

## Syllabus

Research Training Group GRK 1558

# Introduction to Theoretical Semiconductor Optics

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**Description:** This course offers an introduction to crystalline inorganic semiconductors. A central topic of the course will be the linear and nonlinear optical response of semiconductors. The course will deal mainly with theoretical physics, and include a brief introduction to advanced quantum mechanical concepts (second quantization and commutator algebra) and their application to semiconductor optics.

## CONTENTS

1. Basic concepts in solid state physics (crystal structure, electronic band structure).
2. Introduction to many-particle theory (second quantization, commutator algebra, equations of motion in the Heisenberg picture).
3. Review of basic concepts of linear and nonlinear optical response (classical oscillator and two-level systems).
4. Linear and nonlinear optical response of semiconductors (linear optical band edge spectra with and without excitonic effects, absorption and gain, Pauli blocking, semiconductor Bloch equations).

## Literature :

- H. Haug and S.W. Koch, *Quantum Theory of the Optical and Electronic Properties of Semiconductors*, 4th edition (World Scientific, Singapore, 2004) [A good introduction to theoretical semiconductor optics.]
- H. Haken, *Quantum Field Theory of Solids: An Introduction*. (North-Holland, Amsterdam, 1976) [Good introduction to quantum field theory. Easy to read.]
- A. Fetter and J. Walecka, *Quantum Theory of Many-Particle Systems* (McGraw Hill, New York, 1971) [Formal and rigorous introduction to and application of quantum field theory.]
- N.W. Ashcroft and N.D. Mermin, *Solid State Physics* (Rinehart and Winston, New York, 1976) [Comprehensive presentation of many “classical” aspects of the physical properties of solids.]
- C. Kittel, *Introduction to Solid State Physics* (Wiley and Sons, New York, 1986) [Similar to Ashcroft/Mermin. Easy to read.]
- A. Haug, *Theoretical Solid State Physics* (Pergamon Press, Oxford, 1972) [Similar to Ashcroft/Mermin.]
- P.Y. Yu and M. Cardona, *Fundamentals of Semiconductors* (Springer, Berlin, 1996)
- C. Klingshirn, *Semiconductor Optics* (Springer, Berlin, 1995)
- S.L. Chuang, *Physics of Optoelectronic Devices* (Wiley, New York, 1995) [Comprehensive text on application-oriented semiconductor theory.]
- W. Schäfer and M. Wegener, *Semiconductor Optics and Transport Phenomena* (Springer, Berlin, 2002) [A good, comprehensive text on semiconductor optics.]
- Ch. Hamaguchi, *Basic Semiconductor Physics* (Springer, New York, 2001)
- L. Allen and J. H. Eberly, *Optical Resonance and Two-Level Atoms* (Dover, New York, 1975). [A standard book on the theory of two-level optics. In this course, some aspects of semiconductor optics will be compared with two-level optics; therefore the Allen/Eberly book might be very helpful to those students unfamiliar with two-level optics.]