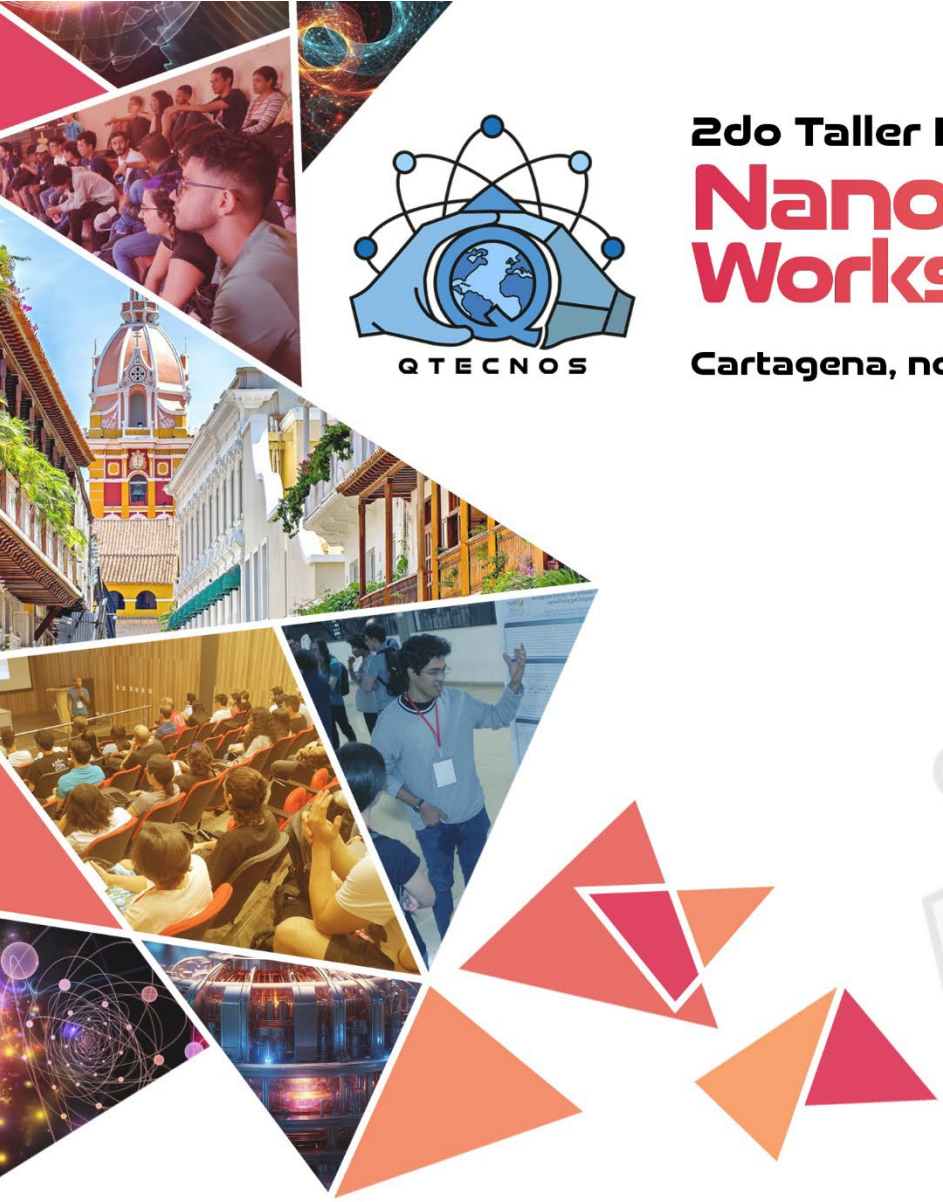


QTECNOS

2do Taller Internacional QTECNOS

Nano & Quantum Workshop 2024

Cartagena, november 25 to 29

Book of Abstracts

Memorias del evento

UNIVERSITY OF OSLO

Universidad de Cartagena
Fundada en 1827

Academia Colombiana de Ciencias Exactas, Físicas y Naturales

SUE CARIBE

Universidad del Atlántico

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About QTECNOS

The Quantum Technology Education Consortium between Norway, South America, and Cuba (QTECNOS) is a program aimed at improving the current state of education in quantum technology, both in Norway and in the Global South. The specific goal is to understand physics and master the fabrication of quantum materials using both computational and experimental methods, laying the foundation for student education in this field.

The consortium was established in 2022 by the University of Oslo in Norway and four partners from the Global South, namely the University of Valle (Colombia), the Association of Colombian State Universities of the Caribbean (SEU-Caribe) (Colombia), the National University of San Marcos (Peru), and the University of Havana (Cuba).

The second QTECNOS International Workshop will be held in Cartagena, Colombia, from November 25 to 29, 2024.

About the NANO & QUANTUM WORKSHOP 2024

Quantum technology education is an emerging multidisciplinary field expected to revolutionize the future of the world. Understanding physics and mastering the fabrication of quantum materials form the foundation of education in this field. In this regard, the second edition of this workshop is designed to provide students and researchers with short courses and lectures offering an overview of current research topics in nanoscale and quantum science, including (but not limited to) nanophysics, materials engineering, photonics, and quantum technology.

Organizing Committee



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Colombia



Luis Eduardo Cortés
Universidad de Cartagena
Colombia

Programme Overview

Nano & Quantum Workshop 2024-General Program

Star	End	25-nov-24	26-nov-24	27-nov-24	28-nov-24	29-nov-24
8:00	8:30	REGISTRATION FORMALITIES				
8:30	9:00					
9:00	9:15	Opening Session	Topic Plenary -Prof. Joakim Bergli	Topic Plenary -Prof. Pablo Rivera Riofano	Topic plenary- Dr. David Rivas	
9:15	9:30					
9:30	9:45	Opening Plenary -Prof. Morten Hjorth-Jensen				
9:45	10:00		Oral contribution 2.1	Oral contribution 3.1	Oral contribution 4.1	NATIONAL AVIARY VISIT
10:00	10:15					
10:15	10:45	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK	
10:45	11:30	Opening plenary- Prof. Angela Guzman	Topic Plenary -Prof. John Henry Reina	Topic plenary -Prof. Juan Carlos Gomez	Topic Plenary -Prof. Omar Calderón	
11:30	12:00	Oral contribution 1.1	Oral contribution 2.2	Oral contribution 3.2	Oral contribution 4.2	
12:00	14:00	LUNCH TIME	LUNCH TIME	LUNCH TIME	LUNCH TIME	LUNCH TIME
14:00	14:30	Oral contribution 1.2	Oral contribution 2.3	Oral contribution 3.3	Oral contribution 4.3	
14:30	15:00	Oral contribution 1.3	Oral contribution 2.4	Oral contribution 3.4	Oral contribution 4.4	
15:00	15:30	Oral contribution 1.4	Oral contribution 2.5	Oral contribution 3.5	Oral contribution 4.5	BARU BEACH VISIT
15:30	16:00	Oral contribution 1.5	Oral contribution 2.6	Oral contribution 3.6	Academic Networks	
16:00	16:30	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK	
16:30	18:00	FORTIFIED TOWN TOUR	POSTER SECCIÓN	BOAT TRIP ON THE BAY	POSTER SECCIÓN	

Monday, 25 November 2024

Star	End	
8:00	9:00	Registration Formalities
9:00	9:30	Opening session
9:30	10:15	Opening Plenary. *Deep learning applied to quantum mechanical many-body problems* Prof. Morten Hjorth-Jensen. Department of Physics and Center for Computing in Science Education, University of Oslo (Norway)
10:15	10:45	**Coffee Break**
10:45	11:30	Opening Plenary. *Quantum Entanglement and the Era of New Quantum Technologies* Prof. Angela Guzmán. Academia Colombiana de Ciencias Exactas, Físicas y Naturales (Colombia)
11:30	12:00	Oral contribution 1.1. *Characterization of Entanglement in a Simulated Optical Network* Jhoan Eusse. Grupo de Física Atómica y Molecular. Universidad de Antioquia (Colombia)
12:00	14:00	**Lunch Time**
14:00	14:30	Oral contribution 1.2 *Quantum State Engineering Experiments with Mesoscopic Optical Fields* Dr. Kishore Thapliyal. Department of Physics. University of Oslo (Norway)
14:30	15:00	Oral contribution 1.3 *Description of an Optical matrix multiplier with the aim of application in All Optical Neural Networks* Andres Felipe Arias Velasquez. Universidad de los Andes (Colombia)
15:00	15:30	Oral contribution 1.4 *Understanding and using the Orbital Angular Momentum of Light for quantum computation with Qudits* Juan Carlos Rojas Velásquez. Universidad de los Andes (Colombia)
15:30	16:00	Oral contribution 1.5 *Optical responses in biofunctionalized spherical semiconductor quantum dots* Angie Liseth Prada Urrea. Universidad EIA (Colombia)
16:00	16:30	**Coffee Break**
16:30	17:30	**FORTIFIED TOWN TOUR**

Tuesday, 26 November 2024

Star	End	
9:00	9:45	Plenary. *Decoherence by low frequency noise and exceptional points of non-Hermitian matrices* Prof. Joakim Bergli. Department of Physics and Center for Computing in Science Education, University of Oslo (Norway)
9:45	10:15	Oral contribution 2.1. *Quantum error correction and the surface code* Delphine Martres and Jesper Lind-Olsen. University of Oslo (Norway)
10:15	10:45	**Coffee Break**
10:45	11:30	Plenary. *Quantum coherence control and decoherence: a neural network approach* Prof. John Henry Reina. Centre for Bioinformatics and Photonics (CIBioFi). Universidad del Valle (Colombia)
11:30	12:00	Oral contribution 2.2 *Cold atom-atom-ion three-body recombination assisted by radiofrequency trap* Ana Carolina Noguera Velasco. Centre for Bioinformatics and Photonics (CIBioFi). Universidad del Valle (Colombia)
12:00	14:00	**Lunch Time**
14:00	14:30	Oral contribution 2.3 *Harnessing Nth Root Gates for Energy Storage* Dr. Marcela Herrera. Universidad Autónoma de Occidente (Colombia)
14:30	15:00	Oral contribution 2.4 *Development of Molecular Logic Gates Based on Symmetrical Tetra (Hydrazones) with Two Arms* Diego Alejandro Monroy Rojas.
15:00	15:30	Oral contribution 2.5 *Supramolecular arrays for quantum superabsorption:Toward a quantum battery* Juan David Álvarez Cuartas. Centre for Bioinformatics and Photonics (CIBioFi). Universidad del Valle (Colombia)
15:30	16:00	Oral contribution 2.6 Use of decoy states as a method for increasing security in a quantum key distribution protocol Jorge Eduardo Arias Muñoz. Universidad del Valle (Colombia)
16:00	16:30	**Coffee Break**
16:30	18:00	**Poster Session**

Wednesday, 27 November 2024

Star	End	
9:00	9:45	Plenary. *Annoys in quantum computation* Prof. Pablo Rivera Riofano. Research Institute of Physics. Universidad Nacional Mayor de San Marcos (Peru)
9:45	10:15	Oral contribution 3.1. *Quantum Application in Ultra-Cold Atoms* Prof. Luis Ever Young Silva. Grupo de Modelado Computaciona. Universidad de Cartagena (Colombia)
10:15	10:45	**Coffee Break**
10:45	11:30	Plenary. *Preliminary Results About Fabrication and Study of DC Josephson Junction based on YBCO Superconductor* Prof. Juan Carlos Gomez. Research Institute of Physics. Universidad Nacional Mayor de San Marcos (Peru)
11:30	12:00	Oral contribution 3.2. Towards a p-n heterojunction of Ga2O3 and diamond Marte Pedersen Stalsberg. Department of Physics and Center for Computing in Science Education, University of Oslo
12:00	14:00	**Lunch Time**
14:00	14:30	Oral contribution 3.3 *Memristor Type Structures Based on TiO_2 Nanotubes for Non-Volatile Memories Applications* Yulied Porras Ramirez. Universidad Nacional de Colombia (Colombia)
14:30	15:00	Oral contribution 3.4 Structural and Optoelectronic Effects of Modified Sol-Gel Synthesized TiO2 Nanoparticle Doping on YBa2Cu3O7-δ: Conduction Mechanisms Silvana Palomino. Universidad del Valle (Colombia)
15:00	15:30	Oral contribution 3.5 *Ultra-thin films of CdS doped with silver: synthesis and modification of optical, structural, and morphological properties by the doping concentration effect* Juan Molina Jimenez. Universidad Popular del Cesar (Colombia)
15:30	16:00	Oral contribution 3.6 Excitation of Localized Surface Optical Plasmon Resonance LSPR in PMMA Capillary Fibers Coated with Ag Nanoparticles for Sensing Applications Yeiner Molina. Universidad Popular del Cesar
16:00	16:15	**Coffee Break**
16:15	18:00	**BOAT TRIP ON THE BAY**

Thursday, 27 November 2024

Star	End	
9:00	9:45	Plenary. *Ion implantation and annealing methods toward quantum emitters in silicon* Dr. David Rivas. Department of Physics and Center for Computing in Science Education, University of Oslo
9:45	10:15	Oral contribution 4.1 *Controlling directionality of emission from quantum defects through microstructures in Silicon* Erlend Lemva Ousdal. Department of Physics and Center for Computing in Science Education, University of Oslo
10:15	10:45	**Coffee Break**
10:45	11:30	Plenary. Testing Simultaneous Einstein-Podolsky-Rosen Elements of Reality for Non-Commuting Observables Using Weak Values Prof. Omar Calderon. Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle (Colombia)
11:30	12:00	Oral contribution 4.2 *Polariton-assisted charge transfer dynamics in organic donor-π-acceptor* Juan Camilo Rodriguez. Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle (Colombia)
12:00	14:00	**Lunch Time**
14:00	14:30	Oral contribution 4.3 *Using surface-facet transitions to tune the electronic spectrum of colloidal silicon quantum rods* Haniel David Robles Cohen. Universidad del Atlántico (Colombia)
14:30	15:00	Oral contribution 4.4 *Single and two-particles dynamics of spin-1 lattice bosons in presence of external periodic magnetic fields* Sebastian Loaiza. Universidad del Valle
15:00	15:30	Oral contribution 4.5 *Ferromagnetic resonance of magnetic multilayers at finite temperature* Juan Sebastian Urquijo Cárdenas. Universidad de Sucre
15:30	16:00	Academic Networks and Associations
16:00	16:30	**Coffee Break**
16:30	18:00	**Poster Session**

Poster Session

A-01 *Kitaev chain qubit simulations*
Eivind Støland. University of Oslo (Norway)

A-02 *Efficiency of a heat engine enhanced by quantum coherences under dissipation*
Freddier Cuenca. Universidad del Valle

A-03 Theoretical and experimental coherent quantum control of single molecules using ultrashort pulses
Juan Manuel Scarpetta. Universidad del Valle

A-04 *Hong-Ou-Mandel Interferometer for Single-Photon Pair Indistinguishability and Quantum Optical Coherence Tomography*
Juan Esteban Murillo Zapata. Universidad del Valle

A-05 *Pinn-Assisted Driven Coherent Dynamics and its Resistance to Dissipation*
Luis Miguel Fabra. Universidad de Córdoba

A-06 *Agent-based modeling meets quantum computing: A study on segregation*
Nixon Lizcano. Universidad Nacional de Colombia

A-07 *Hong-Ou-Mandel interferometer for single-photon pair indistinguishability and quantum optical coherence tomography*
Juan Esteban Murillo Zapata. Universidad del Valle

A-08 *Quantum correlations and redundant information in Quantum Darwinism*
Cesar Navarro Acosta. Universidad de Córdoba

A-09 *Bose-Einstein condensate as a quantum application*
Ana Fuentes and Jaime Correa. Universidad de Cartagena

A-10 *Liquid crystal-based polarization control for secure communications*
Juan Camilo Moreno and Miguel Angel Rojas. Universidad Autónoma de Occidente

A-11 *Analyzing the eigenstate thermalization hypothesis in a system of random free fermions: Insights from random matrix theory and free probability*
Krystifer Campos Muñoz. Universidad del Valle

A-12 *Numerical modeling of the coherent backscattering phenomenon in non-homogeneous media*
Nicolas Aguilera García. Universidad del Valle

A-13 *Analysis of quantum obesity in correlation swapping and DQC1 protocols*
Walter Carreño Durango. Universidad de Córdoba

A-14 *Study of quantum thermodynamics in simple solar cell models for the analysis of energy efficiency*

Johan Sebastian Pinzón Mesa. Universidad de Pamplona

A-15 *Dynamics of a bosonic particle system in an anisotropic double well using path integrals*
Kevin Giraldo Hincapie. Universidad del Valle

A-16 *Floquet dynamics of one-dimensional disordered spin chains with local interactions*
Rafael Alejandro Velez Gonzalez. Universidad del Valle

A-17 *Measurement incompatibility in the multi-object subchannel exclusion*
Fernando Hernandez Ortega. Universidad de Córdoba

B-01 *BODIPY-pyrene halogenation: Optoelectronic effects*
Carlos Andres Jaramillo. Universidad del Valle

B-02 *Nonlinear localized modes in a rhombic lattice*
Edwin David Conrado Dieppa. Universidad del Atlántico

B-03 *Analysis of coherent backscattering of light in aqueous media for the characterization of colloidal particles*
Maria Del Mar Pérez. Universidad del Valle

B-04 *Optical fibers coated with oxidated graphene for sensing applications*
Camila Andrea Noreña. Universidad Popular del Cesar

B-05 *Two-photon absorption of four benzoxazole derivatives: A density functional theory-based approach*
Edwin Rivera. Universidad Popular del Cesar

