4TH SCHOOL ON PHYSICS OF QUANTUM MATERIALS

PROGRAMA OFICIAL

DEL 26 DE OCTUBRE AL 28 DE OCTUBRE, 2026

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Día 28/10 - miércoles, 28 de octubre de 2026

Resúmenes (Abstracts) adjuntos al final

CRONOGRAMA GENERAL DE ACTIVIDADES

4th School on Physics of Quantum materials • Del 26 de octubre al 27 de octubre, 2026

DÍA 26/10
lunes 26 de octubre

08:00 - 09:00
Register
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

09:00 - 09:45
Inauguración

09:45 - 10:45 • CURSOS
Daniel Alejandro Bonilla Moreno
Daniel Alejandro Bonilla Moreno
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

10:45 - 11:25 • PLÁTICA INVITADA
Miguel Angel Santana Aranda
Miguel Angel Santana Aranda
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

11:25 - 11:45
Coffee Break

11:45 - 12:10 • PLÁTICA CONTRIBUIDA
Víctor Andrés González Domínguez
Víctor Andrés González Domínguez
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

12:10 - 12:35 • PLÁTICA CONTRIBUIDA
Luis Abraham García Hernández
Luis Abraham García Hernández
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

12:40 - 13:20 • PLÁTICA INVITADA
Rocío Jáuregui Renaud
Rocío Jáuregui Renaud
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

13:25 - 14:05 • PLÁTICA INVITADA
Romeo de Coss
Romeo de Coss
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

14:05 - 16:00
Lunch time

16:00 - 17:00 • CURSOS
Jose Eduardo Barrios Vargas
Jose Eduardo Barrios Vargas
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

17:00 - 17:25 • PLÁTICA CONTRIBUIDA
Cristian Guillen Almanza
Cristian Guillen Almanza

17:30 - 18:10 • PLÁTICA INVITADA
Isaac Rodriguez Vargas
Isaac Rodriguez Vargas
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

18:10 - 19:00 • PLÁTICA INVITADA
Freddy Jackson Poveda Cuevas
Freddy Jackson Poveda Cuevas
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

DÍA 27/10
martes 27 de octubre

08:00 - 09:00
Register
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

09:00 - 10:00 • CURSOS
Daniel Alejandro Bonilla Moreno
Daniel Alejandro Bonilla Moreno
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

10:00 - 10:40 • PLÁTICA INVITADA
Ricardo Andrés Martínez von Dossow
Ricardo Andrés Martínez von Dossow
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

10:40 - 11:05 • PLÁTICA CONTRIBUIDA
Andrés Augusto Morales Esponda
Andrés Augusto Morales Esponda
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

11:05 - 11:25 • COFFEE BREAK
Coffee Break
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

11:25 - 11:50 • PLÁTICA CONTRIBUIDA
Juan Antonio Cañas Palomeque
Juan Antonio Cañas Palomeque
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

11:50 - 12:15 • PLÁTICA CONTRIBUIDA
Julio Armando Mojica Zárate
Julio Armando Mojica Zárate
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

12:15 - 12:40 • PLÁTICA CONTRIBUIDA
Luis Manuel Rios Ochoa
Luis Manuel Rios Ochoa
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

12:45 - 13:25 • PLÁTICA INVITADA
Mauro Cambiaso Harb
Mauro Cambiaso Harb
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

13:30 - 14:10 • PLÁTICA INVITADA
David Angel Ruiz Tijerina
David Angel Ruiz Tijerina
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

14:10 - 16:00
Lunch time

16:00 - 17:00 • CURSOS
Jose Eduardo Barrios Vargas
Jose Eduardo Barrios Vargas
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

17:00 - 19:00 • CARTELES
Sesión de Pósters
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

CRONOGRAMA GENERAL DE ACTIVIDADES

4th School on Physics of Quantum materials • Del 28 de octubre al 28 de octubre, 2026

DÍA 28/10

miércoles 28 de octubre

09:00 - 10:00 • CURSOS
Jose Eduardo Barrios Vargas
Jose Eduardo Barrios Vargas
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

10:00 - 10:40 • PLÁTICA INVITADA
Neil Vladimir Corzo Trejo
Neil Vladimir Corzo Trejo
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

10:40 - 11:05 • PLÁTICA CONTRIBUIDA
Paulina Moreno Martinez
Paulina Moreno Martinez
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

11:05 - 11:25 • COFFEE BREAK
Coffee Break
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

