ICFO - UNAM International School on the Frontiers of Light

Photons in the NanoWorld
18-22 September 2023,
CFATA, Querétaro, Mexico

POSTER PRESENTATION SESSION

Monday, September 18, 17:00-18:30

1
Alejandra Daniela Lopez Solís
INAOE, Mexico

Creation of a ppktp-Sagnac Polarization-Entangled Photon source

2
Andrés Ramírez Cordero
INAOE, Mexico

Comparative Analysis of Cephalopod Limb Regeneration

3
Bruno Ivan Salgado Molina
CFATA- UNAM, Mexico

Reconstruction of spatial modes of light from deep neural networks

4
Cristian Osvaldo Carreño Vega
CFATA- UNAM, Mexico

Plasmonic intensification of NaYF4:Yb,Er up-conversion emissions in a star-like morphological array

5
Daniela Patiño Vélez
CFATA- UNAM, Mexico

Study of functionalization of a plasmonic chip for the detection of Sars-Cov-2

POSTER PRESENTATION SESSION

Monday, September 18, 17:00-18:30

6 Diana Laura Quijada Ocampo *CFATA- UNAM, Mexico*	Probing Electrical Phase Transitions in Bernal-stacked Bilayer Graphene
7 Luisa Fernanda Cely Ruiz *CICESE, Mexico*	Design and implementation of chebyshev (IIR) high pass digital filter using python programming
8 Edgar Campos Puente *UNAM, Mexico*	User interface for an optical tweezers system developed in LabVIEW
9 Fabián Camas Aquino *IF- UNAM, Mexico*	Spherical vector waves in a 4pi optical array
10 Fernando Eleazar García Ramírez *UNAM, Mexico*	Integration and study of a MOEMS-based endomicroscopic system for early detection of gastrointestinal cancers by SS-OCT

POSTER PRESENTATION SESSION

Monday, September 18, 17:00-18:30

11
Jorge Luis Domínguez Juárez
CFATA-UNAM, Mexico

Sensing of Light-Liquid Interaction with Dual Beam Thermal Lens Spectroscopy

12
Fawad Ali
Abbottabad University of Science & Technology, Pakistan

Manipulation of dielectric microparticles by structured evanescent fields

POSTER PRESENTATION SESSION

Thursday, September 21, 17:00-18:30

13
Jorge Molina-González
CFATA-UNAM, Mexico

Spectroscopic Properties of inorganic Nanoparticles and Applications

14
Joseph Luis Cruz Ayala
IPN, Ecuador

Light-harvesting nanoparticles to stimulate dinoflagellates' secondary metabolites production

15
Luis Alfredo Ayala Fonseca
CFATA-UNAM, Mexico

Gold nanoparticles synthesized by heterobifunctional PEG for breast cancer application: a systematic review

16
Edén Janitzintzin Parra Fuentes
UNAM, Mexico

Development of an optical tweezers system for biological applications

17
Melissa Matrecitos Avila
UNAM, Mexico

Cell membrane tether pulling experiments with optical tweezers

POSTER PRESENTATION SESSION

Thursday, September 21, 17:00-18:30

18
Salva Asghar
International Islamic University Islamabad,Pakistan

Polarizing the emission of Er3+ in tellurite glasses at the nanoscale in the far field using plasmonic structures

19
Saúl Carrasco Saavedra
UNAM, Mexico

Quantum-plasmon interaction in hybrid luminescent Er3+ doped germanate-tellurite glass thin films

20
Stephanie Catalina González Migoni
CFATA-UNAM, Mexico

Direct coupling of interfered evanescent fields with surface plasmon-polaritons

21
Yordan Eduardo Solorzano Roman
Yachay Tech University, Ecuador

Integration of Photonics and Mechatronics for Nanoscale Sensing and Manipulation

22
Piyush Shrivastava
Manipal University Jaipur , India

Cost Effective Method of Light Trapping by Alternative Nobel Plasmonic Nanoparticles At the Hetero Junction of CdTe Thin Film and CdS Nanowires for Solar Cell Applications