B-06 *The aisotropic Bose-Hubbard dimer in the mean field approximation*
Isabella Becerra Arbeláez. Universidad del Valle

B-07 *Architecture dependence in the many-body entanglement structure of local quantum circuits*
Andrés Felipe Valencia. Universidad del Valle

C-01 *Anisotropic and external field effects on a ferrimagnet of spins S = 3 y σ = 7/2*
Jorge Arturo Hoyos García. Universidad de Córdoba

C-02 *Ferromagnetic resonance of a magnetic nanoparticle in the inertial regime*
Calixto Cordero Carmona. Universidad de Sucre

C-03 *Characterization of chaotic magnetic nanoparticle dynamics in the inertial regime*
Juan Romero Huertas. Universidad de Sucre

C-04 *Influence of temperature and ultrasonic energy on the synthesis and properties of Fe_3O_4 nanoparticles*
Maria Vega. Universidad Pedagógica y Tecnológica de Colombia

C-05 *Síntesis y caracterización de nanopartículas de Fe_3O_4 y BaO utilizando el extracto de la hoja de Azadirachta*
Valeria Quíntana y Reinel Enrique Cardenas. Universidad del Atlántico

C-06 *Ferromagnetic resonance of magnetic multilayers at finite temperature*
Camilo García Acevedo. Universidad de Sucre

C-07 *Formation and control of defects in silicon using a potential bias*
Laura Maria Muñoz Martinez. Universidad del Valle

C-08 *Electrical transport measurements on metallic film with constriction*
Melvin James Godoy, Jimmy Cardenas and Jorge Luis Garcia. Universidad Nacional Mayor de San Marcos (Perú)

C-09 *Preliminary results on electrical transport measurements of YBCO Dayem bridge construction*
Melvin James Godoy, Jimmy Cardenas and Jorge Luis Garcia. Universidad Nacional Mayor de San Marcos (Perú)

C-10 *Electronic Spectrum of Ge-core/Si-shell annowires determined by means of atomic efective potencials calculations*
Ailyn Camacho Rocha. Universidad del Atlántico

C-11 *Green synthesis and characterization of carbon quantum dots from Hibiscus Sabdariff*
Jesús Amador Martinez. Universidad Popular del Cesar

C-12 *Synthesis and characterization of Mn-Zn nanocrystalline ferrites obtained via hydrothermal process from Aloe barbadensis Mill (Asphodelaceae) extract for the treatment of water contaminated with organic dyes*
Melissa Quevedo. Universidad del Atlántico

C-13 *Synthesis and characterization of ZnO nanorods: A simple synthesis*
Emely Ruiz Duarte. Universidad Popular del Cesar



Special Plenaries

2do Taller Internacional QTECNOS

Nano & Quantum Workshop 2024

Cartagena, november 25 to 29

Deep learning applied to quantum mechanical many-body problems

Morten Hjorth-Jensen*[1]

[1] *Department of Physics and Center for Computing in Science Education, University of Oslo, Oslo, Norway*

* *mhjensen@uio.no*

In this talk I will attempt at giving an overview, through selected examples [1, 2], on how Machine Learning (and AI based approaches) can aid in studying and analyzing quantum mechanical many-body problems, where deep learning methods provide a promising strategy for studying complicated interacting systems.

Keywords: Neural networks, Deep Learning, Monte Carlo methods, many-body physics.

[1] Jane Kim, Gabriel Pescia, Bryce Fore, Jannes Nys, Giuseppe Carleo, Stefano Gandolfi, Morten Hjorth-Jensen, Alessandro Lovato, **Neural-network quantum states for ultra-cold Fermi gases**, Nature Communications Physics **7**, 148 (2024).
[2] Bryce Fore, Jane M. Kim, Giuseppe Carleo, Morten Hjorth-Jensen, Alessandro Lovato, and Maria Piarulli, **Dilute neutron star matter from neural-network quantum states**, Physical Review Research 5, 033062 (2023)

Quantum entanglement and the era of new quantum technologies problems

Ángela M. Guzmán H.*[1]

[1] *Physics Department, Universidad Nacional de Colombia, Bogotá, Colombia.*

* *amguzmanh@gmail.com*

We have known the quantum nature of light and matter for more than a century but controlling the quantum world through engineering quantum states robust enough to be used in technological applications is recent. We have assimilated into our daily lives the first-generation quantum technologies: lasers, GPS, essentially based on quantum coherence and semiconductor technology. However, we still consider quantum entanglement as a "ghostly" action at a distance, a term coined by Einstein in a letter to Max Born in 1947. During the last century the experiments carried out by the pioneers of the second generation of quantum technologies, based on coherent superposition and quantum entanglement, settled the discussion about the completeness of quantum mechanics and laid the foundations for quantum information science and technology. The conjunction of the new materials sciences, nanoengineering, integrated optics, low-temperature electronics and cold atom physics has led to the incipient but hasty development of the second generation of quantum technologies, among which we can mention, quantum computing, quantum teleportation, quantum cryptography and quantum sensing.

Decoherence by low frequency noise and exceptional points of non-Hermitian matrices

Joakim Bergli*[1]

[1] *Physics department, University of Oslo*

* *jbergli@fys.uio.no*

Decoherence is the main obstacle to constructing reliable quantum computers. Therefore, it is important to understand the physical mechanisms of decoherence. In superconducting quantum devices, it is observed that the noise spectrum of the environment often is dominated by low frequencies, the so-called 1/f noise. I will describe how we can model 1/f noise by random telegraph processes. In this context, there appears a sudden change in behavior as the parameters of the model are changed, which can be understood in terms of an exceptional point of a non-Hermitian matrix. I will explain what this means and how this concept can appear in other contexts.

Keywords: Decoherence, 1/f noise, exceptional points.

Quantum coherence control and decoherence: a neural network approach

John H. Reina*[1]

[1] *Centro de Investigación e Innovación en Bioinformática y Fotónica—CIBioFi, Facultad de Ciencias Naturales y Exactas, Universidad del Valle, Cali 760032, Colombia*

** john.reina@correounivalle.edu.co*

* In collaboration with: Juan M. Scarpetta and Morten Hjorth-Jensen.

Advancing global efforts to realise quantum computing platforms require a sound physics-based description of the effects of noise on their qubits [1]. First-generation quantum processors need to consider scalable and reliable error mitigation protocols that account for the decay channels that arise in externally controlled multi-qubit open dynamics. This task is far from trivial. In this context, quantum coherence [2] and decoherence [3,4] are key issues in the design of imperfection-tolerant hardware and software for noisy intermediate-scale quantum technologies [1].

In an open quantum system, pure dephasing is usually the dominant channel responsible for the loss of information (coherence) in quantum mechanical superposition states - decoherence. To understand and mitigate such information loss, here we discuss the quantum coherent dynamics of an externally driven two-level system subjected to an environment that allows coupling from the weak to the incoherent strong-coupling regime [5], within a driven Spin-Boson (SB) model. Our approach follows the implementation of neural network (NN) algorithms [6] for the classification and approximation of generic spectral density functions by means of dissipative time dynamics data, through the repeated action of effective dephasing and dissipation quantum channels. This is done in two cases: i) a pure dephasing, exactly solvable, independent SB model [4]; ii) a general, externally-driven SB model [5]. We are able to classify the Ohmicity and the coupling regime of the dissipative dynamics. The implemented classification and regression models are tested by comparison with exact analytical [4] and numerical (e.g., HEOM, QUAPI) [5] solutions of the considered problems. Ongoing work aims at the systematic classification of non-Markovian features of the environment, as well as the dependence of quantum coherence on the characteristic bath cutoff frequency and the physical parameters of the external field. The NN models presented here can, in principle, also be used to study quantum effects due to fermionic and spin environments.

Keywords: Quantum coherence, open quantum system, neural network, noise spectroscopy, spectral density, Markovian/non-Markovian decoherence, quantum technology.

[1] J. Preskill. Quantum 2, 79 (2018); Z. Cai et al. Rev. Mod. Phys. 95, 045005 (2023).
[2] A. Streltsov, G. Adesso, M.B. Plenio. Rev. Mod. Phys. 89, 041003 (2017).
[3] A.J. Leggett, et al. Rev. Mod. Phys. 59, 1 (1987); U. Weiss. Quantum Dissipative Systems (World Scientific, Singapore, 2012).
[4] JHR, L. Quiroga, N.F. Johnson. Phys. Rev. A 65, 032326 (2002).
[5] J. Eckel, JHR, M. Thorwart. New J. Phys. 11, 085001 (2009); D Madrid-Úsuga, C.E. Susa, JHR. Phys. Chem. Chem. Phys. 21, 12640 (2019).
[6] G. Carleo et al. Rev. Mod. Phys. 91, 045002 (2019); D.R. Vivas et al. arXiv:2204.12966.

Anyons in quantum computation

P. H. Rivera*[1]

[1] *Facultad de Ciencias Físicas, Universidad Nacional Mayor de San Marcos, Lima, Perú*

* *priverar@unmsm.edu.pe*

Since the observation of integer and fractional quantum Hall states, the topological order in 2D systems play a fundamental rol in the analysis of these systems, specially when the strong interactions between fermions and quantum flux are involucrated originating quasiparticles of fractional statistics which are denominated as anyons. These states with intrinsic topological order exhibit long-range entanglement. And these characteristics suggest that these systems would be used for quantum computation.

In this talk, we made a revision of these ideas and will discuss briefly the theoretical advances, and the experimental results found in the literature about anyons.

Keywords: Neural networks, Deep Learning, Monte Carlo methods, many-body physics.

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Preliminary results about fabrication and study of DC Josephson junction based on YBCO superconductor

J.C. González*[*1], A. Bustamante[1], H. Sánchez[1], M. González-Esqueche[2], J. García[1], P. Paz[1], and F. Mori[1]

[1]Laboratorio de Cerámicos y Nanomateriales. Instituto de Investigación de Física. Universidad Nacional Mayor de San Marcos. Av. Carlos Germán Amezaga #375 - Cercado de Lima. Lima –Perú.

[2]Universidad Nacional de Barranca. Av. Toribio de Luzuriaga # 376, Mz. J, Urbanización La Florida, Distrito y Provincia de Barranca. Lima – Perú

** jgonzalezg1@unmsm.edu.pe*

One of the potential applications of superconductivity is the fabrication of electronic devices based on the Josephson effect using superconducting materials. These are superior to other technologies and have a wide field of applications. We present the preliminary results of the fabrication and study of a Josephson junction at zero voltage in linear configuration using YBCO thin film with a metal barrier. One goal of the project is to grow YBCO-textured thin films onto LaAlO 3 monocrystalline substrates using the sol-gel technique [1]. The results obtained by SEM, AFM, FTIR, Raman, and DRX are presented.

Keywords: YBCO textured, YBCO solgel, DC Josephson Junction.

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Ion implantation and annealing methods toward quantum emitters in silicon

D. Rivas-Gongora*[1], L. Vines[1], A. Galeckas[1], and A. Yu. Kuznetsov[1]

[1] *Department of Physics / Centre for Materials Science and Nanotechnology, University of Oslo, NO-0316 Oslo, Norway*

* *d.r.gongora@smn.uio.no*

Light sources emitting single photons on-demand are at the heart of quantum technologies, such as quantum computers, quantum networks, and quantum communications [1]. During the last decades, single-photon generation has been demonstrated in a variety of systems. Nevertheless, for practical applications, a single-photon source (SPS) must show high efficiency, room temperature functionality, compatibility with present-day integrated circuits manufacturing, and in the case of quantum communications, telecom wavelength operation. The most significant results have been achieved using Quantum Dots (QDs) [2]; however, QDs are typically based on III-IV semiconductors making their integration with silicon-based circuits not obvious. Alternatives such as single-photon emission from point defects in silicon carbide (SiC) [3], and more recently optically-active point defects in silicon (Si) [4] have shown promising results. However, significant advances in defect formation and identification, charge-state control, and tuning emission are still necessary to integrate optically active point defects in silicon-based quantum photonics and nanophotonics devices. In the present study, n- and p-type CZ and FZ Si wafers were irradiated with different proton energies in a range of fluencies from 5E10 to 5E12 cm-2 to obtain Si samples with low density of optical active point defects (1014 defect per cm2). Low-temperature (4K) photoluminescence (PL) spectroscopy was employed for the identification of irradiation-induced defects and for monitoring their evolution during post-annealing treatment. Finally, PL map measurements were used to observe the formation and density of the so-called W, G, and C defects in Si.

Keywords: Quantum technologies, optically-active point defects in silicon, quantum photonics and nanophotonics devices.

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Testing Simultaneous Einstein-Podolsky-Rosen Elements of Reality for Non-Commuting Observables Using Weak Values

Omar Calderón-Losada*[1,4], Tonatiuh T. Moctezuma Quistian[2], Hector Cruz-Ramirez[2], Sebastián Murgueitio Ramirez[3], Alfred B. U'Ren[2], Alonso Botero[3], Alejandra Valencia[1,3]

[1]Laboratorio de Óptica Cuántica, Universidad de los Andes, A.A. 4976, Bogotá D.C, Colombia

[2] Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Apartado Postal 70-543, Ciudad de México 04510, México

[3] Departamento de Física, Universidad de los Andes, A.A. 4976, Bogotá

[4] Currrently at Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, Edificio E20 No. 1069, Cali 760032, Colombia

** omar.calderon@correounivalle.edu.co*

The control of spatial correlations in entangled photon pairs, along with the concept of weak measurements [1], has attracted interest for both applied and foundational studies in quantum mechanics. In this work, we demonstrate that measuring two weak values in entangled photon pairs enables an experimental scheme to examine the type of assertions originally proposed in the seminal 1935 paper by Einstein, Podolsky, and Rosen (EPR) [2], which questioned the completeness of quantum mechanics. Our results indicate that it may be possible to assign simultaneous elements of reality to the weak values of two non-commuting observables [3].

Keywords: Weak measurement, EPR.

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Oral Contributions

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Characterization of entanglement in a simulated optical network

Jhoan Eusse*[1], Elizabeth Agudelo[2], Boris Rodríguez[1]

[1] *Grupo de Física Atómica y Molecular, Universidad de Antioquia, Medellín, Colombia.*

[2] *Theoretical Quantum Optics Group, Technische Universität Wien, Vienna, Austria.*

* *camilo.eusse@udea.edu.co*

Quantum entanglement has become a crucial resource in the rapidly growing field of quantum technologies. Today, applications such as quantum computation, quantum cryptography and quantum sensing rely on the ability to create and sustain this non- classical correlation in different systems and environments.

However, engineering, controlling, and detecting these quantum correlations in realistic setups are challenging tasks due to the presence of noise that can lead to the loss of such resources [1]. Therefore, the characterization of the different quantum correlations in diverse schemes is crucial to efficiently use such information resources.

Our aim is to characterize quantum entanglement in various optical arrangements. We have explored the use of computational tools for simulating and characterizing quantum correlations on a quantum optical network, which is a multimode light system that undergoes interference on a network of beam splitters. Such tools will be useful in the future to examine various configurations and estimate their effectiveness to implement in real-world applications.

We have used the Python library Strawberry Fields, developed by Xanadu, to simulate a quantum optical network comprising three beam splitters, where various quantum Gaussian states were mixed. We constructed a network consisting of a four-mode input Gaussian state and three 50-50 beam splitters as depicted in Figure 1. We combined two initial squeezed modes [2], then, we mixed the resulting output modes of the first beam splitter with two vacuum modes [2] using the other two beam splitters. Moreover, we performed entanglement characterization at different stages of the network using the Simon Criterion [3] and Logarithmic Negativity [4]. Throughout different points in the network, we detected logarithmic negativities above zero and violations of the Simon Criterion, showing entanglement. At the first beam splitter output ports, we detected an entanglement with a logarithmic negativity of 1.44270. No entanglement was detected between the outputs of the second or third beam splitter when analyzed separately. However, entanglement was detected between one output mode of the second beam splitter and one of the third, with a logarithmic negativity of 0.54806. These findings illustrate the entanglement dynamics between different light modes as they traverse the network.

We aim to further explore the use of Strawberry Fields for the construction and analysis of more intricate optical networks, incorporating additional elements, as well as non-Gaussian

transformations and states, to simulate configurations more approximate to real-world scenarios.

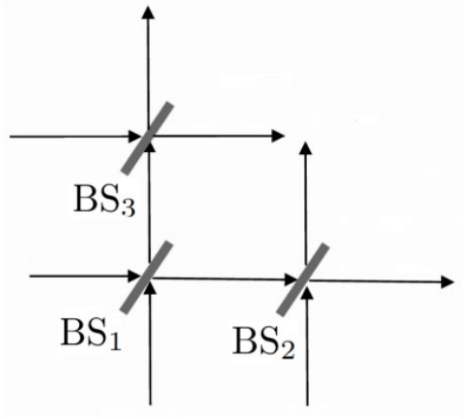


Figure 1. Quantum Optical Network with three beam splitters

Keywords: Entanglement, network, gaussian states.

