

PHYS-645

Physics of random and disordered systems

Müller Markus

Cursus	Sem.	Type
Physics		Opt.

Language of teaching	English
Credits	3
Session	
Exam	Oral
Workload	90h
Hours	42
Lecture	42
Number of positions	

Frequency

Every year

Remark

Next time: Fall 2025

Summary

Introduction to the physics of random processes and disordered systems, providing an overview over phenomena, concepts and theoretical approaches. Topics include: Random walks; Roughening/pinning; Localization; Random matrix theory; Spin glasses; Disorder and critical phenomena

Content

This course provides an overview of salient phenomena, concepts and theoretical approaches to a wide variety of random processes and disordered systems, with an emphasis on intuition and physical insight.

1) Random processes:

- Random walks, diffusion
- Directed polymers in random media,
- Roughening and pinning of interfaces

2) Localization of particles and waves:

- Weak and strong (Anderson) localization
- Many-body localization: concepts, ideas, phenomenology
- Strong randomness approach

3) Random matrix theory:

- Classification of random matrix models, matrix ensembles.
- Distribution of eigenvalues, semicircle law, resolvent method.
- Level spacing statistics: Wigner's surmise, Poisson vs Wigner-Dyson,
- (Coulomb gas method)

4) Spin glasses:

- Concepts, phenomenology, order parameters; random energy model, trap model
- Theory: droplets, replicas
- Mean field theory:

replica symmetry and its breaking;
cavity approach / message passing

5) (depending on time) The role of disorder in critical phenomena:

- Imry-Ma argument
- Harris criterion

Keywords

disordered systems, random processes, random matrix theory, localization, spin glasses

Learning Prerequisites

Required courses

Statistical physics I and II

Recommended courses

Quantum mechanics

Learning Outcomes

By the end of the course, the student must be able to:

- Have an overview over and physical understanding of the phenomena in disordered systems
- Know and explain the concepts, basic techniques and approaches to the main topics

Resources

Bibliography

There will be a Moodle link for this course

Moodle Link

- <https://go.epfl.ch/PHYS-645>