POSTER PRESENTATION SESSION

Thursday, September 21, 17:00-18:30

23

Saleem Shaik
Indian Institute of Technology Kanpur, India

Perturbative description of the Wood Anomalies of metallic diffraction gratings and negative Goos–Hänchen shift

1. Creation of a ppktp-Sagnac Polarization-Entangled Photon source

This article presents the experimental development of a polarization-entangled photons source, prepared in a Bell state. Both photons are generated at a wavelength of 810nm by a PPKTP crystal with type II phase-matching conditions, which is pumped by a laser stabilized at a wavelength of 404.5nm. The crystal is placed in a Sagnac interferometer, which ensures high stability, high indistinguishability, and high brightness. The results obtained include a source with a brightness of 80000 c/mW/s, a heralding efficiency of 25.5%, and polarization correlation measurements showing a visibility greater than 98% in the DA basis and over 99% in the HV basis. Additionally, violating the Bell inequality.

2. Comparative Analysis of Cephalopod Limb Regeneration

Previous evidence supports a broad model for limb regeneration in Cephalopoda. The extent to which this applies to the whole class, rather than simply for notable model organisms within it, has not been well documented. Using three disparate cephalopod species accounting for both Octopoda and Decapoda, the process of limb wound healing and regeneration after amputation was documented over the course of several days. Using histological and fluorescent stains, the behavior of the tissue in the recovering limbs was analyzed and imaged. The results demonstrate that, while there are many conserved characteristics in wound healing, regeneration is not a universal phenomenon among cephalopods.

3. Reconstruction of spatial modes of light from deep neural networks

Structured light beams that carry orbital angular momentum (OAM) have been used to develop strong protocols to code information in optical communication, specially those making up orthogonal groups because of the possibility to overlap and propagate simultaneous beams in the called mode division multiplexing. An example of such beams are the Laguerre-Gauss beams, but their applicability is reduced because of the difficulties to propagate them in media other than vacuum, such as commercial optical fibers for which LG beams are not eigenmodes, causing the loss of spatial profiles.
For this reason I used Convolutional Neural Networks (CNN) to decode these light patterns and identify the original eigenmodes of the LG beams.

4. Plasmonic intensification of NaYF4:Yb,Er up-conversion emissions in a star-like morphological array

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5. Study of functionalization of a plasmonic chip for the detection of Sars-Cov-2

The disease caused by SARS-CoV-2 has been subject of study in recent years. Its importance lies in its mortality rate, contagion rate, mutability and lack of effective medical treatment. Due to the aforementioned factors and the high demand for clinical detection tests, it is necessary to develop new diagnostic tools for virus detection that are fast, reliable, specific and less expensive. Nanostructured metals possess a property known as plasma frequency, at which a collective oscillation of electrons known as plasmon occurs. These structures, deposited on a dielectric substrate, form an interface where a surface plasmon is generated according to the metal's characteristic resonance wavelength and its geometry. Molecular interaction due to functionalization modulates the characteristics of light on the metal surface such as intensity, phase, and polarization. In this work, this interaction was characterized using a Localized Surface Plasmon Resonance LSPR based optical transducer plasmonic biosensor, using the Kretschmann configuration. A study was carried out on the functionalization and in situ detection of binding events in ultrathin films and gold nanoparticles deposited on Corning® 2947N using the DC magnetron sputtering technique. This constitutes the basis of an on-chip plasmonic device integrated with microfluidic channel. The real time detection of the functionalization process and binding events was demonstrated by obtaining sensograms in terms of the resonance wavelength. Assays were performed with synthetic oligonucleotides and with an applicable biotin/streptavidin protein scheme for SARS-CoV-2.