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Quantum state engineering experiments with mesoscopic optical fields

Kishore Thapliyal*[1], J. Peřina Jr.[2], O. Haderka[2], V. Michálek[2], R. Machulka[2]

[1] *Department of Physics, University of Oslo, Norway*

[2] *Faculty of Science, Palacký University, 17. listopadu 12, 779 00 Olomouc, Czech Republic*

* *kishort@fys.uio.no*

Nonclassical states, having negative Glauber-Sudarshan P-function, do not have a classical analogue. These states have paved way for second quantum revolution and photonic quantum technology. A few examples of generation of such states in nonlinear optical processes and its challenges will be discussed. Photon number measurements and post-selection make a plethora of engineering of such quantum state feasible. Quantum state engineering using non-Gaussian operations provides powerful tool for continuous variable quantum information. Practical challenges in their implementation and feasibility of generation of such states will be discussed [1-4]. Twin beams are generated in a nonlinear optical process, namely spontaneous parametric down conversion, under stronger pumping. They are endowed with ideally perfect photon number correlations in the constituting signal and idler beams. This quantum feature is revealed by the sub-shot noise photon number correlations. However, the marginal signal and idler photon number distributions are multimode thermal. We illustrate the generation of engineered multimode quantum states from twin beams by photon subtraction and addition with supporting experimental realization. These states possess sub-Poissonian marginal photon number distribution in addition of the sub-shot noise correlations. Future prospects, in view of our results, will be discussed.

Keywords: Quantum state engineering, Photon addition, Photon subtraction.

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Description of an Optical matrix multiplier with the aim of application in All Optical Neural Networks

Andrés Felipe Arias*[1], Alejandra Valencia[2]

[1] *Laboratorio de Óptica Cuántica, Universidad de los Andes, A.A4976, Bogotá, D.C.,Colombia*

[2] *Laboratorio de Óptica Cuántica, Universidad de los Andes, A.A4976, Bogotá, D.C.,Colombia*

* *a.ariasv@uniandes.edu.co*

Neural Networks have become an extremely relevant topic because of their immense use in the modeling of complex systems and their wide application in diverse fields of physics and science in general. Neural Networks are composed of a series of layers made of neurons, in which the communication between layers is mediated by multiplying an input vector with what is called a weight matrix. Given this, we know that the mathematical operation of matrix multiplication is a crucial step in building a Neural Network. In this work, we describe a method of realizing the inner product between two matrices using Fourier optics and propose an experimental setup for such task. Because of the fact that it is possible to optically multiply matrices, it is viable to build an optical neural network using the architecture of the 4-f Optical Matrix Multiplier, which we describe briefly. Optical Neural Networks have the possibility to drastically reduce the energy and time needed for computations because of their high efficiency and parallel calculations [1].

For this purpose, consider reference [2] in which an optical 4-f System composed of two converging lenses and a mask is used to perform the matrix multiplication. More explicitly, to perform the multiplication A*B, the matrix B is projected in the input plane and the Fourier transform [3] of A is codified in the mask which can be either a spatial light modulator (SLM) or an inscribed acetate plate. This setup has the advantage of being relatively simple and replicable in other labs.

Keywords: Neural Networks, Photonics, Fourier optics.

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Understanding and using the Orbital Angular Momentum of Light for quantum computation with Qudits

Juan C. Rojas-Velasquez*[1], Alejandra Valencia[1]

[1] *Laboratorio de Óptica Cuántica, Universidad de Los Andes, A.A. 4976, Bogotá D.C., Colombia*

** jc.rojasv1@uniandes.edu.co*

Quantum computing has become an important field of study that aims to revolutionize and achieve better results than classical computers in some specific tasks. Typically, quantum computers use quantum systems with two bases, the well-known qubits. However, recently the use of quantum systems whose basis is made up of more than two basis states, known as qudits, has gained attention as an alternative for implementing quantum computing. This is because the implementation of qudits shows advantages over qubits like a higher density of information per physical entities, higher tolerance to noise and more efficient ways of implementing quantum algorithms [1,2].

Orbital angular momentum (OAM) is one of the degrees of freedom of light that would allow the implementation of quantum computing with qudits [2]. To do this, one must be able to manipulate the OAM so transformations on this degree of freedom could be performed. The tool that allows performing these transformations are called holograms; however, the use of holograms with the old-fashioned way (print the hologram pattern into acetate) was very demanding, so in recent years other tools like Spatial Light Modulators (SLM) were developed. These devices allow to project any hologram on the device so any OAM value could be assigned into a light beam. This tool also transforms the OAM and can be used to implement logical gates in an optical setup, which are the basis of any computation system. Inspired on the results obtained by Wang et al. [3], this work explores the generation of light beams with OAM using a SLM and the implementation of logic gates that transform the OAM content of light.

Keywords: Orbital Angular Momentum, High-dimensional quantum computing, Photonics.

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Optical responses in biofunctionalized spherical semiconductor quantum dots

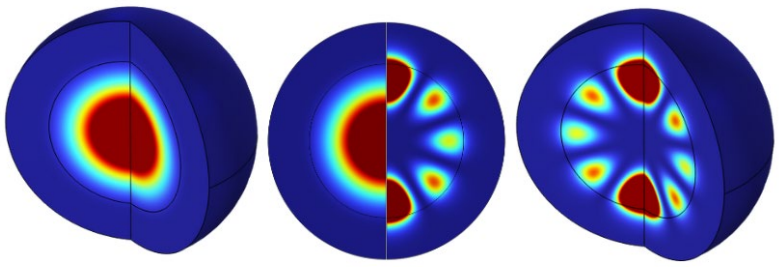
Angie L Prada Urrea*[1], Ricardo L Restrepo Arango[1], Claudia E Echeverri Cuartas[1], Natalia A Agudelo Pérez[1], Álvaro L Morales Aramburo[2], Carlos A Duque Echeverri[2]

[1] *Universidad EIA, C.P. 055428 Envigado, Colombia.*

[2] *Grupo de Materia Condensada-UdeA, Instituto de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Antioquia UdeA, Calle 70 No. 52-21, Medellín 050010, Colombia.*

* *angie.prada@eia.edu.co*

Given the optoelectronic properties of gallium arsenide (GaAs), it is currently a promising candidate for the development of optimal platforms for optical biosensing devices. The biofunctionalization of this semiconductor can be achieved using biomaterials extensively explored in life sciences for diagnostics. In this study, we investigate the synergistic impact of a functional biomaterial shell and a diatomic confining potential on the electronic and optical properties of GaAs/AlGaAs/Bioshell spherical quantum dots. Calculations were conducted within the framework of effective mass and parabolic band approximations, solving the Schrödinger equation for a confined electron using the finite element method (FEM). Our findings reveal that alterations in the sizes of the GaAs core, AlGaAs shell, Biomaterial shell, and confinement potential parameters result in significant variations in the energies of electron quantum dots and the optical absorption spectrum. We conclude that the diatomic confinement potential parameters enable adjustment of both ground and excited state energies, thereby modulating the amplitudes and positions of peaks in the obtained optical properties. This nuanced control over the quantum dot properties holds promise for tailoring device performance in optical biosensing applications. By enhancing sensitivity and specificity in detecting biomolecules, such devices could revolutionize biomedical diagnostics, offering rapid and accurate detection of diseases or biomarkers.



Keywords: Functionalized semiconductor, Spherical quantum dot, Semiconductor, Optical properties.

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Quantum Error Correction and the Surface Code

Delphine Martres*[1], Jesper Lind-Olsen[1]**

[1] *University of Oslo, Department of Physics*

** delphine.martres@fys.uio.no*
*** jesper.lind-olsen@fys.uio.no*

In this short lecture we will introduce basic concepts of Quantum Error Correction (QEC) in the frame of stabilizer formalism, and go on to describe a popular example of stabilizer code: the surface code, which most notably has been recently used by Google to achieve practical realizations of QEC[1].

Keywords: quantum error correction, stabilizer codes, surface code.

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Cold atom-atom-ion three-body recombination assisted by radiofrequency trap

Ana Noguera*[1], Mateo Londoño[2], Javier Madroñero[1]

[1] *Departamento de Física, Universidad del Valle, Edificio E20 No. 1069, 760032 Cali, Colombia*

[2] *Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794, USA*

* *ana.noguera@correounivalle.edu.c*

We developed a molecular dynamics simulation to study the three-body cold atom-atom-ion recombination process in the presence of a radiofrequency trap. Previous studies have demonstrated the presence of vibrational resonances in cold atom-atom-ion collisions under the influence of a radiofrequency field. The lifetimes of these resonances reach nanoseconds, which allows the dimer to interact with a third atom. This interaction leads to three-body recombination, where the third atom removes energy from the dimer, stabilizing it into a diatomic molecule. To investigate this inelastic process, we fully solved the equations of motion for the three bodies, considering that the ion interacts sequentially with each atom. Through these simulations, we calculated the three-body recombination rates by varying the parameters of the radiofrequency trap and the atomic species involved.

Keywords: Paul trap, trapped ion, cold atoms.

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Harnessing Nth Root Gates for Energy Storage

Elliot John Fox[1], Marcela Herrera[2*], Ferdinand Schmidt-Kaler[3], Irene D'Amico[1]

[1] School of Physics, Engineering and Technology, University of York, York YO10 5DD

[2] Facultad de Ingeniería y Ciencias Básicas, Universidad Autónoma de Occidente, Cali 760030, Colombia

[3] QUANTUM, Institut für Physik, Universität Mainz, D-55128 Mainz,

** amherrera@uao.edu.co*

We explore the application of fractional controlled-not gates, specifically Nth-root gates, in quantum thermodynamic protocols for charging quantum batteries. By employing quantum circuits with two and three qubits, we analyze the impact of Nth-root controlled-not gates on energy storage, with a focus on ergotropy as a performance metric. Our results demonstrate that the step-wise operation of these gates enables enhanced control over intermediate ergotropy states, offering advantages over traditional full gate operations. Initial system parameters, such as quantum coherence in one qubit, significantly influence performance, enhancing the ergotropy and efficiency of the battery. We also propose a figure of merit combining ergotropy variation and efficiency to identify optimal configurations. Experimental feasibility is discussed, highlighting the potential for implementation with current quantum technologies such as trapped ions. This work underscores the role of initial quantum coherence and gate optimization in advancing the practical realization of quantum batteries.

Keywords: quantum battery; quantum thermodynamics; ergotropy; quantum computation; quantum protocols

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Supramolecular arrays for quantum superabsorption: Toward a quantum battery

Juan David Álvarez Cuartas[1], John Henry Reina[1]

[1] *Universidad del Valle*

* *juan.david.alvarez@correounivalle.edu.co*

The quantum effect of superradiance, unlike its counterpart, superabsorption, has been extensively studied over the last 70 years, mainly because it dominates in natural systems. However, in the last decade, theoretical work and experimental realizations on different platforms have been made in the field of superabsorption, opening new possibilities for emerging technologies. One of the most promising developments in this area is the so-called "quantum battery" (QB). Unlike classical batteries, QBs exploit quantum effects such as superposition, coherence, and entanglement to achieve enhanced storage capacities and ultrafast charging times.

In this work, we present a theoretical and computational analysis of a QB modeled as an ensemble of N two-level systems (TLSs) coupled to a single mode of the electromagnetic field in a modeled cavity, where an external driving force is used to tune the interaction between the cavity mode and each TLS, allowing us to explore the dynamics and potential advantages of such a system.

The complete system is modeled by the Tavis-Cummings Hamiltonian, and its dissipative dynamics is modeled by the Lindblad master equation, where we used a cumulant expansion to obtain the system dynamics. From this, we obtain the stored energy, the power, and the charging time of the QB. We show that collective effects such as coherent interactions, enhanced by entanglement operation between the TLSs with the single cavity mode, can lead to superextensive behavior, such as superabsorption of energy. Finally, we discuss possible applications, with emphasis on organic supramolecular arrays in a microcavity, driven by an external coherent laser source.

Keywords: Superabsorption, supramolecules, quantum battery, quantum dissipative dynamics, cumulant expansion.

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Use of Decoy States as a Method for Increasing Security in a Quantum Key Distribution Protocol

Jorge Arias Muñoz*[1], Omar Calderón Losada[1], John H. Reina[1]

[1] *CIBioFi, Universidad del Valle, Cali, Colombia*

* *jorge.eduardo.arias@correounivalle.edu.co*

In this work we delve into the implementation of a Quantum Key Distribution (QKD) system using the BB84 protocol enhanced by decoy states [1]. The increasing capabilities of quantum computing threaten classical cryptographic techniques, making QKD an essential solution for secure communications. Decoy states provide a robust mechanism to address security vulnerabilities in practical implementations of the BB84 protocol [2]. This presentation will introduce the core principles of QKD and explain how decoy states improve security against eavesdropping. A computational simulation will be used to compare the performance of the BB84 protocol with and without decoy states, revealing the technical obstacles and solutions for real-world deployment in quantum communication systems.

Keywords: Protocol, eavesdropping, security, communication.

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Quantum Application in Ultra-Cold Atoms

Luis Ever Young Silva[1]

[1] *Grupo de Modelado Computacional, Facultad de Ciencias Exactas y Naturales, Universidad de Cartagena, Cartagena de Indias, 130015, Bolívar, Colombia.*

* *lyoung@unicartagena.edu.co*

In 1924 Albert Einstein predicted the phenomenon that is now known as a Bose-Einstein condensate (BEC) where below a certain temperature, a finite fraction of the total number of particles (bosons) would occupy the lowest-energy single- particle state. The first BEC was observed experimentally only several decades later (in 1995), when a dilute gas of rubidium-87 atoms was cooled to temperatures on the order of nano K. Nowadays many of the static and dynamic properties of an atomic BEC are studied by solving the mean-field Gross-Pitaevskii equation, which is a nonlinear partial differential equation similar to the Schrödinger equation that includes an additional term to describe the short-range atomic interaction [1]. Since the experimental realization of a dipolar Bose-Einstein condensate of atoms with magnetic moments in 2007, BEC of atoms with large dipolar atomic interactions are extensively used in theoretical and experimental studies in the pursuit of novel and interesting properties and features emerging as a consequence of anisotropic long-range dipolar interaction [1]. More recently, the study of supersolids or a superfluid solid, a quantum state of matter that simultaneously possessing the properties of both a solid and a superfluid [2], has gained new momentum among research workers in various fields, after the experimental observation of supersolids in a quasi-one-dimensional (quasi-1D), in a quasi-two-dimensional (quasi-2D) dipolar Bose-Einstein condensate. In the presence of dipolar atomic interactions, the corresponding Gross-Pitaevskii equation becomes a partial integro-differential equation, requiring the implementation of a complex algorithm for calculation of its numerical solution. For this challenge, we have published numerical programs for solving the GP equation including the contact and dipolar interaction in three spatial dimensions [3], and using these codes, here we will present some results using realistic parameters of experimental interest on Bose-Einstein condensates systems with the purpose of introducing their properties as a bridge between theory and possible future studies of phenomenological interest, whereby the results that we show here can be tested experimentally with present knowhow.

Keywords: Bose-Einstein condensate, Dipolar Bose-Einstein condensate, Supersolids.

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Towards a p-n heterojunction of Ga2O3 and diamond

Marte Pedersen Stalsberg*[1], Simon P. Cooil1

1Department of Physics/Centre for Materials Science and Nanotechnology, UiO, Oslo, Norway

** marteps@student.matnat.uio.no*

Optimizing our available power is essential to meet the growing demand for electricity. One way to achieve this is through the implementation of smart grids, electrical networks that combine sensors and digital technologies to anticipate the demand for- and distribute power in real time [1]. To realise smart grids and other power distribution systems, we need power electronics devices that can handle higher voltages, frequencies and currents. Ultra-wide bandgap (UWBG) semiconductors have been highlighted as candidate materials for such power electronics, due to their high critical fields and device figures of merit [2–4]. As the p-n-junction is a fundamental component in most power electronics, many have imagined a p-n-junction using UWBG materials. Creating a p- n-homojunction has proven difficult, as obtaining p- and n- doping in any of the UWBG semiconductors identified to date has been challenging [5]. We suggest a p-n- heterojunction of Ga2O3 and diamond, both UWBG materials that have received attention in later years, especially due to breakthroughs in growth techniques [6]. Reliable n-doping can be achieved in Ga2O3 [7], and its lattice parameters and band gap can be tuned Al- or In alloying [8]. The largest disadvantages to using Ga2O3 is however the lack of p-doping and excessive heating when used in devices [7]. P-doping of diamond has been shown to be controllable [9], and diamond can, due to its high heat capacity, work as a heat sink for Ga2O3 [7]. Using these two materials to make a p-n heterojunction has potential to increase the performance of power electronics beyond the state-of-art. Realising these p-n-junctions will require epitaxial Ga2O3 growth on diamond and knowledge on the electronic properties of the interface and the bulk. We investigate the initial stages of Ga2O3 growth on oxygen terminated (100) diamond using X-ray photoelectron spectroscopy. When Ga as a metal is deposited on the diamond surface, it is observed to bond to available oxygen sites. Further oxidization of the Ga metal layer using O-plasma results in different oxidation states.