11:25 - 11:50 • PLÁTICA CONTRIBUIDA
Mariana Vázquez Ibarra
Mariana Vázquez Ibarra
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

11:55 - 12:35 • PLÁTICA INVITADA
Ramón Castañeda Priego
Ramon Castaneda Priego
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

12:40 - 13:20 • PLÁTICA INVITADA
Cristian Gómez Solis
Cristian Gómez Solis
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

13:25 - 14:05 • PLÁTICA INVITADA
Francisco Sanchez Ochoa
Francisco Sanchez Ochoa
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

14:05 - 16:00
Lunch time

16:00 - 17:00 • CURSOS
Daniel Alejandro Bonilla Moreno
Daniel Alejandro Bonilla Moreno
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

17:00 - 17:20
Clausura
Lugar: Sala de proyecciones de la Biblioteca Central Carlos Maciel Espinosa

DÍA 26/10

LUNES, 26 DE OCTUBRE DE 2026

08:00 – 09:00 — LIBRE / BREAK

REGISTER

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

09:00 – 09:45 — LIBRE / BREAK

INAUGURACIÓN

09:45 – 10:45 — CURSOS

DANIEL ALEJANDRO BONILLA MORENO

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

10:45 – 11:25 — PLÁTICA INVITADA

MIGUEL ANGEL SANTANA ARANDA

UNIVERSIDAD DE GUADALAJARA

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

LEER RESUMEN >>

11:25 – 11:45 — LIBRE / BREAK

COFFEE BREAK

Te recomendamos llevar tu taza (opcional)

11:45 – 12:10 — PLÁTICA CONTRIBUIDA

VÍCTOR ANDRÉS GONZÁLEZ DOMÍNGUEZ

Te recomendamos llevar tu taza (opcional)

UNIVERSIDAD POLITÉCNICA DE CHIAPAS

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

LEER RESUMEN >>

12:10 – 12:35 — PLÁTICA CONTRIBUIDA

LUIS ABRAHAM GARCÍA HERNÁNDEZ

Te recomendamos llevar tu taza (opcional)

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

LEER RESUMEN >>

12:40 – 13:20 — PLÁTICA INVITADA

ROCÍO JÁUREGUI RENAUD

Te recomendamos llevar tu taza (opcional)

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

LEER RESUMEN >>

13:25 – 14:05 — PLÁTICA INVITADA

ROMEO DE COSS

Te recomendamos llevar tu taza (opcional)

CINVESTAV MÉRIDA

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

LEER RESUMEN >>

14:05 – 16:00 — LIBRE / BREAK

LUNCH TIME

16:00 – 17:00 — CURSOS

JOSE EDUARDO BARRIOS VARGAS

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

17:00
17:25

PLÁTICA CONTRIBUIDA

CRISTIAN GUILLEN ALMANZA

UNIVERSIDAD MICHOACANA DE SAN NICOLAS DE HIDALGO

LEER RESUMEN >>

17:30
18:10

PLÁTICA INVITADA

ISAAC RODRIGUEZ VARGAS

UNIVERSIDAD AUTONOMA DE ZACATECAS

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

LEER RESUMEN >>

18:10
19:00

PLÁTICA INVITADA

FREDDY JACKSON POVEDA CUEVAS

UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

LEER RESUMEN >>

DÍA 27/10

MARTES, 27 DE OCTUBRE DE 2026

08:00 – 09:00
LIBRE / BREAK
REGISTER
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

09:00 – 10:00
CURSOS
DANIEL ALEJANDRO BONILLA MORENO
UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

10:00 – 10:40
PLÁTICA INVITADA
RICARDO ANDRÉS MARTÍNEZ VON DOSSOW
PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

10:40 – 11:05
PLÁTICA CONTRIBUIDA
ANDRÉS AUGUSTO MORALES ESPONDA
UNIVERSIDAD DE GUADALAJARA UDG
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

11:05 – 11:25
COFFEE BREAK
COFFEE BREAK
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

11:25 – 11:50
PLÁTICA CONTRIBUIDA
JUAN ANTONIO CAÑAS PALOMEQUE
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

11:50 – 12:15
PLÁTICA CONTRIBUIDA
JULIO ARMANDO MOJICA ZÁRATE
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

12:15 – 12:40
PLÁTICA CONTRIBUIDA
LUIS MANUEL RIOS OCHOA
CINVESTAV
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

12:45 – 13:25
PLÁTICA INVITADA
MAURO CAMBIASO HARB
UNIVERSIDAD ANDRES BELLO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

