New ways of thinking about university physics teaching: A discussion of discursive representations using South African examples

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Cedric Linder

UPPSALA UNIVERSITET

Division of Physics Education Research
Department of Physics & Astronomy
Uppsala University, Sweden

Department of Physics
University of the Western Cape

Faculty of Health and Life Sciences
Linnaeus University

Linnéuniversitetet

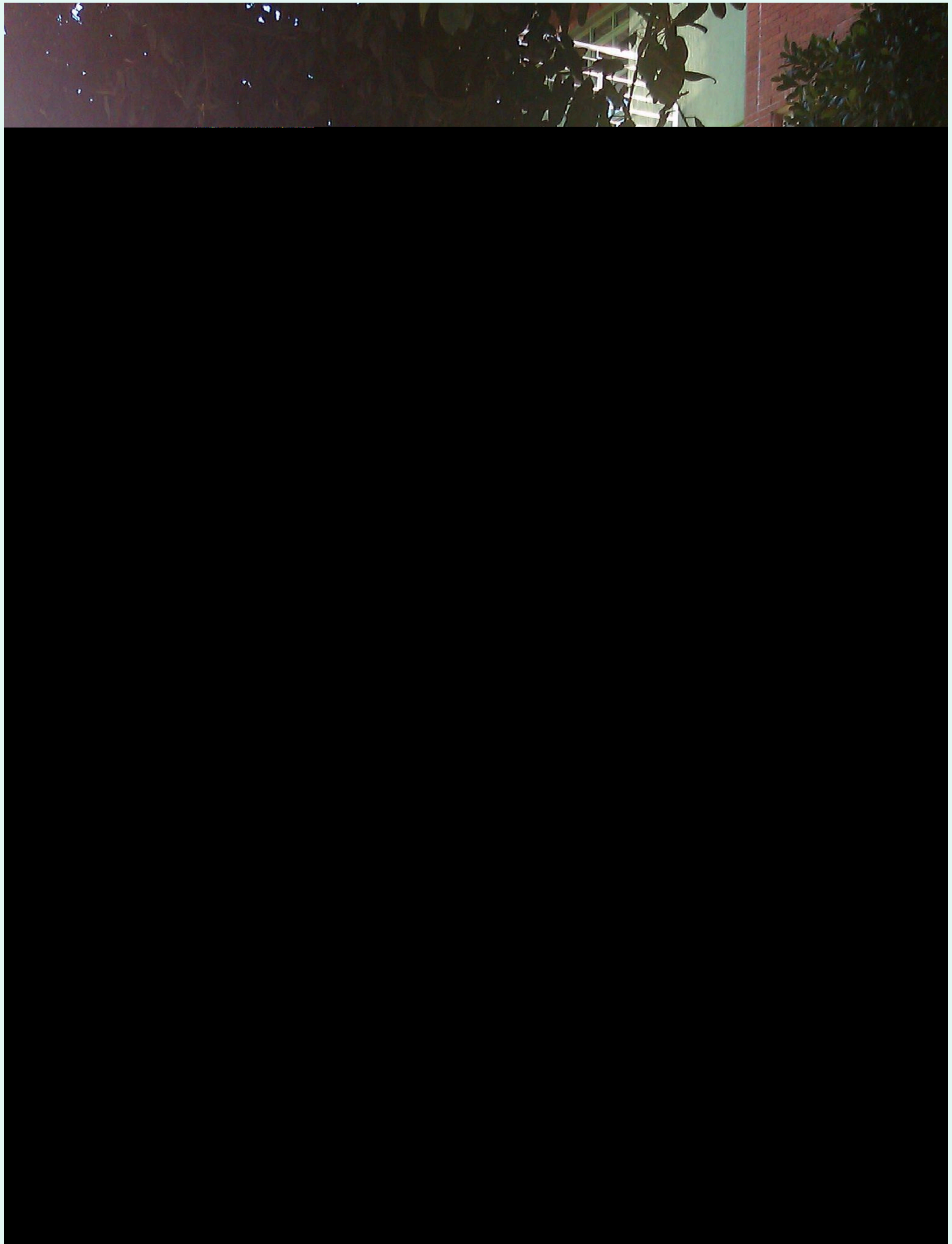
Outline of presentation

- Grounding of interest
- What is meant by representations
- Question of relevance
- Ways that lectures think about representations in their teaching practice, and
  ways that lectures think about dealing with their students’ representational competence

~280 staff:
40 prof's +33 lecturers +67 researchers +15 postdocs + 83 gradade students + 44 support staff: technical + administration

~318 MSEK budget:
58 MSEK for teaching
133 MSEK faculty funding for research
128 MSEK external funding for research

Physics & Astronomy at Uppsala
Ångström Laboratory



Physics Department, UWC

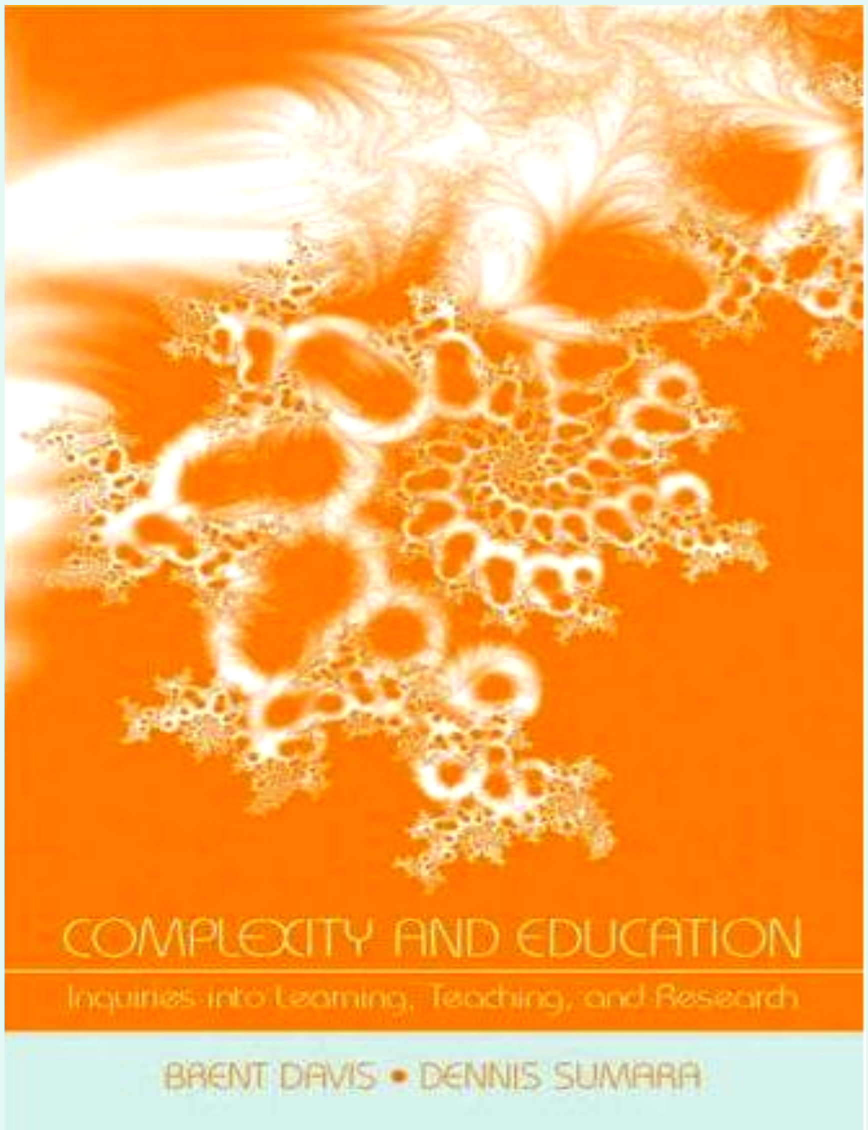
Small staff number and small budget but a long sustaining history of enormous teaching effort

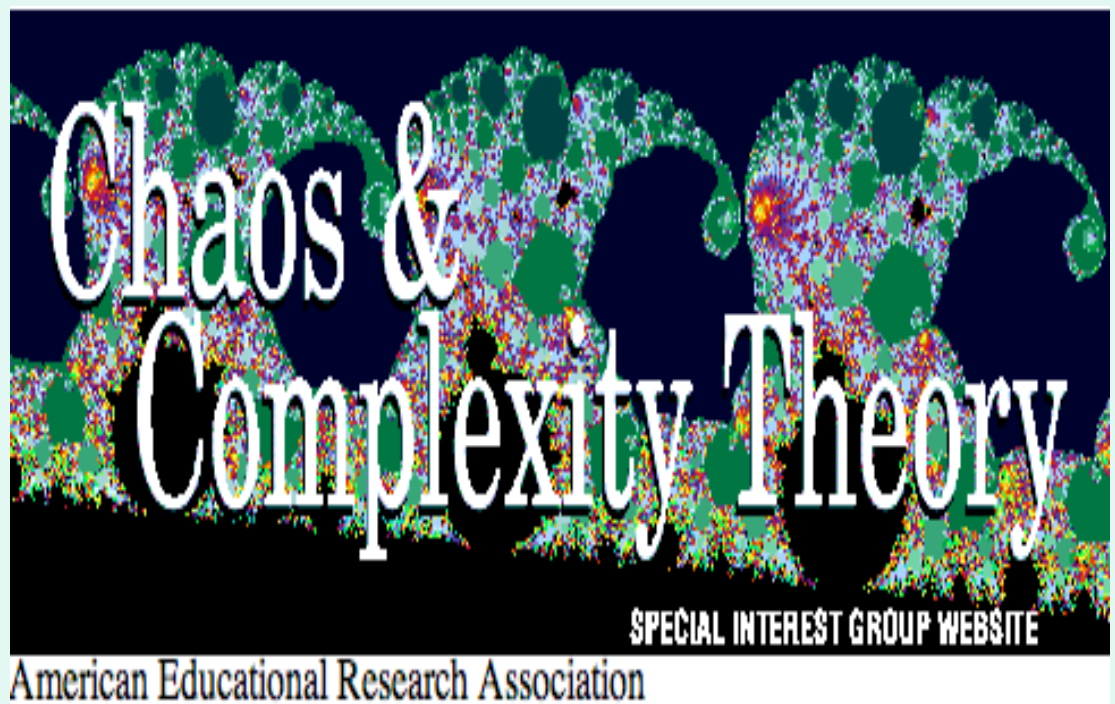
Review of Physics Education in South Africa (CHE-SAIP Report, 2014)

