Title: Time as Organization â€“ Downward Caustation, Structure and Complexity I

Date: Jun 28, 2016 03:00 PM

URL: http://pirsa.org/16060113

Abstract:

Strong emergence, top-down causation, and irreversibility

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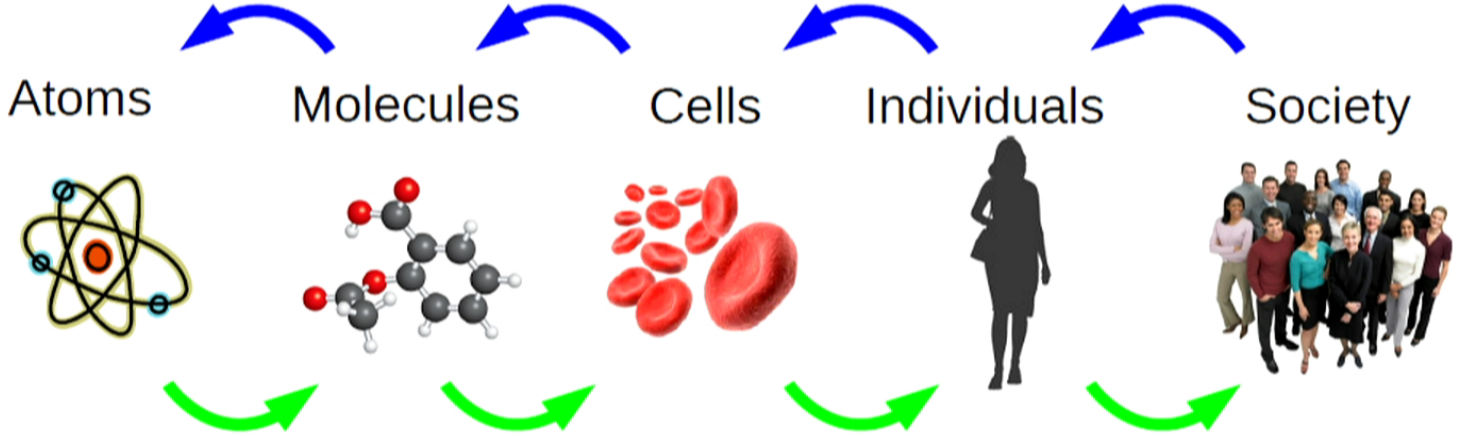

The hierarchical structure of nature

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Reduction

Atoms Molecules Cells Individuals Society

Emergence:
The whole has properties that the parts don't have

The question that divides physicists

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Partial reduction; Top-down causation

Atoms Molecules Cells Individuals Society

Strong emergence; Bottom-up causation

Focus of this talk: strong emergence within physics

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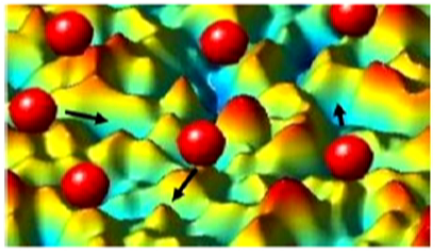
Atomic Physics

Condensed Matter Physics, Statistical Physics



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Arguments for strong emergence

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- The parts have never existed without the whole

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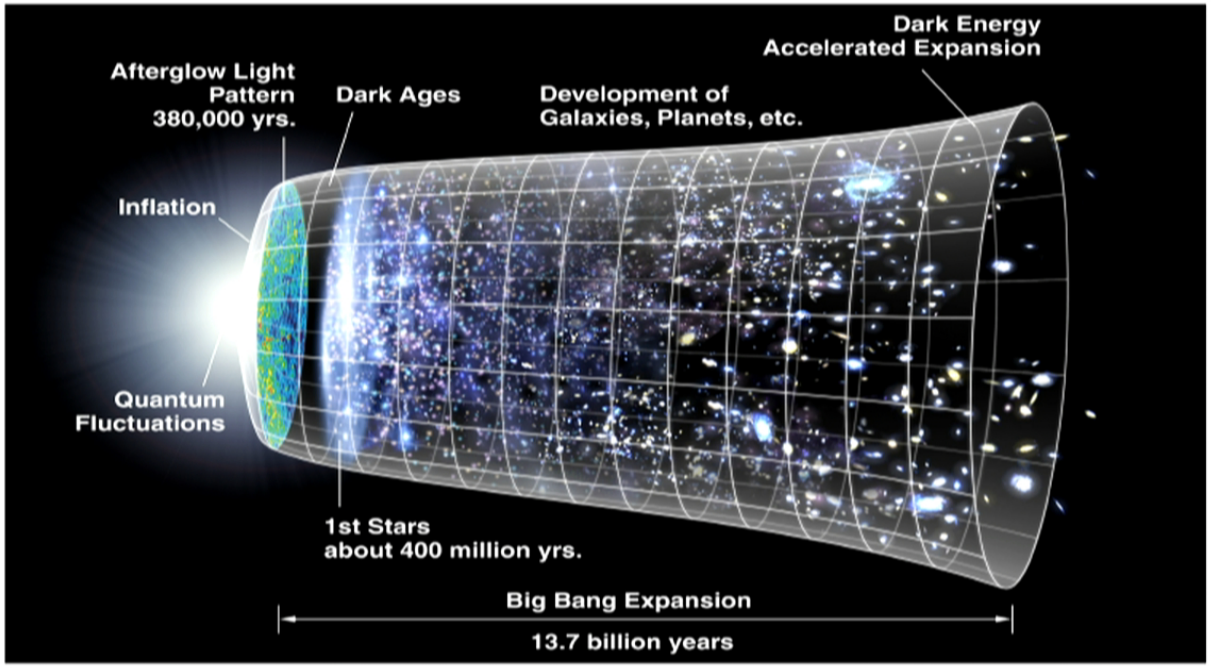