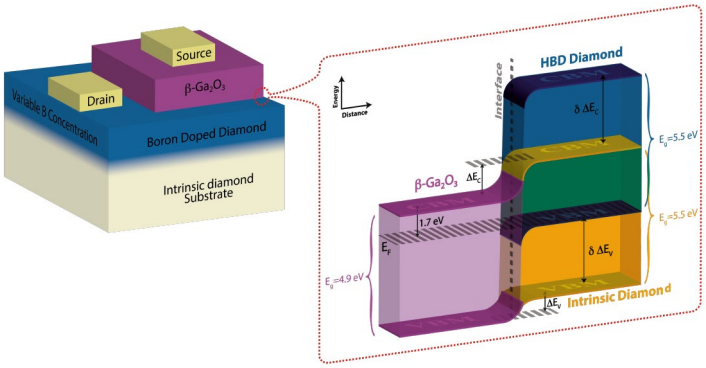


Figure 1. Schematic of the proposed p-n heterojunction and its band alignment at the interface

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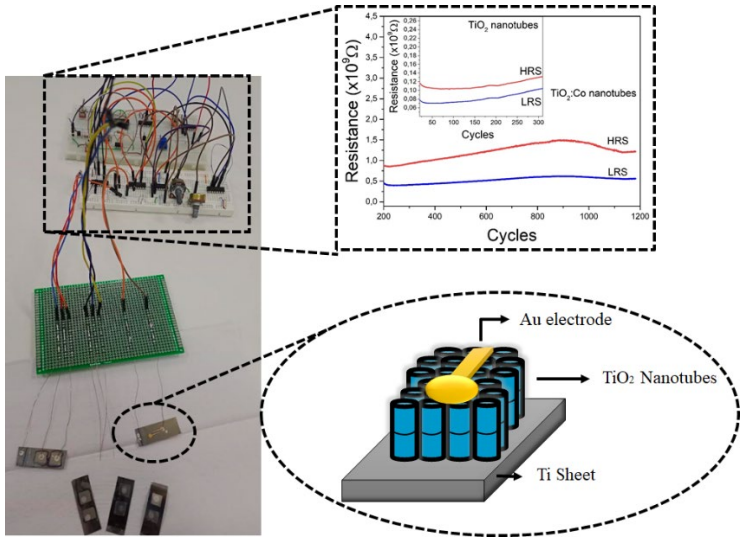
Memristor Type Structures Based On TiO_2 Nanotubes for Non-Volatile Memories Applications

Y. Porras Ramírez*[1], Daniela Laverde Lizarazo[1], Alejandro Gualteros[1], Heiddy P. Quiroz[1], A. Dussan[1]

[1]Universidad Nacional de Colombia - Bogotá, Dpto. de Física, Grupo de Materiales Nanoestructurados y sus Aplicaciones, Cra. 30 No. 45-03, Edificio 404 Yu Takeuchi Lab. 121C/121B-1, Ciudad Universitaria–Bogotá, 110001, Colombia

** yporrasr@unal.edu.co*

In this work, TiO_2 nanotubes were fabricated and implemented for use in Metal/Semiconductor/Metal (M/S/M) devices. The samples were fabricated through the electrochemical anodization method using previously established parameters. Metallic contacts of Au, Ti, and/or Al were deposited via metal evaporation as electrodes in the M/S/M structure. Voltage intervals ranging from -3 to 3 V, -2 to 2 V, and -1 to 1 V were established to perform robustness measurements (I-V curves) with 1200 cycles, aiming to analyze the stability of the resistive changes in the device. Additionally, a circuit was designed to verify the functionality of the device, using two voltage levels (1 and 5 V) to establish the logical states (0 and 1), respectively, which are associated with the binary states of a non-volatile information storage system. The procedure was performed for a specific device size, which holds 1 bit of information. Currently, progress is being made to develop the device at a smaller scale, with the goal of implementing it as a non-volatile memory laboratory prototype.



Keywords: Memristor, Nanotubes, Non Volatile Memories, Electrochemical Anodization.

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Structural and Optoelectronic Effects of Modified Sol-Gel Synthesized TiO_2 Nanoparticle Doping on $YBa_2Cu_3O_{7-\delta}$: Conduction Mechanisms

Silvana A. Palomino*[1], Lorena Marín[1,3], Mario Millán[3], Luis Alfredo Rodríguez[2,3], Juan Gabriel Ramirez[4], Wilson Lopera[1]

[1] *Thin Film Group, Department of Physics, Universidad del Valle, Cali 760032, Colombia*

[2] *Phase Transition and Functional Material Group, Department of Physics, Universidad del Valle, Cali 760032, Colombia*

[3] *Centre of Excellence for Novel Materials (CENM), Universidad del Valle, 760032 Cali, Colombia.*

[4] *Department of Physics, Universidad de los Andes, Bogotá 111711, Colombia*

* *silvana.palomino@correounivalle.edu.co*

Superconductors like $YBa_2Cu_3O_{7-\delta}$ (YBCO) have applications in energy, transport, medicine, and electronics.[1] They carry high currents without losses but need low temperatures. Adding nanometer-sized precursors, like titanium dioxide nanoparticles ($NPTiO_2$), can improve YBCO performance, including critical current density and intergrain connectivity.[2,3,4,5] However, more research is needed on their effects at room temperature.

The main objective of this study is to explore the effect of adding sol-gel modified synthesized $NPTiO_2$ to YBCO on its structural and optoelectronic properties at room temperature, which is essential for better understanding this material and enhancing its use in larger scale applications. TiO_2 nanoparticles were successfully synthesized with good size control using a modified sol-gel process. Key factors for controlling particle size included the *in-situ* formation of H_2O, the use of 2-propanol, and room temperature, where higher HCl concentrations resulted in smaller and more uniform particles.

X-ray diffraction patterns and Rietveld refinements confirmed the presence of YBCO peaks in each sample, without any secondary phases except for those with different oxygen contents. Raman analysis indicated an increase in oxygen content in the sample with 5% $NPTiO_2$, suggesting that the inclusion of $NPTiO_2$ did not negatively impact the oxygen content of YBCO, which is important for its potential applications as a superconductor.

The addition of $NPTiO_2$ altered the optoelectronic properties and conduction mechanisms of YBCO; while pure YBCO exhibited ohmic behavior, samples with $NPTiO_2$ showed space charge limited conduction (SCLC) behavior. This was attributed to the generation of surface traps and additional charge carriers by $NPTiO_2$, significantly altering the conduction mechanism. The hysteresis behavior observed in the current-voltage curves of the 5% $NPTiO_2$ (Figure 1.) sample

could be due to the presence of a resistive switching effect, with potential applications in RRAM memories, but further study is needed for confirmation.

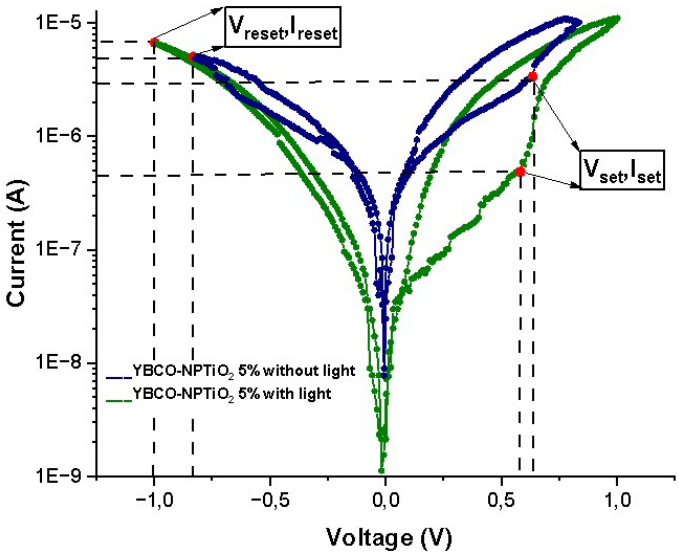


Figure 1. Current-voltage curves in semilogarithmic scale for YBCO-$NPTiO_2$ 5% in the presence and absence of light.

Keywords: $YBa_2Cu_3O_7$-δ (YBCO), titanium dioxide nanoparticles ($NPTiO_2$), conduction mechanisms.

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Ultra-thin films of CdS doped with silver: synthesis and modification of optical, structural, and morphological properties by the doping concentration effect.

Juan Pablo Molina Jiménez*[1*], Sindi Dayana Horta Piñeres[2], Jorge Luis Izquierdo Nuñez[3], Duber Alexander Ávila Padilla[4], Santos Jesús Castillo[5]

[1, 2, 4] *Laboratorio de Óptica e Informática, Universidad Popular del Cesar, Apdo. Postal 200001, Valledupar, Cesar, Colombia.*

[3] *Grupo de Investigación e Innovación en Energía, Institución Universitaria Pascual Bravo, Apdo. Postal 13114, Medellín, Antioquia, Colombia.*

[5] *Departamento de Investigación en Física, Universidad de Sonora, Apdo. Postal 5- 088, CP 83000, Hermosillo, Sonora, México.*

* *jpablomolina@unicesar.edu.co*

Ultra-thin films of CdS and Ag-doped CdS were obtained using the chemical bath deposition (CBD) technique. During synthesis, AgNO3 was added to the solution at molar concentrations of 0.25 mM, 0.5 mM, and 1 mM. The films were characterized by UV-Vis spectroscopy, X-ray diffraction (XRD), Raman spectroscopy, and scanning electron microscopy (SEM). Optical characterization revealed that increasing the doping concentration enhances the average optical transmittance in the visible region. The bandgap for the CdS sample was found to be 2.26 eV, increasing up to 2.35 eV for the film doped with 1 mM due to the concentration effect. XRD analysis confirmed hexagonal phase crystallization for all samples on the (1 0 1), (1 0 2), and (0 0 4) planes. Raman spectra revealed the presence of the first and second longitudinal optical phonon modes (1LO and 2LO), located around 300 and 600 cm^{-1}, respectively, for all samples, except for the CdS:Ag–1 mM thin film, which only displayed the 2LO mode. It was observed that the incorporation of dopants affects the vibrational properties of CdS. Specifically, the 1LO and 2LO modes tend to shift toward lower frequencies due to the reduction in particle size. SEM analysis confirmed that the CdS thin film consists of uniformly distributed granular nanostructures with relatively spherical morphologies, having an average size of 34 nm. After the incorporation of Ag ions, the grain size was reduced to 21 nm for the films doped at 0.25 mM and 0.5 mM. However, the sample doped at 1 mM exhibited grains of 38 nm. The average thickness of the thin films was measured at 46 nm, 21 nm, 20 nm, and 44 nm for the CdS, CdS doped at 0.25 mM, 0.5 mM, and 1 mM, respectively. This confirmed that the CdS and CdS films, especially the CdS and CdS:Ag–0.25 mM samples, are ultra-thin, homogeneous, and uniform. The optical response of all deposited films revealed that the spectral transmittance of the CdS thin film was around 60% in the visible range. After incorporating the Ag dopant, the absorption edge shifted toward shorter wavelengths with increasing concentration, leading to a higher spectral transmittance across most of the visible spectrum. The bandgap of the CdS thin film was 2.27 eV, while the bandgaps of the Ag-doped thin films were 2.33 eV, 2.34 eV, and 2.35 eV for the samples doped at 0.25 mM, 0.5 mM, and 1 mM, respectively. The overall results of this research classify CdS and CdS:Ag– 0.25 mM thin

films as potential candidates for use as n-type optical window layers in heterojunction solar cells.

Keywords: Thin films, semiconductors, CdS, nanostructures.

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Excitation of Localized Surface Optical Plasmon Resonance LSPR in PMMA Capillary Fibers Coated with Ag Nanoparticles for Sensing Applications

Yeiner Molina Fragozo*[1,2], Sindi Horta Piñeres[2], Duber Avila Padilla[2]

[1] *Graduate student in physical sciences, Universidad Popular del Cesar, SUE - Caribe*

[2] *Laboratorio de Óptica e Informática, Departamento de Física, Química y Afines, Universidad Popular del Cesar*

* *yyasshinmolina@unicesar.edu.co*

A sensor device based on the localized surface plasmon resonance (LSPR) phenomenon is presented for the measurement of refractive indices using a capillary fiber made of Polymethylmethacrylate (PMMA). The PMMA fiber was coated with silver nanoparticles (AgNPs) for 10 weeks using the immersion technique. The AgNPs were obtained using the green synthesis technique using the leaf extract of the Bougainvillea spectabilis plant [1]. The UV-Vis characterization of the AgNPs samples showed LSPR bands around 435 nm and another band around 272 nm associated with the leaf extract of the plant. The scanning electron microscopy (SEM) characterization of the capillary showed a homogeneous coating and the optical absorption analysis by diffuse reflectance shows absorption bands around 450 nm and 550 nm associated with the coating with AgNPs of different sizes. The sensing device implements a polymethylmethacrylate (PMMA) capillary fiber (with an average wall thickness of 220 µm and average external diameter of 850 µm) coupled to a 1.0 mm diameter PMMA optical fiber by means of epoxy resin. The experimental scheme uses an optical detector as a mechanism to interrogate the transmitted signal in the device based on the refractive index changes of a medium, and a light source in the range of 350-890 nm. In this device, the transmitted radiation propagates in the walls of the coated capillary fiber where it gives results the excitation of surface optical plasmonic resonances [2], located at resonant wavelengths between 468 nm and 485 nm for refractive indices of 1.3330 RIU and 1.3796 RIU respectively. The device allowed to detect variations in the refractive index of the order of 10^{-2} RIU for analyte quantities in the order of milliliters. During the characterization of the device, plasmon resonance wavelength shifts towards red with increasing refractive index were observed with reproducibility of the measurements with a linear sensitivity of the order of 358.65 nm/RIU.

Keywords: Ag Nanoparticles, Optical plasmon, Capillary fiber, Polymethylmethacrylate

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Controlling directionality of emission from quantum defects through microstructures in Silicon Carbide

E. L. Ousdal*[1], M. E. Bathen[1,2], A. M. Moe[3], A. S. Rongve[1] and L. Vines[1]

[1] *Department of Physics/ Centre for Materials Science and Nanotechnology, University of Oslo, 0316 Oslo, Norway*

[2] *Advanced Power Semiconductor Laboratory, ETH Zürich, 8092 Zürich, Switzerland*

[3] *Washington Mills AS, NO-7300 Orkanger, Norway*

* *e.l.ousdal@smn.uio.no*

Point defects in semiconductors are a highly anticipated platform for quantum technology (QT) with the advantage of being scalable, can potentially operate at room temperature, and relatively inexpensive to make and maintain. Moreover, for some of the material platforms where quantum friendly defects have been demonstrated, such as silicon (Si) and silicon carbide (SiC), there already exists a mature infrastructure for the fabrication of components.

Several point defects in SiC have proven to be single photon sources (SPEs) [1], which is of great interest in quantum applications. In this work, we mainly look at the silicon vacancy (V_{Si}) [2]; however, other defects of interest are the carbon antisite-carbon vacancy (CAV) [3] and the divacancy ($V_{Si}V_C$) [4]. Importantly, the electronic and optical properties of these defects depend on the polytype of SiC.

Here, we study a SiC-powder provided by Washington Mills that consists of 80 % 6H-SiC and the remaining 20% consist of a combination of 3C-, 4H- and 15R-SiC, see Ref. [5]. Thus, we are able to study the defects in the different polytypes simultaneously, enabling a comparison of polytype dependencies. However, the extraction from single photons in this case may depend on the particle size and shape. The powder is made through rough milling so the size and shape of every particle differs greatly, with size-variations of about 2-5 µm and morphologies varying between cubic, circular and triangular as shown in Figure 1.

This work presented in this contribution includes cathodoluminescence (CL) measurements of the SiC micro particles, focusing on emission from the Si vacancy as shown in Figure 2. The measurements were performed using a CL-extension for the JEOL IT-300SEM at 80 K and a varying acceleration voltage. We observe that the shape of the particle is of importance for the emission intensity of the SPE, as shown in Figure 2. The location of the emitter in the particle, i.e., the local morphology of the medium (Fig. 2b), directly impacts the intensity of emission from the Si vacancy (Fig. 2a). As the particle geometry affects the directionality of the photon emission, understanding the relationship between emission intensity and local morphology is a benefit when trying to maximize the signal from the emitter. By exploiting the geometry of the

host particle, we can increase the directionality of the photon emission, thus amplifying the signal.

The experimental work is combined with numerical Finite-Difference Time-Domain (FDTD) simulations using Lumerical, which we use to study emission profiles of idealised geometries such as spheres, cubes and pyramidal shapes as presented in Figure 3. The emission profiles clearly show how the geometry of the host for the emission source affects the directionality of the emission, both from experiments and simulation. There is, however, more work to be done to produce a full model of the impact of local morphology variations on emission from quantum defects in SiC. In the contribution, Angle-resolved CL (ARCL) of SiC micro particles will be discussed to better understand how the geometry affects the intensity and direction of emission from V_{Si}. Furthermore, Lumerical simulations will be used both to support the experimental findings, and to generate a general theoretical model for V_{Si}-waveguiding in SiC that can be of use for more realistic particle geometries. A discussion on the interpretation of Lumerical simulations in comparison to CL intensity maps and ARCL measurements will be presented in the final work.

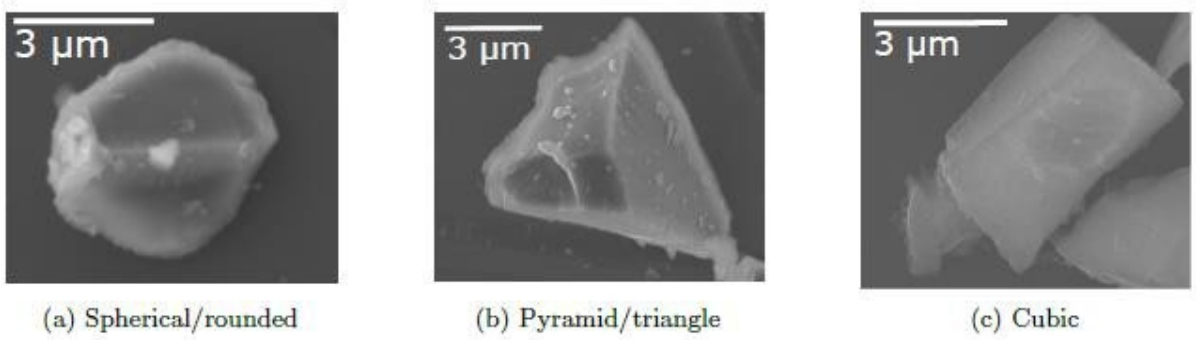


Figure 1. SEM image of SiC particles from the powder provided by Washington Mills. The image shows morphologies that resembles circular, pyramidal and cubic shapes. Obtained using an acceleration voltage of 10 kV for (a) and (b) and 23 kV for (c).