In light of the concerns expressed by the Heads of Physics Departments regarding student competence, to consider the extent to which teaching and learning delivers graduates with the knowledge and skills which would maximize their potential to pursue postgraduate studies and other employment careers.

Education experience is a complex system

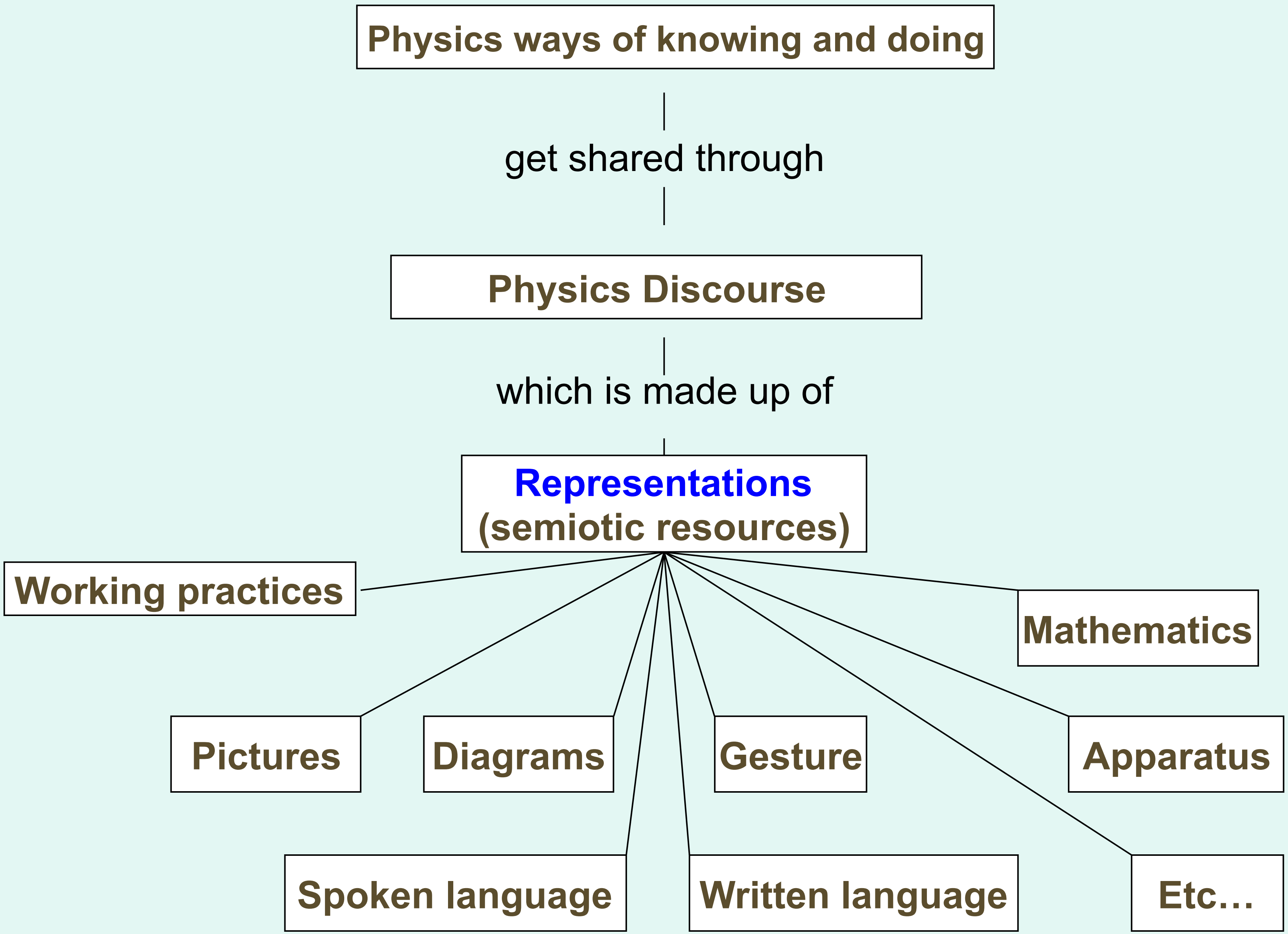
COMPLICITY
AN INTERNATIONAL JOURNAL OF COMPLEXITY AND EDUCATION





Representation

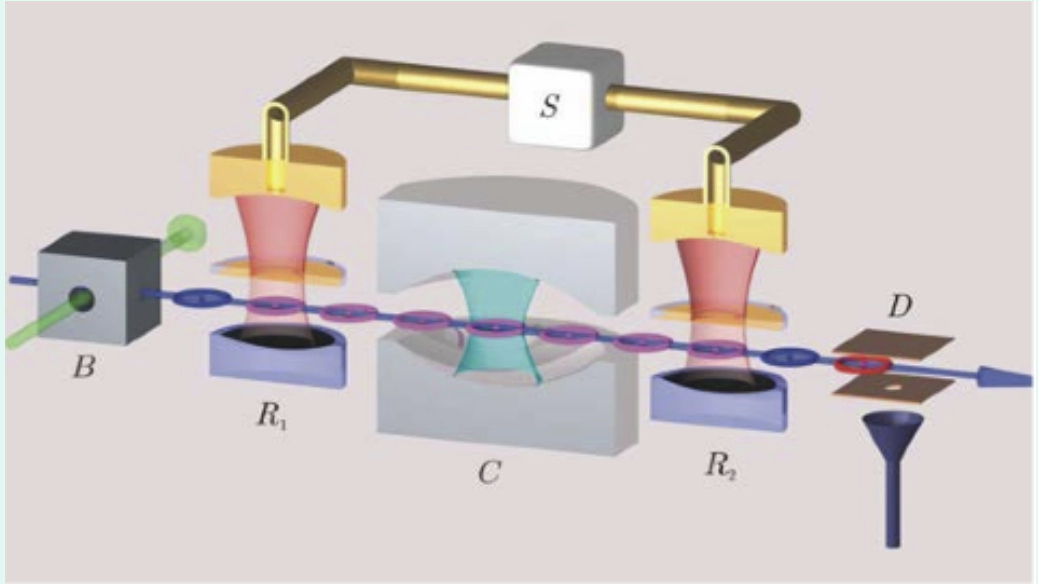
Representations are taken to be the collection of semiotic resources that make up the “text” of all communication