6. Probing Electrical Phase Transitions in Bernal-stacked Bilayer Graphene

Bernal bilayer graphene (BBG) exhibits fascinating phase orders like superconductivity. However, its reduced dimensionality hampers the possibility to use the traditional bulk methods to study these orders. Here we aim to demonstrate that phase transitions in BBG can be probed mechanically via the temperature-dependent resonance frequency. Accordingly, to the previous works done over ultrathin antiferromagnets, the relation between mechanical motion and phase order is shown to be mediated by the specific heat. We expect similar behaviors and results in BBG. With this, we would be able not only to probe phase transitions but, at the same time, inspect the effects of strain.

7. Design and implementation of chebyshev (IIR) high pass digital filter using python programming

This study focused on the design and implementation of high–pass digital filter using python programming. The Chebyshev (IIR) filter was chosen for this purpose. The filter's objectives are to selectively transmit a specific range of frequencies, known as the passband, while attenuating or rejecting all others in the stop-band. Utilizing the bi-linear transformation method to convert the analog transfer function into a digital transfer function, ensuring the essential properties of the analog version preserved. Two results were obtained from this research, firstly, when applying the high-pass Chebyshev I filter, it was observed that a frequency response without ripples was seen compared to the theoretical frequency response, this outcome was achieved by carefully selecting the order and input values. Secondly, the high pass Chebyshev II filter exhibited ripples in the frequency response when compared to the theoretical expectations. Again this can be attributed to the choice of order and input values, comparing the two result, it was observed that, only Chebyshev II matched the theoretical expectation, as it demonstrated a good step response. On the other hand, the Chebyshev I filter displayed a poor step response and does not match the theoretical expectation. These findings highlight the importance of considering the filter's characteristics and parameters when designing digital filters.

8. User interface for an optical tweezers system developed in LabVIEW

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9. Spherical vector waves in a 4pi optical array

We present a theoretical study for the generation of light beams in an optical 4pi configuration with two confocal opposed identical lenses, with special interest on the spherical vector waves.

10. Integration and study of a MOEMS-based endomicroscopic system for early detection of gastrointestinal cancers by SS-OCT

TO BE CONFIRMED

11. Sensing of Light-Liquid Interaction with Dual Beam Thermal Lens Spectroscopy

We show dynamic wave-front sensing as a temperature-induced index of refraction changes for thermalization processes in liquids. Light-liquid interaction is analyzed with the help of visible image changes of a diffraction patterns response. The images were analyzed for studying dynamic of thermophysical properties of organic compounds using a pump-probe thermal lens spectroscopic system. The optical system is a dual femtosecond pulsed laser, using infrared as a pump and probing with visible light. The colinear infrared and visible light beams were focused on the cell of colorless liquids. The transmission of the visible light of the probe exhibited divergence, producing a ring pattern projected onto a screen and captured with a digital camera. The technique reported here allowed us to observe well-defined diffraction patterns from water, colorless organic compounds, and binary mixtures. Visibility and the number of rings depended on the laser power, dimensions of the cell, free convection, initial temperature conditions, and the light absorption of the liquid material.

12. Manipulation of dielectric microparticles by structured evanescent fields

Particle optical traps were originated in the 70's and was discovered by Arthur Ashkin [1]. Based on this work, Kawata and Sugiura [2] propose the use of the radiation pressure of an evanescent field for the displacement of microparticles on the surface of a substrate. Kawata and Sugiura work showed the movement of microparticles in an evanescent field generated by a laser beam incident on a prism under the condition of total internal reflection, this technique allows the displacement of a large number of particles in an extended area.
In this research project we show the design and implementation of optical traps with arbitrary spatial distribution through the interaction of two counter propagating evanescent fields for the trapping and manipulation of dielectric microparticles. The intensity distribution of the desired evanescent fields will be generated through the use of a spatial light modulator and can be controlled dynamically, the special distribution of the evanescent field, structured fields, will form the optical traps where the dielectric microparticles will be confined.

