Title: Emergence as Novel Explanation: Statistical Mechanics vs. Quantum Field Theory

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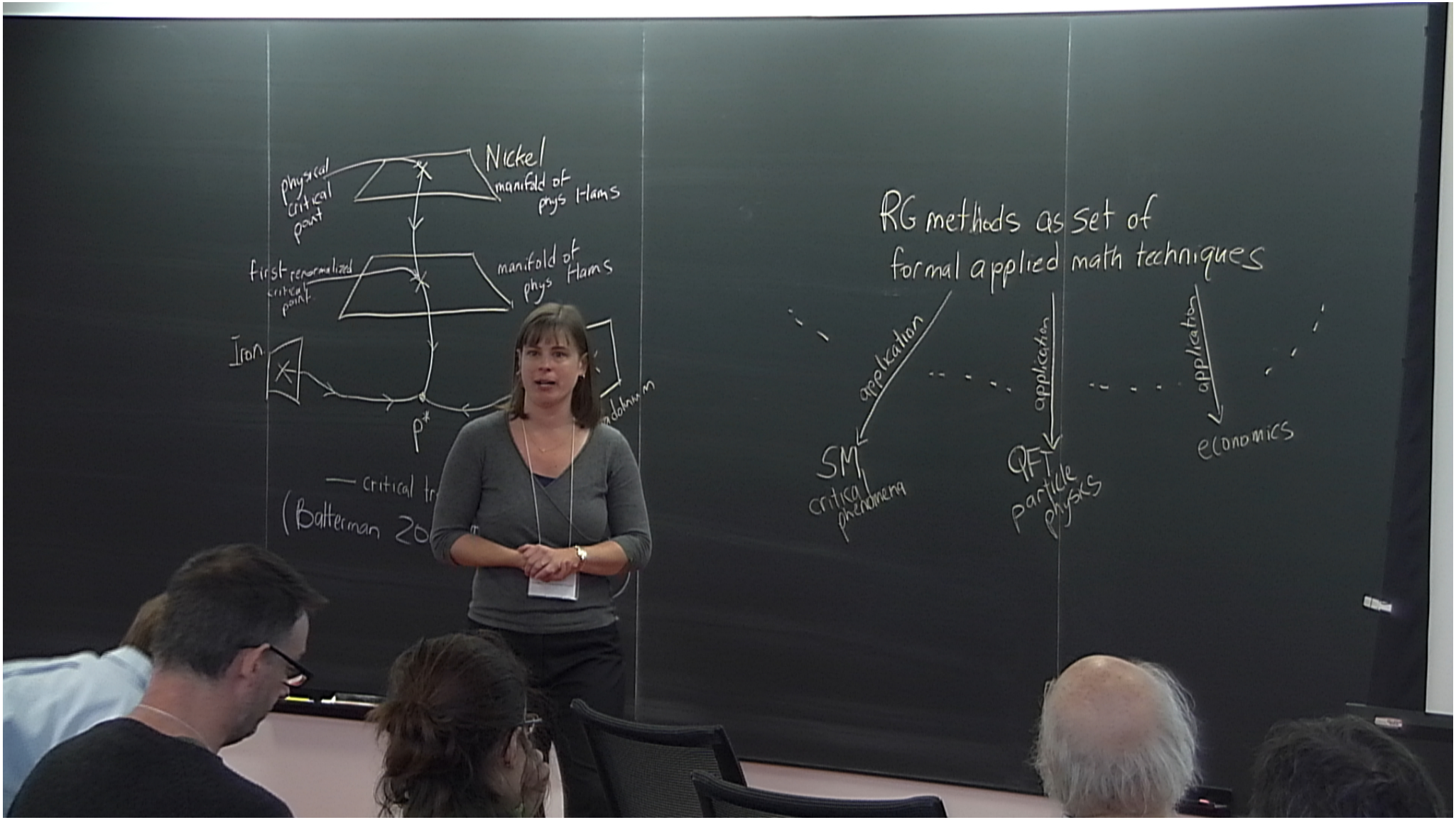
Abstract: In the philosophical literature, effective field theories have been regarded as emergent in the sense of furnishing novel explanations. In particular, Batterman has argued that effective field theories in statistical mechanics are emergent in this sense. I