

PH4035 - Principles of Optics

Credits:	15.0	Semester:	2
Number of Lectures:	27	Lecturer:	Dr Friedrich Koenig
Academic Year:	2018-19		

Overview

This module formulates the main aspects of physics used in modern optics, lasers and optoelectronic systems. Topics covered include: polarised light and its manipulation, with descriptions in terms of Jones' vectors and matrices; Fresnel's equations for transmittance and reflectance at plane dielectric interfaces; reflection and transmission of multi-layer thin films plus their use in interference filters; interpretation of diffraction patterns in terms of Fourier theory; spatial filters; the theory and use of Fabry-Perot etalons; laser cavities and Gaussian beams.

Aims & Objectives

The course will cover fundamental aspects of modern laboratory optics. It will

- derive simple plane-wave solutions from Maxwell equations
- provide macroscopic as well as microscopic models of optical media
- introduce polarisation, Jones vectors and matrices, and practical ways to generate polarised light
- derive wave interaction with dielectric plane surfaces from first principles and discuss important special cases
- develop a formalism for optical thin films and apply it to realistic scenarios
- provide a detailed discussion of different optical instruments for spectroscopy, benchmark, and compare them
- define optical coherence and relate it to spectral and spatial properties of the light source by way of the Wiener-Khintchine theorem
- introduce and develop Kirchoff's theory of scalar diffraction and apply it to different diffraction configurations
- present Gaussian beams as physical solution to Maxwell equations, characterize and manipulate them, and relate them to resonators and resonator stability
- introduce light propagation in non-isotropic materials and discuss novel effects arising
- introduce nonlinear optics and in particular second-harmonic generation
- present the science and technology of optical fibers and fiber-based optical communication

Learning Outcomes

By the end of the module, the students will have a comprehensive knowledge of the topics covered in the lectures and will be able to:

- understand more complicated subjects in the field of optics related to a future research project.
- describe the polarization properties of light with different theoretical concepts and understand most polarization phenomena
- understand the physics at interfaces of different refractive index; in particular for designing multilayer systems.
- calculate the resolving power of a device in order to resolve a spectral feature in an optical signal. - measure coherence properties of light and use them for measurements.
- solve diffraction problems in various geometries and obtain corresponding diffraction patterns. - design optics for Gaussian beams and resonators by using the complex q-parameter.
- know the concept of second harmonic generation.

Synopsis

Review of Maxwell's equations, linear wave equation, plane waves, Poynting-vector. Physical origin of refractive index, dispersion model, Sellmeier equation. Polarisation: linear, circular, elliptical polarisation, Jones vectors and Jones matrices. Production of polarised light by various techniques, wave plates. Light at interfaces: Boundary conditions, Snell's law, Fresnel equations, Energy conservation at interfaces, Brewster's angle, total internal reflection, phase changes. Multilayer films: Simple approach, vector calculus. Fabry-Perot interferometer. Finesse, resolving power,

Michelson interferometer Coherence: spatial vs. temporal coherence, correlation coefficient, Wiener Khintchine Theorem, Van Zittert-Zernicke Theorem, Hanbury Brown Twiss experiment. Diffraction: Huygens principle, Kirchhoff theory, Fraunhofer and Fresnel reflection, Babinet's principle, calculation of diffraction patterns. Gaussian beams: Solution to wave equation, higher order and fundamental modes, qparameter, spot size and radius of curvature, ABCD matrices, focussing, collimating and resonators. Nonlinear optics: nonlinear polarisation, second-harmonic generation, phase matching.

Pre-requisites

PH3081 or PH3082 or (MT2506 and MT2507)

Anti-requisites

None

Assessment

Continuous Assessment (assessed tutorial questions) = 25%, 2 Hour Examination = 75%

Additional information on continuous assessment etc.

Please note that the definitive comments on continuous assessment will be communicated within the module. This section is intended to give an indication of the likely breakdown and timing of the continuous assessment.

Four tutorial sheets are set and expected to be answered by students during the semester. These tutorial sheets are to be submitted as fully written out solutions and are marked and returned. There are additionally four In-class tutorials in this module, which are not assessed and aim to solve problems on the day with support from the lecturer. 25% of the module mark comes from the assessed tutorial solutions

Accreditation Matters

This module may not contain material that is part of the IOP "Core of Physics", but does contribute to the wider and deeper learning expected in an accredited degree programme. The skills developed in this module, and others, contribute towards the requirements of the IOP "Graduate Skill Base".

Recommended Books

Please view University online record:

<http://resourcelists.st-andrews.ac.uk/modules/ph4035.html>

General Information

Please also read the general information in the School's honours handbook.