PHYS-745 Spin Dynamics

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Cursus	Sem.	Type
Physics		Opt.

Language of teaching	English
Credits	4
Session	
Exam	Oral presentation
Workload	120h
Hours	**56**
Courses	28
Exercises	28
Number of positions	

Frequency

Every year

Remark

Next time: Fall

Summary

The course is conceived in the perspective of understanding the fundamentals of spintronics. This implies learning about magnetism at the quantum mechanical level, mechanisms for spin relaxation and spin transport, including Berry phase. Various forms of magnetic resonance are presented.

Content

1. Exchange, superexchange, spin-orbit interaction, Dzialonshinskii-Moriya coupling, Rashba effect
2. Moments in metals, Stoner model, sd interaction, RKKY, orbital angular momentum states
3. Magnetoresistance, historical intro, phenomenology
4. Thermodynamics of spin dependent transport, spin diffusion length, GMR
5. Boltzmann theory : introduction, collisions with spin, two-current model, spin accumulation
6. Perpendicular transport and Berry phase : Boltzmann description of Hall and Nernst effect, Mott relations
7. Principles of spin relaxation : two-level system, relaxation by fluctuating fields, fluctuation-dissipation theorem, spin temperature
8. Mechanisms of spin-flip: spin-orbit scattering, magnetic scattering, Elliott-Yafet and Dyakonov-Perel mechanisms
9. Magnetic resonance+ DNP : Bloch equations, Overhauser effect, transmission ESR, adiabatic demagnetization
10. Feromagnetic resonance: Landau-Lifshitz-Gilbert equation, magnetostatic waves, spin waves, Holstein-Primakov transformation
11. Antiferromagnetic resonance: quasi-static response, Pincus model, magnetic polaritons
12. Coherent spin dynamics (I): quantum mechanics of spin precession, spin-operator formalism, spin echoes
13. Coherent spin dynamics (II) : Quadrupolar echoes, double quantum coherence, coherence transfer
14. Spin Qubits : generating effective entangled states, quantum logic gates with spins, heat-bath algorithmic cooling

Note

The format of the course is ex cathedra classes followed by a presentation by one of the participant. Participants will be challenged to understand and explain the details of a recent paper, using the course material and more.

Keywords

exchange, RKKY, DM, Rashba splitting, magnetic anisotropies, spin relaxation, spin-dependent transport, magnetic resonance, spin waves

Learning Prerequisites

Required courses

2 semester of quantum mechanics, 1 semester solid state physics, 2 semesters statistical physics.

Recommended courses

Quantum mechanics
Prof. D. Grundler's course on magnetism

Learning Outcomes

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

- o conceive new experiments in the field of spintronics and magnetic resonance.

Expected student activities

to be able to understand recent research on spintronics or magnetic resonance

Resources

Bibliography

Lecture notes (500+ pages, 1000+ references)

Moodle Link

- https://moodle.epfl.ch/enrol/index.php?id=15722