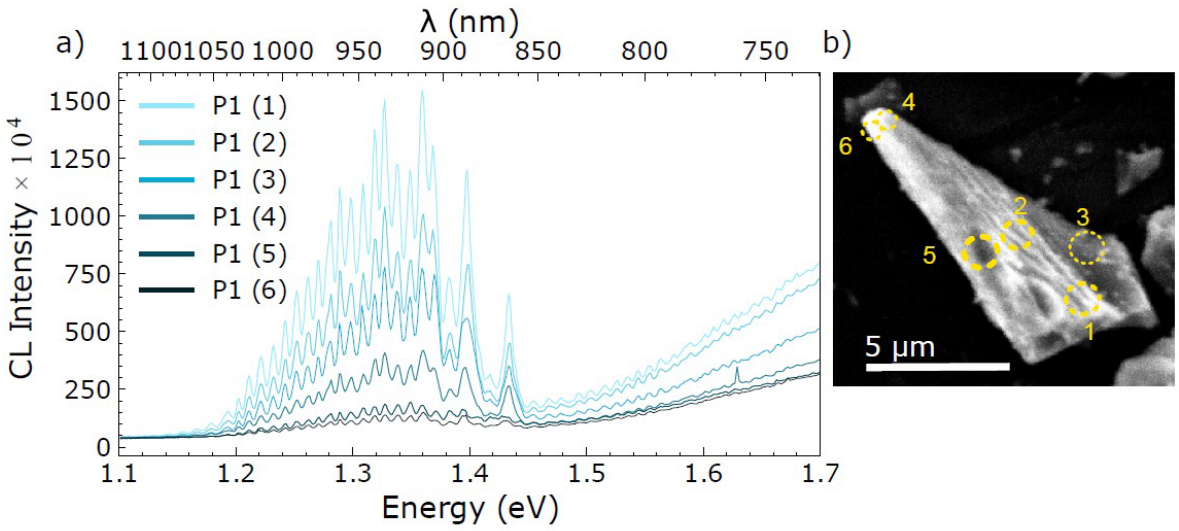


Figure 2. CL measurements from different locations on one SiC micro particle, focusing on the spectrum of the Si vacancy, showcasing how the intensity of the signal depends on where on the particle the signal is taken from. This shows that particle geometry could affect the directionality of defect emission. The CL spectra were collected at [80 K] using 10 kV acceleration voltage and 1 nA current.

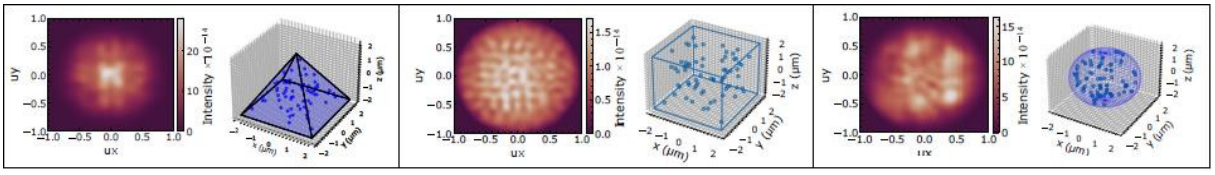


Figure 3. Lumerical simulations of V_{Si}-emission from Sic micro particles. The particle geometries are idealized and should not be treated as a realistic representation of the particles present in the SiC powder. Idealized geometries do, however, give valuable information about general emission mechanisms that can be exploited for waveguiding.

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Polariton-assisted charge transfer dynamics in organic donor-π-acceptor molecules

Juan C. Rodríguez*[1,2], John H. Reina[1,2]

[1] *Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, 760032 Cali, Colombia*

[2] *QuanTIC, Department of Physics, Universidad del Valle, 760032 Cali, Colombia*

* *juan.rodriguez.betancourt@correounivalle.edu.co*

Quantum materials focused on charge and energy transport have gained great importance for several reasons, one of which is the current global climate situation [1]. On the one hand, the charge transfer efficiency of such materials is highly dependent on their molecular and electronic structure [2]. On the other hand, the interaction with their environment induces decoherence [3,4], a process that degrades coherent charge transfer [4]. Overcoming the challenges that nature imposes on quantum transport with light is a task that has been explored in recent years, a field known as polariton chemistry [5].

Here, we model and simulate the open quantum dynamics of the charge transfer between the lower polariton, upper polariton and acceptor states of a donor-π-acceptor (D- π -A) organic molecule coupled to a quantized radiation field inside an optical cavity. The simulations were performed using the Hierarchical Equations of Motion (HEOM) method [6]. First, the time evolution of the molecule immersed in methanol was simulated, modeled as an ensemble of harmonic oscillators [7], without the influence of the optical cavity. Subsequently, the charge transfer in the D- π -A coupled to a perfect cavity was simulated at different coupling strengths. It was found that the effect of the perfect cavity QED increases the charge transfer rate and improves the transport efficiency between the polaritonic and acceptor states. Thus, we further propose the implementation of optimal quantum control techniques to tailor the charge transfer between the polariton and acceptor states. By exploiting the couplings between these states and taking into account the dissipation of the system, we aim to transfer the charge to the acceptor state in an efficient and accurate manner. The results of this study provide a foundation for the design of novel quantum materials and new quantum information technologies and protocols based on molecular qubits, and hopefully drive the implementation of such developments toward a greener future.

Keywords: Polariton chemistry, decoherence, open quantum systems, charge transfer, quantum control.

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Using surface-facet transitions to tune the electronic spectrum of colloidal silicon quantum rods

H. D. Robles*[1*], J. R. Cárdenas[1]

[1] *Universidad del Atlántico, Cra 30 No. 8-49, Puerto Colombia, 081007, Atlántico-Colombia*

* *hdrobles@mail.uniatlantico.edu.co*

The idea of inducing controlled changes in the electronic structure of nanometric devices via surface modifications has been proposed in the last few years by different authors [1]. In this work, we show that the judicious combination of surface facets on silicon colloidal quantum rods leads to strong modifications of the electronic structure. In this work, we propose a silicon nano rod structure where the ratio of surface facets (100)/(110) is modified along the system (fig. 1). Our results, obtained by means of atomistic calculations and effective pseudopotentials [2], show an energy bandgap more closely related to the symmetry rather than to the number of atoms or size of the system (fig. 2), exhibiting a reduction of the bandgap, in comparison to more uniform nanostructures, which may be convenient for opto-electronic application. Moreover, the wave function localization of the LUMO and HOMO states can be associated to a type-II heterostructure, which is unexpected considering that there is only one atomic species present all over the structure.

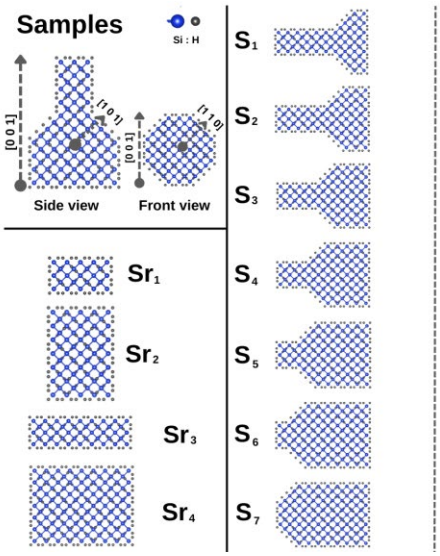


Fig. 1. Nanorod structures showing the atomic composition. The left-hand side shows the crystallographic orientations.

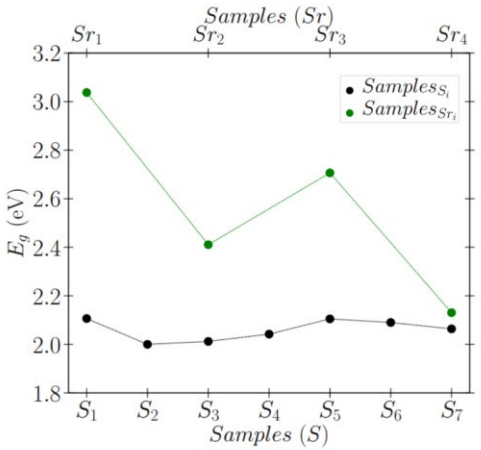


Fig. 2. Energy bandgap according to the shown in Fig. 1.

***Keywords**:* Atomistic calculations, electronic structure, semiconductor nanostructures.

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Single and two-particles dynamics of spin-1 lattice bosons in presence of external periodic magnetic fields

Sebastián Loaiza*[1], Karem Rodríguez[2]

[1] *Physics Department, Universidad del Valle, A.A 25360, Cali, Colombia*

* *loaiza.sebastian@correounivalle.edu.co*

In this work, we analyze the temporal dynamics of one and two bosons (alkaline atoms) with the lowest internal spin degree of freedom, i.e., spin 1, confined in a one-dimensional optical lattice [1]. The optical lattice simulates the crystalline structure of a solid, and in this work the kinetic energy dominates over the bosonic interaction, so this leads to the superfluid regime [2]. The interactions are limited only to bosons in the same potential well and the chemical potential regulates the addition or subtraction of particles. We use the Spin-1 Bose-Hubbard Hamiltonian, commonly represented in the basis of Sz. However, it is proposed to use the spin coherent basis and the quadrupolar basis [3], taking advantage of the SU(3) symmetry present in the system, in addition to being relevant to study the properties of the system in the presence of external magnetic fields. Temporal dynamics are modeled using Floquet's theory [4], establishing parallels with Bloch's spatial analysis but in a temporal framework. It was shown that even in the absence of interactions, for the case of a single particle, local spin-1 states inherently exhibit both spin and quadrupole order in time, and it even seems that the competition between these two orders can be condensed into a single inequality. Furthermore, for the two-particle case distinct phases and regimes were generated in the system due to the presence of external magnetic fields, the interaction regime (interaction dominates), the Zeeman regime (the dynamics turn off) and an inflection point between these, the spin-mixing resonance [5].

Keywords: Optical lattices, Spin-1 Bose-Hubbard model, Superfluid regime, Floquet theory.

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Ferromagnetic resonance of Magnetic Multilayers at Finite Temperature

J.S. Urquijo*[1], J.A. Otálora[2], O. J. Suarez[1]

[1] *Departamento de Física, Universidad de Sucre, A.A. 406, Sincelejo, Colombia;*

[2] *Departamento de Física, Universidad Católica del Norte, Av. Angamos 0610, Antofagasta, Chile*

* *juan.urquijo@unisucrevirtual.edu.co*

In the recent history of nanotechnology, nanomagnetism has played a pivotal role. The discovery of the fundamental properties of nanomagnets has driven technological advances in data processing, nanotechnology, and biotechnology. Examples include magnetic random access memories (MRAM), information filters, and high-frequency devices [1]. Understanding the magnetic properties of nanosized systems at finite temperatures is crucial for achieving significant technological advancements with practical applications. This work calculates a multilayer system's equilibrium configurations and the dispersion relation at finite temperature. Figures a) and b) show the geometry and configuration used for the system under study, which employs so-called "exchange springs", composed of multilayer systems with weak (S) and strong (H) anisotropy, connected through dipolar and exchange interactions [2]. The magnetic configurations of the S/H/S and H/S/H systems are analyzed. Furthermore, using the Landau-Lifshitz-Bloch equation (LLB), general expressions for the dispersion relation are derived that depend explicitly on system parameters such as temperature, applied field, wave vector, and the number of ferromagnetic films considered. It is found that the spin-wave properties and the precession frequency of the magnetic moments show reciprocity due to the spatial symmetry along the thickness, presenting a remarkable decrease with increasing temperature.

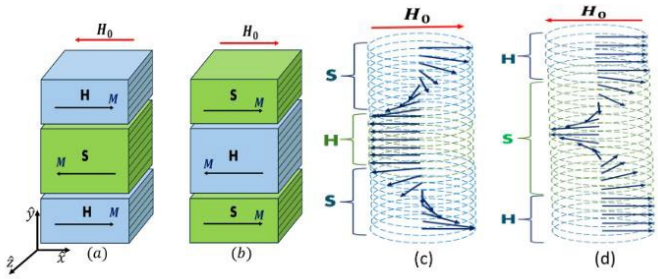


Figure: Geometry of the three-layer spring nanostructures (a) H/S/H and (b) S/H/S. Figures (c) and (d) represent the magnetizations in the different sublayers of the Soft (S) and Hard (H) blocks for both configurations.

Keywords: Spin Waves, exchange springs, multilayer systems.

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Kitaev chain qubit simulations

Eivind Støland*[1], Joakim Bergli[1], Yuri M. Galperin[1]

[1] *Department of Physics, University of Oslo*

* *eivind.stoland@fys.uio.no*

Quantum computation is challenged by decoherence of physical qubit systems. The proposed ways of getting around this problem is mainly either to use quantum error correction methods, or to construct more robust physical qubits. This work revolves around the latter of the two options, namely with topological qubits, where the two basis states of the qubit are related typically by non-local operations. This non-locality protects the state of the system against local perturbations from the environment, which is a major source of decoherence in commonly used systems. The Kitaev chain is a simple one-dimensional model which can host qubits with topologically protected states (topological qubits), and is experimentally realizable. The qubit states for this model are (degenerate) ground states of the system, and they are separated by a non-local operation at the two endpoints of a finite chain. Intentionally changing the state of the system is also difficult, but by encoding a set of logical qubits onto the physical qubit states of a multi-qubit setup, one can perform quantum gate operations on the logical qubits by braiding the endpoints of the chains that make up the qubits [2]. Braiding operations rely on adiabatic time evolution in order to be robust, as higher energy states of the system also exist separated from the ground state by a finite energy gap. We present parts of [1], spefically time evolution simulations of Kitaev chain qubits with finite rate of change in time in order to evaluate the non-adiabatic errors that arise. These simulations serve as proof of concept for simulations of braiding operations, both with or without certain kinds of (potentially time dependent) disorder effects. Simulating braiding operations require using more optimized numerical methods. The simulations presented here used direct diagonalization, and we therefore assume that we can find more efficient methods, opening up the avenue to study braiding operations numerically.

Keywords: *Kitaev chain, topological qubit, quantum computation, numerical simulation.*

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Efficiency of a heat engine enhanced by quantum coherences under dissipation

Freddier Cuenca Montenegro*[1, 2], Marcela Herrera[3], John Henry Reina[1, 2]

[1] *Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, Cali, Colombia*

[2] *Departamento de Física, Universidad del Valle, Cali, Colombia*

[3] *Facultad de Ingeniería y Ciencias Básicas, Universidad Autónoma de Occidente, Cali, Colombia*

* *freddier.cuenca@correounivalle.edu.co*

Quantum heat engines, depending on the dynamics of their cycles, can surpass the efficiency of classical engines [1]. This advantage arises from uniquely quantum features, such as quantum coherence, which play a pivotal role in boosting performance. In [2], Leggett and Garg proposed an inequality based on conditions that hold for macroscopic systems but are violated by quantum mechanics. This inequality allows us to detect non-classical temporal correlations in the dynamics of individual quantum systems [3, 4]. In this work, we examine a single quantum heat engine by analyzing the role of quantum decoherence in the working substance and its impact on both the extracted work and efficiency throughout the entire thermodynamic cycle. Additionally, we employ the violation of the Leggett-Garg inequality to demonstrate the non-classical nature of the quantum heat engine. Subsequently, the studied system is implemented in a quantum circuit, through unitary gates with their associated noise, so that the results obtained can be verified.

Keywords: Quantum thermodynamics, Quantum heat engine, quantum correlations, quantum dissipation.

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Theoretical and experimental coherent quantum control of single molecules using ultrashort pulses

Juan Manuel Scarpetta[1,2,3], Omar Calderón-Losada[1,2] and John H. Reina[1,2]

[1] *Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, 760032 Cali, Colombia*

[2] *Quantum Technologies, Information and Complexity Group (QuanTIC), Departamento de Física, Universidad del Valle, 760032 Cali, Colombia*

[3] *University of Oslo, N-0316 Oslo, Norway*

* *juanmsc@uio.no*

Quantum coherent control is a powerful technique used across various fields to manipulate and control quantum systems. This approach exploits interference effects to modify transition rates, often achieved through optical phase modulation[1, 2]. Despite challenges posed by inhomogeneities in materials and dissipation effects, single molecules have offered promising avenues for coherent control experiments [3]. In this project we develop a comprehensive theoretical framework for coherent control of two and three-level molecular quantum systems, optimizing pulse shaping to evaluate dissipative quantum dynamics and coherence propagation through simulations. An experimental implementation is also designed employing femtosecond pulse shaping technology to enable precise manipulation of spectral properties in the optical pulses. By integrating data analysis and machine learning algorithms to the experimental data, this work establishes a protocol for the extraction of relevant information about single molecule ultrafast dynamics and photophysical properties, leading to potential applications in the field of optical quantum technologies.

Keywords: Quantum coherent control, ultrafast spectroscopy, femtosecond dissipative dynamics

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Implementing a Hong-Ou-Mandel interferometer for single-photon pair indistinguishability and quantum optical coherence tomography

Juan E. Murillo*[1,2], Omar Calderón-Losada[1,2], John H. Reina[1,2]

[1] *Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, 760032 Cali, Colombia*

[2] *Quantum Technologies, Information and Complexity Group (QuanTIC), Departamento de Física, Universidad del Valle, 760032 Cali, Colombia*

* *juan.esteban.murillo@correounivalle.edu.co*

In a groundbreaking experiment conducted in 1987 by Hong, Ou and Mandel (HOM) [1], a significant quantum phenomenon known as the HOM effect was discovered. In this experiment, it was observed that when two indistinguishable photons impinge on a 50:50 beam splitter, each at one of the two input ports, the probability of coincident detections at the output is nullified [1]. This is because the probability amplitude of the two photons transmitted through the beam splitter cancels the probability amplitude of the two reflected photons.