Arguments for strong emergence

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- The parts have never existed without the whole
- Full reduction to QM of 10^{23} particles is never done in condensed matter physics

Reduction is never really done

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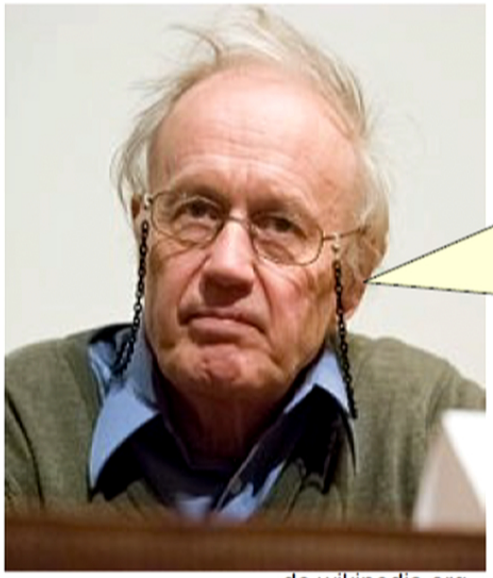

de.wikipedia.org

Tony Leggett

"On the nature of research in condensed-state physics" (Foundations of Physics, 1992)

No significant advance in the theory of matter in bulk has ever come about through derivation from microscopic principles. (…) The so-called derivations (…) from microscopic principles *alone* are almost all bogus.

Reduction is never really done

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Walter Kohn

„The many-electron wave function is not a legitimate scientific concept for N > 1000 … because the wave function can neither be calculated nor recorded with sufficient accuracy“ (Nobel lecture 1999)

Arguments for strong emergence

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- The parts have never existed without the whole
- Full reduction to QM is never done in condensed matter physics
- Emergent phenomena are determined by higher-order principles which are independent of many microscopic details

Higher-order principles

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Bob Laughlin

„The Josephson quantum is exact because of … continuous symmetry breaking. The quantum Hall effect is exact because of localization. Neither of these things can be deduced from microscopics, and both ... would continue to lead to exact results even if the Theory of Everything were changed.“

(Laughlin & Pines, “The theory of everything”, PNAS 2000)

Higher-order principles

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Phil Anderson

Broken symmetries !

("More is different", Science, 1972)

Arguments for strong emergence

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- The parts have never existed without the whole
- Full reduction to QM is never done in condensed matter physics
- Emergent phenomena are determined by higher-order principles
- “Higher-level” theories require new fundamental laws