13:30 – 14:10
PLÁTICA INVITADA
DAVID ANGEL RUIZ TIJERINA
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

14:10 – 16:00
LIBRE / BREAK
LUNCH TIME

16:00 – 17:00
CURSOS
JOSE EDUARDO BARRIOS VARGAS
UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

17:00
19:00

CARTELES

SESIÓN DE PÓSTERS

SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

DÍA 28/10

MIÉRCOLES, 28 DE OCTUBRE DE 2026

09:00 – 10:00
CURSOS
JOSE EDUARDO BARRIOS VARGAS
UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

10:00 – 10:40
PLÁTICA INVITADA
NEIL VLADIMIR CORZO TREJO
CINVESTAV
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

10:40 – 11:05
PLÁTICA CONTRIBUIDA
PAULINA MORENO MARTINEZ
CINVESTAV
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

11:05 – 11:25
COFFEE BREAK
COFFEE BREAK
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

11:25 – 11:50
PLÁTICA CONTRIBUIDA
MARIANA VÁZQUEZ IBARRA
CENTRO DE INVESTIGACIÓN Y DE ESTUDIOS AVANZADOS DEL INSTITUTO POLITÉCNICO NACIONAL
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

11:55 – 12:35
PLÁTICA INVITADA
RAMÓN CASTAÑEDA PRIEGO
Ramon Castaneda Priego • UNIVERSIDAD DE GUANAJUATO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

12:40 – 13:20
PLÁTICA INVITADA
CRISTIAN GÓMEZ SOLIS
UNIVERSIDAD DE GUANAJUATO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

13:25 – 14:05
PLÁTICA INVITADA
FRANCISCO SANCHEZ OCHOA
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA
LEER RESUMEN >>

14:05 – 16:00
LIBRE / BREAK
LUNCH TIME

16:00 – 17:00
CURSOS
DANIEL ALEJANDRO BONILLA MORENO
UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

17:00 – 17:20
CLAUSURA
SALA DE PROYECCIONES DE LA BIBLIOTECA CENTRAL CARLOS MACIEL ESPINOSA

SECCIÓN DE ABSTRACTS

CURSOS

4th School on Physics of Quantum materials

1

Applied Quantum Field Theory in Condensed Matter

Daniel A. Bonilla[1]

Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México
Mexico City, Mexico
daniel.bonillam@correo.nucleares.unam.mx

Abstract

This course presents quantum field theory as a practical tool for addressing concrete problems in condensed matter physics and quantum materials. Rather than developing the formalism in an abstract or exhaustive way, the course will be organized around representative examples in which QFT techniques allow us to reformulate, simplify, and solve many-body problems, identify the relevant degrees of freedom, and construct effective low-energy descriptions.

The emphasis will be on the calculation procedure: starting from a microscopic model, formulating it in the appropriate field-theoretical language, introducing the necessary tools, and following the derivation through to physical observables or concrete predictions. Throughout the course, we will show how seemingly formal concepts acquire a direct physical interpretation when applied to condensed matter phenomena, and how common techniques and strategies—perturbation theory, diagrammatic methods, integrating out degrees of freedom, constructing effective actions, and analyzing relevant scales—reappear across different physical problems.

Key words: Quantum field theory, condensed matter physics, quantum materials, many-body physics, effective field theories.

Acknowledgments: D.A.B. gratefully acknowledges support from the Postdoctoral Fellowship Program of the Universidad Nacional Autónoma de México

References

[1] A. Altland and B. Simons, *Condensed Matter Field Theory*, 2nd ed., Cambridge University Press (2010).

[2] P. Coleman, *Introduction to Many-Body Physics*, Cambridge University Press (2015).

[3] N. Nagaosa, *Quantum Field Theory in Condensed Matter Physics*, Springer (1999).

From Classical to Quantum Light: Engineering Topological Matter

J. Eduardo Barrios-Vargas[1]

[1] *Departamento de Física y Química Teórica, Facultad de Química, Universidad Nacional Autónoma de México*
Ciudad de México 04510, México
jebarrios@quimica.unam.mx

[1] Presenting author.

Abstract

Light offers a powerful way to probe and manipulate the electronic, geometric, and topological properties of quantum materials. Beyond conventional optical spectroscopy, electromagnetic fields can dynamically break symmetries, reshape electronic band structures, induce topological phase transitions, and generate electronic states without equilibrium counterparts.