The HOM effect is one of the hallmarks of the quantum behaviour of light and cannot be understood in terms of classical wave interference. This effect has shown great promise for use in several quantum-optical applications, in particular for investigating the degree of indistinguishability between a pair of photons [2] and for probing the morphology of a sample using the quantum optical coherence tomography (QOCT) protocol [3, 4]. In this study, a HOM interferometer was implemented to evaluate the indistinguishability of photon pairs generated by the spontaneous parametric down-conversion process in a nonlinear β-BBO crystal, achieving a high interference visibility of (91 ± 2)%. The results obtained confirm its ability to produce identical photon pairs with a coherence time of (79 ± 3) fs, demonstrating its suitability as a light source for QOCT applications [5]. Furthermore, despite the challenges posed by noise in the QOCT measurements, a method for determining a two-layer sample thickness from the data gave an accurate measurement of (131 ± 1) μm with only 0.8 % error.

Keywords: Hong-Ou-Mandel interference, indistinguishable photons, nonlinear β-BBO crystal, quantum optical coherence tomography.

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Pinn-assisted driven coherent dynamics and its resistance to dissipation

Luis Miguel Fabra Martínez*[1], Cristian E. Susa Quintero[1], Francisco J. González Sibaja[2]

[1] *Department of Physics and Electronics University of Cordoba 230002, Montería*

[2] *Department of Physics, University of Sucre 700001, Sincelejo*

e-mail: luisfabra28@gmail.com

Quantum systems do not usually exist in perfect isolation but interact with their surrounding. The dynamics of these open quantum systems is then affected by the properties of the environment and the way in which this latter interact with the system of interest. In this work, we study the effects of decoherence processes on the dynamics of a two-level system that is driven by a coherent control predicted by a Physics-Informed Neural Network (PINN). For doing so, the PINN is trained to predict a control according to a desired closed dynamics. Then, the system is considered to be affected by either a pure dephasing or amplitude damping process. The fidelity of the open dynamic to recovered the previously proposed closed dynamics is analysed in terms of the decoherence parameters. We also consider non-Markovian effects by considering time-dependent damping rates in the corresponding master equation approach.

Keywords: Quantum control, Physics-informed neural network, Open quantum system dynamics.

Agent-Based Modeling Meets Quantum Computing: A Study on Segregation

Nixon D. Lizcano*[1], Diego A. Muñoz[1]

[1] *Departamento de Matemáticas, Universidad Nacional de Colombia, Medellín, Antioquia, 050034, Colombia*

* *nlizcanos@unal.edu.co*

Schelling's segregation model offers insights into hidden segregation patterns arising from mild preferences within groups. Traditionally modeled as a random process, agents select new grid locations at random to maximize their "happiness" parameter. In this work, we reinterpret Schelling's model as a probabilistic Quadratic Unconstrained Binary Optimization (QUBO) problem, solved on a Quantum Annealer. By leveraging quantum superposition and entanglement, we aim to efficiently explore the computational complexity and the state-space of possible agent configurations. We also study existing algorithms for inverting agent-based models, such as those used in certain variants of Conway's Game of Life, to determine if a given output state can be generated by a set of rules, further deepening our understanding of algorithmic complexity in these systems.

Keywords: Quantum Computing, Quantum Annealing, Schelling, Cellular Automata, QUBO

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Quantum correlations and redundant information in quantum Darwinism

César Andrés Navarro*[1], Cristian E. Susa[1]

[1] *Department of Physics and Electronics, University of Córdoba, 230002 Montería*

* *cnavarroacosta83@correo.unicordoba.edu.co*

Quantum Darwinism explains how classical reality emerges from open quantum systems as amplified information witnessed by the environment. Quantum discord is a manifestation of non-classicality in quantum systems that is intimately related to the quantum-classical transition. When the system interacts with the environment, the information is distributed by means of decoherence. In this work, we discuss the relationship between quantum discord and redundant information. For doing so, we consider a set of qubits interacting with an environment (also considered to be qubits) through a unitary transformation [1].

Keywords: quantum Darwinism, quantum discord, redundancy of information.

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Bose-Einstein Condensate as a Quantum application

Jaime A. Correa*[1], Ana K. Fuentes[1] and Luis E. Young***[2]**

[1] Programa de Matemática, [2] Departamento de Física

Grupo de Modelado Computacional, Facultad de Ciencias Exactas y Naturales, Universidad de Cartagena, Cartagena, 130014, Bolívar, Colombia.

** jcorreop@unicartagena.edu.co,** afuenteso@unicartagena.edu.co, ***lyoung@unicartagena.edu.co*

The Bose-Einstein condensate is a state of matter discovered theoretically by Nath Bose and Albert Einstein around 1925 and experimentally in 1995 with Rubidium-87 and Sodium-23 atoms [1], when reaching temperatures nearly of nano Kelvin in dilute gases of these bosons systems with a typical size of the order of μm. It is well known that the Schrödinger equation describes the behavior of quantum systems. In a Bose-Einstein condensate, it is possible to apply the so-called mean-field approximation to obtain the Gross-Pitaevskii equation [2], which consists of a variation of the Schrödinger equation, including a nonlinear term characterizing the atomic contact interaction to describe the collective behavior of this microscopic system.

In quantum computing works based on the application of principles of quantum mechanics, unlike classical computers whose unit of information is a bit that can be 0 or 1, qubits can take advantage of quantum principles, which makes the information processing time very different from that of a classical computer [3]. Qubits must then behave as quantum objects, which is why a Bose-Einstein condensate is a good alternative to study these types of systems. Data transfer in the quantum machine is also a great challenge, it is here where the use of solitons in Bose-Einstein condensates becomes interesting since solitons are waves that propagate stably at constant velocity maintaining their shape, due to a scattering cancellation effect and nonlinear attraction, these waves are seen in the formation of a Bose-Einstein condensate as excitations arising in the interaction between bosonic particles experimentally with Litium-7 and Rubidium-85 atoms considering strong traps in two transverse directions [4]. Solitons in Bose-Einstein condensates could be used to simulate and try to understand the process to store and transmit quantum information, which would be of great help for information transfer in quantum computing, as seen in previous studies [5]. Starting from the Gross-Pitaevskii equation in a cylindrical symmetry under a harmonic oscillator-type confinement trap, considering a weak potential in the z direction compared with trap in the $x-y$ plane, we use the following equation to modeling solitons:

$$i\hbar\frac{\partial\Psi(\rho,z,t)}{\partial t}=\left[-\frac{\hbar}{2m}\nabla^2+\frac{n\omega^2}{2}\left(\rho^2+\lambda^2z^2\right)+g|\Psi(\rho,z,t)|\right]\Psi(\rho,z,t)$$

With normalization condition ∫ |Ψ(ρ, z, t)| ; where is the 2dr = 1 ρ = (x, y), $\hbar$ reduced Planck's constant, m the mass of the atom, ω the frequency of the confinement trap, λ is the constant that moderate the trap in z −direction, g =− 4π $\hbar 2aN$ /m the atomic interaction constant, where a (scattering length)

must be attractive and N is the number of particles in the condensate. In this work we will present results on Bose-Einstein condensates systems with the purpose of introducing their properties as a bridge between theory and possible future studies of quantum applications to motivate research and developments of this physical phenomenon.

Keywords: Bose-Einstein Condensate, Gross-Pitaevskii equation, soliton, qubit.

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Liquid Crystal-Based Polarization Control for Secure Communications

Miguel Ángel Rojas*[1], Juan Camilo Moreno[1], Marcela Herrera[1,2] and Omar Calderon[2,3]**

[1] Facultad de Ingeniería y Ciencias Básicas, Universidad Autónoma de Occidente, Cali, Colombia

[2] Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, Cali, Colombia

3Departamento de Física, Universidad del Valle, Cali, Colombia

**miguel_angel.rojas@uao.edu.co, ** juan_cam.moreno@uao.edu.co*

The quick advancement of quantum computing introduces both opportunities and challenges in secure communications. Classical cryptographic methods, such as RSA, are under threat from quantum computers capable of breaking their security protocols, so we face a fascinating challenge: how do we keep our communications secure in the quantum era? Quantum Key Distribution (QKD) emerges as a viable solution to ensure secure information exchange, with the BB84 protocol being the first and most prominent approach [1]. This project aims to contribute to the advancement of QKD systems by developing a device to control the polarization states of light, using liquid crystal technology to enhance the precision and stability required for photon-based secure communication.

Our project seeks to overcome critical technical challenges associated with the optical implementation of the BB84 protocol, particularly in the precise control of photon polarization, a key aspect for the quality and effectiveness in real-world implementation [2, 3]. By using liquid crystals, we aim to provide a non-mechanical, stable, and cost-effective means of controlling light polarization compared to traditional rotating motor-based methods [4]. The use of commercial LCD-extracted liquid crystals presents an accessible approach to enhance the viability of quantum cryptography systems.

The project involves designing and building a prototype that integrates electronic and optical schemes for controlling the polarization of light, followed by extensive experimental validation to ensure the accuracy and reliability of the system. We are not just building a prototype; we're creating a bridge between quantum theory and its practical application in conventional networks, in doing so, our goal is to make quantum encryption so practical and efficient that it can be integrated into existing telecommunications infrastructure without major complications. Ultimately, the outcome of this project is expected to benefit academic research in quantum optics and cryptography, as well as industries and governmental bodies needing secure communication channels resistant to quantum-based threats.

Keywords: Quantum Computing, Quantum Key Distribution (QKD), BB84 Protocol, Photon Polarization, Liquid Crystal, Quantum Cryptography, Secure Communication.

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The Eigenstate Thermalization Hypothesis in a system of Random Free Fermions: Insights from Random Matrix Theory.

Krystifer Campos Muñoz*[1], Javier Madroñero Pabón[1], William Esteban Salazar[1,2]

[1] *Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, Edificio E20 No. 1069, 760032 Cali, Colombia,*

[2] *ICTP South American Institute for Fundamental Research, Instituto de F´ısica Te´orica, UNESP Univ. Estadual Paulista, Rua Dr. Bento Teoobaldo Ferraz 271, 01140-070, S˜ao Paulo, SP, Brazil*

** krystifer.campos@correounivalle.edu.co*

The Eigenstate Thermalization Hypothesis (ETH) offers a framework for understanding the emergence of thermal behavior in closed many-body quantum systems. In this work, we present an analytical evaluation of ETH in a system of Random Free-Fermionswith all-to-all couplings [1]. By comparing the two-, and four-point correlation functions of local-operators against thermal ones (predicted by the Gibbs-distribution), we identify the regime in which ETH holds. Additionally, we calculate the sub-leading contributionsto those correlators induced by Random Matrix Theory by averaging over the 3 classical Gaussian Ensembles.

Keywords: Thermalization, Random Matrix Theory, Gaussian Ensembles.

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Numerical Modeling of the Coherent Backscattering Phenomenon in Non-Homogeneous Media

Nicolas Aguilera*[1], Omar Calderon[2], Javier Madroñero[2]

[1] *Departamento de Física, Universidad del Valle, Cali, Colombia*

[2] *Departamento de Física, Universidad del Valle, Cali, Colombia*

* *nicolas.aguilera@correounivalle.edu.co*

During light-matter interaction, a scattering phenomenon occurs in which part of the light beam's intensity is redirected from the direction of propagation into all directions. When observing angles close to backscattering, a cone-shaped peak in the intensity of the reflected light can be observed. This phenomenon, known as coherent backscattering, arises from the constructive interference of waves propagating in opposite directions through the medium [1,3]. Previous studies have found relationships between the width of this peak, spatial anisotropy, and the intensity distribution with the size of the scattering particles [2,4]. In this project, Monte Carlo simulations were developed, focused on tracking the transformations of the electric field along ray propagation, to model the interaction between light and the scattering medium using the phase function of the Rayleigh-Debye regime. This allows us to take into account different particle characteristics, such as shape and size. We also consider the polarization changes that occur in each scattering event using the Jones matrix formalism. From these simulations, we explore the behavior of coherent backscattering in scattering media composed of mixtures of different types of particles, identifying patterns in the signal profiles related to the different particles present in the scattering medium.

Keywords: Scattering, coherent backscattering, polarization, Monte Carlo simulation.

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Analysis of quantum obesity in correlation swapping and DQC1 protocols

Walter Carreño*[1], Cristian E.Susa[1], Pedro Rosario[2]

[1] *Departamento de Física y Electrónica, Universidad de Córdoba, 230002, Montería Colombia*

[2] *Departamento de Física, Universidad Federal de Sao Cãrlos*

* *wcarrenodurango@correo.unicordoba.edu.co*

We use quantum obesity, a type of quantum correlation defined through the volume of the quantum steering ellipsoid of a bipartite system, to characterize the correlations present in two significant scenarios in quantum information theory: The swapping of quantum correlations protocol and the deterministic quantum computation with one qubit (DQC1) model. For swapping protocol, we discuss the amount of quantum obesity that is swapped according to its analytical formula in terms of the obesity of initial quantum states and the intermediate measurement process. In the DQC1 model, we examine the obesity between the control qubit and the auxiliary qubits by considering local filtering and post-selection operations.

Keywords: Quantum steering ellipsoid, entanglement swapping, DQC1.

Study of Quantum Thermodynamics in Simple Solar Cell Models for the Analysis of Energy Efficiency

Johan Sebastian Pinzón Mesa*[1]. Ph.Oscar Hernando Bohorquez Martinez[1].**

[1] *Universidad de Pamplona*

* *johan.pinzon@unipamplona.edu.co*

** *oscar.bohorquezma@unipamplona.edu.co*

Photovoltaic cells is the fundamental units in solar panel construction, which play a crucial role in the energy transition as a renewable energy source. Their operation is based on the collection of solar radiation and its conversion into electrical energy through the use of p-n semiconductor materials. Since the first cells were manufactured with an energy efficiency of 1%, technological progress has led to continuous improvements in their performance; however, much remains to be done to approach the theoretical limit, the Shockley-Queisser limit, which is around 30 %. In this work we study two quantum models proposed for the operation of a photovoltaic cell; the first, a simple representation consisting of a system of two energy levels with a single relaxation mechanism with the environment; the second, a donor-acceptor type model consisting of a system of four energy levels and different relaxation mechanisms between levels and with the environment; both systems will interact with Gaussian photon pulses. The dynamics of the studied models are described by the Lindblad equation and the interaction with light is studied by the Jaynes-Cumming model. For the four-level system, two types of studies were conducted: one using realistic parameters and another using non-realistic parameters to observe the thermodynamic behavior under different conditions. The results include numerical simulations of the thermodynamic variables, aiming to evaluate and compare the energy efficiency with the literature, using the Shockley-Queisser limit as a reference.

Keywords: Photovoltaic cell, energy efficiency, Lindblad equation, thermodynamic variables and energy levels.

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Dynamics of a bosonic particle system in an anisotropic double well using path integrals

Kevin Giraldo*[1], Javier Madroñero[1], William E. Salazar[2]

[1] *Departamento de Física, Universidad del Valle, 760032 Cali*

[2] *South American Institute for Fundamental Research, Instituto de Física Teórica, UNESP, São Paulo*

* *kevin.giraldo.hincapie@correounivalle.edu.co*

From a theoretical point of view, much attention has been paid to weakly interacting many-particle systems, for which mean-field techniques provide very accurate results. In this work we study the dynamics of an anisotropic Bose Hubbard dimer in the limit of a large (but finite) number of particles. By means of the Schwinger representation of the SU(2)-algebra, the many-body partition function of the Dimer is computed via the path integral one of a single spin in the presence of transversal, and longitudinal magnetic fields. The Bose-Hubbard model has emerged as a prototype for describing interacting bosons in a lattice, playing a crucial role in understanding quantum phase transitions and many-body dynamics. It is proposed to analyse the dynamics of this particular system in order to better understand its properties and behaviour. To this end, we seek to calculate the partition function at the perturbative level for the bosonic particle system in an anisotropic dimer using the formalism of spin path integrals and the Schwinger mapping. Additionally, thermodynamic observables obtained from the partition function in the infinite-particle limit will be analysed with the mean-field approximation.

Keywords: Bose-Hubbard model, dimer, Schwinger mapping, path integrals.

Floquet Dynamics of one-dimensional disordered spin chains with local interactions.

Rafael Alejandro Vélez González*[1], Javier Madroñero Pabón[1], William Esteban Salazar[2]

[1] *Departamento de Física, Universidad del Valle, Edificio E20 No. 1069, 760032 Cali, Colombia*

[2] *ICTP South American Institute for Fundamental Research. Instituto de Física Teórica, UNESP, São Paulo.*

* *velez.rafael@correounivalle.edu.co*

Spin chains are intriguing both theoretically and experimentally, as they encompass various aspects of many-body chaos, including thermalization [1], localization effects and entanglement [2, 3]. In this work, we study the dynamics of a perturbed and periodically excited Ising-type spin-1/2 chain of particles in a one-dimensional ring in the presence of transverse and longitudinal magnetic fields. By means of the space-time dual formalism introduced in [3, 4], we analyze the Floquet dynamics of the spin chain by mapping it into a two-dimensional model of classical spins in the presence of a random magnetic field.

Keywords: Floquet theory, Ising model, dual space-time.