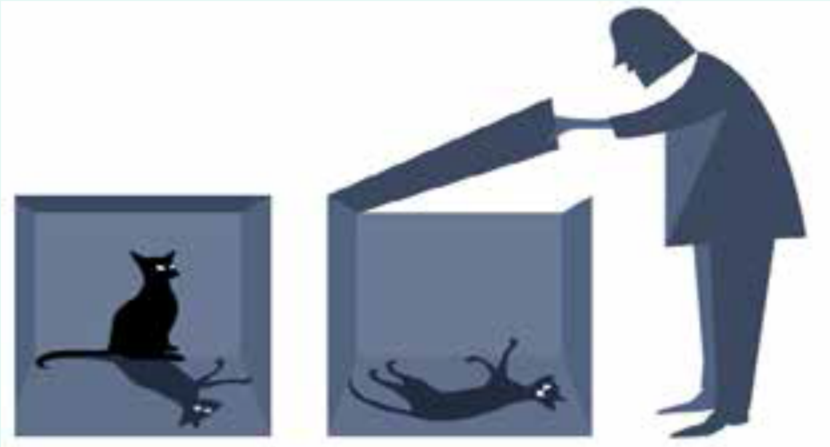


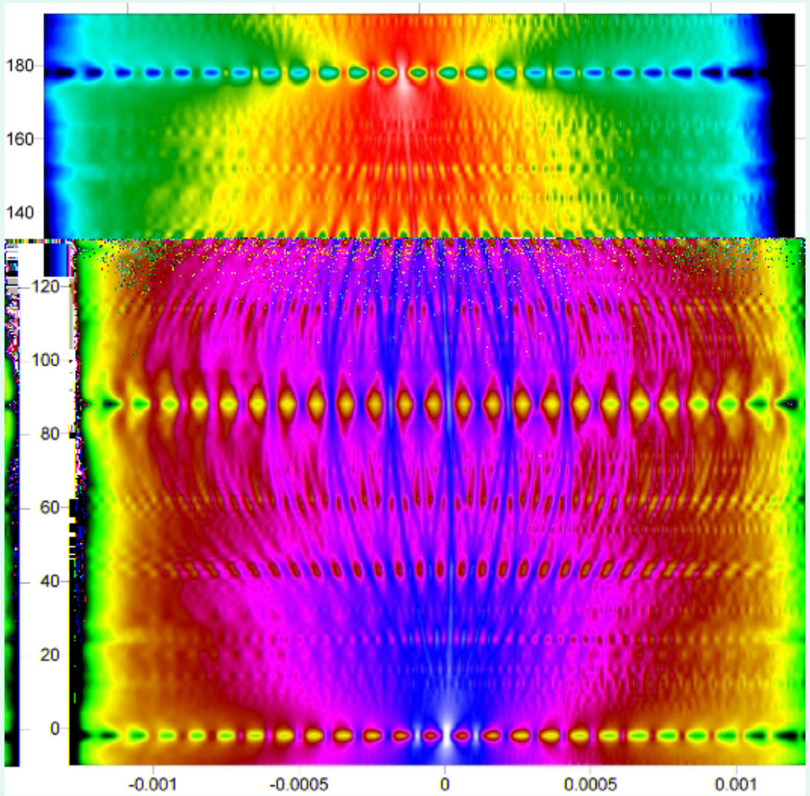
After Airey & Linder 2009

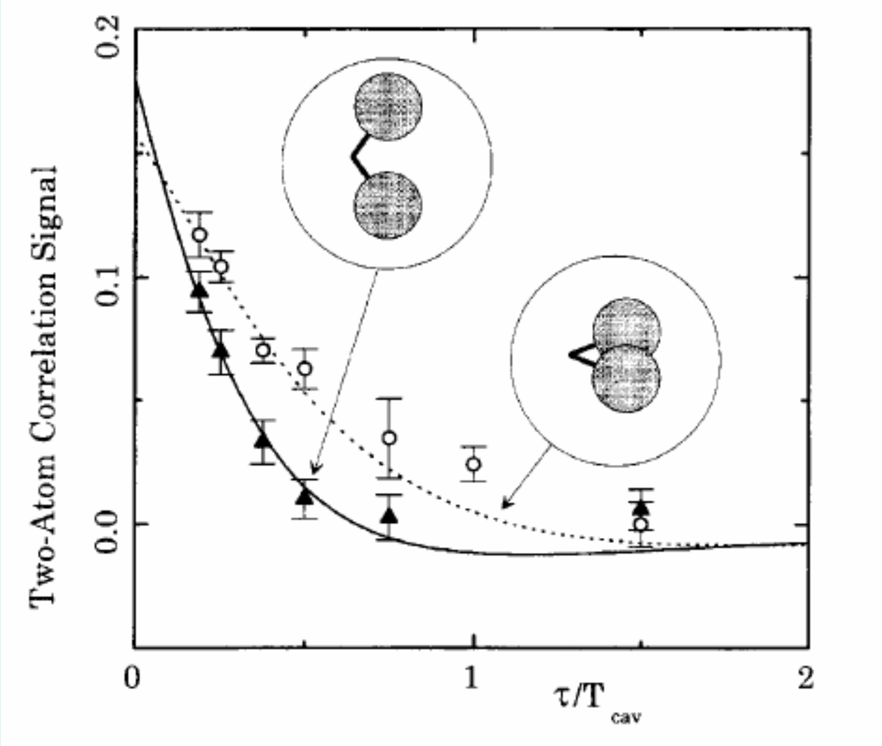
Examples

$$F_g = G\frac{m_1 m_2}{r^2}$$









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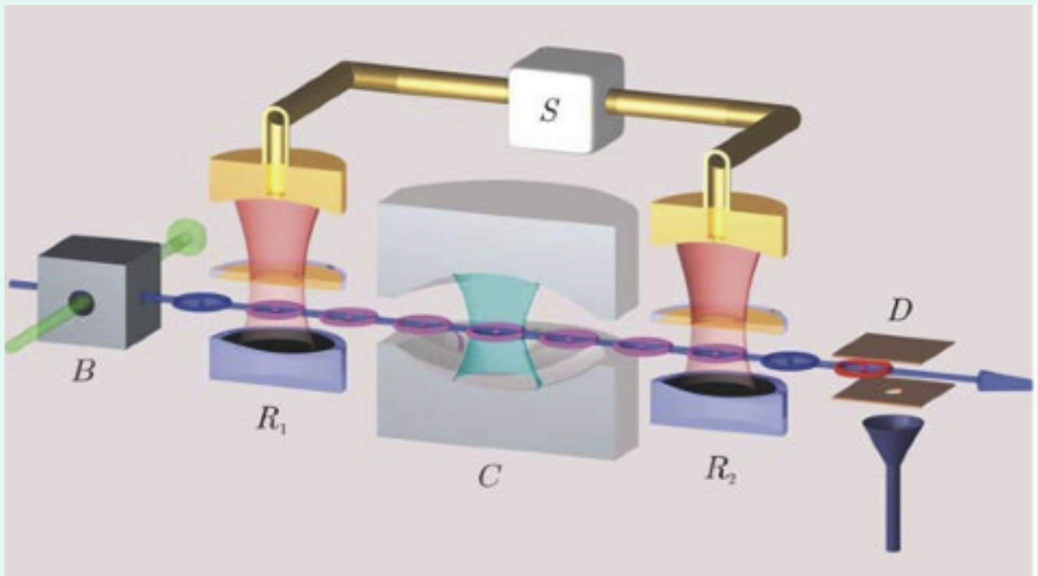

