PHYSICS 268BR David R. Nelson Spring 2020 MWF 10:30–11:45am

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PHYSICS 268BR
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Renormalization Group Methods in Condensed Matter Physics

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Renormalization group ideas have had a major impact on condensed matter physics. We plan to develop and illustrate the theory by studying at least three of the following topics: (1) critical phenomena near four dimensions; (2) quantum critical points in Heisenberg spins; (3) flexural phonons in free-standing graphene; and (4) the fluid dynamics of the forced Navier-Stokes equations.

Course Requirements: Four or five problem sets and a take-home final. Problem sets and the final will each count ½ your grade. Late problem sets will count ε, where $\varepsilon << 1$.

Required text: Mehran Kardar, Statistical Physics of Fields

Recommended texts: Nigel Goldenfeld, Lectures on Phase Transitions and the Renormalization Group

David R. Nelson, Defects and Geometry in Condensed Matter Physics

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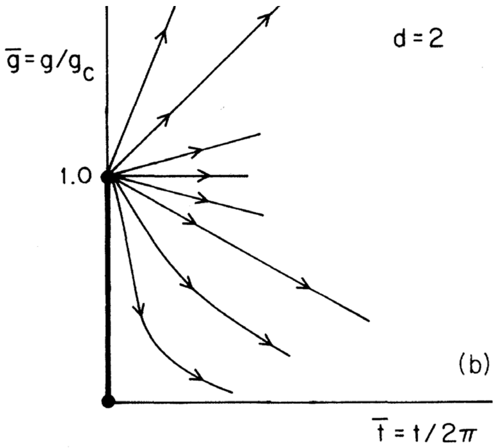
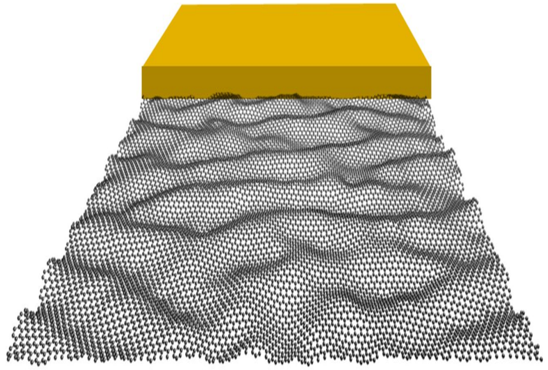


1. *Critical phenomena in classical spin systems*

a. n-component spin models and Landau theory
b. Polymer physics and the limit n→0
c. Breakdown of Landau theory in low dimensions
d. Fluctuations and physics in 4 – ε and 2 + ε dimensions



2. *Quantum critical points in quantum rotor models*

a. Transfer matrices and path integrals in imaginary time
b. Renormalization group for quantum antiferromagnets in 2+1 dimensions
c. Spin S quantum ferromagnets and antiferromagnets at low temperatures

3. *Flexural phonons in free-standing graphene*

a. Continuum elasticity theory for sheets and ribbons
b. Renormalization group for flexural phonons
c. Scale-dependent bending rigidity and Young's modulus

4. Dynamics of the forced Navier-Stokes equations

a. Fluid mechanics and Reynolds numbers
b. Dynamical renormalization group
c. Forced Navier-Stokes equations near 4 dimensions