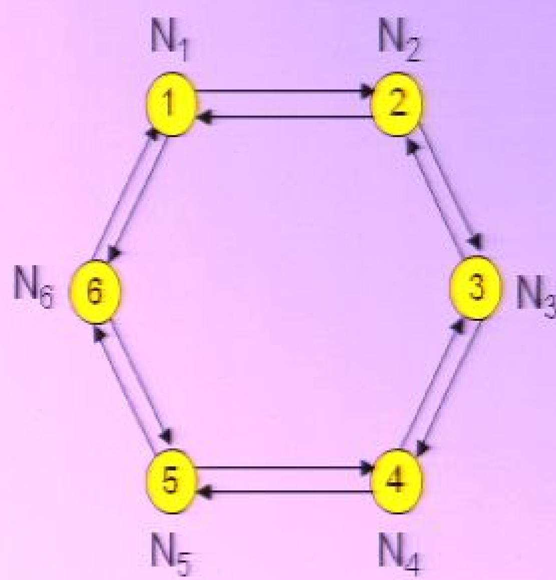

- Both the conifold and its orbifold are non-chiral. The ranks can be arbitrary.

Fractional branes

- We want to consider ranks: $(N_c, N_c, N_c, 1, 0, 0)$

Sebastian Franco

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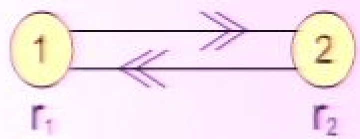

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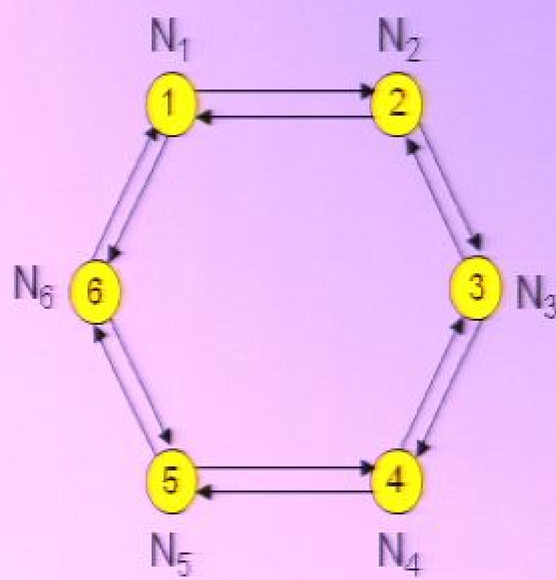

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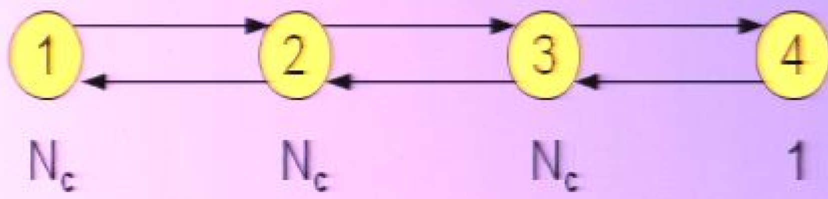

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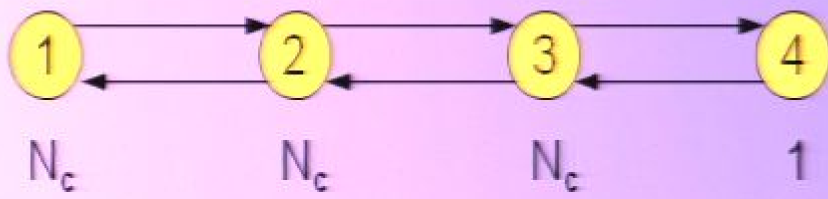

Fractional branes can be classified according to the IR dynamics of the gauge theories on them

Franco, Hanany, Saad and Uranga

Sebastian Franco

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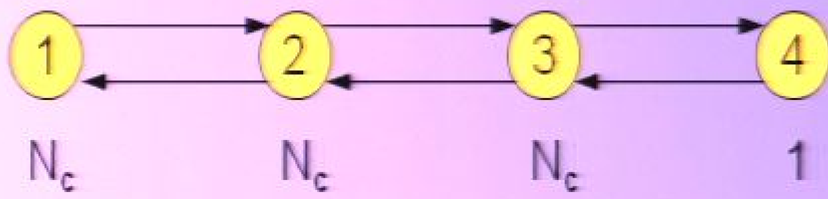

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Fractional branes

- Deformation
- N=2
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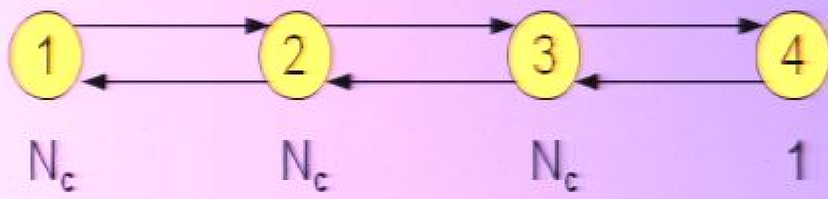

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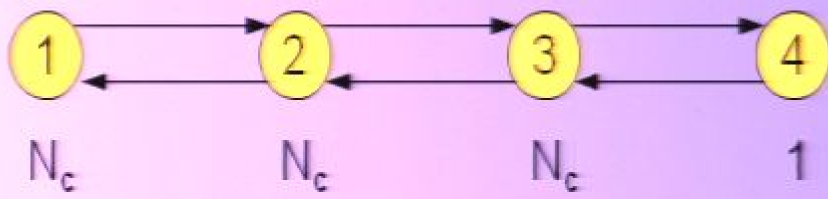

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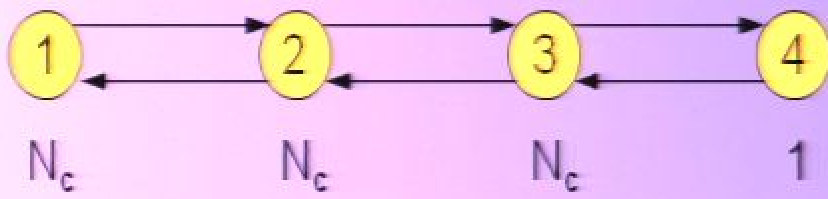

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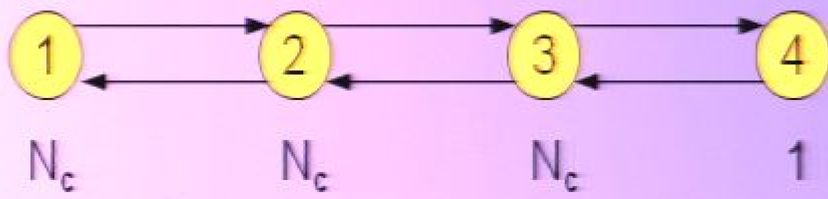

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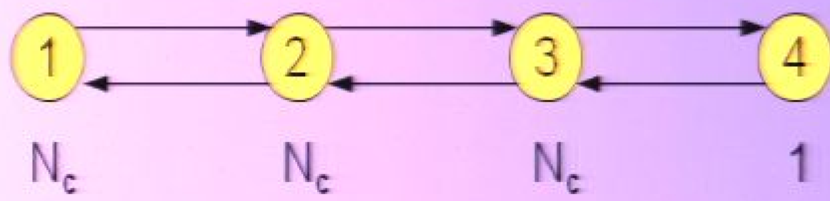

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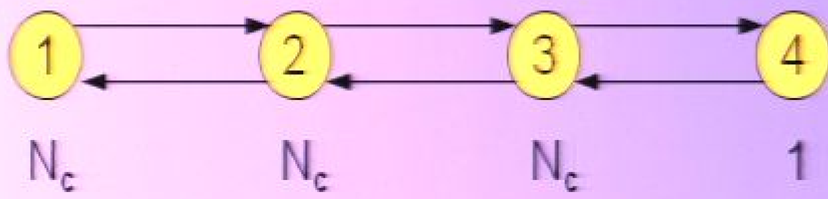

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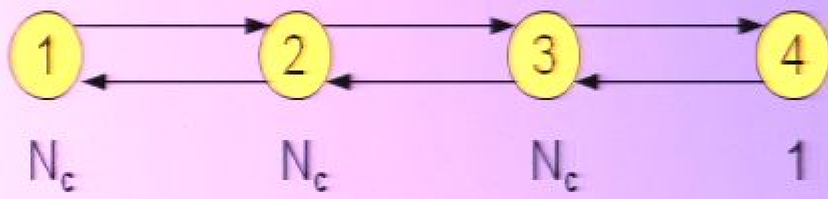

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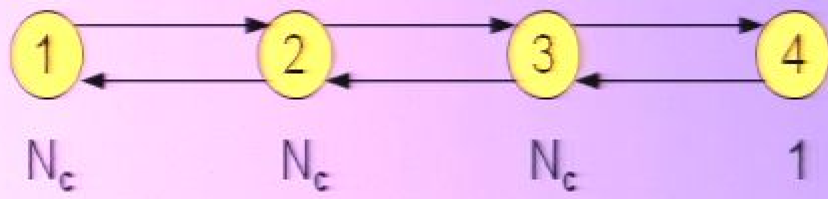
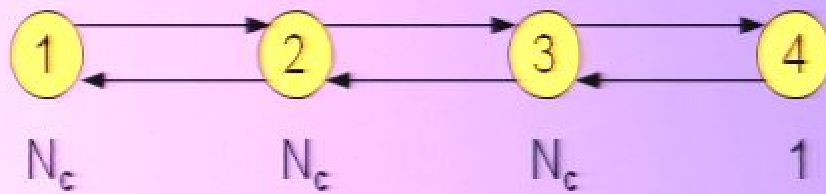
The dynamics



$$W = h(X_{12}X_{23}X_{32}X_{21} - X_{23}X_{34}X_{43}X_{32}) + mX_{43}X_{34}$$

$h\Lambda_1^2 << m$

The dynamics



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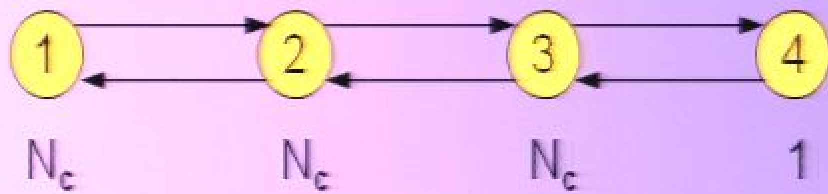
↳ stringy instanton

Node 1 has $N_c = N_f$

The dynamics



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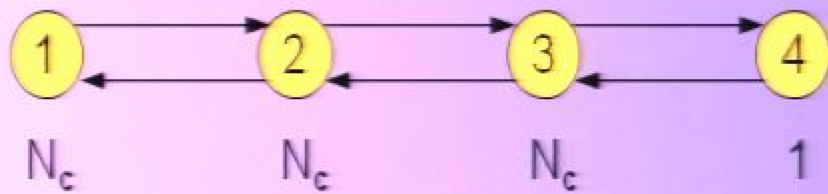
stringy instanton

Node 1 has $N_c = N_f$ → quantum moduli space → $\det M_{22} - B\tilde{B} = \Lambda_1^{2N_c}$

The dynamics



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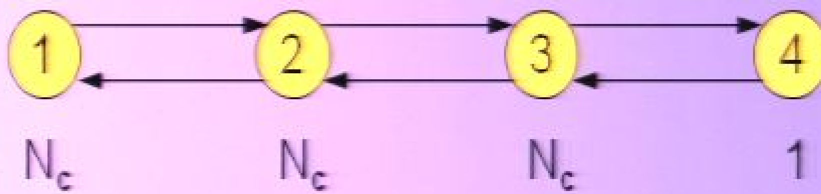

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$mX_{43}X_{34}$ → stringy instanton

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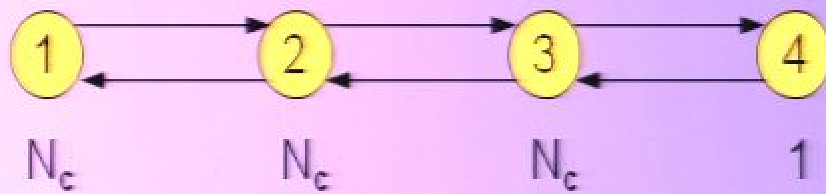