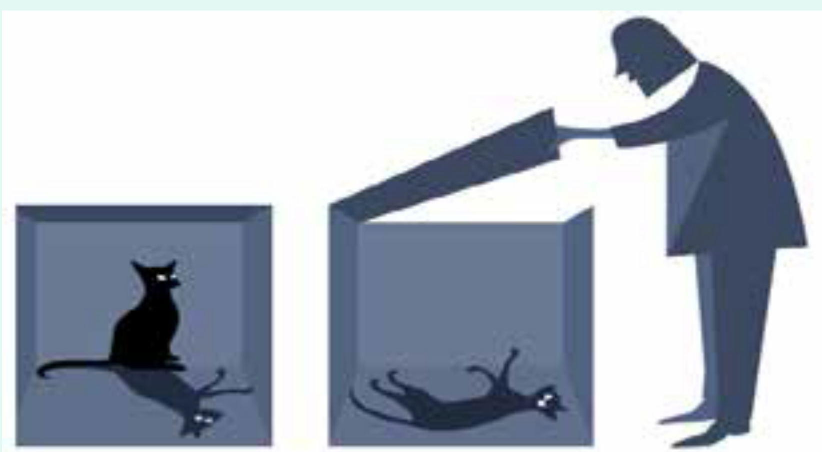

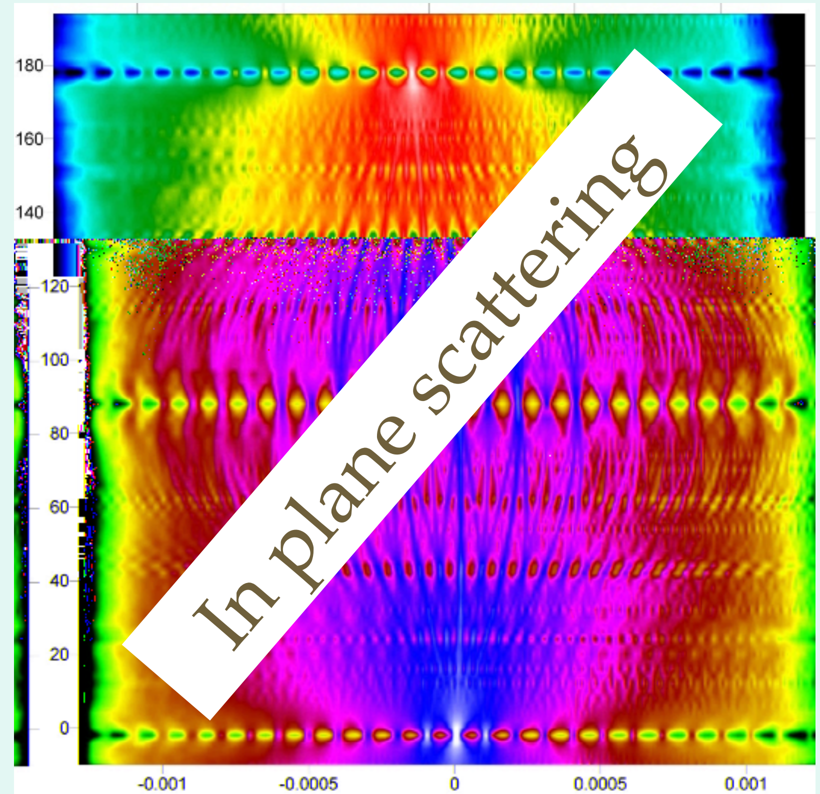

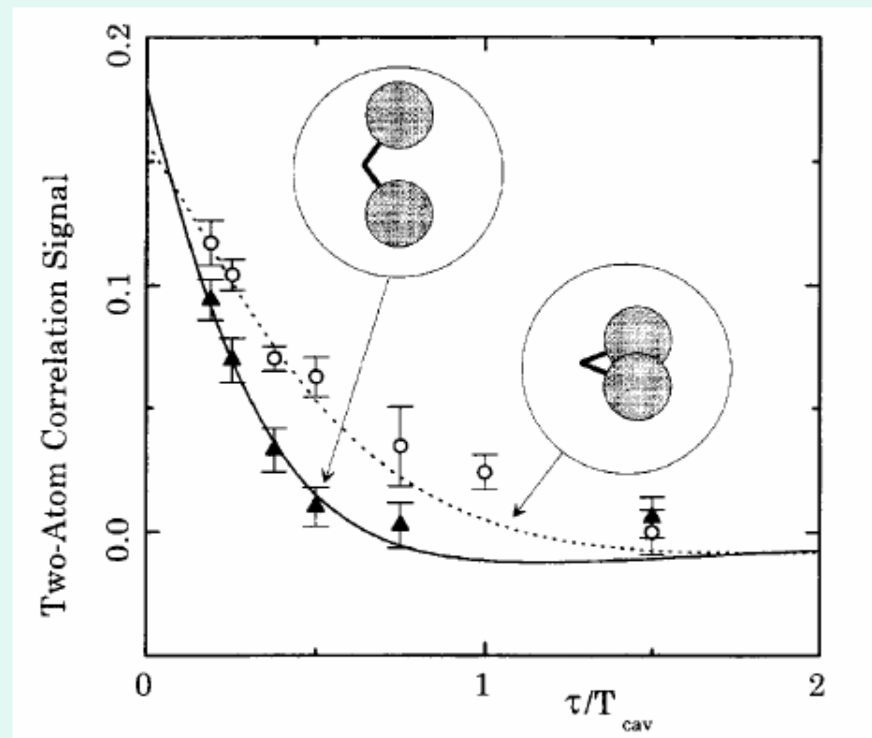

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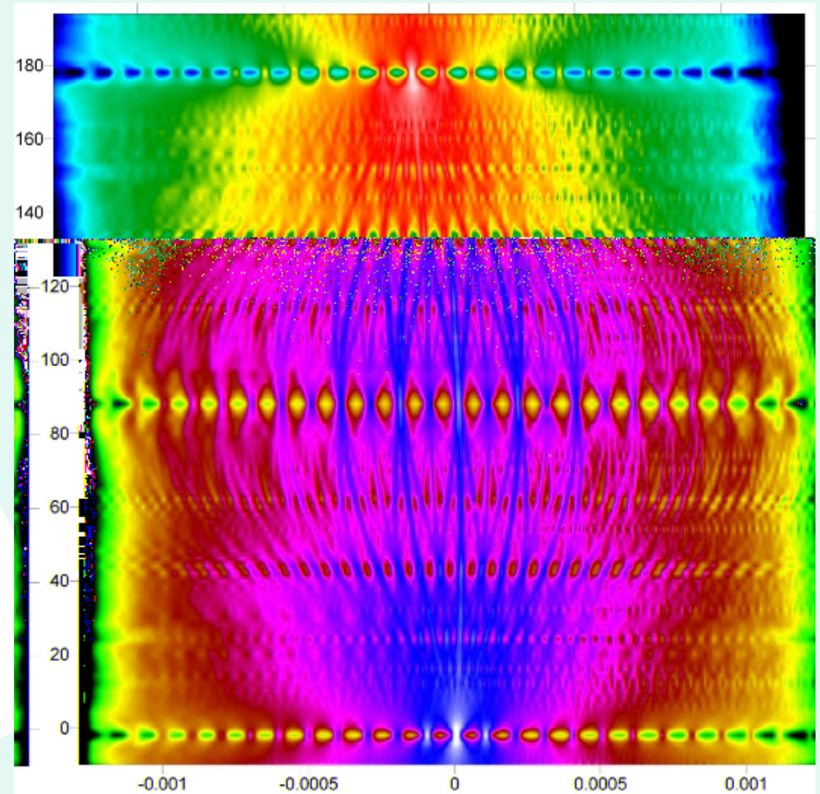
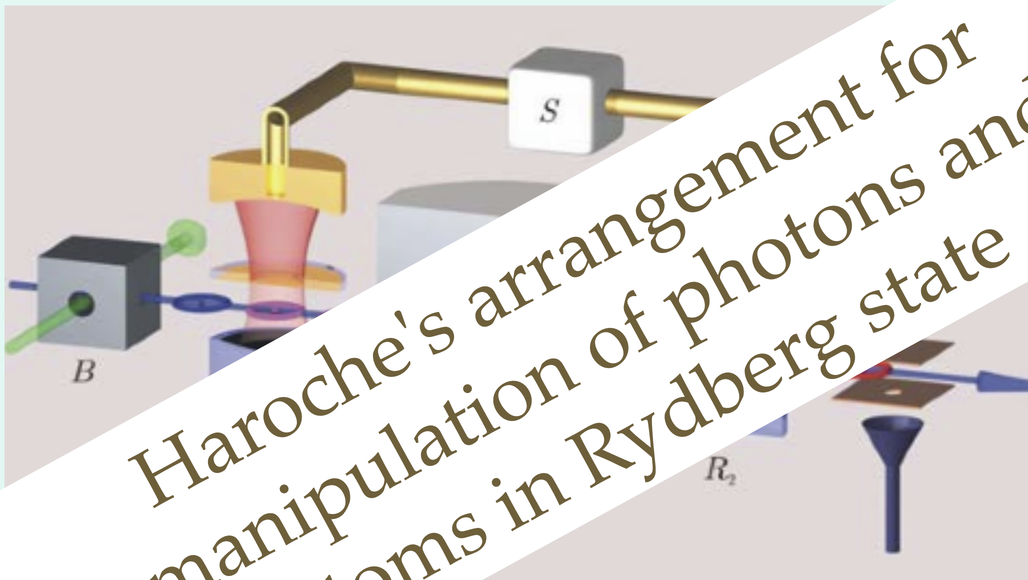
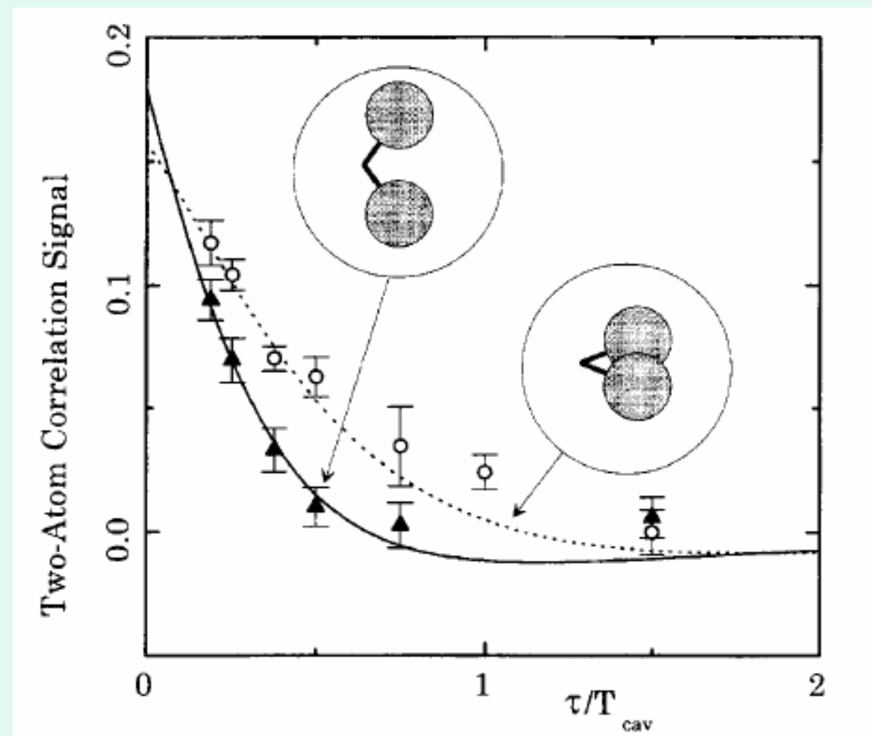