This course introduces the theoretical foundations of light-induced topology, emphasizing the interplay between symmetry, electronic structure, Berry curvature, and light–matter coupling. It devotes particular attention to Floquet theory, which describes quantum systems under time-periodic driving, and to the distinction between classical electromagnetic fields and quantized photon modes.

The course progresses from semiclassical descriptions of periodically driven electrons to Floquet topological band engineering and, finally, quantum light–matter interactions in optical cavities.

Keywords: Light-Matter Interaction, Floquet Engineering, Topological Quantum Materials

SECCIÓN DE ABSTRACTS

PLÁTICAS DE CONTRIBUCIÓN

4th School on Physics of Quantum materials

2

4th School on Physics of Quantum Materials

¿Efímero o viable? Estabilidad dinámica y térmica de un catenoide molecular de carbono

Víctor A. González-Domínguez[1,2]

Resumen

Los métodos de primeros principios permiten hoy proponer con gran rapidez nuevas moléculas y nanoestructuras que aún no han sido sintetizadas, y con frecuencia se afirma que son "estables" con base únicamente en la optimización de su geometría. Hoffmann *et al.* advirtieron que este uso no calificado del término resulta insuficiente, y propusieron distinguir entre estructuras *efímeras*, que solo son mínimos locales de la superficie de energía potencial, y estructuras *viables*, que además deben resistir fragmentación e isomerización, lo cual puede explorarse mediante dinámica molecular [1]. Siguiendo estos criterios, en este trabajo analizamos la estabilidad de una nueva estructura hipotética: un catenoide molecular de carbono, $C_{104}H_{32}$, con curvatura gaussiana negativa. Los cálculos se realizaron con la teoría del funcional de la densidad en el código SIESTA [2], con el funcional PBE [3], pseudopotenciales que conservan la norma [4] y una base doble zeta polarizada. En el análisis dinámico, tras la relajación completa de la geometría, el espectro de modos normales no presenta frecuencias imaginarias, lo que confirma que la estructura es un mínimo local. En el análisis térmico, simulaciones de dinámica molecular con el algoritmo de Verlet muestran que el catenoide conserva su conectividad y su geometría a 385 K, sin ruptura de enlaces ni reacomodos topológicos. Estos resultados llevan al catenoide molecular más allá del nivel de estructura efímera y lo señalan como un candidato a estructura viable, cuya confirmación definitiva quedará en manos de su eventual síntesis experimental.

Palabras clave:

Catenoide molecular, Curvatura gaussiana negativa, Estabilidad dinámica, Estabilidad térmica, Dinámica molecular, DFT

Referencias

[1] R. Hoffmann, P. von R. Schleyer y H. F. Schaefer III, "Predicting molecules—more realism, please!," *Angew. Chem. Int. Ed.*, vol. 47, pp. 7164–7167, 2008.

[2] J. M. Soler, E. Artacho, J. D. Gale, A. García, J. Junquera, P. Ordejón y D. Sánchez-Portal, "The SIESTA method for ab initio order-N materials simulation," *J. Phys.: Condens. Matter*, vol. 14, pp. 2745–2779, 2002.

[3] J. P. Perdew, K. Burke y M. Ernzerhof, "Generalized gradient approximation made simple," *Phys. Rev. Lett.*, vol. 77, p. 3865, 1996.

[4] N. Troullier y J. L. Martins, "Efficient pseudopotentials for plane-wave calculations," *Phys. Rev. B*, vol. 43, p. 1993, 1991.

Modelado microscópico y respuesta magneto-óptica del plasmón superficial en nanopartículas de ferrita

Luis Abraham García-Hernández*

Instituto de Física, Universidad Nacional Autónoma de México
Circuito de la Investigación Científica s/n, Ciudad Universitaria, 04510, Ciudad de México, México
abraham@fisica.unam.mx