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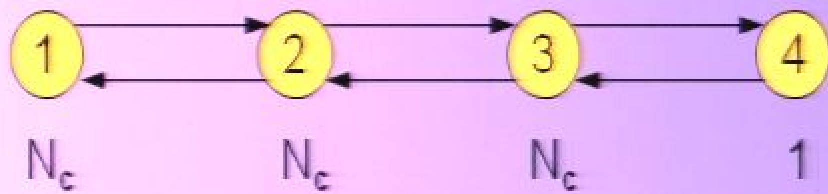

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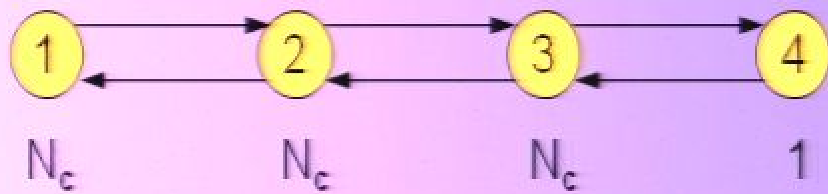

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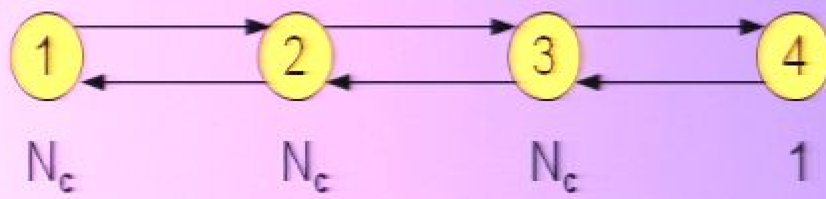

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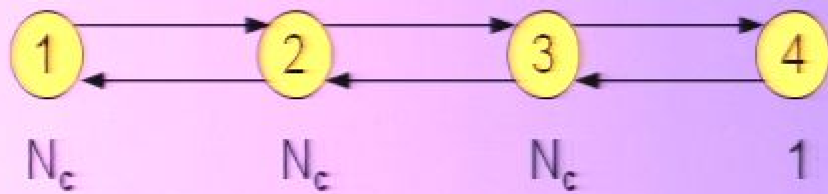
- We obtain the ISS model with $N_f = N_c + 1$ massive flavors

The dynamics



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Kitano, Ooguri and Ookouchi

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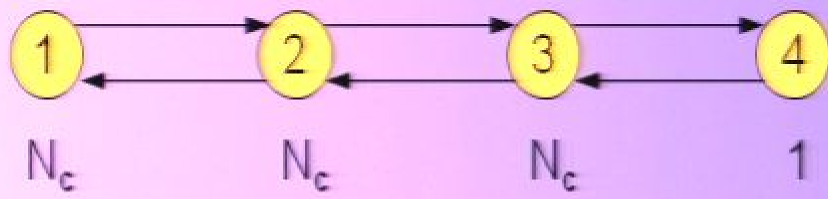

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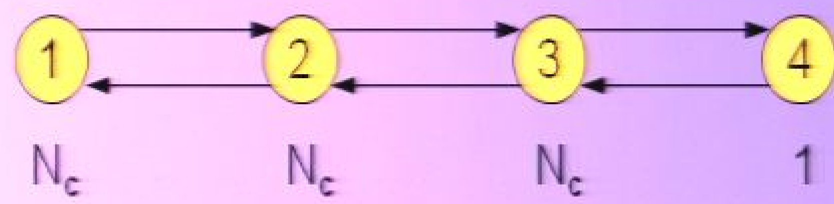
- Using Seiberg duality, we can see that there is a metastable SUSY-breaking vacuum with:

The dynamics



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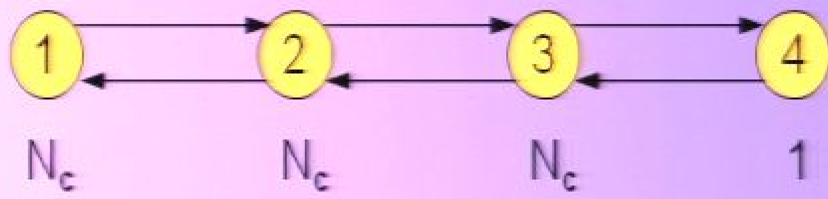

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$$V = |h\Lambda_0|^2 \sum^{N_c} |M_i|^2 - N|h\Lambda_0\Lambda^2|^2$$

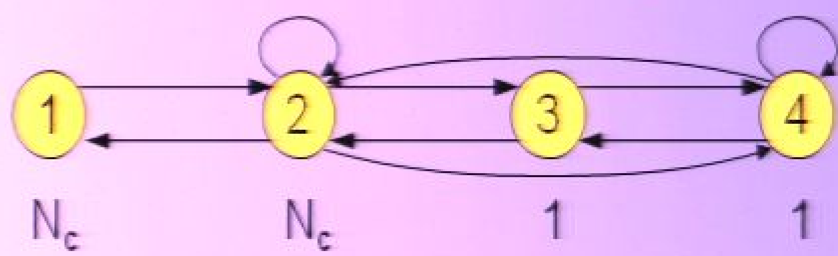
Metastable vacuum

- To find the metastable vacuum

Sebastian Franco

Metastable vacuum

- To find the metastable vacuum ⟶ use magnetic dual



$$W = (h\Lambda_3)(M_{22}\phi_{22} - \Lambda_3\phi_{24}\phi_{42}) + m\Lambda_3\phi_{44} - \phi_{22}Y_{23}Y_{32} - \phi_{44}Y_{43}Y_{34} + \phi_{24}Y_{43}Y_{32} + \phi_{42}Y_{23}Y_{34}$$

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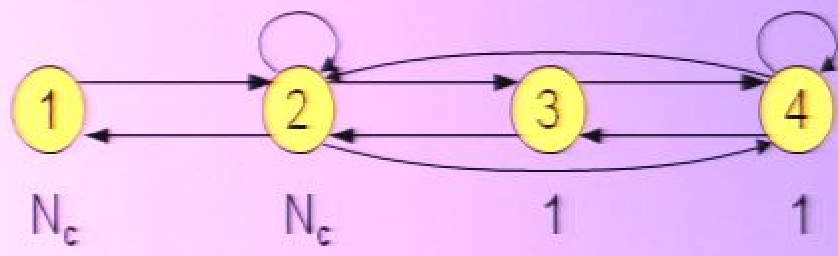

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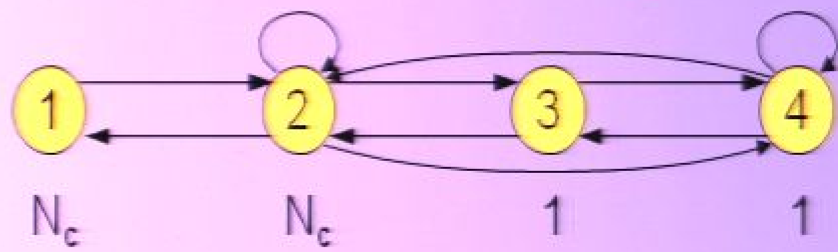

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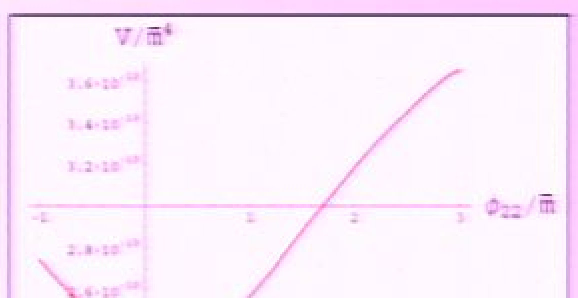

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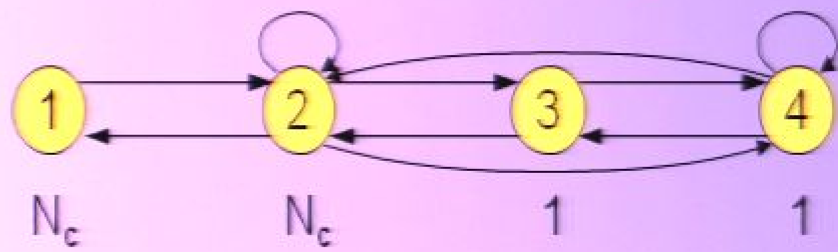

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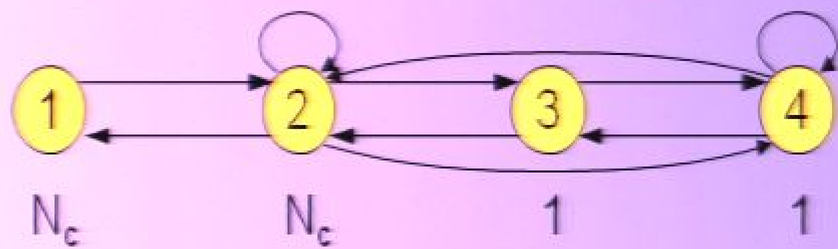

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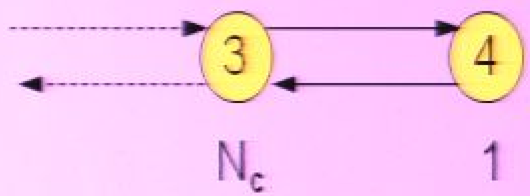

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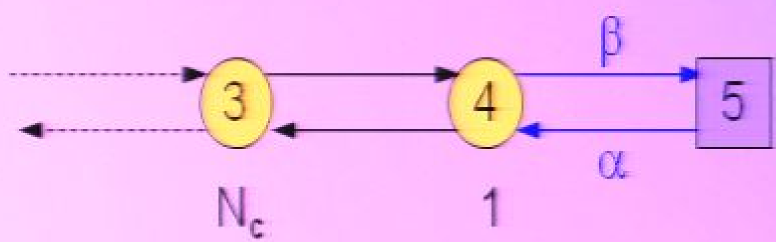

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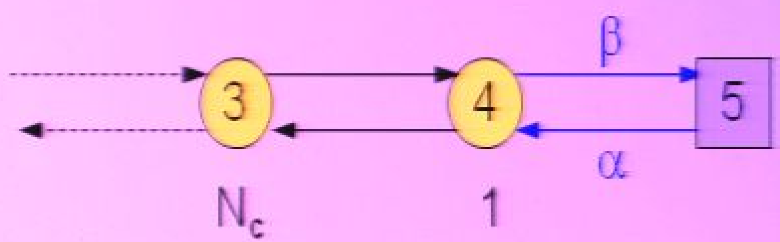

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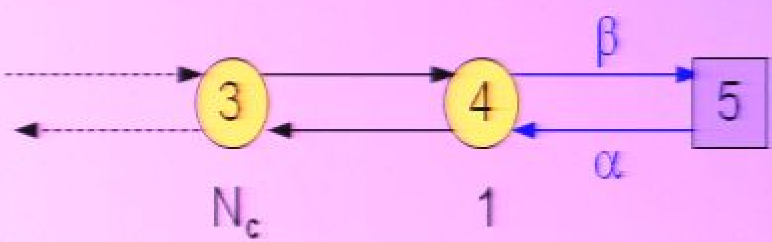

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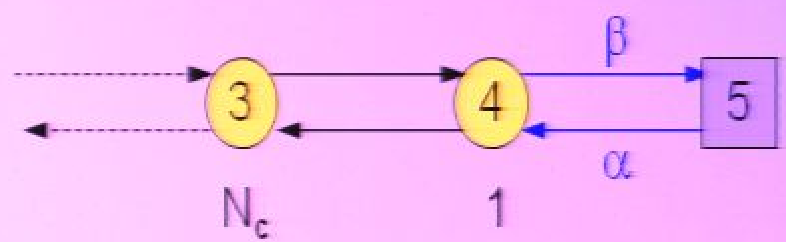

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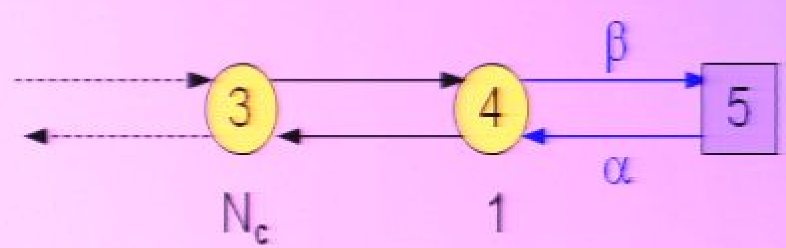

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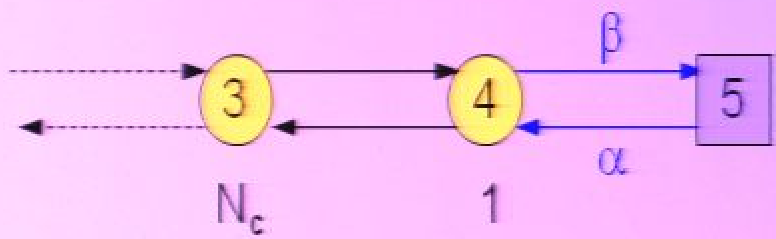