Haroche's arrangement for manipulation of photons and atoms in Rydberg state



Examples

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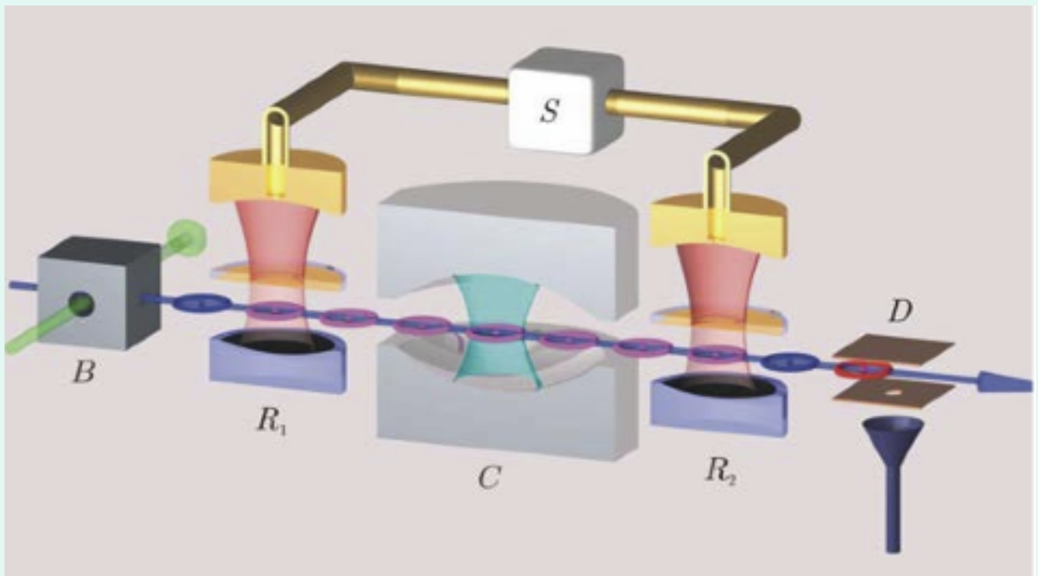
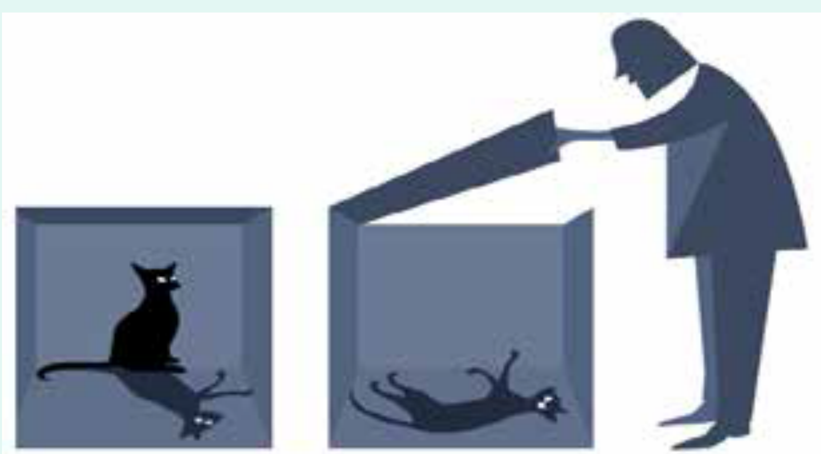
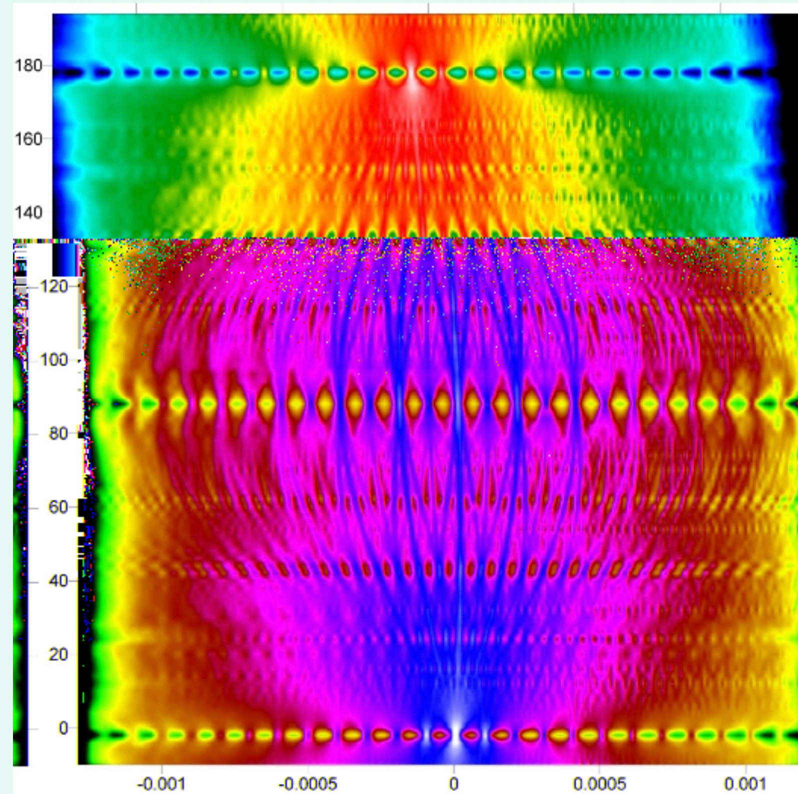
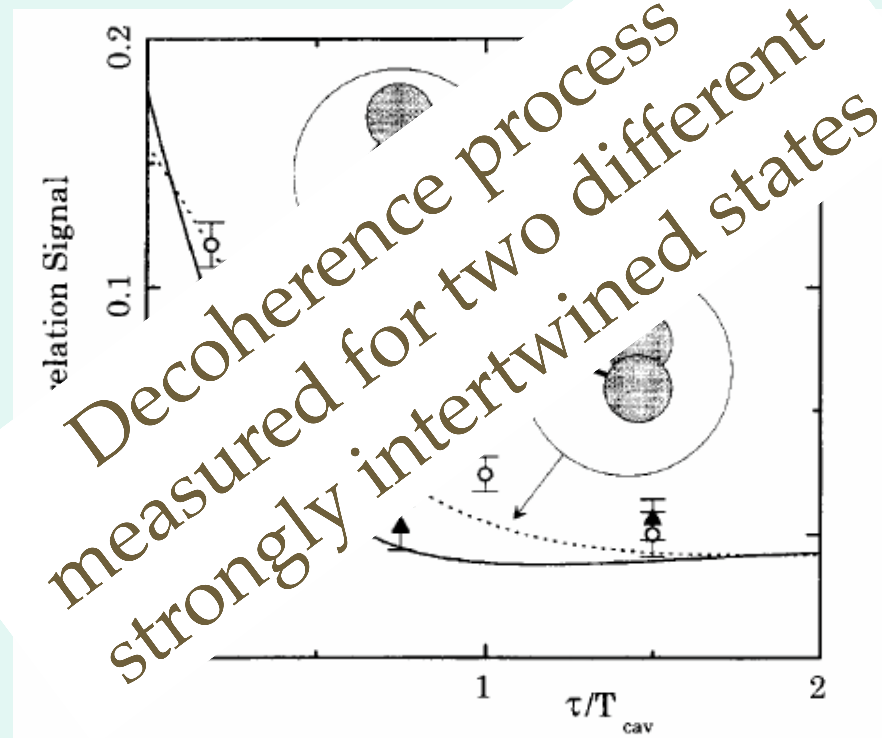
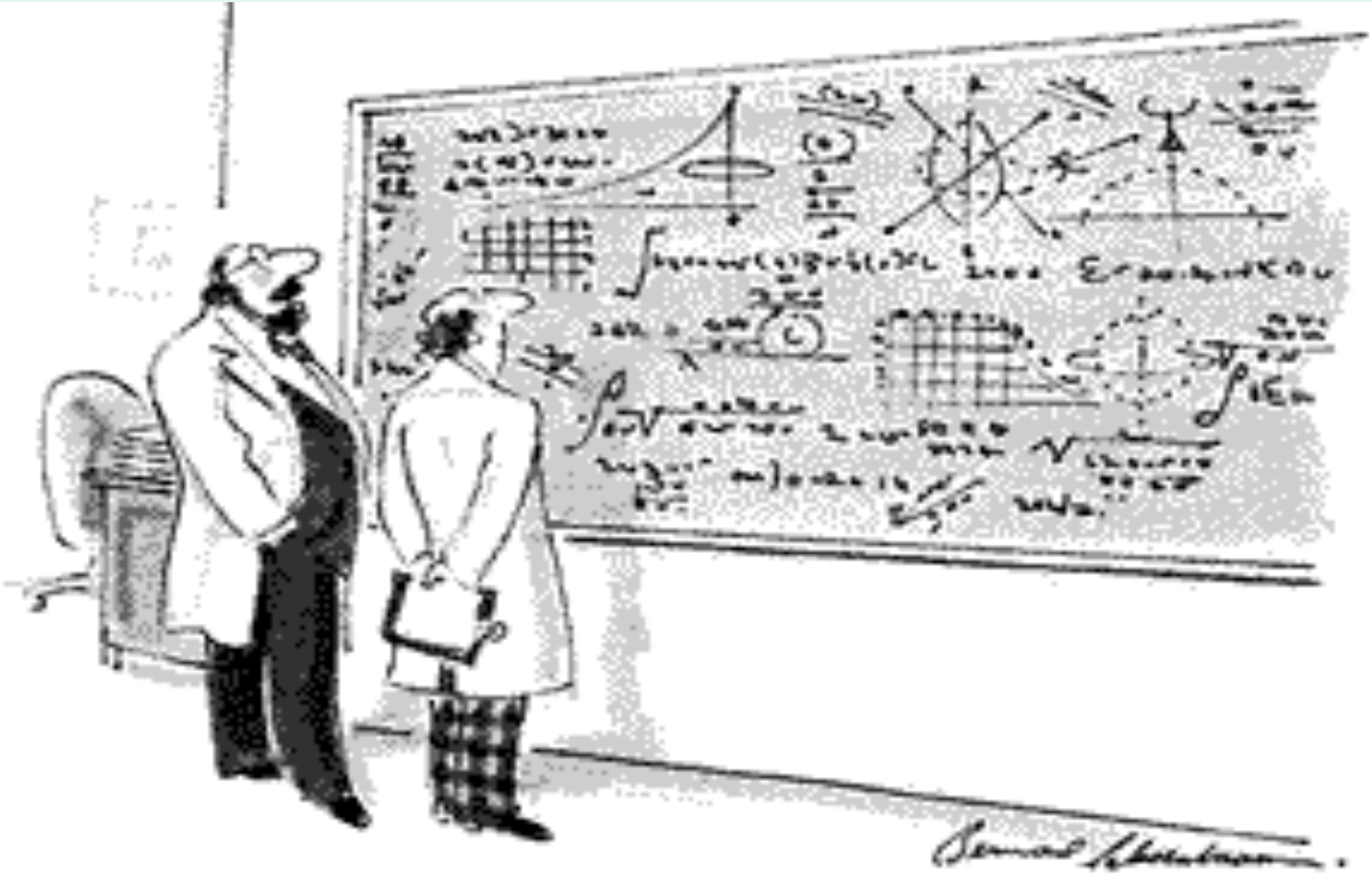