New law in statistical mechanics

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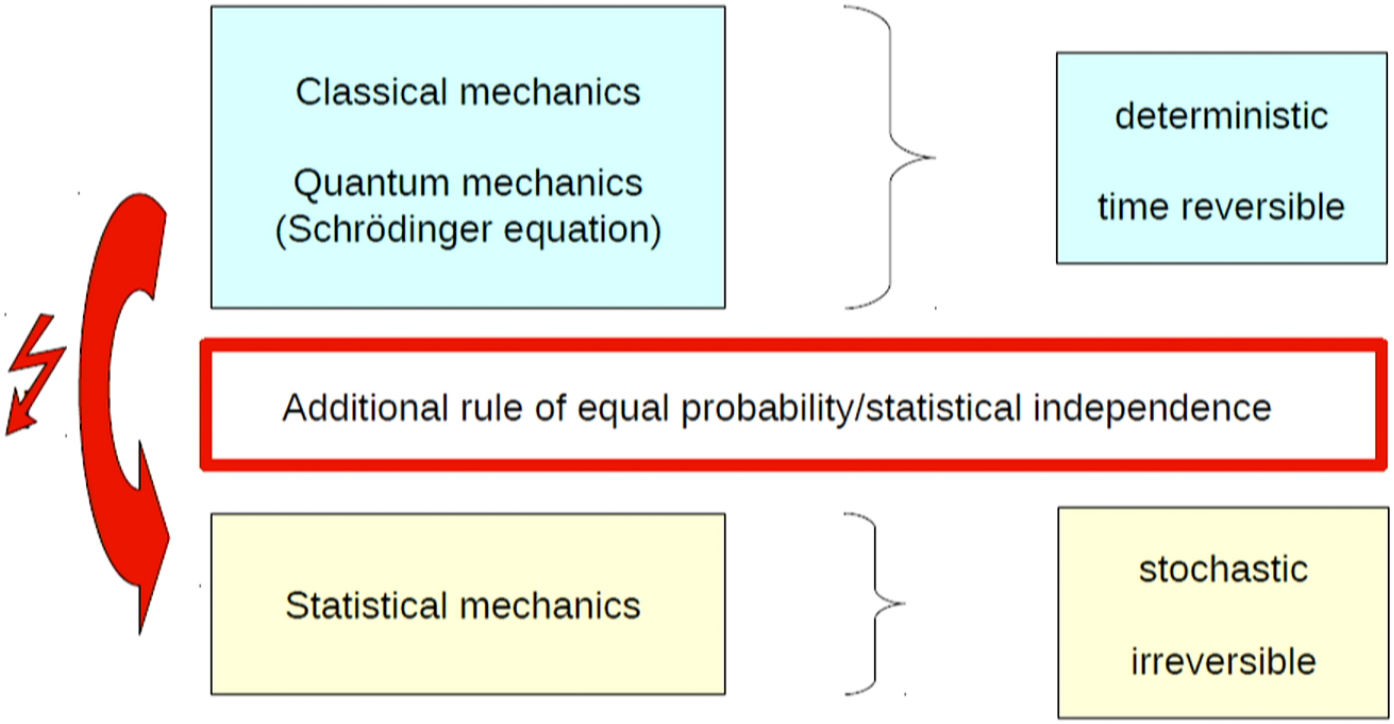

Arguments for strong emergence

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- The parts have never existed without the whole
- Full reduction to QM is never done in condensed matter physics
- Emergent phenomena are determined by higher-order principles
- “Higher-level” theories require new basic laws
- “Lower-level” theories are neither exact nor complete

Not exact

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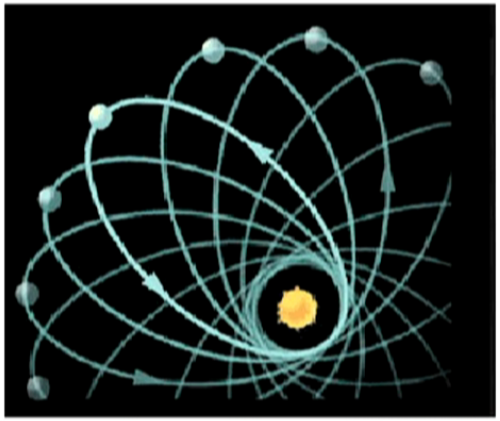

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We should have learned this from the history of classical mechanics

Not complete

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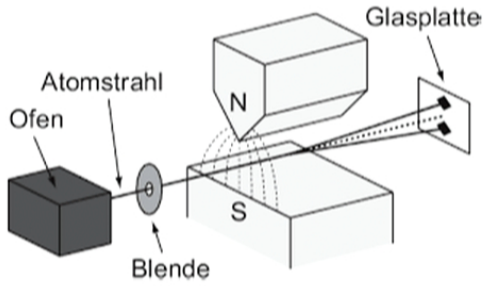

The context determines what can happen

Quantum-mechanical chance is a top-down effect!

Not complete

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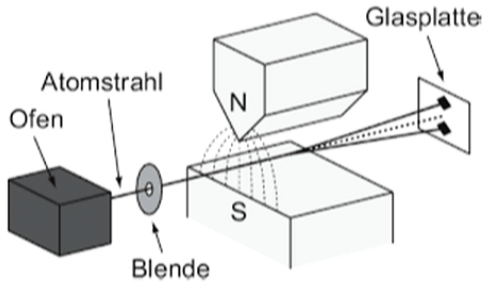

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