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instanton

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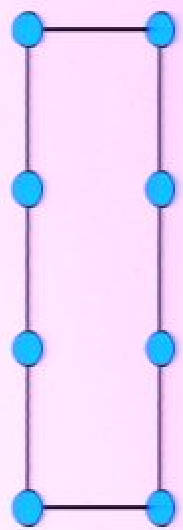

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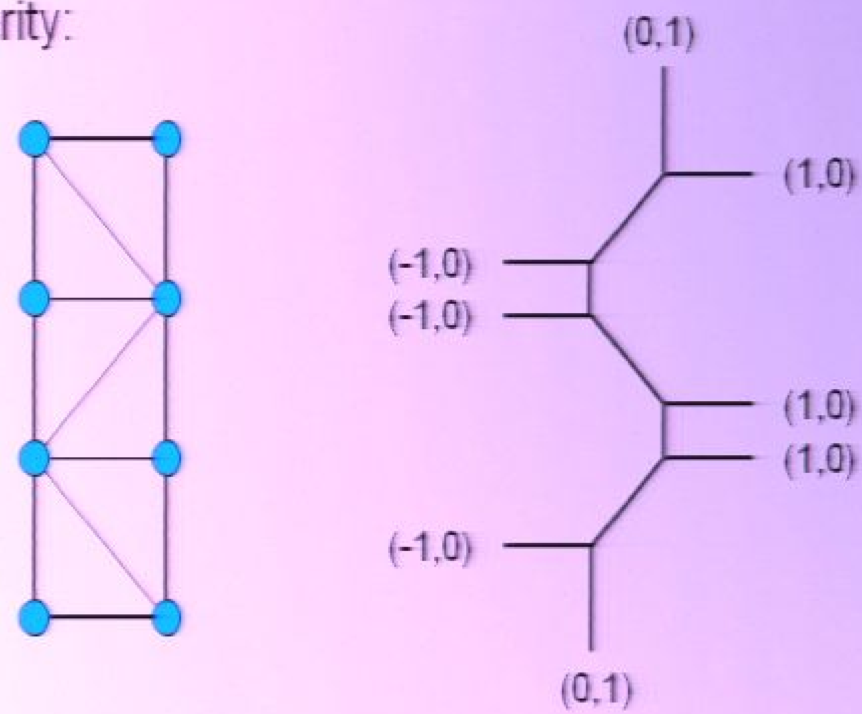

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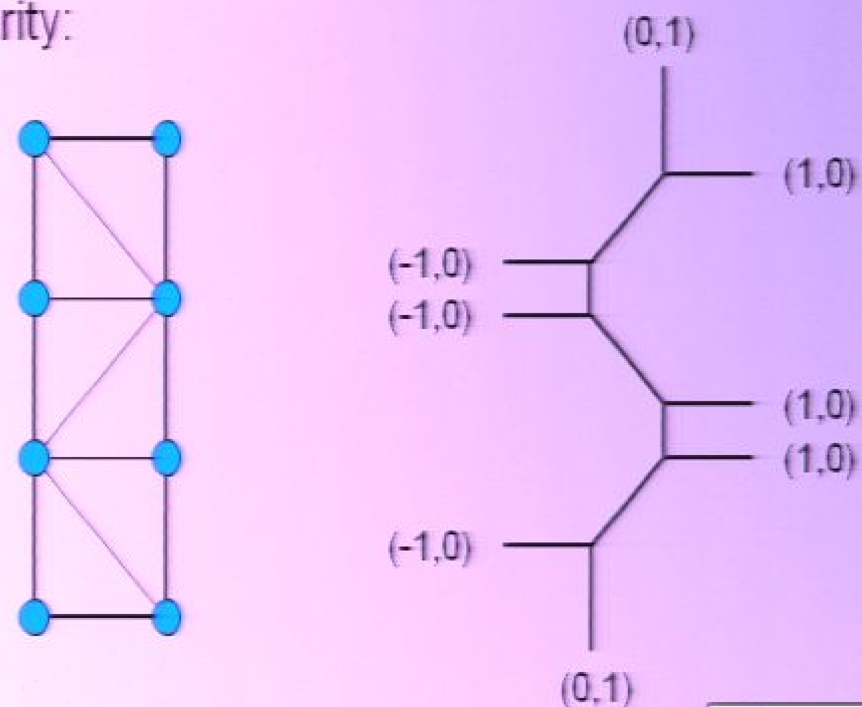

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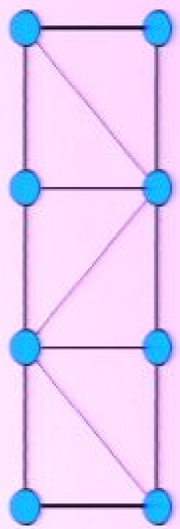

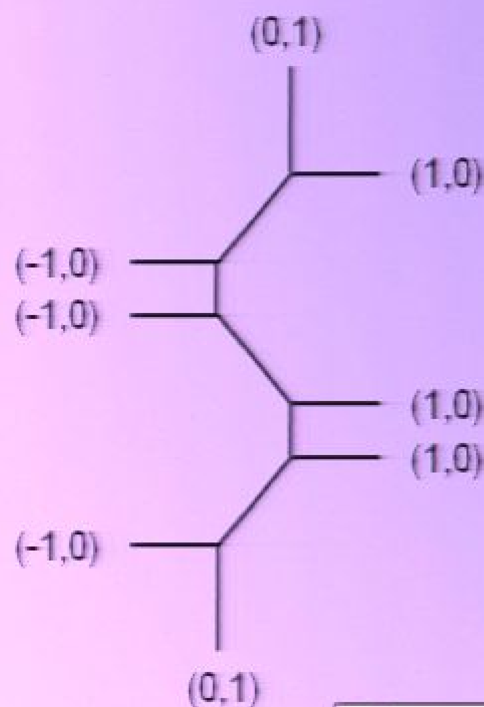

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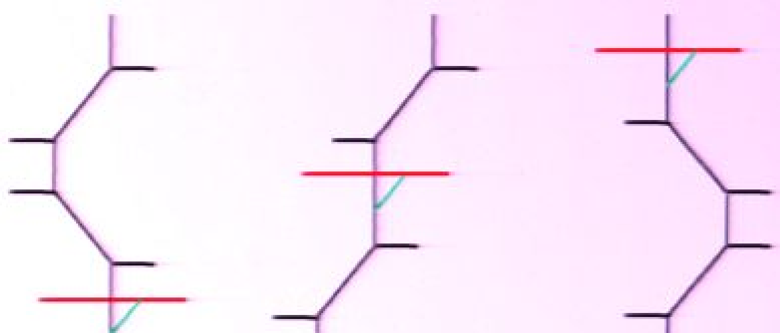

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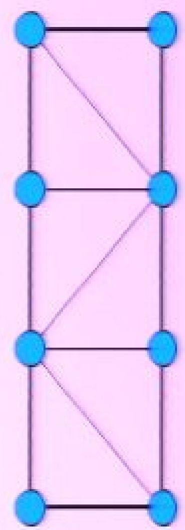

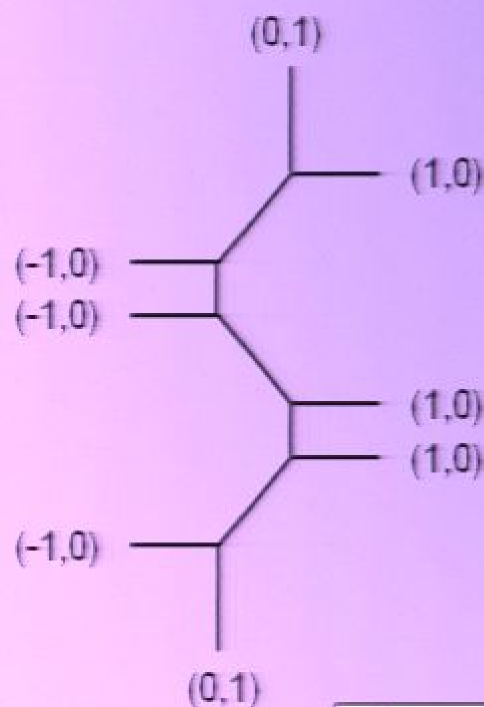

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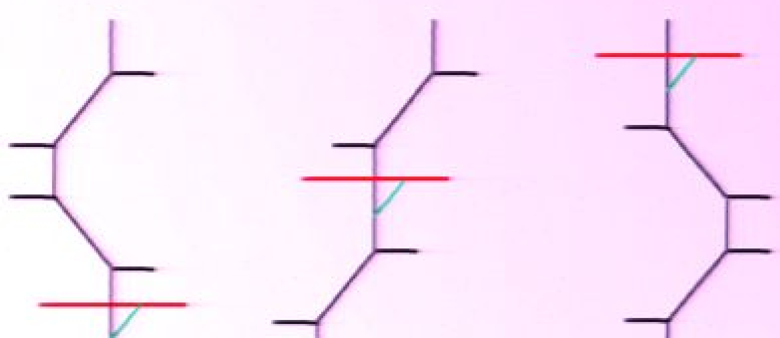
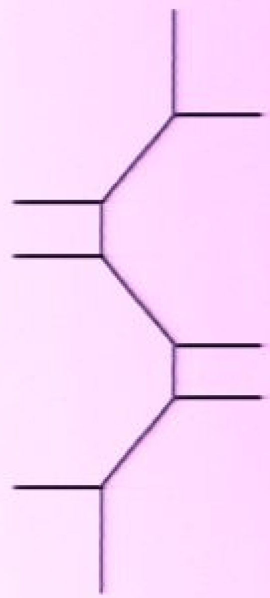


Three non-trivial compact 3-cycles A_i

$\int \Omega = \epsilon_i$

- Consider two of the 3-cycles are blown-up to the same size: $(xy-\epsilon)^2 xy = uv$



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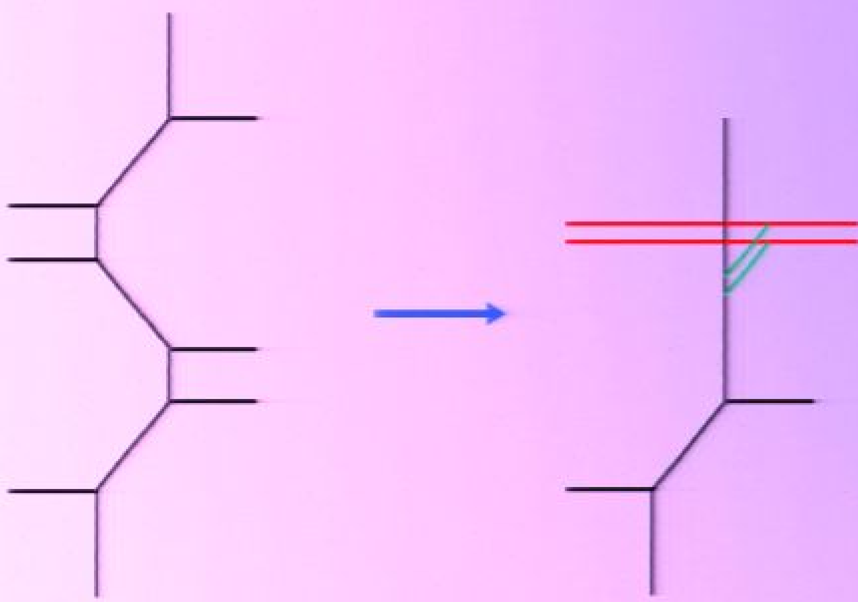