[1] Ashkin, A. (1970). Acceleration and Trapping of Particles by Radiation Pressure. Physical Review Letters, 24(4), 156–159.
[2]Kawata, S., & Sugiura, T. (1992). Movement of micrometer-sized particles in the evanescent field of a laser beam. Optics Letters, 17(11), 772.

13. Spectroscopic Properties of inorganic Nanoparticles and Applications

TO BE CONFIRMED

14. Light-harvesting nanoparticles to stimulate dinoflagellates' secondary metabolites production

Dinoflagellates are mainly marine microorganisms. A significant number of species are photosynthetic; they produce oxygen and chemical energy by harvesting light. Some species live in symbiotic relationships with larger animals such as corals, jellyfish, sea anemones, and nudibranchs, and some are free-living. With certain ocean conditions, some free-living dinoflagellates' cell densities may increase to millions of cells per liter, causing Harmful Algal Blooms (HABs), also known as red tides. Some dinoflagellates produce potent toxins, and when their cell density increases, they can severely affect the marine food web by intoxicating organisms of all trophic levels, including humans, through seafood consumption. But dinoflagellates do not only produce toxins; these microorganisms are astounding secondary metabolite producers, and some of these compounds may have pharmacological applications. However, research on these metabolites has been hampered due to complications in producing these metabolites since dinoflagellates grow slowly and in low densities in culture. For this reason, we propose the addition of nanoparticles with a high quantum efficiency (high conversion factor from green light to red or blue light) to dinoflagellates in culture to assist the photosynthetic process, obtain higher cell densities, and improve the secondary metabolites production.

15. Gold nanoparticles synthesized by heterobifunctional PEG for breast cancer application: a systematic review

Cancer is the leading cause of death and the most critical barrier to increasing life expectancy in all countries of the world. In particular, breast cancer is ranked second in frequency and fifth place as the cause of death in the world. Gold nanoconjugates exhibit properties of higher binding affinity and selective tumor capacity, causing low immunogenic responses ideal for the treatment of cancer. The gold nanoparticles (GNP) synthesized by heterobifunctional poly (ethylene glycol) PEG allows the obtaining of specific cell types images and the directed internalization of the GNP, saving them from immunological recognition, and prolonging their permanence in the blood circulation and increasing their concentration in the tissue tumor. For the suitable permeability and retention effect (EPR) and the hypoxic nature of the tumor tissue; the application of PEGylated GNPs in radiotherapy (RT), photothermal therapy (PTT), chemotherapy, bioimaging, and gene delivery make it a highly functional, selective and the effective component in the detection and therapeutic applications of patients with breast cancer and their metastases.

15. Development of an optical tweezers system for biological applications

TO BE CONFIRMED

17. Cell membrane tether pulling experiments with optical tweezers

TO BE CONFIRMED

18. Polarizing the emission of Er3+ in tellurite glasses at the nanoscale in the far field using plasmonic structures

The polarization state is a fundamental property of light, and its manipulation exhibits important applications in transmitting information on optical technologies. The development of polarization controllers on the nanoscale with noble materials has attracted the attention of researchers in the last decades. In this scenario, plasmonic structures in thin metals exhibit remarkable properties such as the generation of surface plasmon polaritons (SPPs) and extraordinary optical transmission (EOT), which is a consequence of the SPP-light coupling and can be used for polarization controlling. For instance, the bull's eye nanostructures give rise to beaming with a focusing property on the subwavelength regime. In this research, bull's eye nanostructures were fabricated in gold films on Er3+-doped oxyfluoride tellurite glasses to study their polarization performance at 1.5 μm. The glasses were fabricated by melt-quenching technique, the gold deposition with conventional sputtering, and the nanostructure fabrication with a focused ion beam. The characteristic of these nanostructures is their elliptical aperture, which leads to selecting a specific polarization state. This system works as follows: the Er3+ is excited under 980 nm, emitting at 1.5 μm (4I13/2 → 4I15/2 transition), which covers the S, C and L communication windows. The emitted light couples with the nanostructure, generating polarized EOT through the aperture. The polarization behaviour was demonstrated by Malu's law of polarization in a micro-luminescence optical setup. Therefore, it was possible to manipulate light at the nanoscale for photonic and signal-processing applications.

