



## Program of **OPTICS**

Prof. Eugenio FAZIO

### **Electromagnetic waves and light**

Maxwell equations and EM wave equation. Spherical and plane waves. Frequencies and wavelengths of EM waves. Microscopical interpretation of the refractive index. Active and reactive polarisation and the complex refractive index. Sellmeyer equation for the refractive index dispersion. Abbe number and Abbe space for glasses. Poynting vector and light energy. Lightning quantities.

### **Reflection and refraction**

Fermat "minimal action" principle and Snell Law. Fresnel coefficients. Critical angle and total reflection regime. Evanescent waves and Goos-Hänchen phase shift. Geometrical interpretation of optical fibres and waveguides.

### **Geometrical Optics**

Short wavelength approximation. Reflection and mirrors. Refraction and dioptric surfaces. Thin lenses. Ray-tracing and ABCD matrices. Thick lenses and principal planes. Centred optical systems. Pupils/stops/f-number/numerical aperture. Vignetting and *cosine-to-the-fourth-power* law. Principal optical aberrations. Chromatic aberration and Achromatic doublet.

### **Interference and interferometers**

Interference of 2 co-propagating waves. Wave beating. Continuous waves and pulses. Phase and group velocities. Spatial and temporal interference. Young's experiment. Interference of 2 contra-propagating waves: stationary waves and resonators. Fabry-Perot resonator. Optical fibres as transverse resonators. Multilayer interferent systems. Design of dielectric mirrors and band-pass filters.

### **Diffraction**

Huygens-Fresnel principle and integral. Near field regime and Fresnel Integral. Far field and Fraunhofer integral. Diffraction from a slit. Focusing limit of a lens. Diffraction from a stop. Diffraction from a grating. Harmonic and anharmonic gratings. Nano-optics.

### **Anisotropic optics**

Anisotropic crystals. Index Ellipsoid. Uniaxial and biaxial crystals. Dichroism. retardation plates.

### **Nonlinear Optics**

Nonlinear response. Anharmonic oscillator. Second order effects. The nonlinear optical tensor. Optical harmonic generation. Parametric effects. The Pockels electro-optic effect. Electro-optic modulators. Photorefractivity and self-assembling optical structures. Spatial solitons and solitonic waveguiding. Smart systems, Machine Learning and Photonic Artificial Intelligence.

## **GENERAL INFORMATION**

- **e-mail:** [eugenio.fazio@uniroma1.it](mailto:eugenio.fazio@uniroma1.it)
- **Reception for explanations:** for an explanation meeting on unclear points send an e-mail (write RICEVIMENTO in the object)
- **Information on the course:** <http://www.sbai.uniroma1.it/users/fazio-eugenio> and on **GOOGLE CLASSROOM:** course code **prj5dmd** (register with the institutional e-mail address: [surmane.matricola@studenti.uniroma1.it](mailto:surmane.matricola@studenti.uniroma1.it))

**Books:**

F. Gori, *Elementi di Ottica*, ed. Accademica  
 P. Mazzoldi/M.Nigro/C. Voci, *Elementi di Fisica-Onde*, EdISES  
 K.D. Moller, *Optics*, Springer  
 A. Yariv, *Quantum Electronics*, John Wiley & Sons  
 Wyszecki & Stiles, *Color Science*, Wiley Classics Library  
 H. Zappe, *Fundamentals of Micro-Optics*, Cambridge University Press

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|---|----------------------|
| <b>CLASS SCHEDULE – aula 17 @ San Pietro in Vincoli Faculty (Via Eudossiana 18)</b> |                      |
| <b>WEDNESDAY</b>  | <b>15:00 - 17:00</b> |
| <b>THURSDAY</b>   | <b>10:00 - 13:00</b> |

**EXAMS**

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|----------------|-------------------|---|
| SUMMER SECTION | JUNE 14, 2024     | BOOKING DEADLINE ON INFOSTUD: JUNE 13, 2024     |
|                | JULY 12, 2024     | BOOKING DEADLINE ON INFOSTUD: JULY 11, 2024     |
| FALL SECTION   | SEPTEMBER 5, 2024 | BOOKING DEADLINE ON INFOSTUD: SEPTEMBER 4, 2024 |

**MASTER Thesis:** topics for stages are available on request on the following topics: plasmonic artificial intelligence; all-optical machine learning; photonic psycho-memories; optical recognition of viruses and bacteria, optical design (in collaboration with private companies). Please contact the professor for details.