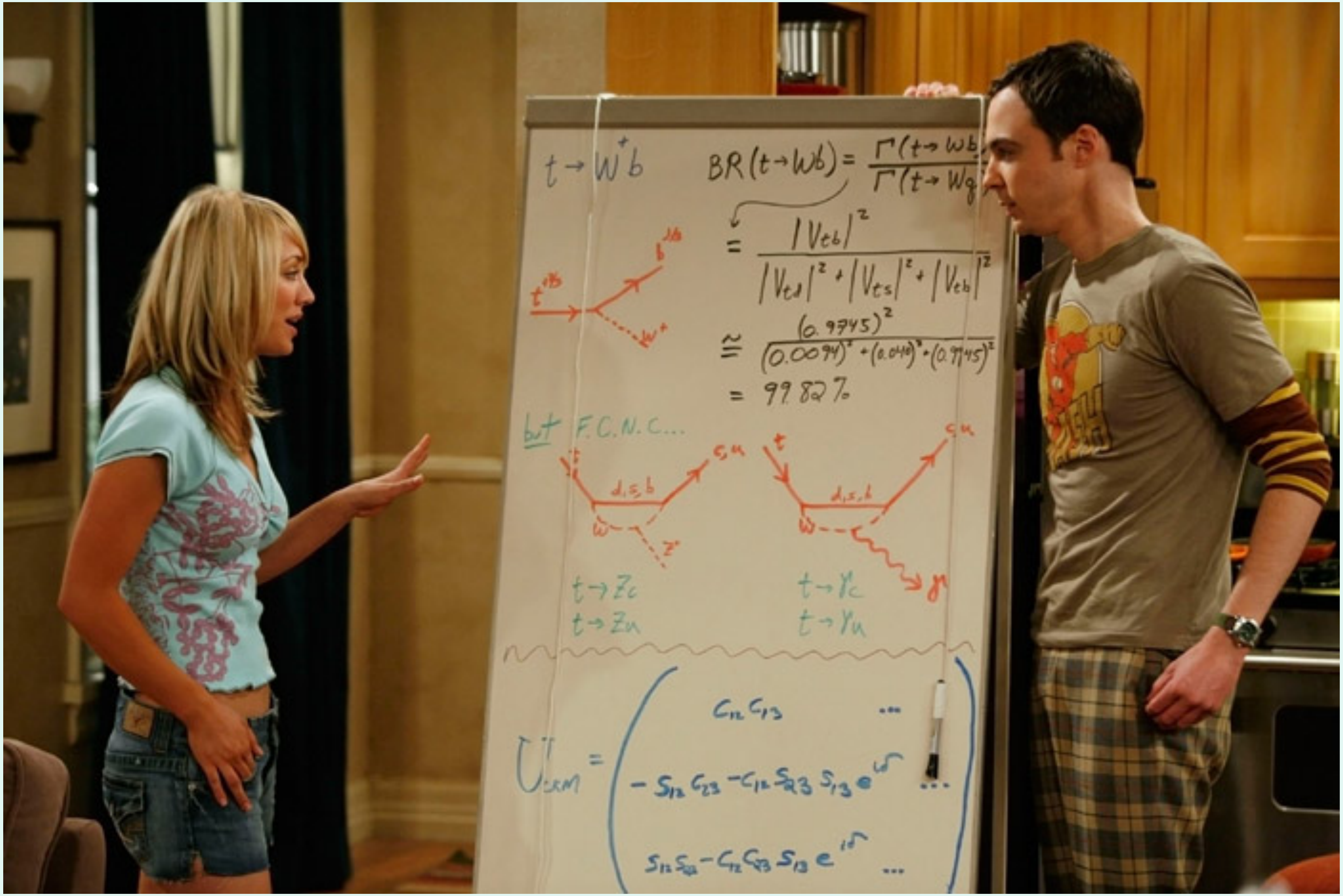




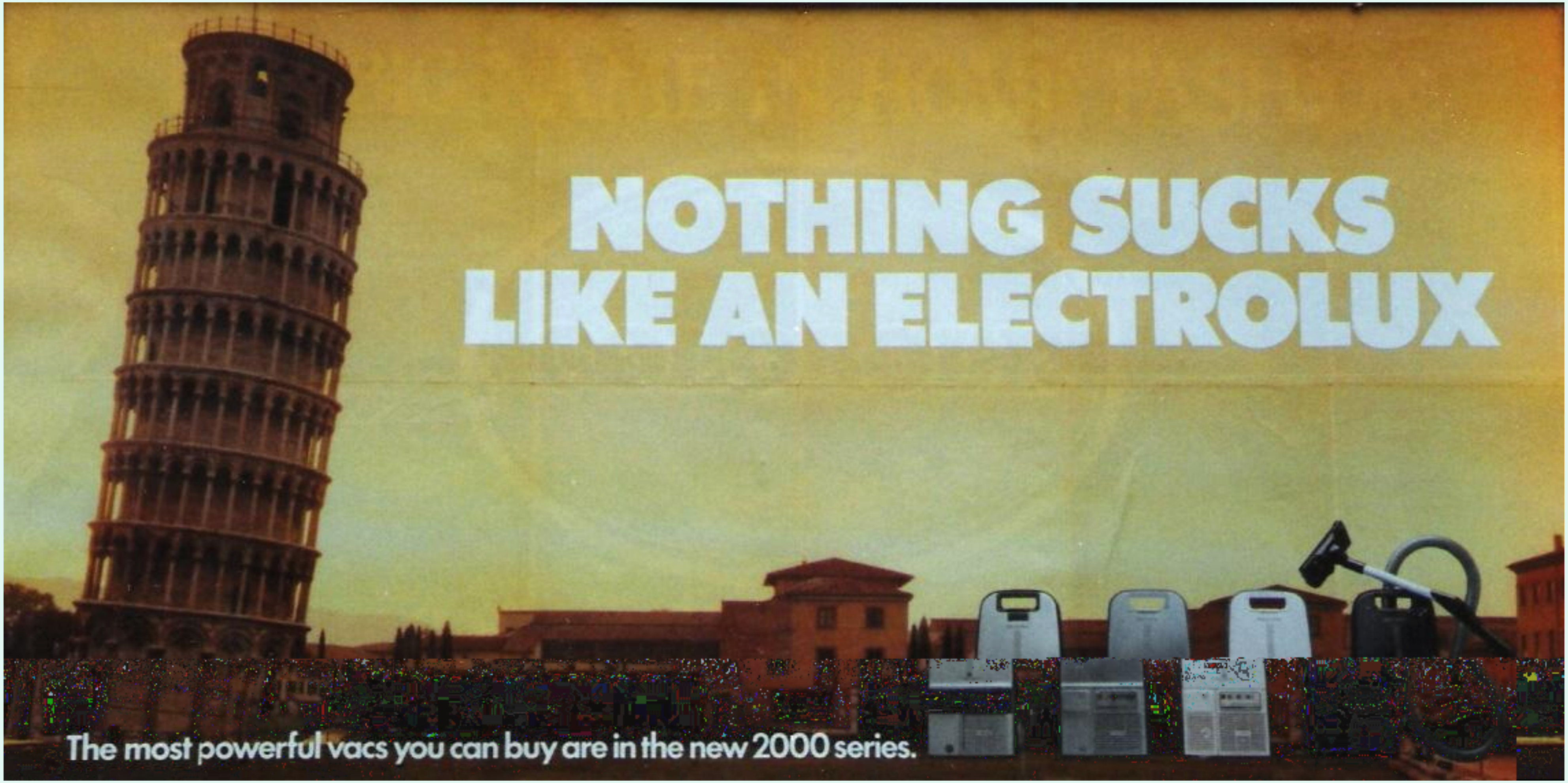
Decoherence process measured for two different strongly intertwined states



