Master Physique fondamentale et applications
Advanced theoretical optics

Informations

Composante : Faculté des Sciences

Responsables

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Langue(s) d'enseignement

Anglais

Contenu

Rays and Waves

An overview is given of the many ways to understand the connection between the ray and wave models, and the corresponding ways to construct models for propagating waves based exclusively on rays. Analogies with other areas of physics are stressed, particularly that with the connection between the classical and quantum models for particles.

1.1 Mathematical elements

- Asymptotic methods: stationary phase and saddle points
- Fourier uncertainty
- Phase-space representations: Wigner, Husimi/Q/Spectrogram, Kirkwood/Rihaczek/Dirac

1.2 Ray-wave connection in the paraxial limit

- Review of wave optics in the paraxial regime
- Review of ray optics in the paraxial regime: phase space representation
- Collins formula and LCT for connecting rays and waves
- Complex ray bundles and Gaussian beams

1.3 Ray-wave connection in the short-wave limit

- Nonparaxial scalar wave optics in terms of amplitude and phase: super- and sub-oscillations (Gouy phase)
- Use of stationary phase and Feynman integral picture.
- Flux lines and Bohmian paths
- Debye asymptotic series
- The many faces of ray optics: Eikonal equation, Fermat's principle and the Ibn Sahl-Decartes-Snell law
- Ray-based wave estimates in the position representation: connection with WKB
- Caustics
- Angular spectrum/Fourier regime
- Ray-based wave estimates in the direction/momentum representation: connection with Debye-Wolf (& Richards-Wolf)
- Direction/momentum caustics
- Connections through stationary phase
- Diffraction: Keller's diffracted rays
- Uniform asymptotics
- Gaussian summation methods

1.4 Ray-wave connection in the low coherence limit

- Basic elements of spatial coherence: the cross-spectral density and the Wolf equations
- Radiative transfer equation: the radiance or specific intensity
- Wave-based definitions of the radiance and conservation along rays
- Analogies in other areas of optics and physics.

Structured light

This course presents the basic elements of structured light beams, including properties and applications. General aspects of optical fields are also discussed such as polarization, geometric phase, energy flow, and gradient and scattering forces on particles.

2.1 Scalar solutions

- Types of self-similarity
- Plane-wave superposition
- Talbot effect
- Closed-form solutions of wave equations through separation of variables
- Propagation-invariant beams: Bessel, Mathieu, others
- “Accelerating” beams: Airy and its variants
- “Self-healing”, “acceleration” and other apparently strange behavior
- Structured Gaussian beams: Hermite-Gauss, Laguerre-Gauss, Ince-Gauss, others
- Ray pictures
- Applications in imaging, machining, manipulation, and information transfer

2.2 Polarization

- Review: Jones vectors, Stokes parameters, Poincaré sphere
- Polarizers, birefringent elements, and geometric phase
- Vector beams and non-uniform polarization
- Orbital and Spin angular momentum in the paraxial regimes; interaction with particles.

2.3 Nonparaxial generalizations

- Modeling strongly focused light: angular spectrum, Debye-Wolf and Richard-Wolf integrals
- Multipolar expansions
- Scalar structured nonparaxial fields
- Montgomery effect
- Orbital and spin angular momenta in the nonparaxial regime, and spin-orbit coupling
- Nonparaxial descriptions of polarization
- Trapping forces and torques
- Principles of Mie theory: forces and torques.

VOLUME HORAIRE

- Volume total: 40 heures
- Cours magistraux: 40 heures

Codes Apogée

- SPFCU41J [ELP]

Pour plus d'informations

[Aller sur le site de l'offre de formation...]

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