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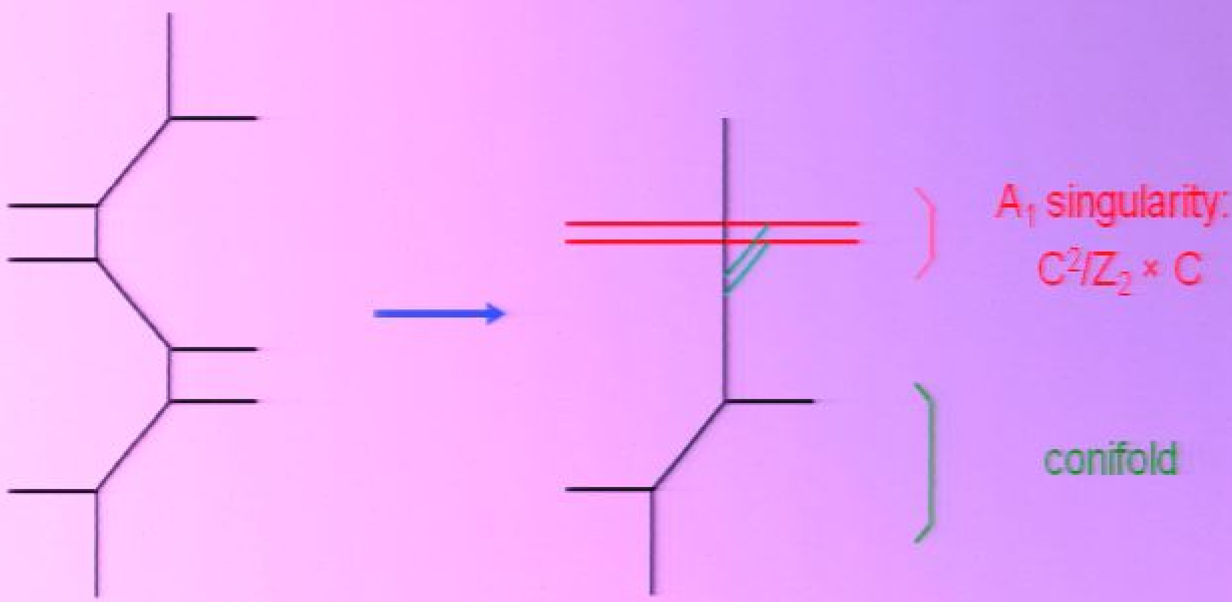

- After a geometric transition, the N_c deformation branes on node 3 turn into flux:

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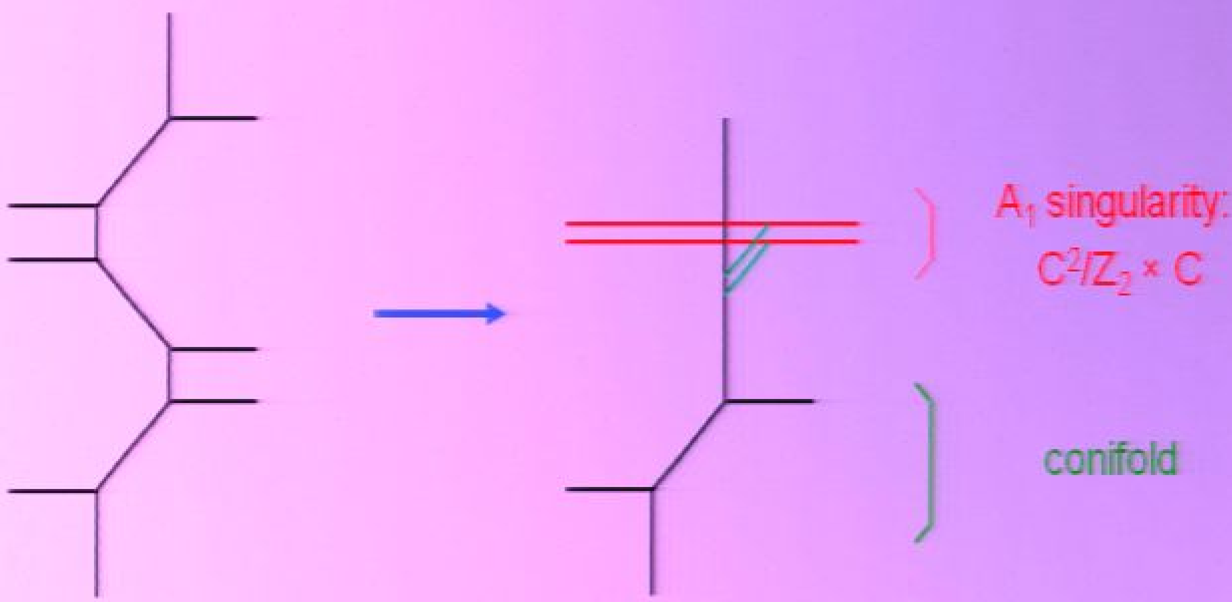

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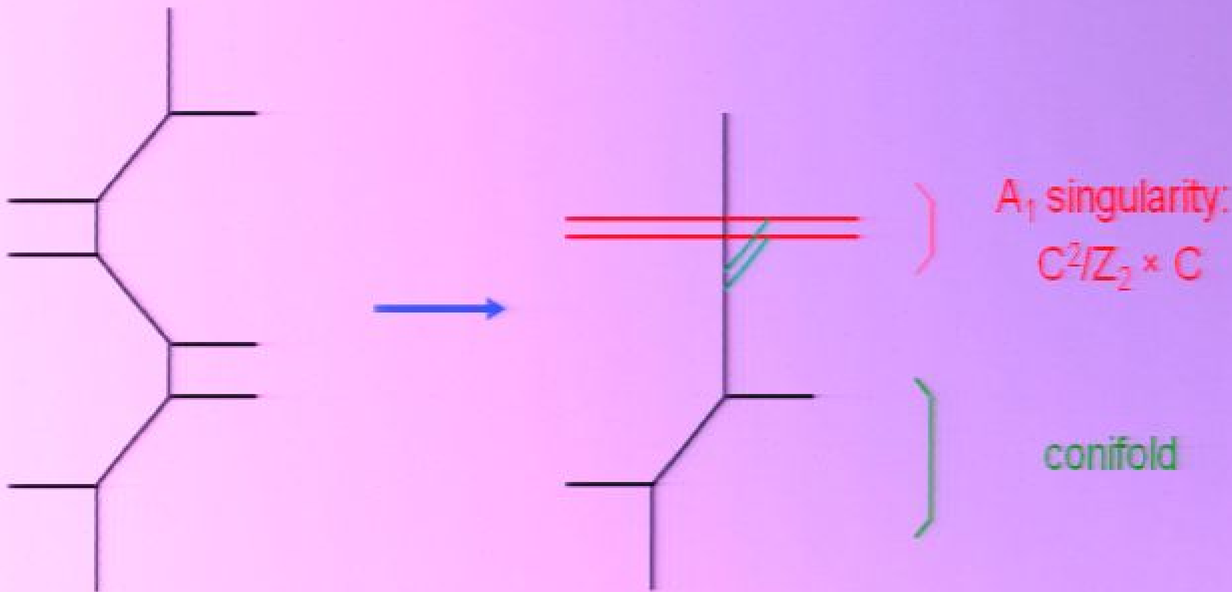

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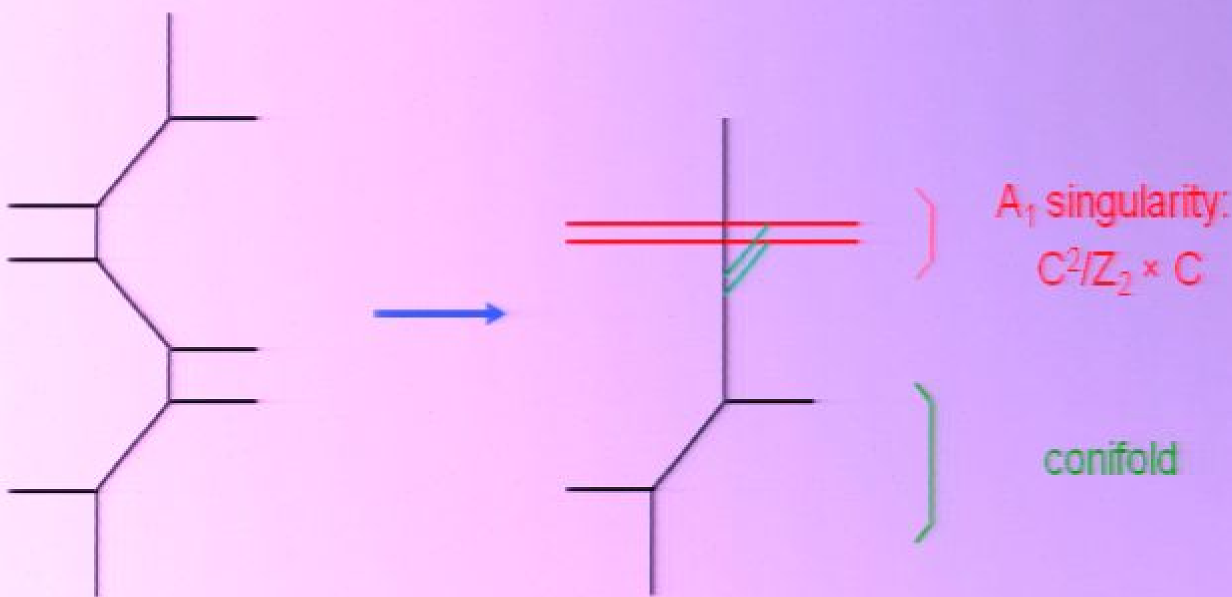

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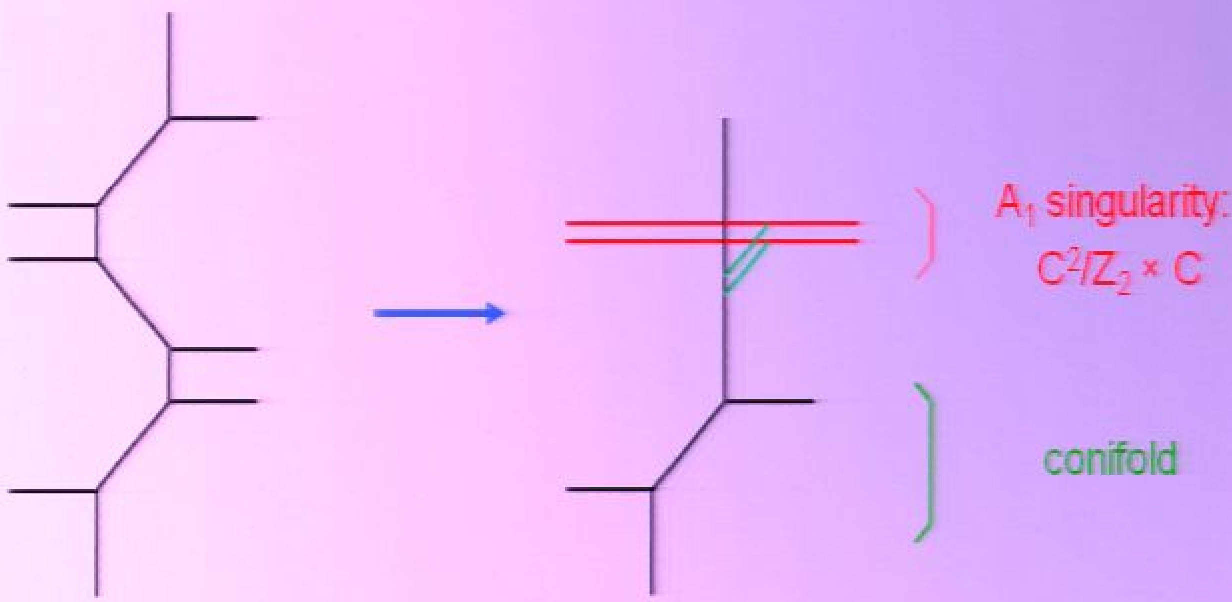

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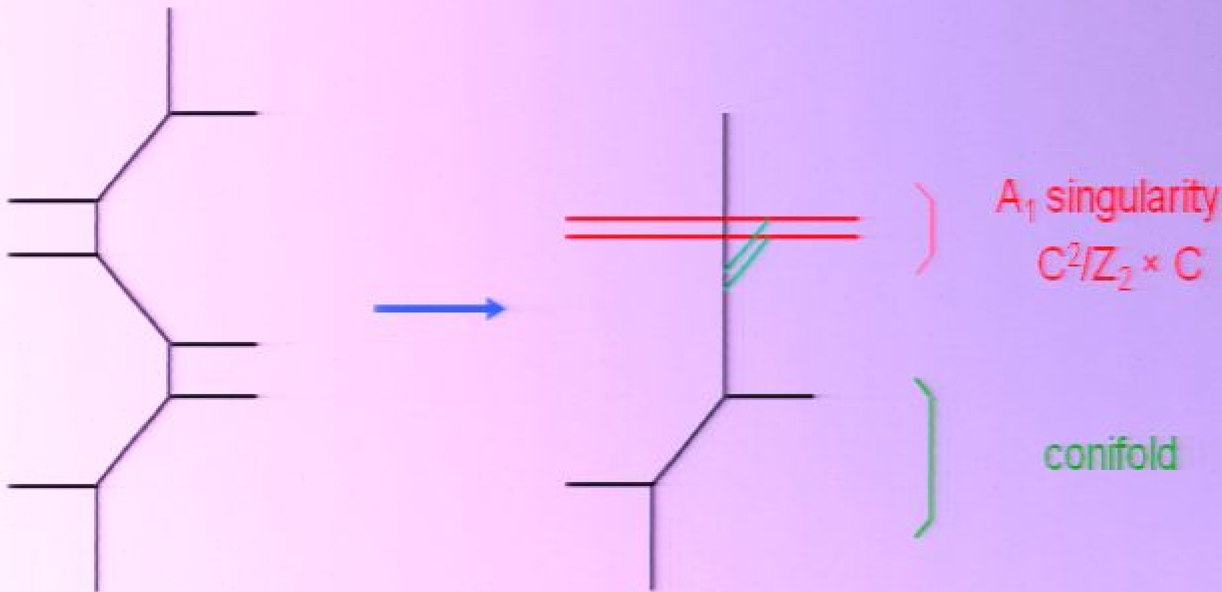

