Seminarske/mag. teme, 2. stopnja fizike

2024

Fundamentals and Applications of Second Harmonic Generation in Nonlinear Optics

- **Overview**: Introduce the basic principles of SHG, including phase matching, the role of nonlinear susceptibilities, and the physics behind frequency doubling. Discuss various applications in optics, including laser technology and microscopy.
- **Key points**:
    - Nonlinear polarization and SHG theory
    - Phase matching conditions
    - Applications in laser frequency conversion
    - SHG in biological and material sciences (e.g., SHG microscopy)
- **Why it fits**: Covers both fundamental concepts and practical applications, making it suitable for a well-rounded presentation.

Second Harmonic Generation in Crystals: Material Dependence and Phase Matching Techniques

- **Overview**: Focus on how different materials exhibit SHG, emphasizing the importance of crystal symmetry and material properties. Explore various phase matching techniques (e.g., Type I, Type II) and the impact of crystal orientation and birefringence.
- **Key points**:
    - Symmetry requirements for SHG in different crystals
    - Material properties affecting SHG efficiency (e.g., KTP, BBO crystals)
    - Quasi-phase matching and periodic poling
    - Applications in optical devices (e.g., lasers)
- **Why it fits**: Combines theoretical aspects with experimental considerations, ideal for a more advanced audience.

Nonlinear Optical Properties of Ferroelectric Liquid Crystals

- **Overview**: Explore the nonlinear optical properties of ferroelectric liquid crystals, focusing on how their large spontaneous polarization enhances their nonlinear optical response. Discuss applications in second harmonic generation (SHG), electro-optic modulation, and tunable photonic devices.
- **Key points**:
    - Nonlinear optics in ferroelectric liquid crystals

- Second harmonic generation and electro-optic modulation
    - Applications in tunable lasers and optical communication systems
    - Comparison with traditional nonlinear materials
- **Why it fits**: Combines nonlinear optics with liquid crystal physics, offering an advanced yet accessible topic for students with interests in both fields.

Nonlinear Optical Imaging of Ferroelectric Liquid Crystals: Combining SHG Microscopy with Localized IR Heating (tudi mag. tema)

- **Overview**: Explore the combination of SHG microscopy and localized IR laser heating to study the dynamic behavior of ferroelectric liquid crystals. Discuss how localized heating influences the ferroelectric-to-paraelectric transition and how SHG microscopy is used to monitor the real-time changes in polarization and structure.
- **Key points**:
    - Fundamentals of SHG microscopy for visualizing ferroelectric phases
    - Localized IR heating and its role in phase transitions
    - Real-time imaging of polarization dynamics during phase changes
    - Applications in dynamic optical systems and memory devices
- **Why it fits**: Offers an advanced look at how nonlinear optical imaging can be combined with controlled thermal manipulation to study ferroelectric liquid crystals in real time.

Localized IR Laser Heating and SHG Microscopy for Studying Defects in Ferroelectric Liquid Crystals (tudi mag. tema)

- **Overview**: Focus on how localized IR laser heating, combined with SHG microscopy, can be used to study and manipulate defects in ferroelectric liquid crystals. Discuss how thermal gradients influence defect dynamics and how SHG microscopy provides insight into the local symmetry-breaking around these defects.
- **Key points**:
    - Nature of defects in ferroelectric liquid crystals (e.g., disclinations, domain walls)
    - Using localized heating to manipulate and control defect dynamics
    - SHG microscopy for visualizing symmetry-breaking and defect structures
    - Applications in defect engineering and advanced materials research
- **Why it fits**: Provides a nuanced approach to understanding and controlling defects in FLCs, linking theoretical concepts with experimental techniques.

Thermal Control of Ferroelectric Domains in Liquid Crystals: SHG Microscopy and IR Laser Heating Techniques (tudi mag. tema)

- **Overview**: Explore how SHG microscopy and IR laser heating can be used to control and manipulate ferroelectric domains in liquid crystals. Discuss how localized heating affects domain nucleation, growth, and switching, and how SHG microscopy visualizes these changes in real time.
- **Key points**:
    - Ferroelectric domain structures and dynamics in liquid crystals
    - Localized IR laser heating for inducing domain growth and switching
    - SHG microscopy for real-time monitoring of domain behavior
    - Applications in ferroelectric memories and tunable optical devices
- **Why it fits**: Focuses on ferroelectric domain control using thermal and optical techniques, making it ideal for students interested in solid-state physics and materials engineering.

Collective Behavior of Magnetic Nanoplates in Suspension: Self-Assembly and Structure Formation

- **Overview**: Examine the collective behavior of magnetic nanoplates in suspension and how they self-assemble into ordered structures due to magnetic interactions. Discuss how external fields and flow conditions affect the formation of chains, clusters, and other structures, with potential applications in soft matter physics and materials science.
- **Key points**:
    - Collective dynamics and self-assembly of magnetic nanoplates
    - Role of magnetic interactions and hydrodynamics in structure formation
    - External control through magnetic fields and flow conditions
    - Applications in soft matter systems, metamaterials, and responsive materials
- **Why it fits**: This topic bridges soft matter physics with magnetic behavior, offering a sophisticated and engaging subject.

Intracellular Transport and Dynamics: Imaging Vesicle Trafficking in Eukaryotic Cells

- **Overview**: Focus on intracellular transport mechanisms, particularly the movement of vesicles within the cell. Explore how advanced microscopy techniques (such as fluorescence microscopy, confocal microscopy, and live-cell imaging) allow scientists to monitor these dynamics in real-time. Discuss how vesicle trafficking is altered under cellular stress conditions (e.g., oxidative stress, nutrient deprivation).
- **Key points**:
    - Mechanisms of vesicle transport (microtubules, motor proteins)
    - Techniques for visualizing vesicle dynamics (fluorescent tagging, live-cell imaging)
    - Effects of stress (e.g., oxidative stress) on vesicle movement
    - Implications for diseases (e.g., neurodegenerative diseases)

- **Why it fits**: Combines cell biology with microscopy techniques, offering insights into fundamental intracellular processes.

Principles of Raman Spectroscopy and Its Applications in Material Science

- **Overview**: Introduce the fundamental principles of Raman scattering, including the theory behind vibrational modes, Stokes and anti-Stokes shifts, and selection rules. Discuss the applications of Raman spectroscopy in material science, such as characterizing crystal structures, studying phase transitions, and identifying chemical compositions.
- **Key points**:
    - Basics of Raman scattering and vibrational modes
    - Stokes vs. anti-Stokes scattering
    - Applications in material identification and analysis
    - Raman spectroscopy for studying phase transitions in solids
- **Why it fits**: Combines a clear theoretical introduction with applications in a core field like material science, making it accessible and practical.
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Raman Microspectroscopy in Biological Systems: Non-invasive Analysis of Cells and Tissues

- **Overview**: Focus on Raman microspectroscopy and its applications in biological systems. Discuss how this technique can be used to monitor intracellular processes, identify biomolecules, and observe changes in cells and tissues without the need for labeling. Explore specific applications in medical diagnostics and cancer research.
- **Key points**:
    - Principles of Raman microspectroscopy
    - Non-invasive detection of biomolecules (e.g., lipids, proteins, nucleic acids)
    - Applications in live-cell imaging and tissue analysis
    - Role in cancer diagnosis and detection of abnormal tissue
- **Why it fits**: Highlights the interdisciplinary nature of Raman microspectroscopy, combining physics with biology and medical applications.