19. Quantum-plasmon interaction in hybrid luminescent Er3+ doped germanate-tellurite glass thin films

This work explores the quantum-plasmon interaction in hybrid luminescent thin films composed of Er3+-doped germanate-tellurite nanoglasses on a PMMA polymeric matrix deposited on Au metasurfaces. These films offer a unique platform to investigate the coupling between quantum emitters and plasmonic resonances. By studying this interaction, we aim to gain insights into enhanced light-matter interaction and explore potential applications in nanophotonics. Experimental results will be presented, highlighting the spectroscopic characterization and theoretical modeling of quantum-plasmon coupling effects. The findings contribute to improving our understanding of quantum-plasmonic interactions and pave the way for the development of new optoelectronic devices based on hybrid materials.

20. Direct coupling of interfered evanescent fields with surface plasmon-polaritons

This work introduces a novel configuration for exciting surface plasmon-polaritons (SPP). The proposed approach involves the direct coupling of interfered evanescent fields with SPP. The study focuses on a metal-dielectric interface where interfered evanescent waves propagate within the dielectric medium and illuminate a planar metal surface. By employing this coupling mechanism, a two-dimensional structured plasmon field is generated, thereby enhancing the capabilities of plasmon optics models, including diffraction, interference, and focalization. This research opens up new avenues for advancing the field of SPP and its applications in optics.

21. Integration of Photonics and Mechatronics for Nanoscale Sensing and Manipulation

The research thesis aims to explore the integration of optics and mechatronics in nanoscale sensing and manipulation. Incorporating an integration of mechanical and electronic software systems by integrating optical principles of light generation, control and detection, this research seeks to develop new techniques and sensing devices precisely and applied at the nanoscale level. The research will explore the possible synergies of these two disciplines and their applications in various fields such as biomedical engineering, materials science, nanotechnology etc. The research will include theoretical analysis, numerical simulation and experimental validation to see how photonics and integrated mechatronics techniques will be more efficient and effectively - accessible The findings of this study have the potential to significantly advance the field and contribute to the development of new technologies for various applications in nanoscience and engineering.

22. Cost Effective Method of Light Trapping by Alternative Nobel Plasmonic Nanoparticles At the Hetero Junction of CdTe Thin Film and CdS Nanowires for Solar Cell Applications

Finite Difference Time Domain (FDTD) simulations were performed to find the enhancement in the absorption due to the localized surface plasmon (LSPR) coupling in CdS - CdTe heterojunction semiconductor Nano Rod (NR) structure decorated with Mg Nanoparticles (NP) in the visible wavelength range(350 nm – 900 nm) as compared to the noble(Au, and Ag) metallic NP. Propagating modes were also observed on the surface of the NR due to the LSPR coupling.

23. Perturbative description of the Wood Anomalies of metallic diffraction gratings and negative Goos–Hänchen shift

This study focuses on the analysis of the well-known Wood anomalies observed in the diffraction of white light by metallic gratings, which serve as experimental evidence for the existence of surface plasmon polaritons (SPP). These anomalies manifest as diffuse peaks and dips in the reflected spectrum for p-polarized light. The main objective of this work is to provide a theoretical and numerical investigation of these anomalies, with particular attention given to the underlying multiple scattering processes responsible for their occurrence.
Utilizing a perturbative approach based on the Reduced Rayleigh Equation (RRE), we demonstrate that the Wood anomalies primarily arise from the destructive interference between the field reflected specularly and a multiple scattering contribution involving the excitation and subsequent diffraction of SPP. Furthermore, we extend our analysis to encompass illumination by a Gaussian beam. Our findings reveal that the diffraction of SPP induces a lateral displacement and produces a Goos-Hänchen shift-like effect in the reflected beam, which can exhibit a negative value depending on the specific coupling order associated with SPP.