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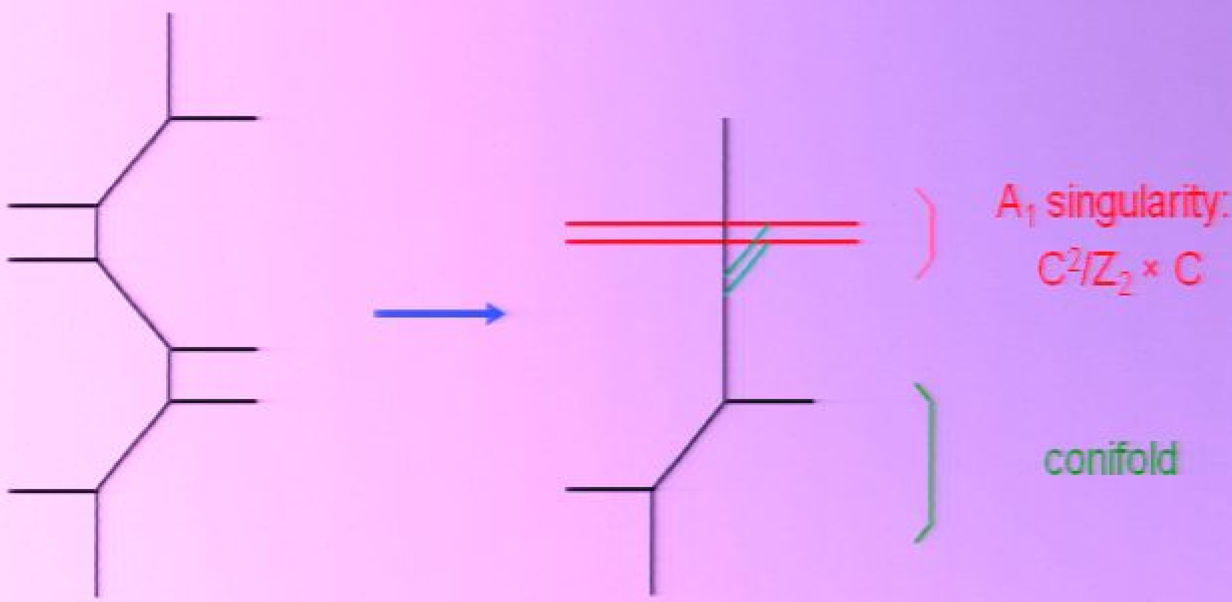

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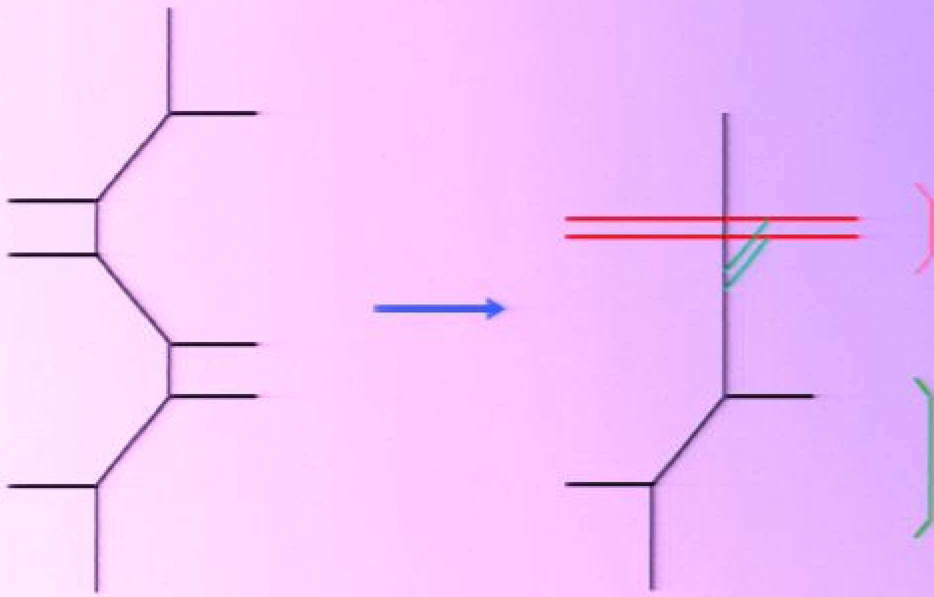

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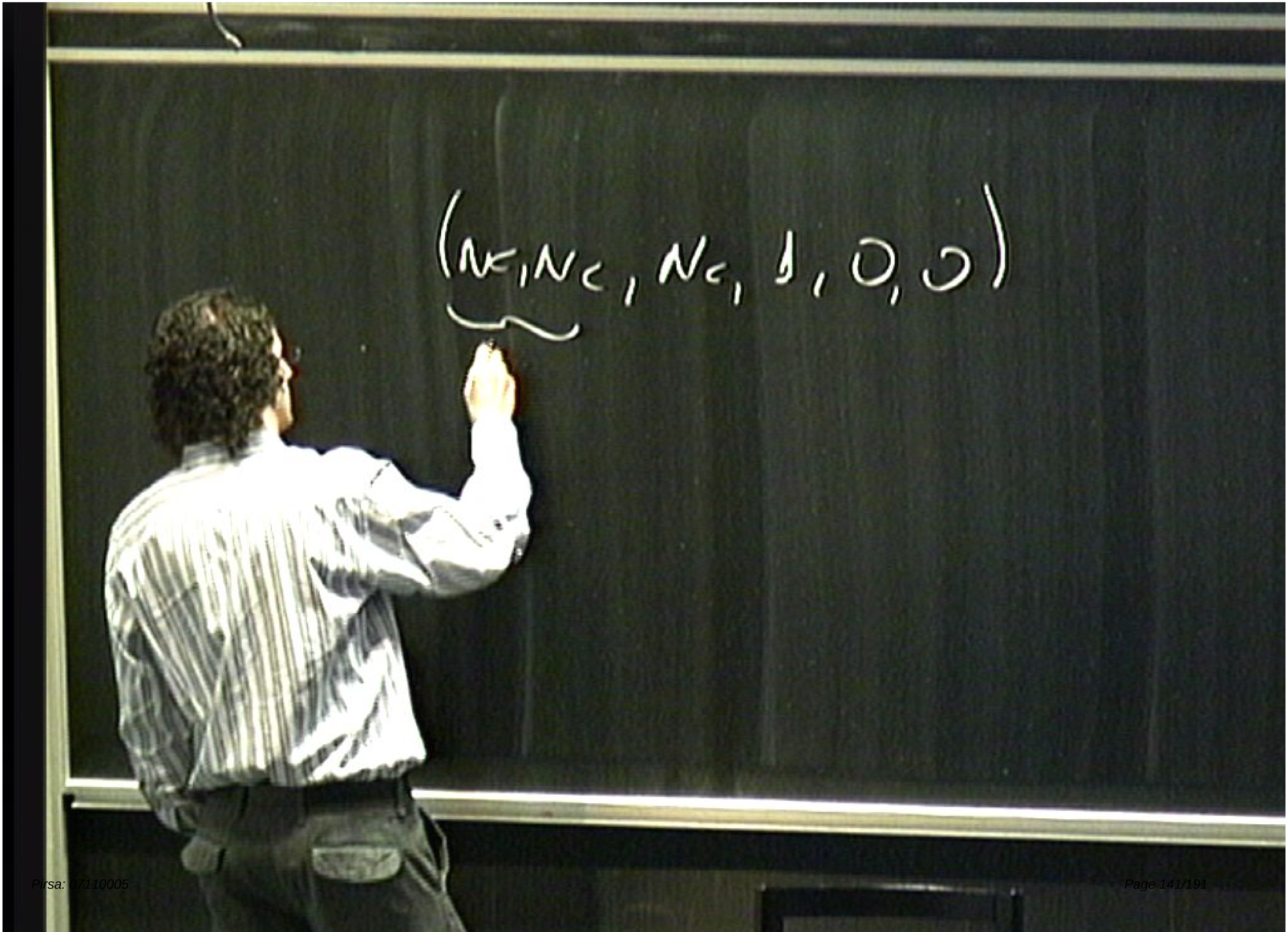
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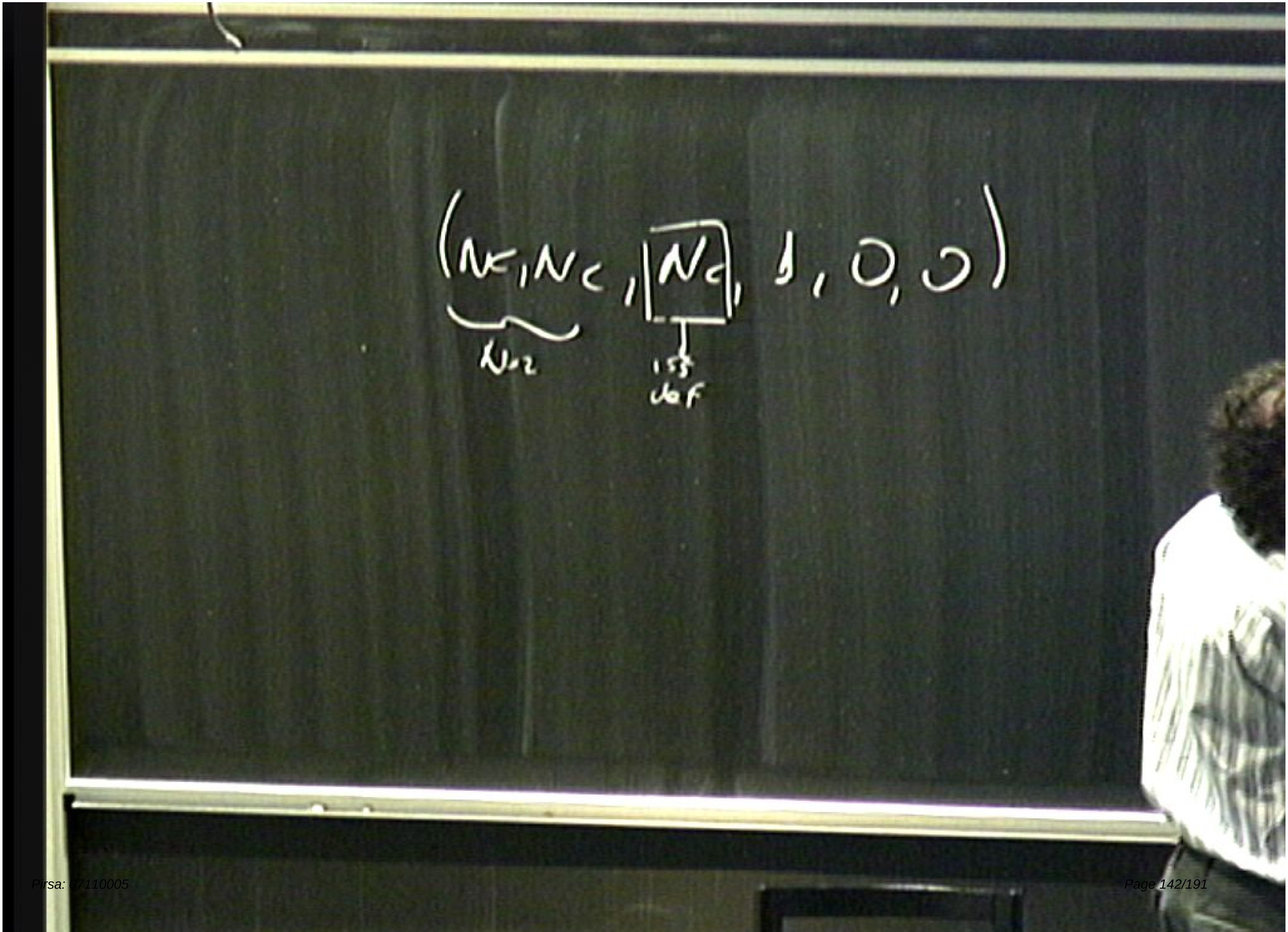
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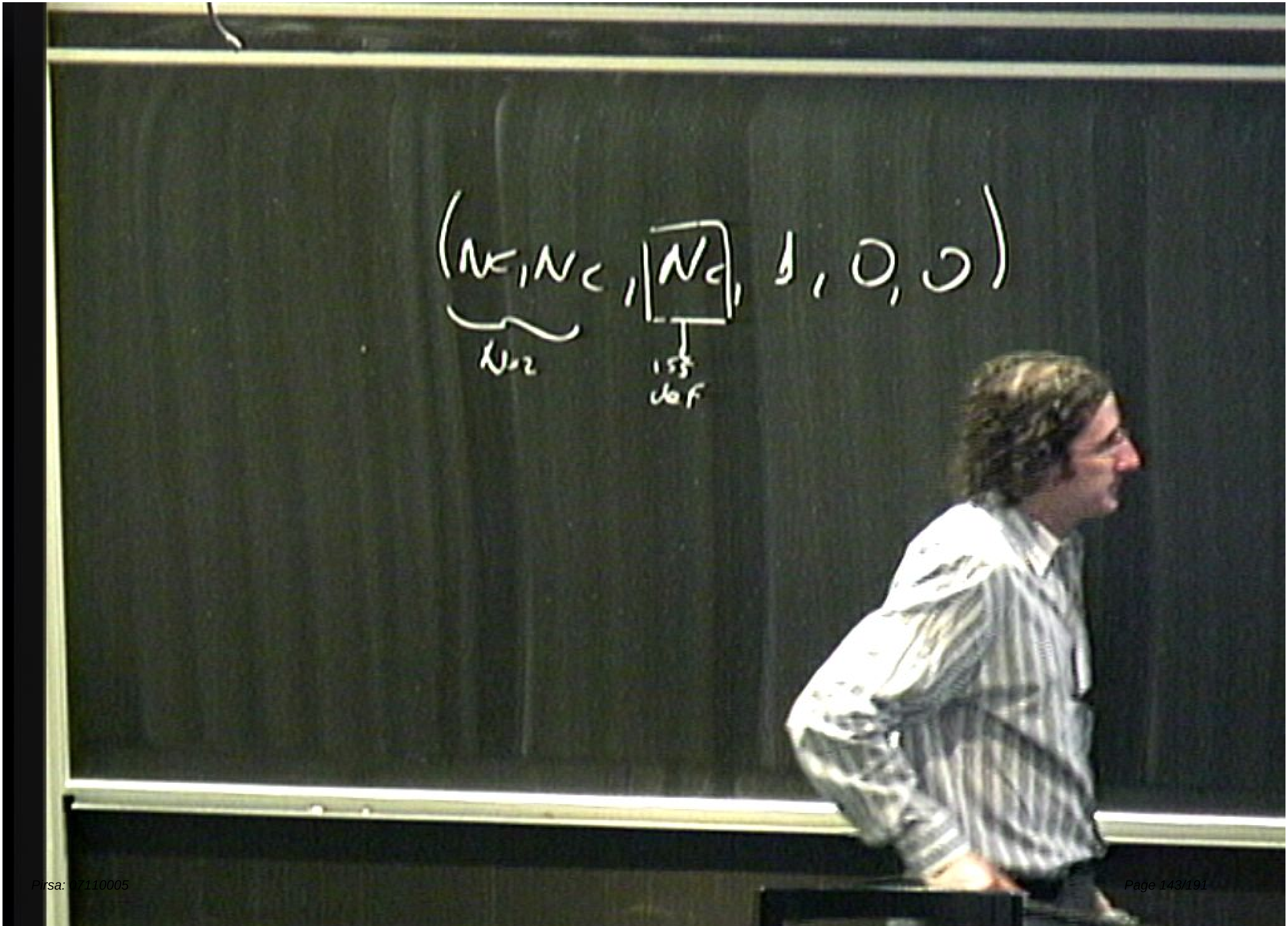
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- Non-SUSY states of a field theory can be obtained by adding anti-D3 branes to the dual confining geometry. Kachru, Pearson and Verlinde