Abstract

Las ferritas de espinela inversa M-Fe_2O_4 (M = Fe, Co, Ni) combinan orden ferrimagnético con una respuesta óptica activa, lo que las convierte en candidatas para plataformas magneto-plasmónicas. A diferencia de los metales nobles, cuya resonancia de plasmón superficial localizado (LSPR) cae en el espectro visible, en ferritas puras la condición de Fröhlich se satisface en el infrarrojo medio, lo que abre aplicaciones en sensado vibracional y dispositivos no recíprocos. En este trabajo se presenta un modelo que conecta la física microscópica con la respuesta óptica: (i) el modelo de Stoner-Wohlfarth para la temperatura de bloqueo T_B en función del diámetro D; (ii) simulaciones de Monte Carlo del modelo de Heisenberg tridimensional y el modelo de Néel-Brown para la magnetización reducida $m(H,T)$; y (iii) la teoría de Mie con un modelo de Drude magneto-óptico para calcular la eficiencia de extinción $Q_{ext}(\lambda, H)$ en nanopartículas de 5 a 25 nm. Se cuantifica el desplazamiento del pico de LSPR inducido por el campo magnético en el rango 0–10 kOe y $\lambda = 3-4$ μm, y se evalúa su dependencia con la temperatura y el diámetro para los tres materiales.

Key words:
Ferrite nanoparticles; Surface plasmon resonance; Magneto-optical effect; Mie theory; Néel-Brown model; Mid-infrared Acknowledgments:

Al Programa de Becas Posdoctorales de la DGAPA-UNAM por el apoyo otorgado.

Referencias

[1] Coey, J. M. D. *Magnetism and Magnetic Materials*; Cambridge University Press, 2010.

[2] García-Hernández, L. A. Light scattering and plasmonic response of Au–Fe_3O_4 nanoparticles. *SN Appl. Sci.* 2, 1844 **2020**.

[3] García-Hernández, L. A.; Guzmán-Hernández, C. B.; Oza, G. *J. Nanopart. Res.* 27, 281 **2025**.

Localization phenomena in disordered dissipative media

Cristian Guillén Almanza [1] **& Luca Tessieri** [2**]

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C. de Santiago Tapia 403, Centro, 58000 Morelia, Michoacán, México.
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C. de Santiago Tapia 403, Centro, 58000 Morelia, Michoacán, México.
luca.tessieri@umich.mx

*Autor que presenta el trabajo.
**Cristian Guillén Almanza.

Abstract
Disorder plays a fundamental role in determining the transport and localization properties of quantum systems. In this talk, we study wave propagation through a one-dimensional disordered medium modeled as a finite barrier connected to two semi-infinite perfect leads. The site energies inside the barrier are described by complex random variables, whose real part represents the random potential, while the imaginary part accounts for absorption or amplification processes in the medium. Using the transfer-matrix method, we obtain the transmission and reflection coefficients and analyze the combined effects of disorder and the active character of the system. Particular attention is given to the role of spatial correlations in the disorder and their influence on transport through the barrier. We discuss analytical and numerical results for both short and extended disordered systems, highlighting the interplay between transport, disorder, and localization. These results provide insight into the behavior of one-dimensional quantum systems with random and non-conservative environments, with possible connections to the study of quantum materials, wave transport in complex media and non-hermitian systems.

Key words: Disordered systems, Anderson's localization, transfer matrices, non-Hermitian systems.

Referencias

[1] P.W. Anderson, *Phys. Rev.* **109** 1492 (1958)

[2] Jean Heinrichs. *J. Phys.: Condens. Matter* **18** 4781 (2006)

[3] F. M. Izrailev and A. A. Krokhin *Phys. Rev. Lett.* **82** 4062, (1998)

[4] K. Ishii. *Prog.Theo. Phys. Suppl.* **53** 77 (1973)

[5] R de L. Kronig, W. G. Penney. *Proc. Roy. Soc.* A **130** 499 (1931).

[6] Kramer, A. MacKinnon, *Rep.Prog.Phys.* **56** 1469 (1993)

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Categories and the fractional quantum Hall effect

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Abstract
Category theory is currently a powerful mathematical tool capable of describing complex structures across various areas of contemporary physics. This presentation outlines a framework that employs category theory—specifically, modular tensor categories (MTC's)—to explain the physical aspects of anyons in the Fractional Quantum Hall Effect (FQHE). The discussion focuses on the Ising anyon model, a structure that allows for the precise description of their topological behavior, including fusion rules (the F-matrix), braiding (the R-matrix), and topological spin, among other fundamental properties.