will argue that effective field theories in quantum field theory do not furnish analogous novel explanations. There are relevant disanalogies between statistical mechanics and quantum field theory with regard to the roles played by idealizations and the explanatory goals of the application of renormalization group methods. Contrasting the statistical mechanics and quantum field theory cases highlights the role that the physical interpretation of the formalism and the goals of theorizing play in determining whether a particular effective theory counts as emergent.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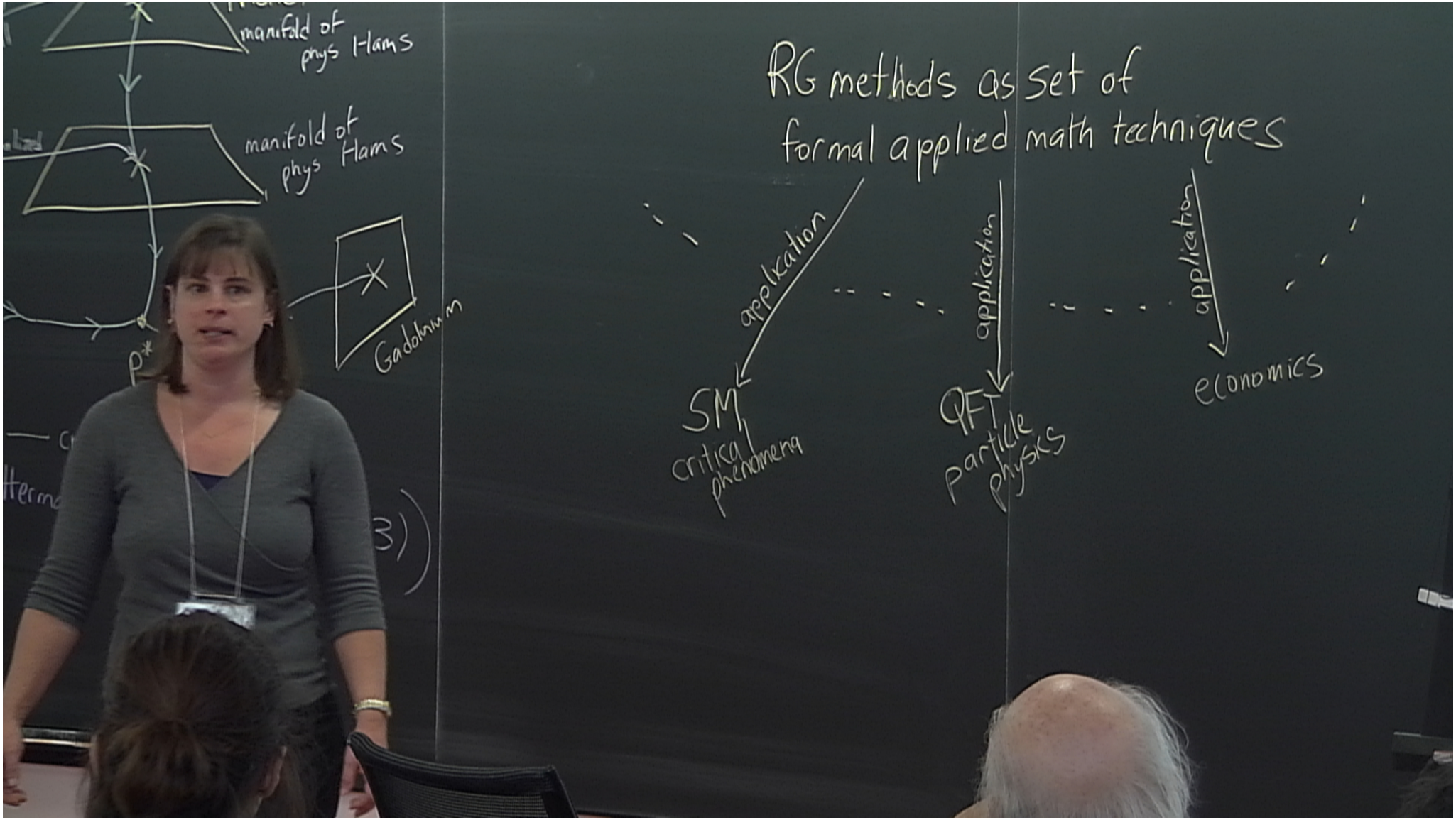
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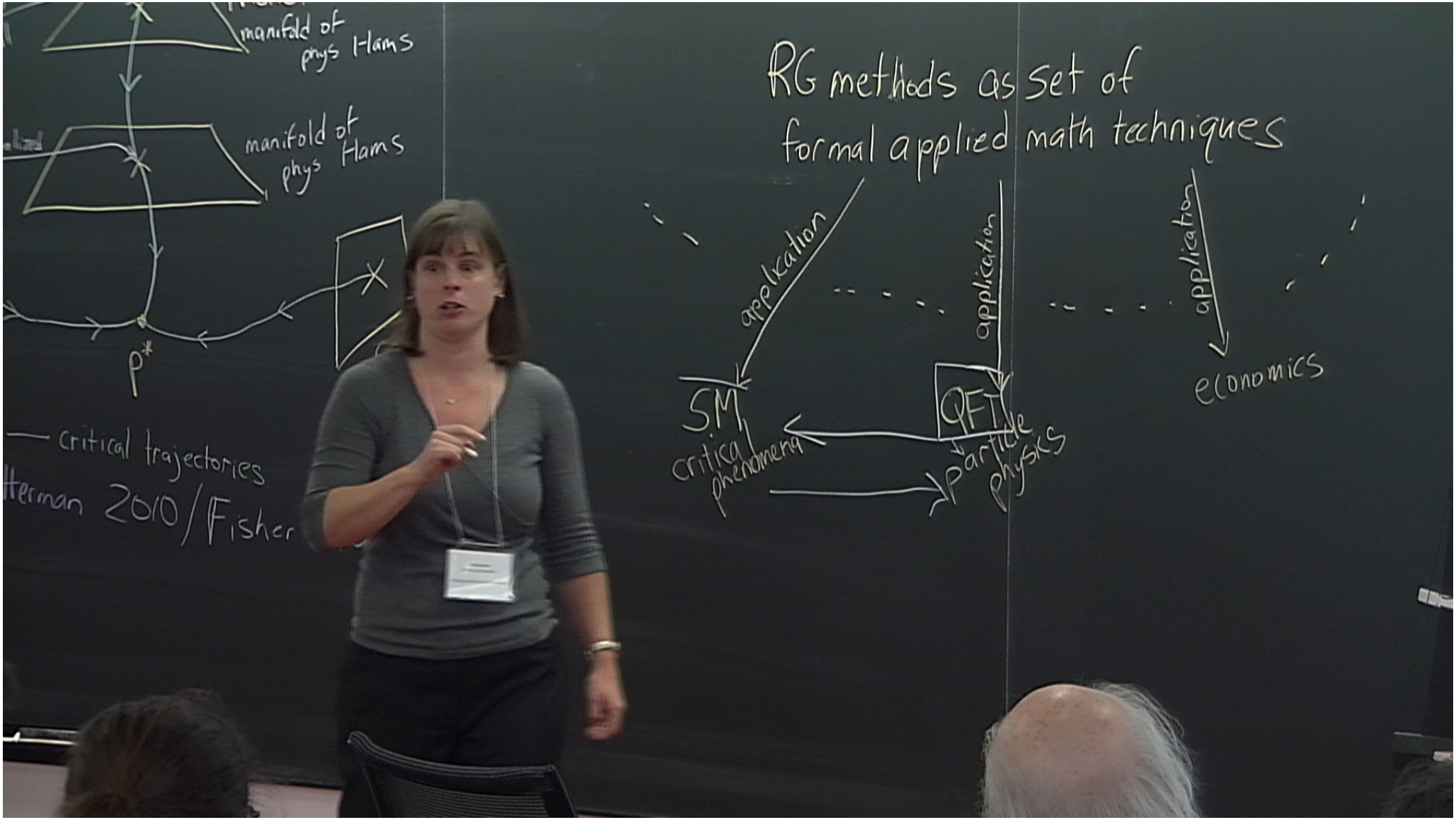
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Emergence as Novel Explanation: Statistical Mechanics vs. Quantum Field Theory

