EC562: FOURIER OPTICS

Instructor: Prof. Luca Dal Negro

Fall 2022 -Course Syllabus

Prerequisites:

Matlab programming, Electromagnetics, and knowledge of statistics (with stochastic processes). Talk to the instructor if unsure.

1. Fundamentals

1.1. *The mathematics of waves and wave equations*
1.2. *Special functions used in engineering optics*
1.3. *What is Fourier Optics?*
1.4. *Spatial frequency and Fourier transforms in engineering*
1.5. *Review of integral transforms for optical engineering*
1.6. *Electromagnetics review: radiation and scattering*
1.7. *Matlab programming examples*

2. Basic diffraction theory

2.1. *From vector to scalar diffraction*
2.2. *Point patterns and kinematic diffraction*
2.3. *Random phasor sums and optical speckles*
2.4. *First-order speckle statistics*
2.5. *Rigorous diffraction theory: Fresnel-Kirchhoff's diffraction*
2.6. *The Rayleigh-Sommerfeld formulation*
2.7. *The angular spectrum of fields*
2.8. *Engineering applications to diffractive optics and antenna theory*
2.9. *Matlab programming examples*

3. Optical Systems

3.1. *Analysis of optical systems in spatial frequency domain*
3.2. *Optical coherence: diffraction of partially coherent light*
3.3. *Coherent and incoherent optical systems*
3.4. *Image formation*
3.5. *Aberration and effects on frequency response*
3.6. *Optical resolution*
3.7. *Coherent and modulation transfer functions*
3.8. *Imaging beyond classical diffraction*
3.9. *Matlab programming examples*

4. Fourier analysis of engineering systems

4.1. *Lens-based systems (e.g., microscopes, telescopes, transformation optics)*
4.2. *Diffractive gratings and Fresnel phase plates*
4.3. *Microscopy, optical and infrared imaging cameras*
4.4. *Optical signal processing*
4.5. *Lensless imaging systems: aperture synthesis*
4.6. *Imaging as computation*
4.7. *Matlab programming examples*

5. Advanced concepts in diffractive optics and meta-optics

5.1. *Multi-level diffractive optical elements*
5.2. *Axilenses, photon sieves, and multifunctional optics*
5.3. *Flat imaging devices and metalenses*
5.4. *Super-oscillation focusing*
5.5. *Speckle imaging*
5.6. *AI-driven imaging methods*
6.11 *Matlab programming examples*

Textbook
Introduction to Fourier optics, by J.W. Goodman, 4th edition (W. H. Freeman, NY)

Other references (not required)
Engineering Optics, by K. Iizuka (Springer-Verlag, 3rd edition, 2007)
Speckle phenomena in optics, by J.W. Goodman (Roberts and Company, 2007)
Computational Fourier optics, by D. Voelz (SPIE Press, 2011)
Waves in Complex Media, by Luca Dal Negro (Cambridge University Press 2022)

Lecture notes prepared by the instructor will be delivered per course topic