- If the brane charges at infinity are kept fixed, these states are interpreted as vacuum states of the same gauge theory (at strong 't Hooft coupling).

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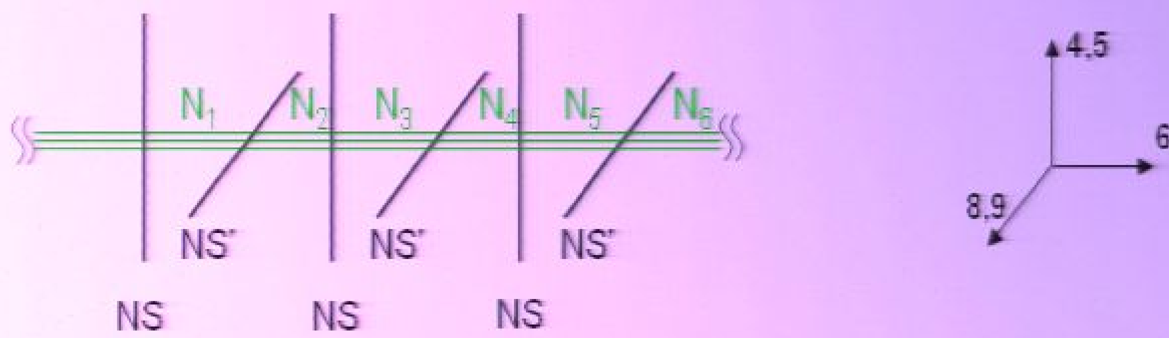

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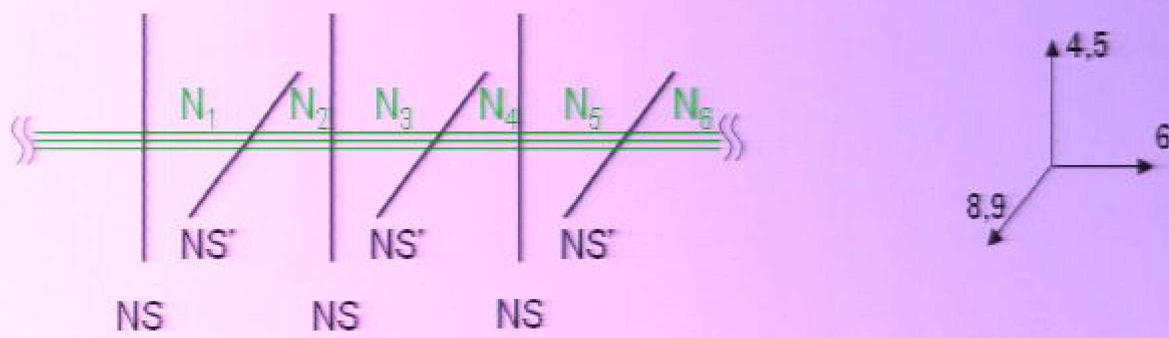

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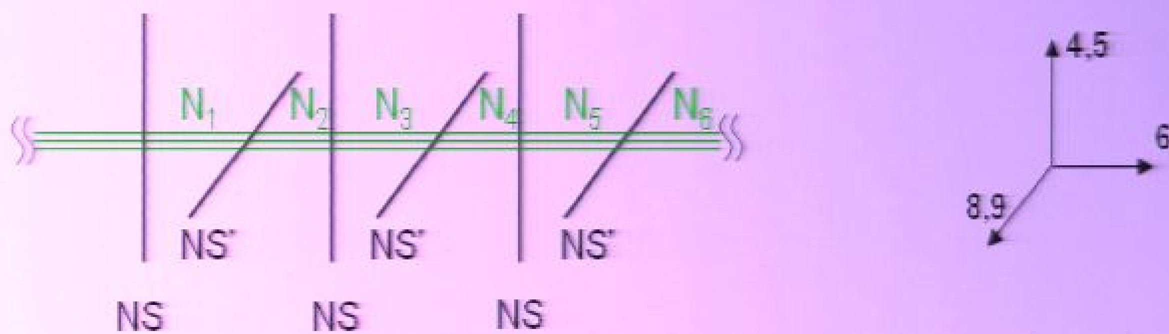

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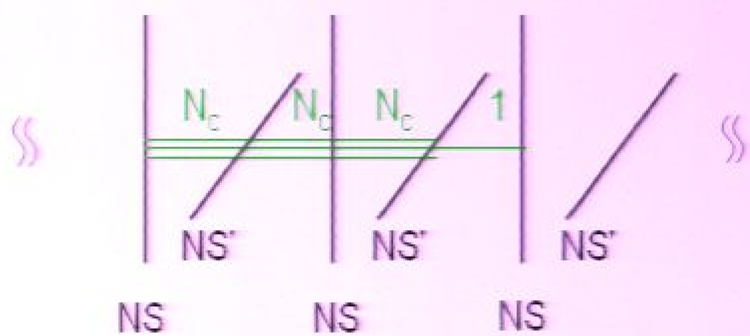

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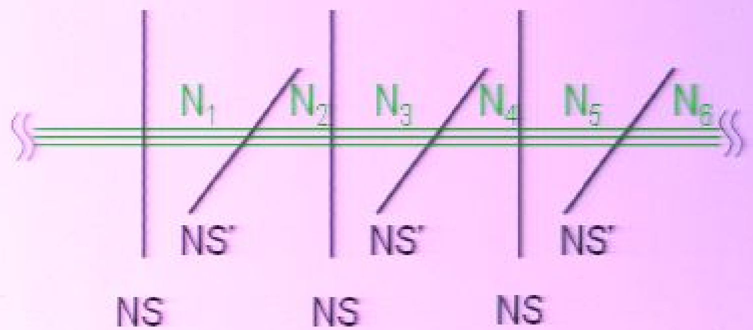

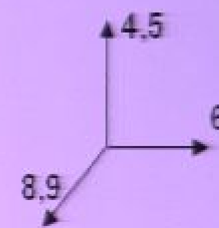

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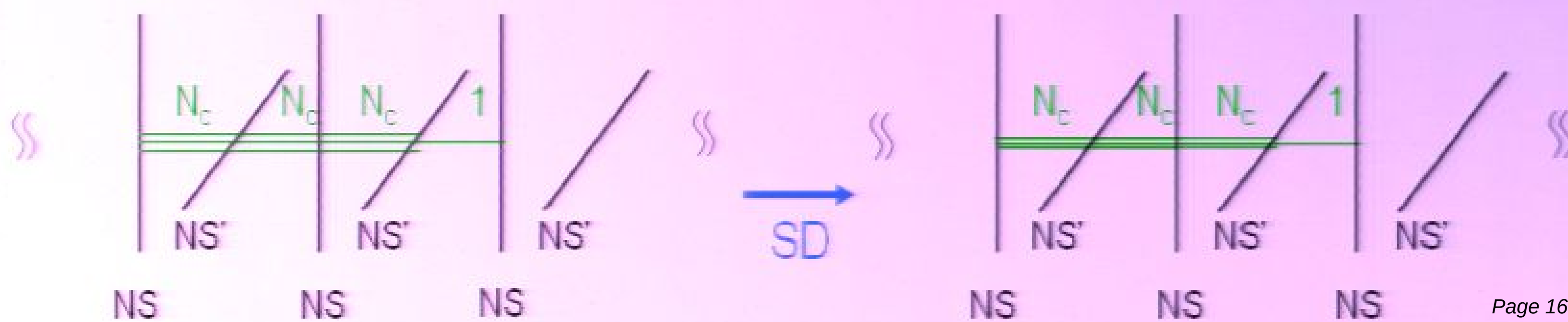

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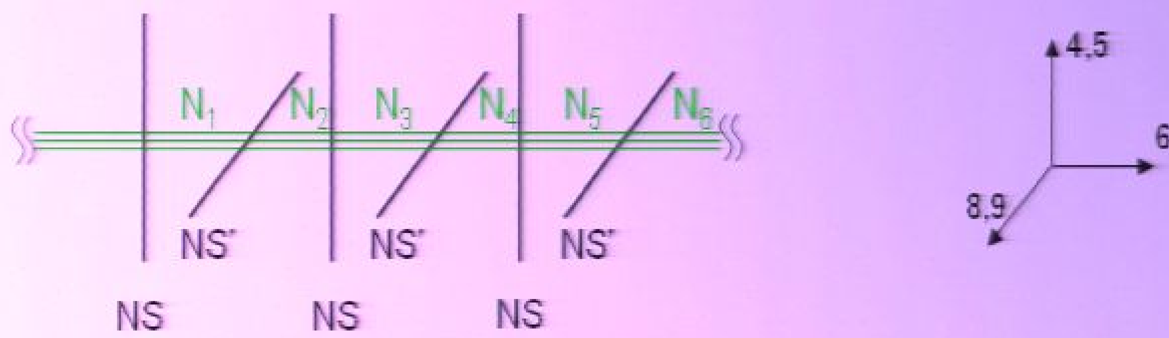