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Overview

1. the explanation of universal behaviour of second order phase transitions in SM with an infinite number of degrees of freedom that is underwritten by RG methods and Batterman's analysis of this explanation as indicative of emergence
2. the analogue "explanation" underwritten by RG methods for particle physics QFT

Claim: the different interpretation of the RG formalism in particle physics QFT (vs. SM) undermines analgous conclusions about explanation and emergence

Explaining universal behaviour of second order phase transitions in SM

(Following Batterman (2010), "Emergence, Singlularities, and Symmetry Breaking," *Foundations of Physics*)

Explanatory question: why do the order parameters for various physically distinct fluids (and even magnets where the order parameter is the net magnetization) scale as a specific power law t^{β}? $[\Psi = |\rho_{liq} - \rho_{vap}| \propto t^{\beta}$ and $t = \left|\frac{T - T_C}{T_C}\right|]$

Features that make this a genuine demand for an explanation:

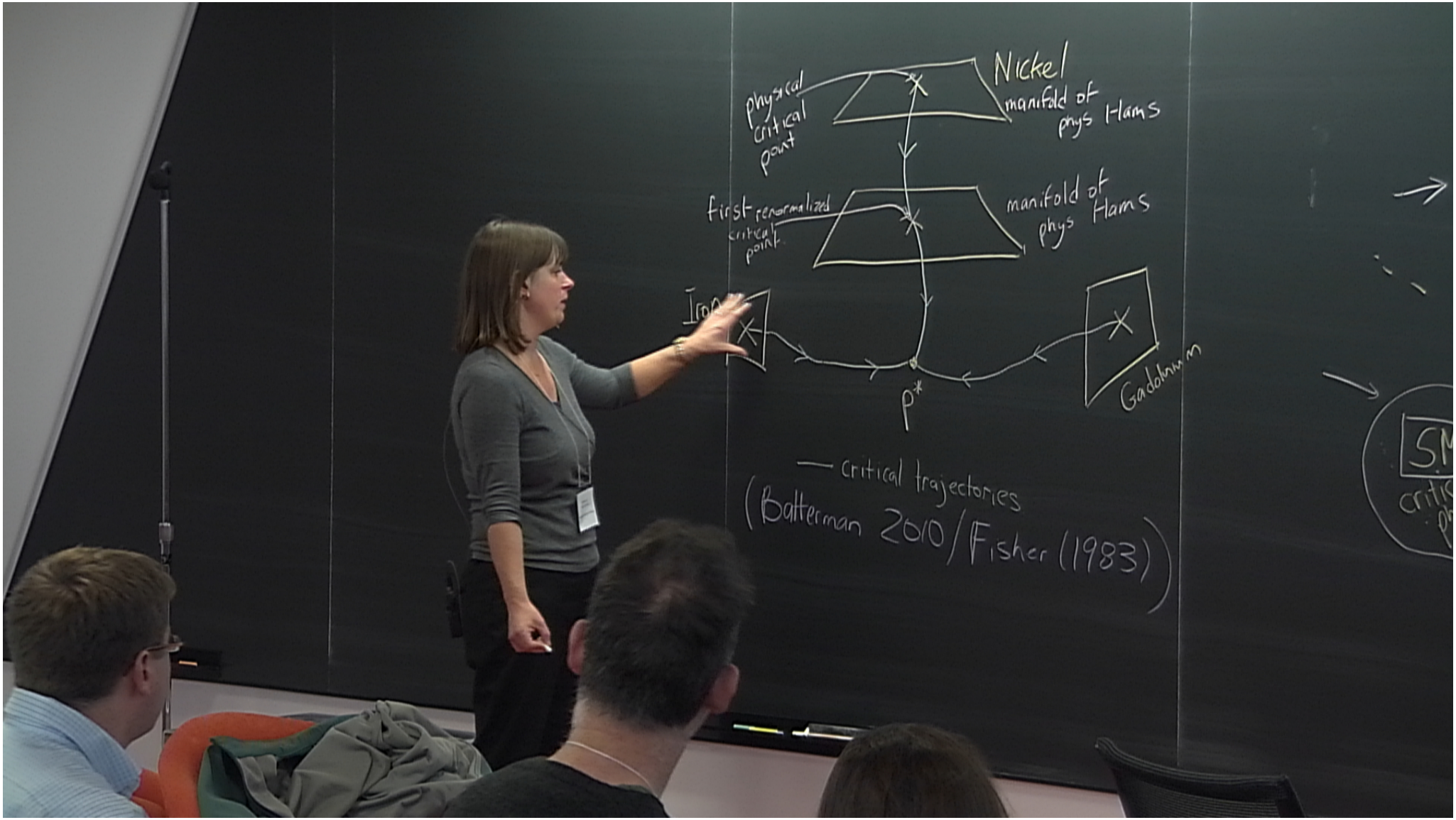
- the phenomenon is (was) empirically confirmed
- this empirical phenomenon is unexpected from the point of view of a single micro-theory

Explaining universal behaviour of second order phase transitions in SM (Batterman)

Explanatory question: why do the order parameters for various physically distinct fluids (and even magnets where the order parameter is the net magnetization) scale as a specific power law t^{β}?

Explanatory answer: the Hamiltonians for the physically distinct fluids at their critical points are all in the basin of attraction of the same fixed point

Elaboration: Hamiltonians in the basin of attraction may have different irrelevant couplings, but irrelevant couplings (essentially) do not affect the value of critical exponent β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(Batterman 2010/Fisher (1983))

Analogue "explanation" for particle physics QFT

Explanatory answer (SM): the Hamiltonians for the physically distinct fluids at their critical points are all in the basin of attraction of the same fixed point
Elaboration: Hamiltonians in the basin of attraction of the same fixed point have different irrelevant couplings, but irrelevant couplings (essentially) do not affect the value of critical exponent β or the long-ranged correlation functions

Explanatory answer (QFT): Hamiltonians/Lagrangians in the basin of attraction of the same fixed point have different irrelevant couplings, but irrelevant couplings (essentially) do not affect the low energy S-matrix elements calculated from the effective field theory

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