PhD COMPREHENSIVE EXAMINATION
OPTICS SYLLABUS

6. Models of light

Electromagnetic theory of light propagation in homogeneous dielectric and conductive media. Dispersion. Fresnel–Kirchhoff diffraction theory. Light scattering.

Fundamentals of geometrical optics. Properties of optical systems; paraxial, third-order and diffraction approximations for the evaluation of imaging performance. Correction of monochromatic and chromatic aberrations. The process and tools of optical design.

7. Optical and photonic devices

Basic components for imaging: condenser, collimator, achromatic doublet, photographic lens, relay lens, eyepiece, telescope, optical microscope, illumination methods. Photonic devices for the manipulation of intensity, frequency, phase, polarization and direction of light. Waveguides and periodic multilayer structures.

Thermal radiation, incandescent lamps. Gas discharge. Types of gas-discharge lamps and their characteristics. Semiconductor light sources. Semiconductor devices based on photon emission and absorption.

8. Laser physics

Fundamentals of laser operation. Phenomenological theory of the light–matter interaction. Resonators. Description of continuous wave (CW) and pulsed operation, mode-locking. Generation and applications of ultrashort pulses. Laser amplifiers.

Semiclassical laser theory, quantum theory of lasers. Application of lasers in medicine, telecommunications, industry and research.

9. Optical metrology and spectroscopy

Types, operation and properties of photodetectors. Methods and limits of optical power measurement. Interferometry, interferometers. Holography and its applications. Optical shape and distance measurement. Imaging systems in metrology.

Interaction of light and matter in case of atoms, molecules and solids. Absorption, emission, light scattering. Devices for spectral measurements and their properties. Quantities in photometry and radiometry.

10. Optical materials

Crystal optics. Special effects in transparent solids (electro-optic effect, photoelastic effect and acousto-optics, nonlinear and other phenomena). Physical properties of main optical materials.

Properties and materials of optical multilayer structures. Main manufacturing processes of optical materials (glasses, crystals). Manufacturing of bulk optical elements. Fabrication of optical multilayer structures. Patterning, integrated optics.

Fundamentals of nonlinear optics; frequency doubling, parametric amplification, phase conjugation. Importance of frequency and phase matching, and the photon approach.