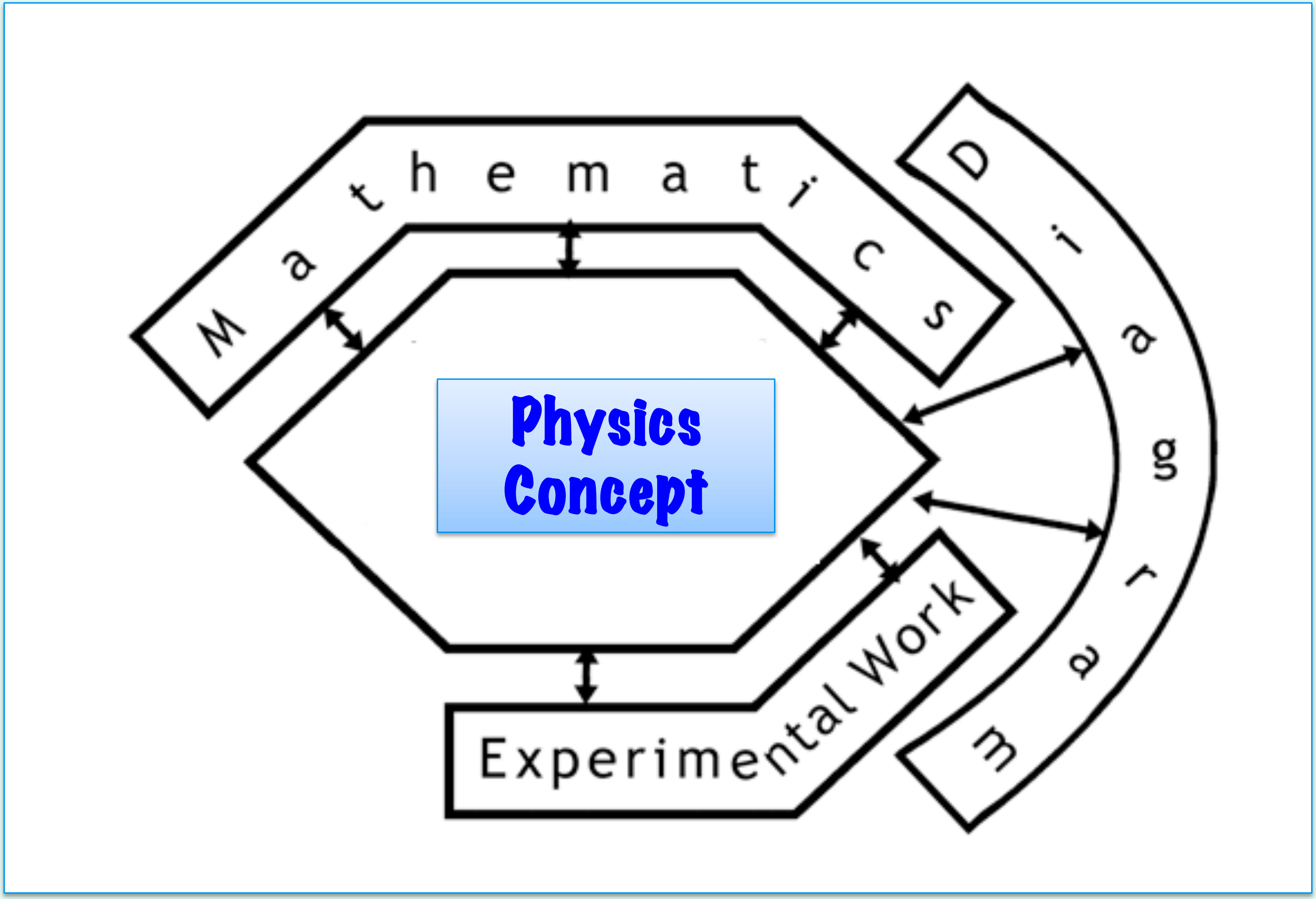
"Oh, if only it were so simple."


t → W⁺b
BR(t→Wb) = Γ(t→Wb) / Γ(t→Wq)
= |Vtb|² / (|Vtd|² + |Vts|² + |Vtb|²)
≅ (0.9745)² / ((0.0094)² + (0.040)² + (0.9745)²)
= 99.82%
but F.C.N.C...
d,s,b
t → Zc
t → Zu
t → γc
t → γu
U_CKM =
c12 c13 ...
− s12 c23 − c12 s23 s13 e^iδ ...
s12 s23 − c12 c23 s13 e^iδ ...


Hercul


NOTHING SUCKS
LIKE AN ELECTROLUX
The most powerful vacs you can buy are in the new 2000 series.

Different representations have different disciplinary affordances, that is different possibilities to share critical aspects of physics knowing and doing



After Airey & Linder 2009

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Now the inverse sine was the sigma, but left-to-right reflected so that it started with the horizontal line with the value underneath, and then the sigma. That was the inverse sine, NOT $\sin^{-1} f$—that was crazy! They had that in books! To me, $\sin^{-1}$ meant 1/sine, the reciprocal. So my symbols were better.

I didn't like f(x)—that looked to me like f times x. I also didn't like dy/dx—you have a tendency to cancel the d's—so I made a different sign, something like an & sign. For logarithms it was a big L extended to the right, with the thing you take the log of inside, and so on.

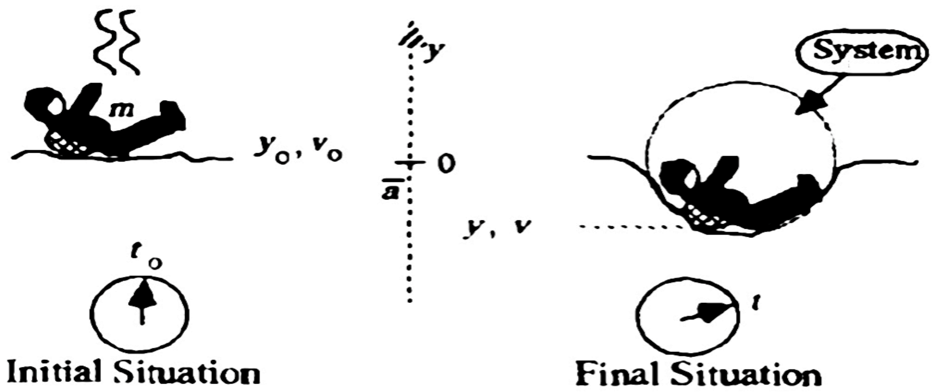
I thought my symbols were just as good, if not better, than the regular symbols—it doesn't make any difference what symbols you use—but I discovered later that it does make a difference. Once when I was explaining something to another kid in high school, without thinking I started to make these symbols, and he said, "What the hell are those?" I realized then that if I'm going to talk to anybody else, I'll have to use the standard symbols, so I eventually gave up my own symbols.

(*From Surely you're joking Mr Feynman*)

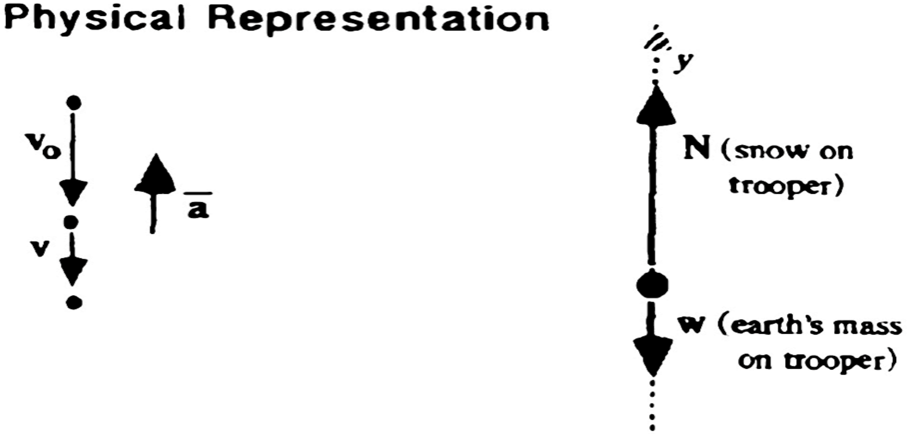
(a) Words

A parachutist whose parachute did not open landed in a snow bank and stopped after sinking 1.0 m into the snow. Just before hitting the snow, the person was falling at a speed of 54 m/s. Determine the average force of the snow on the 80-kg person while sinking into the snow.

(b) Pictorial Representation



(c) Physical Representation



(d) Math Representation

$$\boxed{2\bar{a}(y - y_o) = v^2 - v_o^2}$$

$$\boxed{\Sigma F_y = N - w = m\,\bar{a}}$$

Alan Van Heuvelen, Learning to think like a physicist: A review of research-based instructional strategies, Am. J. Phys., 59 (1991) 891-897.