Key words: categories, anyon

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Effects of substitutional impurities on the topological phase transition of a SSH Chain

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Abstract

We investigate the robustness of the topological phase in a one-dimensional Su-Schrieffer-Heeger chain subjected to randomly distributed non-Hermitian substitutional impurities. By introducing site-dependent, non-reciprocal hopping amplitudes, we numerically compute the energy spectrum and the real-space winding number. While a single localized impurity preserves a perfectly quantized topological invariant, introducing a finite concentration of random defects leads to strong wavefunction hybridization and level repulsion, broadening the defect modes into an impurity mini-band. Crucially, this macroscopic disorder drives the breakdown of the topological phase by smearing the topological phase boundary. Through finite-size scaling analysis, we extract a correlation length critical exponent of $\nu \approx 1{,}455$, demonstrating a marked physical crossover that strictly departs from the pristine SSH universality class ($\nu = 1{,}0$). Furthermore, we demonstrate that ν systematically and monotonically increases with the impurity density r. This continuous growth provides direct physical evidence of the macroscopic smearing, confirming that the effective correlation length becomes intrinsically bounded by the inter-defect distance rather than the system size. Finally, we show that an asymmetric configuration of the impurity hoppings leads to a displacement of the transition's critical point, reducing or enhancing the topological phase.

Key words: SSH model, Non-Hermitian systems, Substitutional impurities, Finite-size scaling, Real-space winding number

Transport properties of a graphene nanoribbon under a magnetic field with zigzag and armchair boundaries

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Abstract

This work investigates the transport properties of a graphene nanoribbon in the presence of a perpendicular magnetic field, considering both zigzag and armchair boundaries. The nanoribbon is confined along the x direction and translationally invariant along y. Within the low-energy Dirac description, the spectral problem reduces to a Weber-type equation, whose solutions are determined by imposing the corresponding boundary conditions [1]. The resulting energy spectra exhibit bulk and edge states associated with magnetic confinement and the finite width of the nanoribbon. Using the corresponding eigenstates, the conductivity tensor is calculated within the Kubo formalism [2]. The longitudinal and Hall conductivities are analyzed for both boundary configurations, allowing a direct comparison of their transport properties and their relation to the corresponding electronic spectra.

Key words: graphene nanoribbon, magnetic field, zigzag edges, armchair edges, Kubo formalism, magnetotransport.

Acknowledgments: J.A.M.-Z. was supported by the SECIHTI PhD fellowship No. 1140196. J.C.P.-P. was supported by SECIHTI under the program "Estancias Posdoctorales por México" with CVU number 671687. A.M.-R. acknowledges financial support by UNAM-PAPIIT project No. IG100224, UNAM-PAPIME project No. PE109226, SECIHTI project No. CBF-2025-I-1862, and the Marcos Moshinsky Foundation.

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Quantum fluids based on atomic Rubidium vapors for quantum simulation

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Abstract

In this work, quantum fluids of light are studied as a platform that allows addressing many-body physics problems. This is possible because the mathematical description of light propagation through a nonlinear medium is equivalent to the wave function of a two-dimensional quantum fluid, offering an alternative or a complement to classical platforms such as cold atoms or superfluid helium. In this type of experiment, the nonlinear medium is a material that exhibits the Kerr effect, where the refractive index depends on the light intensity; in our case, atomic rubidium vapors. Preliminary results are then presented on the measurement of the nonlinear refractive index, equivalent to the effective photon-photon interaction term in this quantum fluid, as well as results on the formation and detection of vortices.

Key words:
Quantum fluids of light, Rubidium atomic vapors, Kerr nonlinearity, quantum simulation

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Development of a decoupled dual-beam optical tweezers system for precision manipulation and characterization in materials physics

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Abstract

Optical manipulation at the microscale has become an essential tool for the non-invasive probing of mechanical, thermal, and dynamic properties in physical systems and mesoscopic materials [1]. However, in conventional multi-beam configurations, optical cross-talk and parasitic interference impose severe limits on positional stability and independent spatial control, where standard deflector schemes often face acoustic and bandwidth artifacts [2, 3]. In this work, we present the design, development, and experimental implementation of a fully decoupled dual-beam optical tweezers system based on an acousto-optic modulator (AOM) deflection architecture driven by direct digital radio-frequency control. This configuration enables dynamic, independent trap steering and stiffness tuning at the focal plane, effectively suppressing unwanted interference and cross-power fluctuations. We outline our progress in optomechanical integration, automated signal synchronization, and spatial calibration of the setup. Finally, we discuss the capabilities of this platform as a versatile instrument for probing inter-particle interactions, non-equilibrium dynamics in colloidal systems, and its prospective applications for precision force sensing and reconfigurable trap architectures relevant to quantum technologies and atomic assembly [4].

