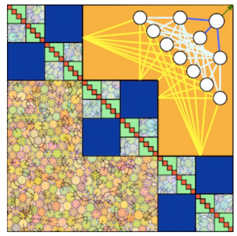
A new graduate course in Physics: P 265

"Statistical Mechanics of Spin Glasses and Neural Networks"



General:
The theory of random magnetic systems, spin-glasses, has transformed our understanding of the impact of disorder and complexity in many areas such as physics, biology, computer science, statistics, neuroscience, and AI. The purpose of the course is to survey advanced spin glass theoretical approaches, including Replica Theory, Dynamic Mean Field Theory, the cavity method, and belief propagation. Applications include the physics of spin glasses, combinatorial optimization, random matrices, chaos in random recurrent networks, associative memory, and learning in deep neural networks.

Syllabus (Tentative)

- Origins: Experiments and phenomenology of spin glasses (SGs)
- SG Ising models: The Edwards-Anderson and the Sherrington-Kirkpatrick models
- Symmetries and Symmetry Breaking in SGs
- The Replica Method and Replica Symmetry Breaking
- Cavity method and the TAP equations
- Applications to combinatorial optimization problems
- Random Matrix Theory
- Dynamic Mean Field Theory
- Chaos in random recurrent neural networks
- Hopfield model of associative memory and its modern extensions
- Statistical mechanical approaches in deep learning theory

Course Instructor: Prof. Haim Sompolinsky hsompolinsky@mcb.harvard.edu
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Time: Monday and Wednesday, 3-4.15pm
Location: TBD
Credits: 4

Course level: primarily for graduate students. Advanced undergraduate students accepted by permission of course instructor.
Homework Assignments: 4-6 homework problem sets. Final take-home exam. Final grade: 40% homework, 40% exam, 20% active participation.

Prerequisites: Mastering of linear algebra, multi-variate calculus, probabilities, complex analysis; basic coding skills (Matlab or Python).
Strongly recommended: familiarity with the fundamentals of statistical mechanics (including random walks, Markov processes, Gibbs distribution, phase transitions, Ising model).