Wave Optics and Optical Metrology

- **Introduction**
  Historical Introduction
  Waves: harmonic waves, complex representation, phase velocity, wavefront types.

- **Basic Principles:**
  Maxwell equations, wave equation, Poynting vector, intensity
  Index of refraction, dispersion – absorption. Classical dispersion theory.

  - **Polarization:**
    Polarization state, degree of polarization, non polarized light.
    Linear, elliptical, circular polarization
    Jones vectors and matrices, Stokes parameters and Mueller matrices
    Linear polarizers, retardation plates.

    Birefringence: birefringent crystals, the dielectric tensor, refractive index ellipsoid, wavefront surface, eigen polarizations, optical activity,
    Polarization by scattering, Polarization by reflection, evanescent waves

  - **Interference:**
    Group velocity, coherence, interference conditions, types and localization of interference fringes
    Two wave interference, multiple plane wave interference
    Wavefront splitting interferometers: Young's experiment
    Amplitude splitting interferometers: Equal inclination fringes (thin film interference), Equal thickness fringes, interference under multiple reflections.

- **Wave propagation:**

  - **Diffraction:**
    Fresnel zones, Helmloltz-Kirchhoff integral theorem, Kirchhoff diffraction theory.
    Fraunhofer and Fresnel diffraction: slit, rectangular, circular opening. Resolution, diffraction limited systems.
    Array of diffracting openings: multiple slits

  - **Paraxial approximation:**
    The paraxial wave equation, numerical examples
    Equivalence to the Schrödinger equation

  - **Eikonal equation :**
    Optical rays,
    Derivation of the eiconal equation, geometrical wave surfaces, ray equation, paraxial approximation
    Propagation in inhomogeneous media.

  - **Computational methods of wave propagation:**

    - **Angular Spectrum**

Angular spectrum, paraxial approximation, application in the analytical solution of 1D Gaussian beam propagation.

- **Numerical solutions**
  Introduction to the open source platform Maxima.
  Virtual wave propagation and analysis laboratory ***wP*** (*wave Propagator*) & ***wP Analysis***
  Numerical examples

- **Optical metrology:**
  - **Methods**
    - Interferometry
    - Holography
    - Spectroscopy
    - Spectral Interferometry
  - **Applications**
    - Material characterization
    - Surface topology
    - Thickness
    - Optical radar
    - Distribution of refractive index
    - Concentration measurements

- **Wavefront shaping**
  Basic principles.
  Amplitude and phase Spatial Light Modulators (SLMs)
  Generation of complex wavepackets
  Numerical examples