Key words: Optical Tweezers, AOM, Dual trap, crosstalk.

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Quantum cryptography in Cinvestav Querétaro

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Abstract

The BB84 protocol, proposed by Bennett and Brassard in 1984, is based on fundamental principles of quantum mechanics, such as superposition and the no-cloning theorem, which enable the detection of any interception attempt [A]. At CINVESTAV Querétaro, the BB84 protocol has been successfully implemented in a single-photon regime, achieving a quantum bit error rate (QBER) of 2 % under out-of-laboratory conditions using a 1-km multimode fiber as the quantum channel. This represents the first implementation of quantum cryptography outside the laboratory in Mexico. In addition, 1 km of optical fiber has been installed to extend these tests to real-world conditions. This implementation contributes to international efforts in which QKD transmissions outside the laboratory have already been demonstrated in China [B], Europe [C], and the United States [D].These efforts position CINVESTAV as a key contributor to the development of quantum cryptography in Mexico, with potential applications in government communications, the financial sector and medical data protection.

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Key words: Quantum cryptography, Quantum key distribution, BB84 and Quantum error rate
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SECCIÓN DE ABSTRACTS

PLÁTICAS INVITADAS

4th School on Physics of Quantum materials

3

Advantages of the layered bismuth oxyhalides for photocatalytic processes

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Abstract

Photocatalytic phenomena have been broadly studied within the last 6 decades, due to the relevance for our planet's ecology from a couple of fronts: its direct use on environmental remediation by decomposition of polluting molecules, such as dyes and pharmaceuticals in water, or VOCs in air; as well as the reduction of energy costs in catalytic processes of commercial interest, like CO_2 conversion and Hydrogen evolution [1]. For a considerable period, TiO_2, along with ZnO and SnO_2, prevailed on the subject; they were used pure, doped, and decorated with other materials, engineering their surfaces to propitiate catalytic processes and reducing the photon energy required to produce electron-hole pairs using visible light. Since 2006, a family of compounds with additional physical advantages have been studied pursuing these goals, the bismuth oxyhalides (BiOX, X= Cl, Br, I), which structurally consist of layers stacked by van der Waals interactions [2]. Here we present some of the advantages these compounds show over the traditional set of materials. An electronic structure with an indirect bandgap, which extends the carrier recombination time. A spontaneous electric field built-in between the forming layers, with potential to spatially separate electron-hole pairs, preventing their recombination. And a relevant quantum-size effect in ultrathin nanosheets, that shifts positively the valence band, increasing the material's capacity for oxidation [3]. Finally, we present some experimental results comparing BiOX's photocatalytic activity with that of a TiO_2 commercial standard [4].

Keywords: Photocatalysis; Bismuth oxyhalides; Layered materials; TiO_2; Water.
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Collisions of Quantum Droplets

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We present a theoretical study of the implications of binary, frontal and non-frontal collisions between quantum droplets composed of atomic Bose-Bose mixtures. We perform numerical experiments of the outcomes of collisions between identical and different-sized droplets in a phase diagram defined by the impact parameter and the Weber number [1, 2]. Our realistic computational simulations deliver parameters that can be accessed in ultracold experimental setups, and open new opportunities for studying the evolution of a quantum self-confined and deformable medium whose dynamics allow the nucleation of diverse topological excitations, including vortex rings, linear vortices, and phase dislocations [3].

Key words: Quantum droplets, Bose-Einstein Condensates, Topological excitations
Acknowledgments: UNAM-DGPA- PAPIIT: IG101826,

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Exploring topological states in one-dimensional quantum materials: a first-principles approach

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Abstract

The search for one-dimensional topological insulators is a current topic of interest in the field of quantum materials. One-dimensional topological insulators are materials that exhibit a bulk band gap while hosting localized states precisely at their endpoints, offering a platform for emergent quantum phenomena. Thus, using first-principles calculations, we explore the electronic structure and magnetism of one-dimensional quantum materials in search of signatures of topological states. In particular, we have studied one-dimensional systems derived from fused nanographenes that exhibit spin magnetic moments. Finally,

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we present a perspective on the realization of spin chains with quantum topological properties, such as the Haldane chain.