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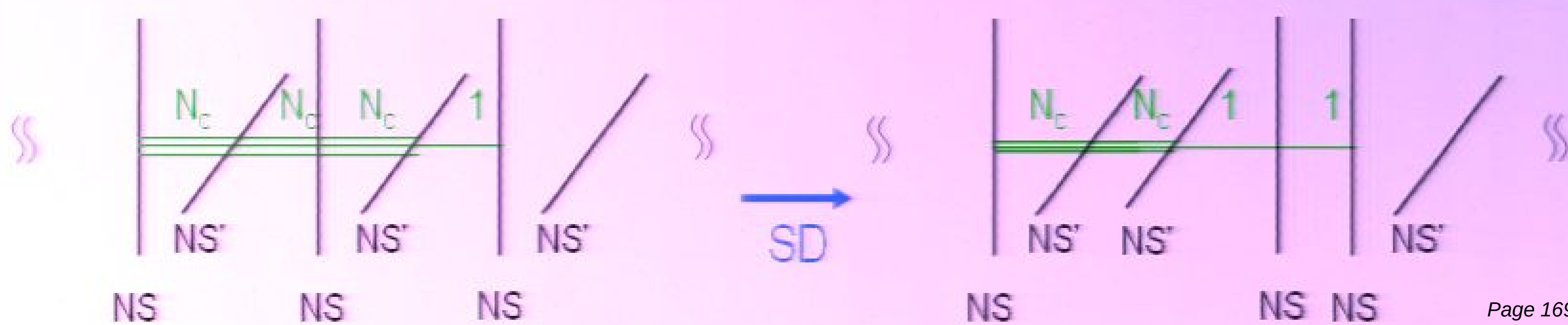

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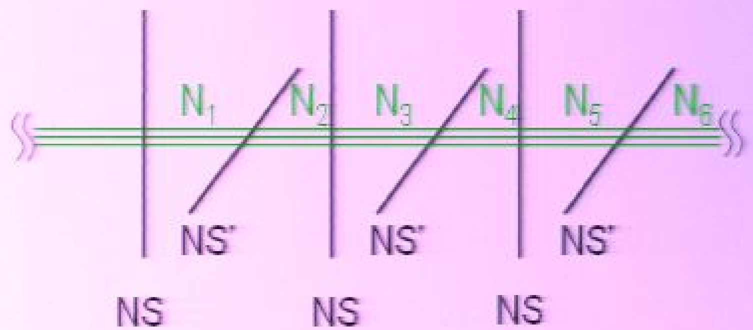

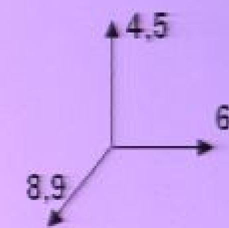

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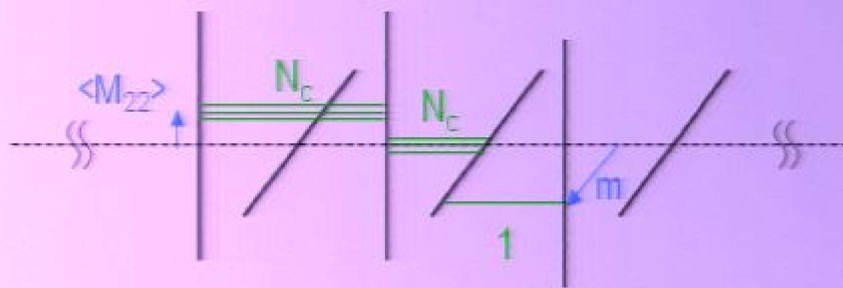

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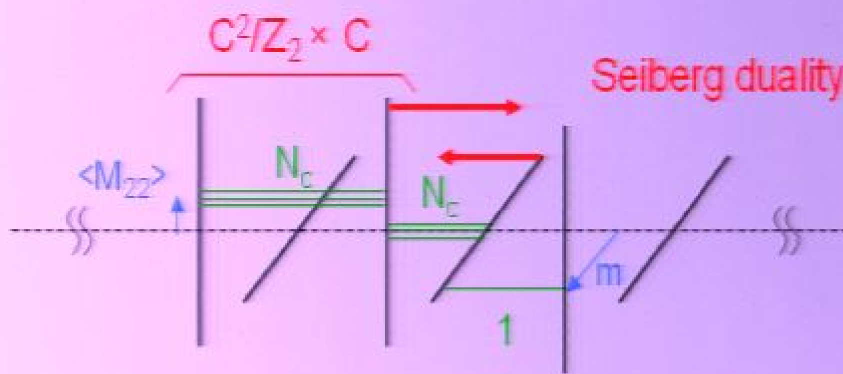

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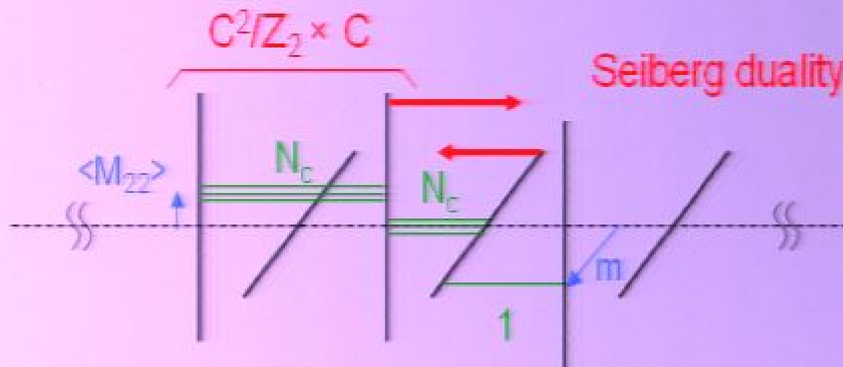

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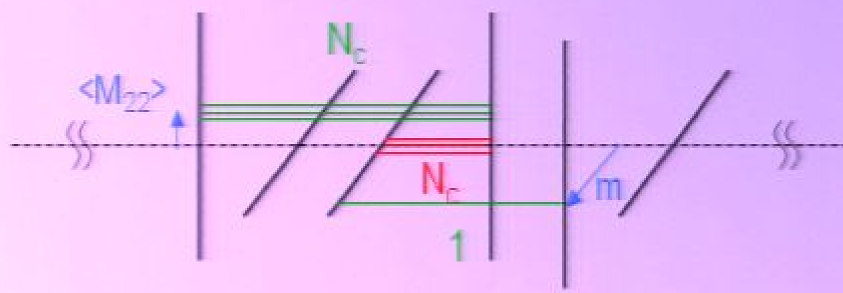

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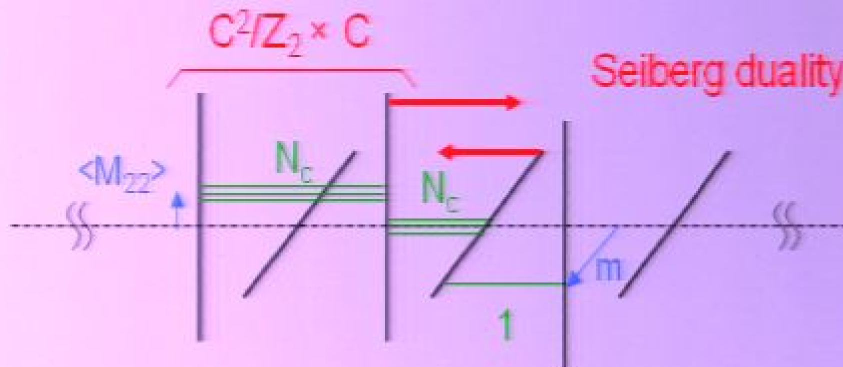

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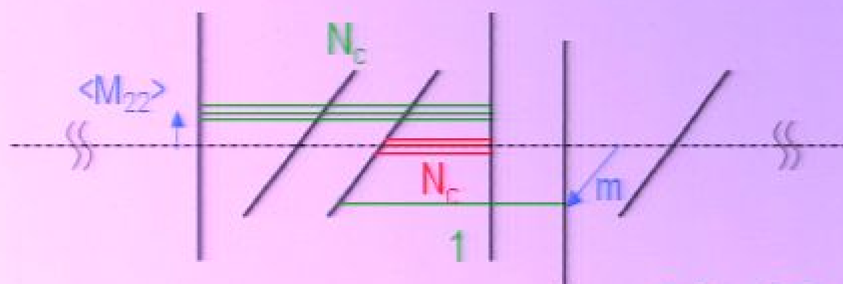

explicit anti-branes due to failure to overlap

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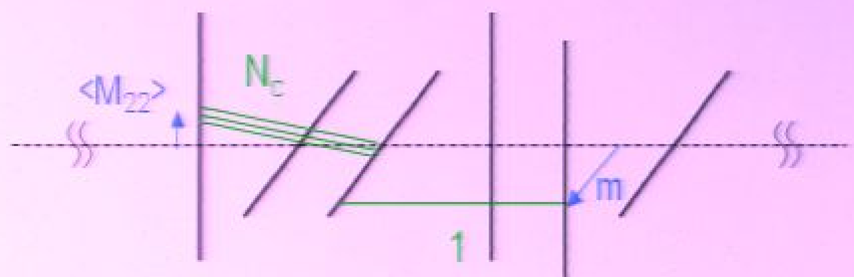

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- String instanton effects play an important role.