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BODIPY-pyrene halogenation: Optoelectronic effects

Carlos A. Jaramillo*[1,2], John Henry Reina[1,2], Omar Calderon-Losada[1,2]

[1] *Quantum Technologies, Information and Complexity Group (QuanTIC), Universidad del Valle, 760032 Cali, Colombia*

[2] *Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, 760032 Cali, Colombia.*

* *carlos.andres.jaramillo@correounivalle.edu.co*

The demand for materials with efficient charge transfer properties highlights the importance of using spectroscopic techniques to characterize molecular dynamics. We used time-resolved fluorescence spectroscopy to study the emission spectrum and fluorescence lifetime of BODIPY-pyrene (PyBDP) molecules. Based on the results for Rhodamine B, we laser-tuned our measurements. This enabled the first report of halogenation affecting PyBDP, PyBDP-Br and PyBDP-I molecules. The second-order correlation function of the fluorescence emission of individual PyBDP molecules was determined for the promising brightness property, with the aim of searching for single-photon sources.

Keywords: Time-resolved fluorescence spectroscopy, emission spectrum, fluorescence lifetime, PyBDP, PyBDP-Br, PyBDP-I and second-order correlation function.

Nonlinear Localized Modes in a Rhombic Lattice

E. Conrado Dieppa*[1], Cristian Mejía-Cortés[1]

[1] *Programa de Física, Facultad de Ciencias Básicas, Universidad del Atlántico, Puerto Colombia 081007, Colombia*

* *edconrado@mail.uniatlantico.edu.co*

The propagation of light in waveguide arrays exhibits unique characteristics of discrete systems, enabling the design and control of their diffraction properties. This control opens new possibilities for manipulating light flow, including phenomena such as diffraction-free propagation and the reduction of power requirements through nonlinear effects [1,2]. In this work, the behavior of light in a quasi-one-dimensional waveguide array with a rhombic periodic geometry is studied. The study focuses on how the structure and coupling between waveguides affect light propagation, providing a foundation for the design of future photonic devices.

The analyzed system assumes an infinite, discrete Kerr-type nonlinear medium composed of waveguides arranged in a rhombohedral geometry. The modeling of optical beam propagation is performed using the Discrete Nonlinear Schrödinger Equation (DNLSE). Initially, localized modes are obtained by numerically solving the system's stationary equations with an iterative method and the Newton-Raphson algorithm. The solutions are classified into families, and their stability is evaluated through linear stability analysis. Subsequently, the dynamics of localized modes are studied using the DNLSE to explore their behavior.

The results reveal the existence of different families of solutions, some of which exhibit soliton-like solutions, arising from the interaction between the discrete diffraction imposed by the structure and the medium's nonlinearity. Additionally, two families with energetic similarities were identified, enabling transverse mobility within the network between them under the application of an external energy impulse. This phenomenon also facilitated the generation and manipulation of Bloch oscillations within the network.

Keywords: DNLSE, Waveguide arrays, Soliton.

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Analysis of Coherent Backscattering of Light in Aqueous Media for the Characterization of Colloidal Particles

María Del Mar Pérez Bejarano*[1], Omar Calderón Losada[2]

[1] *Departamento de Física, Universidad del Valle, Edificio E20 No.1069,760032Cali, Colombia*

* *maria.perez.bejarano@correounivalle.edu.co*

Coherent backscattering of light (CBS) is a phenomenon of multiple wave scattering in a disordered medium. It occurs because scattering paths through a colloidal solution can be traced in two opposite directions. The two counter-propagating waves along each scattering path emerge in phase from the solution, constructively interfering exactly in the backscattering direction. This characteristic has become a valuable tool for characterizing particles in suspension, as it allows the study of particle properties such as size and concentration, providing crucial information for various applications. This research focuses on studying the CBS phenomenon in aqueous media by implementing a technique for the characterization of colloidal particles through the design and development of a compact optical setup.

Keywords: Coherent Backscattering, Particles in Suspension, Characterization, Concentration, Size.

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Optical Fibers Coated With Oxidated Graphene For Sensing Applications

Camila Noreña Julio[1], Sindi Horta Piñeres[2], Duber Ávila Padilla[2]

[1] *Estudiante de Maestría en Ciencias Físicas. SUE Caribe, Joven Investigador, Universidad Popular del Cesar, Valledupar, Cesar, Colombia*

[2] *Grupo de óptica e Informática, Universidad Popular del Cesar, Departamento de Física, Química y Afines, Valledupar, Cesar, Colombia*

** e-mail of candreanorena@unicesar.edu.co*

Oxidized graphenes are materials characterized by being compounds with interesting optical, electrical, thermal and mechanical properties. These materials are currently used for multiple applications in different fields of science and engineering, such as optical sensing and detection applications. On the other hand, refractive index (RI) sensors are interesting devices with a wide range of applications for the measurement of physical, chemical and biological variables, as well as the detection of chemical components and biological elements that are difficult to detect using commercial devices. In this research we propose the use of oxidized graphenes to improve the sensitivity of optical sensors based on optical fibers through two different configurations for the measurement of refractive index. The developed devices were implemented through a tapered optical fiber configuration and a knot-shaped configuration. These devices were coated using the heating-assisted immersion technique in a liquid solution of oxidized graphene obtained from the sonication and mechanical exfoliation technique. The obtained oxidized graphenes were characterized using optical absorption and Raman spectroscopy techniques. For the characterization of the device for measuring refractive index changes, the sensor in knot configuration was fabricated from a multimode optical fiber and characterized with a halogen light source in the range of 370 nm to 1000 nm. For the characterization of the device in the tapered optical fiber configuration, the sensor was fabricated using a single-mode optical fiber and excited with a light source in the ranges of 370-1000 nm (halogen light source), 1030-1090 nm (superluminescent diode) and 1500-1600 nm (tunable laser diode). For the interrogation of transmitted light, an optical detector and an OSA optical spectrum analyzer were used in water samples with sucrose in the range of 1.33 - 1.42 RIU, which were able to show a shift towards longer wavelengths with the increase in the refractive index at the transmission peaks. In the case of the device in the tapered optical fiber configuration, the increases in refractive index cause a decrease in the intensity levels of the transmitted light. The results reveal sensitivities of the order of 715 nm/RIU for the configuration in knot-shaped optical fiber and 5.2 mW/RIU for the configuration in tapered optical fiber. Within the conclusions of the research, it is possible to reveal that the control for the homogeneous coating of optical fibers with oxidized graphenes is a challenge for the academic

community, however, this can be balanced with its capacity to measure chemical variables and detect compounds and molecules that are difficult to detect with traditional techniques.

Keywords: Oxidized graphene, optical sensor, optical fiber.

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Two-Photon Absorption of Four Benzoxazole Derivatives: A Density Functional Theory-Based Approach

Edwin Rivera*[1], Oriana Avila[1], Rubén Fonseca[1]

[1] *Optical and Laser Spectroscopy Group (GEL), Universidad Popular del Cesar, Valledupar, Colombia*

* *edwinrivera@unicesar.edu.co*

In the last decade, the study of the nonlinear optical properties of organic compounds (OCs) has gained prominence due to their direct relationship with various applications of interest in fields such as engineering, medicine, photonics, and materials science. One of the most relevant nonlinear optical phenomena for its applications is two-photon absorption (TPA). According to the literature, advances in the study of this phenomenon have enabled the synthesis of new materials with applications in two-photon microscopy, photodynamic therapy, photopolymerization, laser generation, and advanced optical devices. Currently, there is a growing demand for organic materials with high TPA capacity for the development of lasers applicable in telecommunications, microstructure fabrication, and high-efficiency photonic devices for optical computing. In this context, the study of two-photon absorption (TPA) of four benzoxazole derivatives is proposed using Density Functional Theory (DFT). Methodologically, the benzoxazole derivatives were designed and modeled by elongating the molecular structure with three consecutive aromatic rings (benzene, oxazole, and benzene), as well as including steric substitutions of amino groups and nitrogen dioxide, both individually and simultaneously, to incorporate the push-pull effect in the corresponding region of the molecule. The molecules were optimized for their ground state in the gas phase, in methanol, and in toluene, employing stationary DFT with the hybrid functionals CAMB3LYP and the Gaussian bases 6-311++g(d,p). TPA calculations were performed using TD-DFT with the same functionals and Gaussian bases. Among the obtained results, it is noteworthy that the TPA spectra show the following variations: in the gas phase, absorption peaks reach 15 GM at 475 nm, while in methanol higher values are observed, close to 160 GM at 470 nm, and in toluene, approximately 170 GM at 480 nm. The compounds exhibit a decrease in TPA absorption efficiency starting at 550 nm, dropping below 20 GM until approximately 700 nm. In conclusion, all studied compounds absorb two photons in the blue region of the visible spectrum.

Keywords: Two-photon absorption, Organic compounds, Density functional theory.

The anisotropic Bose-Hubbard dimer in the mean-field approximation

Isabella Becerra Arbeláez*[1,2,3], William Esteban Salazar Estrada[1,2,3], Javier Madroñero Pabón[1,2,3]

[1] Universidad del Valle, Campus Meléndez Calle 13 # 100-00, Cali, Colombia.

[2] Centre for Bioinformatics and Photonics (CIBioFi) , Campus Meléndez Calle 13 # 100-00, Cali, Colombia.

[3] Quantum Technologies, Information and Complexity (QuanTIC), Campus Meléndez Calle 13 # 100-00, Cali, Colombia.

* isabella.becerra@correounivalle.edu.co

The system formed by two coupled Bose-Einstein condensates, also known as the Josephson bosonic junction, is studied in a double well model in which ultracold atoms are trapped. Special attention will be paid to the little-studied case in the literature of asymmetric wells, which can be produced by an external static field (Wannier-Stark effect). A large number of particles is considered, which makes it possible to use the semiclassical mean-field approximation. The Hamilton-Jacobi equations are calculated and an analysis of fixed points with their classification is made. The breaking of the symmetry in the well is observed, which is reflected as a dissipative process in the semiclassical dynamics, which in turn leads to the fact that the fixed points in the phase space do not correspond to an imbalance (expected value of the particle difference in each well) null, as was the case with the analogous system of symmetrical wells.

Keywords: ultracold atoms, optical lattices, dimer, and Wannier-Stark effect.

Dependence in the Many-Body Entanglement Structure of Local Quantum Circuits

Andres Valencia*[1], Javier Madroñero[1], William Salazar[2]

[1] Quantum Technologies, Information and Complexity Group (QuanTIC), Departamento de Física, Universidad del Valle, 760032 Cali, Colombia

[2] ICTP South American Institute for Fundamental Research, Institute of Theoretical Physics, UNESP,São Paulo

* andres.valencia.fonseca@correounivalle.edu.co

One of the most interesting properties in quantum information is entanglement, which is a valuable resource in quantum computing and information applications. Despite its significance, there remain fundamental questions, such as how to quantify and detect entanglement. These questions have been approached in various ways, generally by assigning a metric using the system's entropy to quantify entanglement. Rényi entropy (Sn), which generalizes a family of entropies, offers a versatile approach for studying entanglement. To explore its behavior in relation to circuit architecture, a technique called the minimal cut method has been developed [1], which is based on finding the number of non-zero coefficients in the Schmid decomposition through cuts in the circuit, to obtain Hartley's entropy, $S0$, providing an upper bound for Sn, transforming the problem of entropy behavior into a geometric problem [2].

In this work, an algorithm inspired by graph theory is developed to calculate the minimum number of cuts in a quantum circuit, with the aim of analyzing unitary quantum circuits with a random architecture of local one and two qubits. A uniform probability distribution of the gates is studied, investigating the behavior of entropy as a function of the number of qubits and the circuit depth, additionally, the thermodynamic limit for these parameters is obtained analytically, allowing the study of quantum entanglement growth. Finally, a comparison is made between the numerically exact entropy and the estimation based on the minimum cut.

Keywords: Entanglement, entropy, minimal cut, random unitary dynamics, quantum computing and information.

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Anisotropic and external field effects on a ferrimagnet of spins S = 3 y σ = 7/2

Jorge Arturo Hoyos García*[1], Nicolás de la Espriella Vélez[1]

[1] *Department of Physics, Grupo Gamasco, Universidad de Córdoba, Córdoba 230002*

* *jorgehoyosg@correo.unicordoba.edu.co*

By means of Monte Carlo simulations, the thermomagnetic behavior of a spintronic configuration of S=3 and σ=7/2 values, structured in a bipartite, ferrimagnetic, square lattice of A and B sublattices, is described. The thermomagnetic description consists in the analysis of finite temperature phase diagrams of magnetization as a function of temperature and external magnetic fields. Considering anisotropic single ion (D_s and D_σ), external field (B) and exchange (J_1,J_2) interactions in the Hamiltonian of the model, we find compensation (T_comp), discontinuous (T_k) and hysteretic phenomena. The results show that the negative decrease in the anisotropies of the subgrids implies an increase in the critical and discontinuity temperatures. T_comp increases with the negative decrease in D_σ and decreases with the positive increase in D_s. The influence of D_σ anisotropy generates multiple hysteresis loops and superparamagnetic phenomena for various values of the temperature and external field. All these phenomena are very useful when studying nanostructured materials, among other applications of scientific relevance.

Keywords: Spin, Monte Carlo, Anisotropy, Histéresis

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Ferromagnetic Resonance of a Magnetic Nanoparticle in the Inertial Regime

C.C. Carmona*[1], J.D. Romero[1], J.A. Otalora[2], and O.J. Suarez[1]

[1] *Departamento de Física, Universidad de Sucre, A.A. 406, Sincelejo, Colombia*

[2] *Departamento de Física, Universidad Católica del Norte, Av. Angamos 0610, Antofagasta, Chile*

* *calixto.cordero@unisucrevirtual.edu.co*

The study of magnetization dynamics in magnetic nanoparticles faces limitations when using the Landau-Lifshitz-Gilbert (LLG) equation. This equation does not account for magnetic inertia, which restricts its applicability to long-time scales and low frequencies (GHz). It is necessary to incorporate inertial terms into the LLG equation to address dynamics at shorter time scales and higher frequencies (THz), resulting in the inertial Landau-Lifshitz-Gilbert (ILLG) equation. In this study, we examine the ferromagnetic resonance of an anisotropic magnetic nanoparticle in the inertial regime by applying a resonant field perpendicular to the easy anisotropy direction. The investigation involves calculating the dynamic magnetic susceptibility tensor and analyzing bifurcation diagrams to describe the system's response in the terahertz (THz) frequency range. The system exhibited two resonance peaks: one due to precessional dynamics and another due to nutation dynamics. The resonance frequencies strongly depend on the relaxation time τ, highlighting the importance of considering inertial terms to describe ultrafast dynamics. Nutation dynamics provide new perspectives for the design of nanoscale and high-frequency magnetic switching technologies.

Keywords: Magnetic inertia, Ferromagnetic resonance, Precessional dynamics,Nutation dynamics and Relaxation time (τ).

Characterization of Chaotic Magnetic Nanoparticle Dynamics in the Inertial Regime

J.D. Romero*[1] and O.J. Suarez[1]

[1] *Departamento de Física, Universidad de Sucre, A.A. 406, Sincelejo, Colombia*

* *juan.romero11@unisucrevirtual.edu.co*

In recent years, the study of the nonlinear dynamics of the magnetization of magnetic nanoparticles has been the subject of numerous investigations both at experimental and theoretical levels due to its application in magnetic recording technologies, which has the potential to improve the data storage capacity by allowing the speed of the read-write processes in these technologies to be increased. The need for the magnetization reversal processes in these devices to be done in the shortest possible time has highlighted the importance of studying the magnetization dynamics at time scales where nutation dynamics become relevant. In this context, in this research work, a characterization of the different dynamic behaviors of an anisotropic magnetic nanoparticle is carried out in the inertial regime using the Inertial-Landau-Lifshitz-Gilbert (ILLG) equation. In the high frequencies (THz) regime, the system's different dynamic behaviors obtained by varying the control parameters are analyzed by calculating Lyapunov Exponents, Bifurcation Diagrams, and Fourier Power Spectra. It is found that the system presents multiple transitions between regular and chaotic regions. The results are compared with those reported in the literature using the LLG equation. The inertial term modifies the dynamic regions in the parameter space obtained from the LLG equation, showing transitions from regular to chaotic behaviors and vice versa.

Influence of Temperature and Ultrasonic Energy on the Synthesis and Properties of Fe_3O_4 Nanoparticles

María Camila Vega Sosa*[1], Carlos Arturo Parra Vargas[1], Daniel Llamosa Perez[2]

[1] *Universidad Pedagógica y Tecnológica de Colombia-Tunja*

[2] *Universidad Antonio Nariño- Bogotá*

* *maria.vega04@uptc.edu.co*

Iron oxide (Fe_3O_4) nanoparticles are currently highlighted for their applications in areas such as technology, medicine and the environment. These applications range from data storage systems and applications in magnetic hyperthermia therapies to the treatment of contaminated water, making it crucial to develop efficient and sustainable production processes. This work focuses on a detailed investigation of the effects of reaction temperature and ultrasonic energy on the synthesis of Fe_3O_4 nanoparticles, analyzing how these variables influence their structural, morphological and magnetic properties. Several characterization techniques were used to evaluate the properties of the nanoparticles, including X-ray diffraction (XRD), Fourier transform electron diffraction (FTIR), transmission electron microscopy (TEM) and select area electron diffraction (SAED), and vibrating sample magnetometry (VSM).