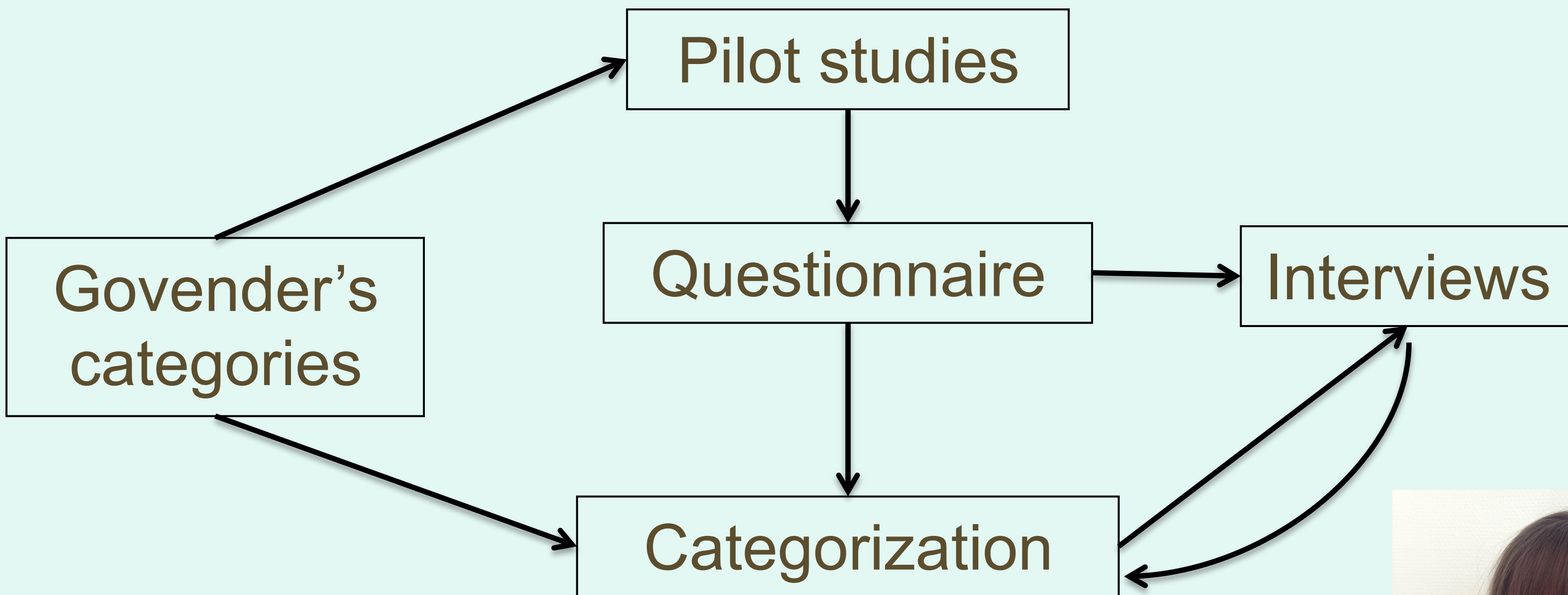
SA example #1

How relevant and prevalent today?

Category	*Description*
A	Algebraic signs are not applied in vector-kinematics
B	Algebraic signs are applied as magnitude only
C	Algebraic signs are applied as changing magnitude
D	Algebraic signs are applied as both magnitude and direction
E	Algebraic signs are applied as directions

Govender (1999)

Method and Setting



65 Swedish students

30 South African students

Moa Eriksson

Summary of Results

- No differences found between the Swedish and South African students.
- Four of the original five categories were identified.
- Students were inconsistent when using signs
- Students had limited appreciation of the significance of using signs

Algebraic signs are not applied in vector-kinematics
~~*Algebraic signs are applied as magnitude only*~~
Algebraic signs are applied as changing magnitude
Algebraic signs are applied as both magnitude and direction
Algebraic signs are applied as directions

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SA example #2

Part 1: How teachers think about the representations that they use in their teaching?

Part 2: How teachers respond to a lack of representational competence in their students?

Anne Linder

Susanne Wickman

Nokhanyo Mayaba

John Airey

Paul Webb

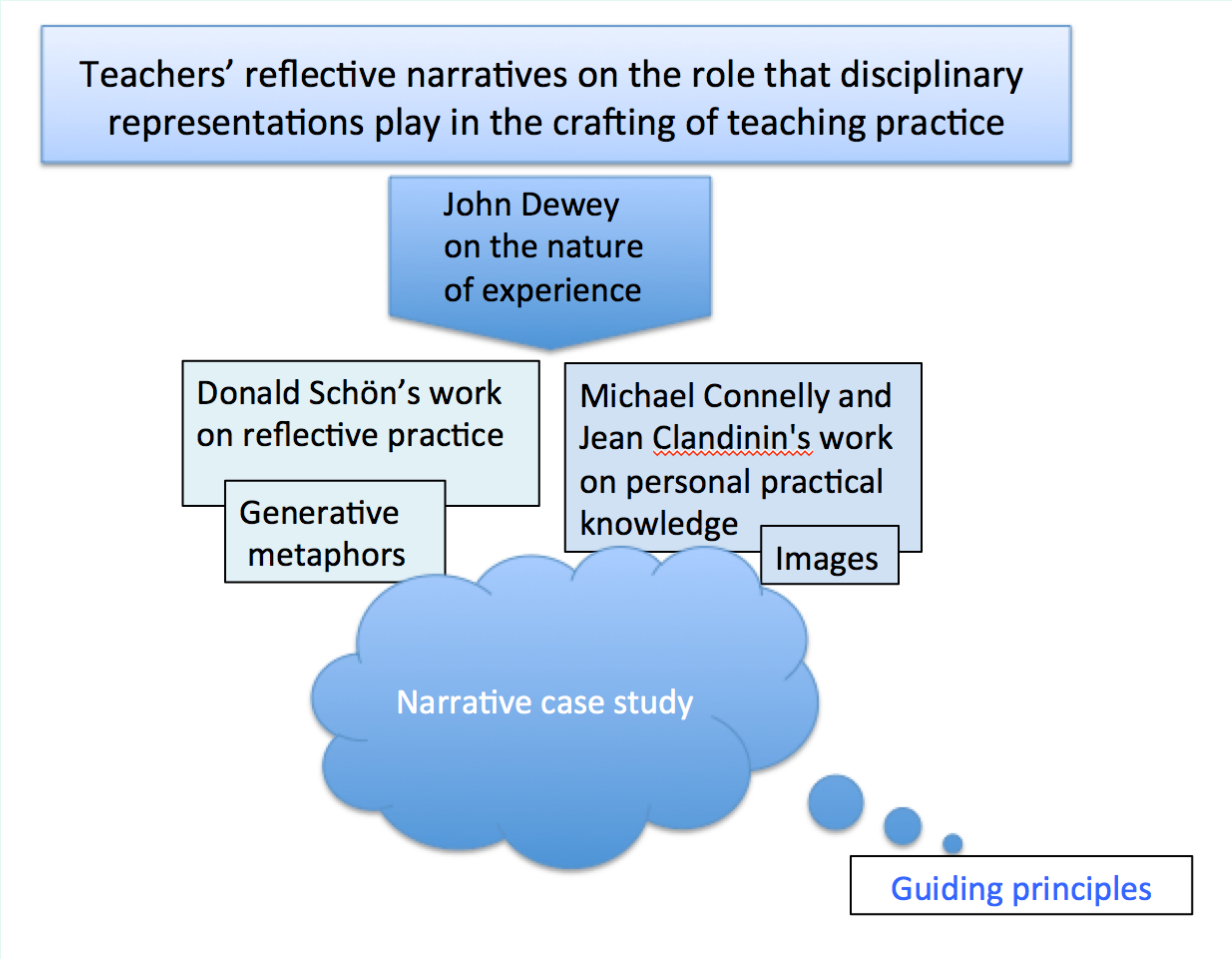
Setting for Part 1

How teachers think about the representations that they use in their teaching?

Semi-structured interviews (30-45 mins)

15 lecturers from four SA physics departments.

Categories constructed in terms of what guided their thinking


Teachers' reflective narratives on the role that disciplinary representations play in the crafting of teaching practice
John Dewey on the nature of experience
Donald Schön's work on reflective practice
Generative metaphors
Michael Connelly and Jean Clandinin's work on personal practical knowledge
Images
Narrative case study
Guiding principles

Results

How teachers think about the representations that they use in their teaching?

[i] Guided by a taken-for-granted tool-box of disciplinary style

[ii] Guided by insight into personal learning experience

[iii] Guided by perceived student learning-needs

This category builds on insight into students' reactions, knowing where students are coming from, and their learning difficulties. The storylines contain a strong practical reasoning component with a growing theoretical base.

[iv] Guided by efforts to contextually extend the possibility of learning for students

This category builds on choice of actions that are tested against both outcomes and conceptualizations of educational value. The storylines contain a much stronger blending of practical and theoretical reasoning.

Part 2: The study setting

How teachers respond to a lack of representational competence in their students?

Semi-structured interviews (approx 1 hr)

20 lecturers from five very different* SA physics departments.

*The student intake for these 5 departments represent a cross-section of different linguistic and socio-cultural backgrounds

Results

All the physics lecturers recognized a lack of representational competence in their students

Six-level system of response strategies:

1. Not relevant
2. Relevant, but not my job
3. Encourage translation to alternative representations
4. Offer passive support
5. Actively engage with the challenge

Discussion

Not relevant
Relevant but not my job
Avoid problematic representations

Encourage translation to alternative representations
Offer passive support
Actively engage

Attempts to develop language competence was only done for English

Lecturers did not appear to think that students would have problems “translating” their (English language) physics knowledge into settings where other languages may be called for (society and workplace).

Representational-Competency Questions

- Which representations do students need?
- Which type of representational competence is needed (interpret or use)?
- Competence for where? Society, Workplace or just Physics?
- Whose job is it to teach students this?
- What about languages other than English?

Conclusion

To address the concerns in the CHE-SAIP report lectures need to better understand what is critical about the representations they use in their teaching ….

and to craft that understanding into their teaching practice in a positive and productive way

Thank you!

cedric.linder@physics.uu.se