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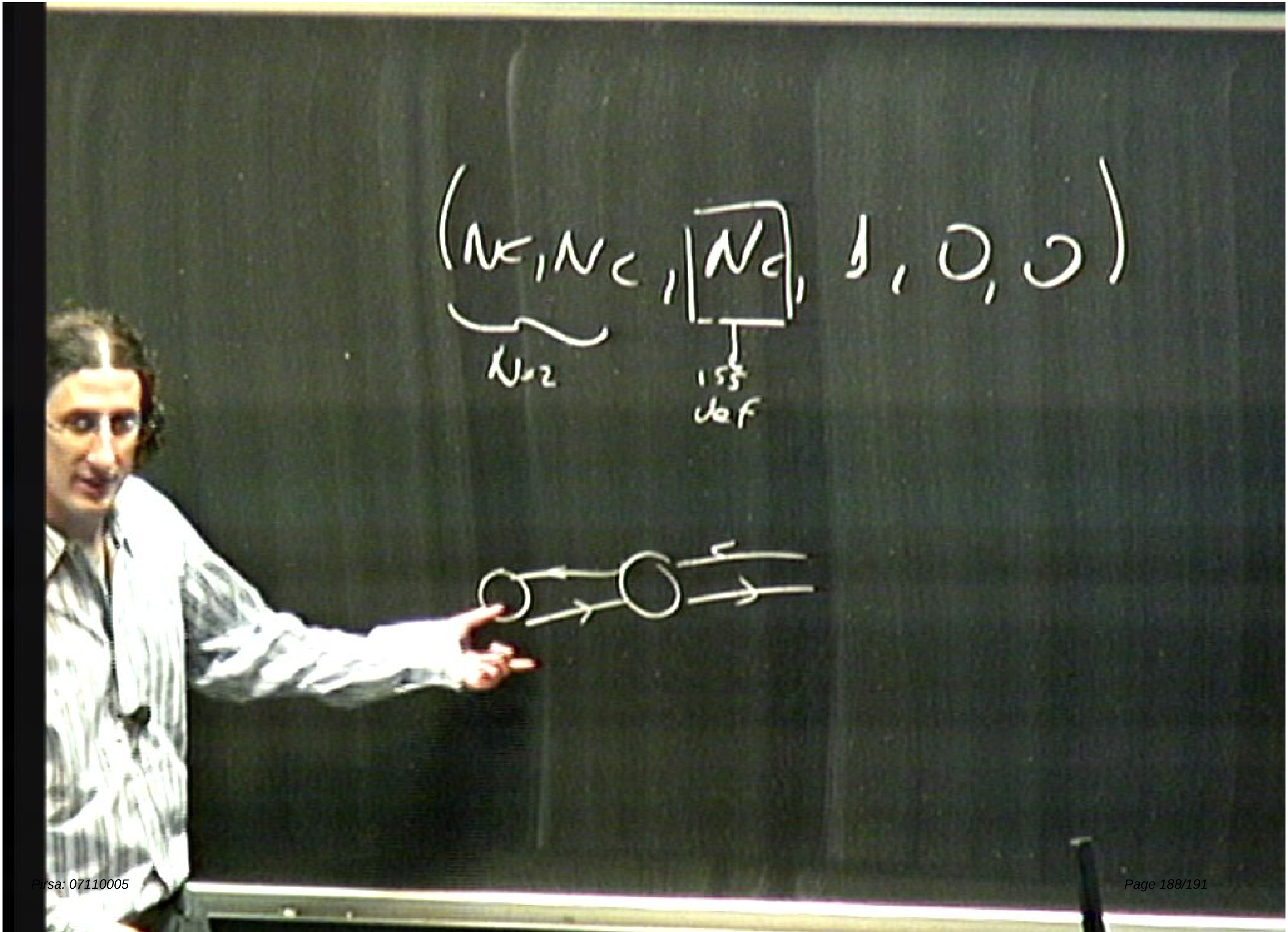
Franco, Rodriguez-Gomez and Verlinde (in progress)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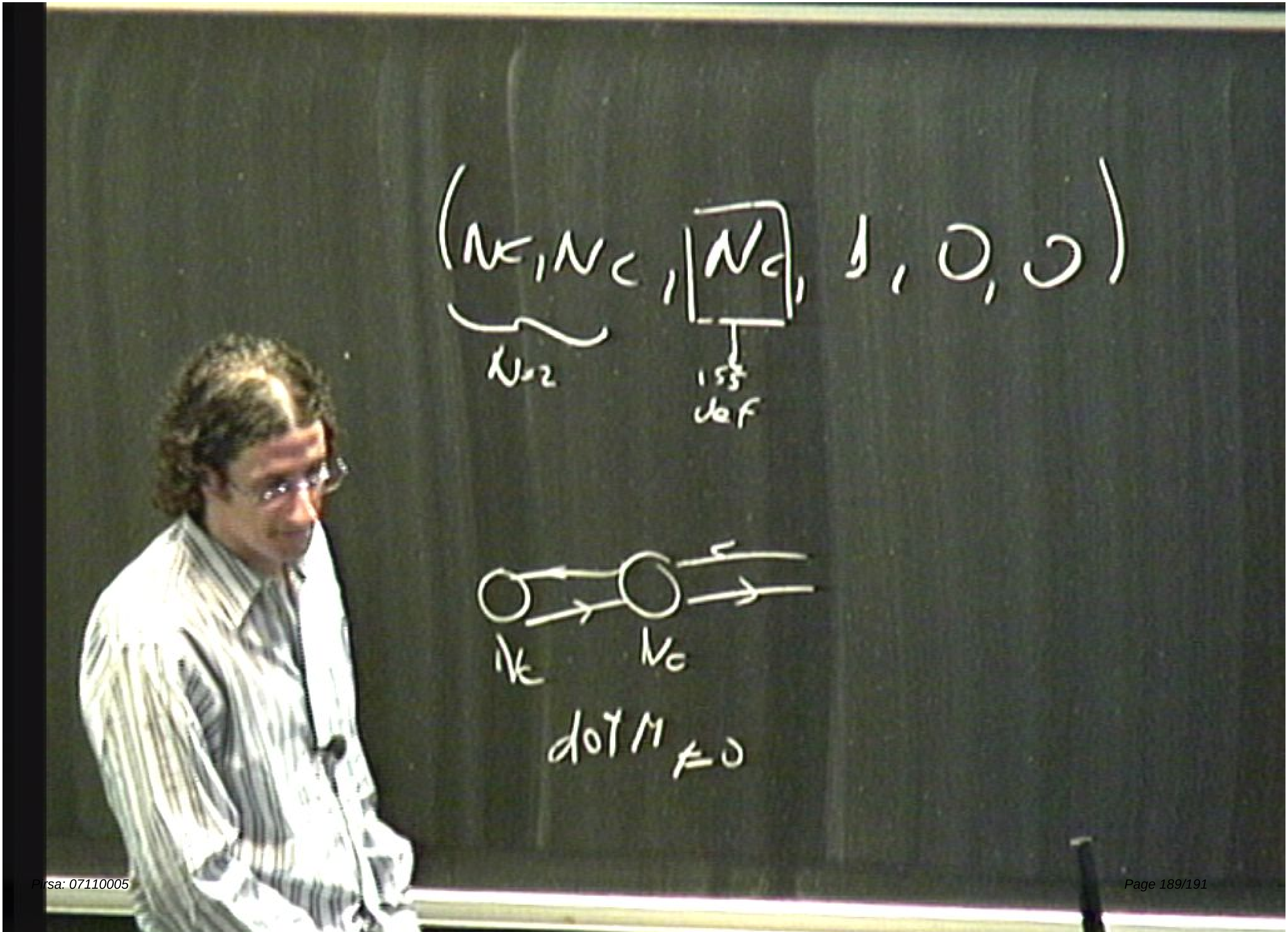
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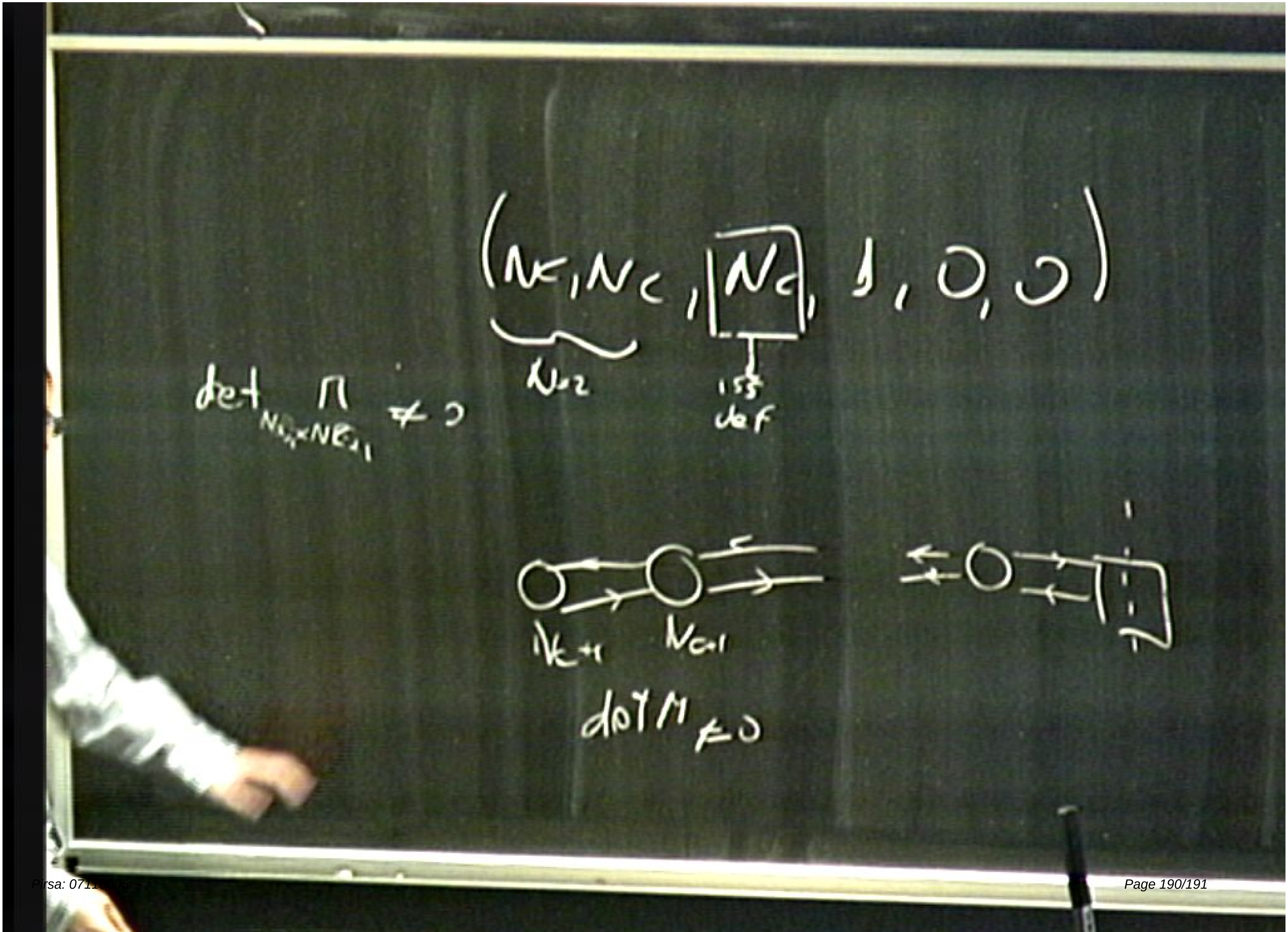
Nc
Nf
Nc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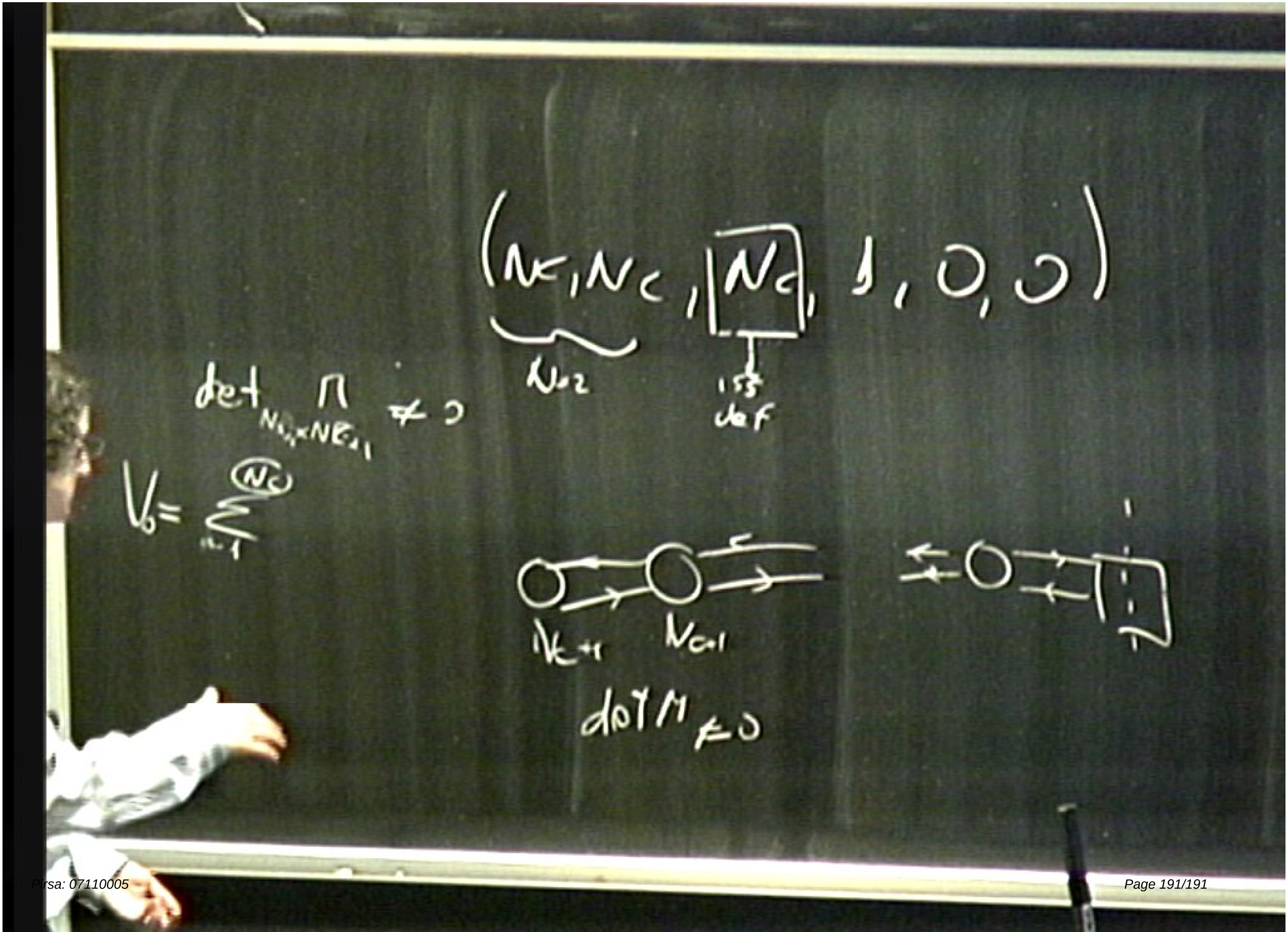
det M ≠ 0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