The results show that the synthesis parameters, particularly the reaction temperature and ultrasonic energy, play a fundamental role in the formation of Fe_3O_4 nanoparticles with superparamagnetic properties. The study observed that an increase in temperature or ultrasonic energy increases the grain size of the nanoparticles, varying from 8 to 20 nm. Furthermore, the modification of these parameters significantly affects the magnetic properties of the particles, which is relevant to optimize their characteristics according to the desired application. These findings offer important information for the development of more effective production methods tailored to industrial demand, thus contributing to the potential of Fe_3O_4 nanoparticles in future applications in various industries.

Keywords: Nanoparticles, Reaction temperature, Ultrasonic energy, Fe_3O_4

Synthesis and Characterization of Fe3O4 and BaO Nanoparticles Using Azadirachta indica Leaf Extract for Environmental Applications

Reynel Cárdenas H.*[1], Valeria Quintana M.[1], Zulia Caamaño d. Á.[1]**

[1] *Materials Science and Characterization Research Group, Physics Program, Universidad del Atlántico, Colombia*

* *recardenas@mail.uniatlantico.edu.co*, ** *vquintana@mail.uniatlantico.edu.co*

Water pollution from heavy metals and organic dyes is one of the most pressing challenges impacting both society and the environment. Although Colombia is rich in water resources, it faces significant water pollution issues [1]. Metal-based nanoparticles (NPs), known for their catalytic potential, exhibit a high surface area that allows for effective adsorption of organic molecules and interaction with various compounds [2]. To contribute to reducing water pollution by organic dyes and heavy metals, nanoparticles of magnetite (Fe3O4) and barium oxide (BaO) were synthesized through the coprecipitation method, using Azadirachta indica leaf extract as a stabilizing and protective agent. The resulting BaO and Fe3O4 nanoparticles were characterized to investigate their physicochemical properties and environmental applications, employing techniques such as Thermogravimetric Analysis (TGA), Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), Vibrating Sample Magnetometry (VSM) and X-Ray Diffraction (XRD).

Keywords: Nanoparticles, Water pollution, Environmental applications.

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Resonancia magnética de un material ferrimagnético a temperatura finita

C.A .Garcia*[1], A J.A. Otalora[2], and O.J. Suarez[1]

[1] *Departamento de Física, Universidad de Sucre, A.A. 406, Sincelejo, Colombia*

[2] *Departamento de Física, Universidad Católica del Norte, Av. Angamos 0610, Chile*

* *camilo.garcia@unisucrevirtual.edu.co*

This work addresses the study of the magnetic resonance of the ferrimagnetic material GdxFeCo1−x, motivated by the growing need to better understand the magnetic properties of these materials for their use in nanotechnology applications, such as storage devices and magnetic nanosensors. The magnetic behavior of rare earth alloys and transition metals, such as Gadolinium (Gd) and Iron-Cobalt (FeCo), offers a fertile field of research due to the possible transitions between ferromagnetic and antiferromagnetic states under different concentrations and temperatures. This study is carried out considering the theoretical framework of the Landau-Lifshitz-Bloch equation for a Ferrimagnet, which describes the time evolution of the magnetization vector at finite temperature. Since exchange interactions between rare earth elements and transition metals, such as Gd and FeCo, induce an antiparallel alignment of their magnetic moments, the study focuses on the dynamic behavior under the influence of static and oscillating external magnetic fields. In particular, a static magnetic field H0 along the z axis and a resonant field in the (x,y) plane are applied. This perturbation allows us to explore the changes in the magnetic resonance frequency as a function of the Gd and FeCo concentrations and the temperature [1].

The results reveal that the ferrimagnetic material GdxFeCo1−x, at a 50/50 concentration and zero temperature, exhibits a resonance frequency on the order of 50 GHz. As the concentration of the rare earth element Gd decreases, the resonance frequency drops to a minimum of 20 GHz at a concentration of 32%, then increases again to 70 GHz at a concentration near 0%. This behavior in resonance frequency is attributed to the competition between the magnetizations of each sublattice as the concentration varies. Additionally, with increasing temperature, the minimum resonance frequency decreases from 20 GHz to 6 GHz at around 0.3TC. Understanding the effects of concentration and temperature on the resonance frequency of ferrimagnetic materials is essential for their potential technological applications.

Keywords: Magnetic resonance, Ferrimagnetic material, Concentration and temperature.

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Formation and control of point defects in silicon: towards electrical- driver single-photons sources.

Laura M. Muñoz*[1], David Rivas-Góngora[2], Omar Calderón-Losada[1], John H. Reina[1]

[1] Centre for Bioinformatics and Photonics (CIBioFi), Universidad del Valle, Cali, Colombia.

[2] Centre for Materials Science and Nanotechnology, University of Oslo, Oslo, Norway.

* laura.maria.munoz@correounivalle.edu.co

Silicon (Si)-based quantum technologies represent a crucial milestone in integrating quantum capabilities into the existing infrastructure of silicon-based technologies [1]. Recent research has demonstrated that optically-active point defects in silicon can function as single-photon sources [2, 3]. This discovery paves the way for utilizing silicon as a platform for developing advanced quantum technologies such as quantum telecommunication and quantum computing [4]. However, integrating single-photon sources into Si-based optoelectronic devices presents significant challenges, including the precise control of point defect formations and a thorough understanding of their behavior under the application of an electrical field [5]. The last requirement is critical for the implementation of electrical-driver single-photon devices based on Si. In this research, we use the implantation of ions such as carbon, silicon, and protons, and different heat treatments to induce bright optically-active point defects in Si. Photoluminescent (PL) measurements have been used to study the formation of the so-called W, C, and G centers as well as analyze their optical emission under an applied bias voltage (Bias-dependent PL).

Keywords: Silicon, point defects, potential bias, quantum technologies, Bias-dependent PL.

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Electrical transport measurements on metallic film with constriction

M. Godoy*[1], J. García[1], J. Cárdenas[1], H. Sánchez[1], A. Bustamante[1] and J.C. Gonzalez[1]

[1] Laboratorio de Cerámicos y Nanomateriales. Instituto de Investigación de Física. Universidad Nacional Mayor de San Marcos. Av. Carlos Germán Amezaga # 375 - Cercado de Lima. Lima - Perú.

** melvin.godoy@unmsm.edu.pe*

The ability to make electrically conducting structures of ever smaller size such as constrictions, at micro and nanoscale, has brought with it entry into a wonder that semiclassical theory cannot explain. This theory may not be applicable when the coherence length, the Fermi wavelength, and the mean free path of the carriers are in the order of the sample size. The sample size is important for defining the system's properties if it becomes of the de Broglie wavelength size. We present the study of aluminum film grown by evaporation technique onto ITO substrate. Constriction was created in the middle of the film with mechanical lithography. Longitudinal and transversal I-V curves, by four-point technique, were performed illuminating the constriction with UV energies at the same time. The results from the characterization by I-V curves, UV-Vis, SEM, AFM, and DRX are presented.

Keywords: Metallic film, Electrical transport measurements, I-V curves, Constriction.

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Preliminary results on electrical transport measurements of YBCO Dayem bridge construction

M. Godoy*[1], J. García[1], J. Cárdenas[1], H. Sánchez[1], A. Bustamante[1] and J.C. Gonzalez[1]

[1] Laboratorio de Cerámicos y Nanomateriales. Instituto de Investigación de Física. Universidad Nacional Mayor de San Marcos. Av. Carlos Germán Amezaga # 375 - Cercado de Lima. Lima – Perú.

** melvin.godoy@unmsm.edu.pe*

New physical “processes” take place on new scaling lengths and energies and can dominate over tunnel effects. The occurrence of the Josephson effect, it is necessary that the two superconductors be weakly connected by some means. In thin film junctions the quantum mechanical tunneling considered so far realizes this circumstance. We present the preliminary results of fabrication of YBCO Dayem bridge. YBCO textured films were grown onto monocrystalline substrates of LaAlO3 using the sol-gel technique. This Dayem bridge was created in the middle of the film with mechanical lithography. Longitudinal I-V curves, by four-point technique were performed. The results from the characterization by I-V curves, SEM, and AFM are presented.

Keywords: YBCO thin film, Transport measurements, I-V curves, YBCO constriction.

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Electronic spectrum of Ge-core/Si-shell nanowires determined by means of Atomic Effective Potentials calculations

A. Camacho[1],*, J. R. Cárdenas[1]

[1] *Universidad del Atlántico, Cra 30 No. 8-49, Puerto Colombia, 081007, Atlántico-Colombia*

* *acamachor@mail.uniatlantico.edu.co*

Core-shell nanowires have gained attention recently, both experimentally and theoretically due to their diverse technological applications and the chance to modulate the electronic properties by changing the composition of the nanowire. Moreover, SiGe-based nanostructures offer the additional benefit of a direct implementation in the actual Si-based modern technology [1]. In this work, we conduct atomistic calculations for the electronic structure of Ge-core/Si-shell nanowires. We consider structures grown along the [100] direction with different surface facet configurations. In order to study the compositional effects on the electronic properties of the nanowires, we fixed the sample diameter to approximately 5 nm and set the Ge-core diameter to values ranging from 0.7 nm to 3.8 nm. The calculation process involves 1) setting the Si and Ge nonlocal atomic effective pseudopotentials [2] to reproduce the band offset in Si/Ge interfaces reported by recent experimental reports, 2) defining and optimizing the atomic structure to consider the strain using classical elastic theory [3], and 3) solving the single particle Schrödinger equation. Our results show that the band gap can be modulated by changing the Ge content while the total diameter of the nanowire remains fixed. We also found that the band alignment is consistent with the formation of type-II heterostructures, where the VBM and CBM are localized in the core and shell, respectively (Fig. 1), in good agreement with other theoretical reports.

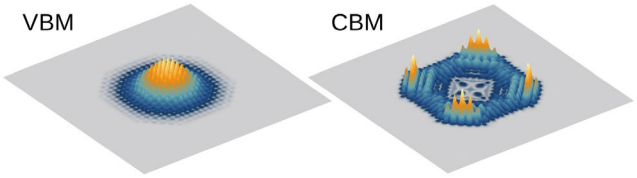


Fig. 1. Squared-averaged wavefunctions of the VBM and CBM.

Keywords: Core-shell nanowires, atomic effective pseudopotentials, electronic structure.

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Green synthesis and characterization of carbon quantum dots from Hibiscus Sabdariffa

Jesús Daniel Amador Martínez[1], Juan Pablo Molina Jiménez[1]

[1] *Laboratorio de Óptica e Informática, Universidad Popular del Cesar, Apdo. Postal 200001, Valledupar, Cesar, Colombia.*
**jamador@unicesar.edu.co*

This study proposes an alternative for the production of carbon quantum dots (CQDs) through green synthesis using Hibiscus Sabdariffa as the main carbon source. The synthesis methodology incorporates a mesoporous zeolite as a refractory material and as a sieve for particle size selection. Additionally, thermal treatment was performed at different temperatures to evaluate the fluorescence phenomenon of the CQDs when exposed to UV wavelength and to detect emissions close to the blue wavelength. The CQDs showed absorption bands associated with $\pi - \pi*$ transitions located around 200 nm. Transmission electron microscopy (TEM) analysis established that the size of the CQDs presents a narrow distribution centered at 2 nm. This synthesis alternative provides significant advantages for obtaining CQDs, as it does not require high costs for the synthesis process. Furthermore, with more rigorous studies on the SERS effect of these CQDs on test molecules, important implications could be obtained for their potential application in various fields.

Keywords: Carbon quantum dots, green synthesis, absorption bands.

Synthesis and characterization of Mn-Zn nanocrystalline ferrites obtained via hydrothermal process from Aloe barbadensis Mill (Asphodelaceae) extract for the treatment of water contaminated with organic dyes

Melissa Quevedo*[1], Zulia Caamaño[2], Maria Fernanda Pilaquinga[2]

[1] *University of Atlantico*

[2] *Pontificia Universidad Catolica de Ecuador*

* *mquevedo@mail.uniatlantico.edu.co*

The synthesis of nanocrystalline spinel ferrites has become an important part of novel materials research. The study of these materials has great relevance in modern technological applications in various industrial and biological fields [1]. It is well known that the preparation method can strongly affect the composition and microstructure of spinel-type nanocrystalline ferrites, and therefore, their chemical, structural and magnetic properties. Among the existing physical and chemical methods for the synthesis of spinel nanocrystalline ferrites, as high energy mechanical alloy [2], sol-gel method, polyol process, co-precipitation method, solid state reaction method, auto-combustion method, ceramic processing method [3]. However, recent research has reported the synthesis of spinel nanoferrites via hydrothermal, using eco-friendly solvents from plant extract. In this study, Mn1-xZnxFe2O4 nanocrystalline ferrites (x = 0, 0.2, 0.4, 0.6, 0.8, and 1.0) were synthesized by varying the compositions of Mn and Zn through the hydrothermal method, using Aloe barbadensis mill plant extract as an environmentally friendly solvent. From the various characterization techniques used—SEM, TEM, XRD, VSM, UV-Vis, TGA, DLS, FTIR—it was confirmed that the nanocrystalline ferrites are quasi-spherical in shape (SEM) and have an average size of 19.50 – 53.55 nm according to TEM. XRD analysis showed that all samples formed the characteristic spinel structure typical of these systems.The average crystallite size ranged from 8.37 to 45.80 nm, and the lattice parameter ranged from 8.3862 to 8.453 Å. Magnetic hysteresis loops obtained by VSM demonstrated the soft magnetic behavior of the ferrites and the change in saturation magnetization with increasing Zn content. UV-Vis analysis showed an increase in the band gap with higher Zn content, and the ferrites absorbed in the UV spectrum. TGA analysis revealed mass loss due to the elimination of surface-adsorbed water or solvent. In the MnFe2O4 sample, the conversion of metal hydroxide (Mn and Fe) into metal oxide was observed. The results obtained from DLS corroborated the findings from SEM and TEM, showing that the ferrites were agglomerated, and the different distributions of the DLS hydrodynamic diameter ranged from 172.1 to 445.1 nm. FTIR analysis revealed the presence of different functional groups—OH, C-H, C=O from the aloe vera extract; the C-C group for the x=0.4 and x=1 samples, with the functional groups corresponding to those in the extract except for the band around 590 cm^{-1} for x=0.4 and 548

cm^{-1} for x=1.0, which are compatible with metal-oxygen vibrations in a tetrahedral lattice. Finally, it was evaluated that the x=0.8 and x=1 compositions of the Mn1-xZnxFe2O4 system were the most effective for treating water contaminated with Congo red dye at the laboratory scale. Considering variables such as concentration, time, and pH, it was found that the best conditions were at concentrations above 100 ppm, with a treatment time of 30 minutes at pH 7 and pH 5.

***Keywords*:** nanocrystalline ferrites, hydrothermal, XRD, SEM, TEM, UV-Vis, FTIR, TGA, DLS, VSM, water contaminated pH.

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Synthesis And Characterization Of Zno Nanorods: A Simple Sythesis

Emely Ruiz Duarte*[1,3], Juan Pablo Molina[2,3], Yeiner Molina Fragozo[2,3], Cesar Torres Moreno[3], Manuel Cortez Valadez[4], Duber Ávila Padilla[3] and Sindi Horta Piñeres[3].

[1] Estudiante de Maestría en Ciencias Ambientales. SUE Caribe, Universidad Popular del Cesar, Valledupar, Cesar, Colombia

[2] Estudiante de Maestría en Ciencias Físicas. SUE Caribe, Universidad Popular del Cesar, Valledupar, Cesar, Colombia.

[3] Grupo de óptica e Informática, Universidad Popular del Cesar, Departamento de Física, Química y Afines, Valledupar, Cesar, Colombia.

[4] Departamento de Investigación en Física, Universidad de Sonora, Apdo. Postal 5- 088, CP 83000, Hermosillo, Sonora, México.

** evanessaruiz@unicesar.edu.co*

In the present study, zinc oxide nanorods (ZnO-NB) were synthesized by zinc acetate calcination method. The ZnO powder was characterized optically, morphologically and structurally. X-ray diffraction analysis showed peaks at 31.81º, 34.42º, 36.26º, 47.58º, 56.69º, 62.95º, 66.36º, 68.01º, 69.17º, 72.59º and 77.0º indexed with standard ICSS card (#70-0207) to lattice planes (h, l, k) of (1 0 0), (0 0 2), (1 0 1), (102), (1 1 0), (1 0 3), (2 0 0), (1 1 2), (2 0 1), (0 0 4), and (2 0 2), respectively, which are indicative of a hexagonal wurtzite phase with a space group P63mc(186), with an average crystal lite size of about 11 nm according to the Debye–Scherrer equation. SEM images of the ZnO-NBs showed the homogene ous rod-like structures with diameters in the range of 30 nm and lengths in the range of microns. The UV–Vis absorption spectrum of the ZnO-NB samples showed a characteristic absorption band around the wavelength of 368 nm with a band gap energy (Eg) of 3.36 eV. Raman spectroscopy analysis at 96 cm^{-1} is usually associated with the E2 (low) mode, which is a non-polar vibration of the ZnO crystal lattice. The band at 380 cm^{-1} is attributed to the A1(TO) mode, which is an optical longitudinal vibration. The Raman band at 432 cm^{-1} corresponds to the E2 (high) mode, related to the vibrations of oxygen atoms in the crystal lattice. The FTIR analysis presents a single band at 582 cm-1 associated with the stretching vibrations of Zn-O. Zinc acetate calcination is a simple and efficient method to produce zinc oxide nanorods. This method can control the crystalline and morphological properties of ZnO as function of temperature and calcination time, obtaining particles with specific characteristics that can be implemented in various industrial and scientific applications, such as sensors, coatings and electronic materials.

Keywords: Zinc oxide nanoparticles, ZnO Nanorods, Calcination method.

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