Key words: 1D topogical insulator, fused nanographenes, Haldane chain

Quantum transport in complex structures based on 2D materials

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Abstract

Here, we show the electronic transport in complex structures based on 2D materials. In particular, self-similar structures conceived in terms of the well-known triadic Cantor set with electrostatic gates acting on bilayer graphene. The charge carriers are described as massive Dirac electrons and the electronic transport is obtained with the hybrid matrix method and the Landauer-Büttiker formalism. The scaling and fractal characteristics of the electronic transport ara analyzed for different generation of the bilayer graphene self-similar structure. We find self-similar and fractal characteristics as long as some symmetry of the system is broken. In the case of bilayer graphene the broken of the interlayer symmetry gives rise to self-similar and fractal electronic transport.

Key words: Quantum transport, Complex structures, 2D materials

Modes, field Operators, and ultracold atoms: A second-quantized framework for harmonic traps

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Abstract

Ultracold quantum gases are confined using magnetic, optical, or magneto-optical traps, allowing them to reach temperatures on the order of 100 nK [4]. In this regime, the thermal energy is insufficient for the atoms to overcome the potential barriers, so they remain trapped and, upon reaching thermal equilibrium, accumulate in the central region of the trap [1]. Because these potentials are smooth and exhibit a single minimum, their shape can be locally approximated by a three-dimensional harmonic potential,

$$U(\mathbf{r}) = \frac{1}{2} m \left(\omega_1^2 x_1^2 + \omega_2^2 x_2^2 + \omega_3^2 x_3^2 \right), \tag{1}$$

where m is the particle mass and $\omega_1, \omega_2, \omega_3$ are the characteristic confinement frequencies in each spatial direction [2]. This approximation accurately captures the structure of the potential background and determines the natural basis for describing the accessible states.

Within the framework of second quantization, the field operators are expanded in a basis of Hermite functions, whose orthogonality and completeness properties make them suitable for representing the modes of the harmonic oscillator,

$$\hat{\Xi}(\mathbf{r}, t) = \sum_{\boldsymbol{\nu}} \left[\prod_{k=1}^{3} A_{\nu_k} \, e^{-x_k^2/2} \, H_{\nu_k}(x_k) \right] \hat{d}_{\boldsymbol{\nu}}(t). \tag{2}$$

The operators $\hat{d}_{\boldsymbol{\nu}}(t)$ and $\hat{d}^{\dagger}_{\boldsymbol{\nu}}(t)$ correspond to bosonic or fermionic annihilation and creation operators, depending on the statistics of the gas [3], establishing a direct correspondence with the states of the Fock space. The structure of the quantum number vector $\boldsymbol{\nu}$ determines whether the state is symmetric or antisymmetric, ensuring that quantum statistics are automatically incorporated through the commutation or anticommutation relations.

From this expansion, the one-body Hamiltonian is expressed in a diagonal form, reproducing the harmonic oscillator spectrum and assigning a well-defined energy to each mode. On the other hand, two-body interactions are modeled via a contact potential, which introduces couplings between modes and enables the study of how populations are redistributed across different confinement levels. This interaction term is essential for capturing effects beyond the mean field, such as particle correlations and modifications to the collective properties of the gas [5].

Finally, a Bogoliubov-type expansion allows for the description of collective excitations around a highly occupied state, as well as the corrections induced by the interactions [1]. This approach provides a systematic framework for analyzing quantum fluctuations, collective modes, and condensate depletion processes. Altogether, the developed formalism offers a comprehensive and coherent description of many-particle neutral systems confined in harmonic potentials [4], naturally incorporating quantum effects beyond the mean-field approximation [6, 7].

Key words: ultracold gases, second quantization, hermite function basis, bose and fermi gases

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Electromagnetic response of tilted Dirac surface states in topological insulators

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Abstract

We study the electromagnetic response of gapped surface states of three-dimensional topological insulators [1] characterized by a tilted Dirac cone. The system is described by massive, tilted Dirac fermions in the insulating regime within an effective (2+1)-dimensional QED formulation. The tilt is encoded in a constant deformation tensor of unit determinant. Going beyond the gapless case studied in [2], we include the gap-opening mass term, which generates the Chern–Simons sector, and compute the higher-derivative corrections to the polarization tensor from its low-energy expansion. The known results [3, 4] are recovered in the untilted limit. The antisymmetric part retains the Chern–Simons structure, with a leading coefficient independent of the tilt, while the symmetric, Maxwell-like part depends explicitly on the deformation. We derive the induced charge and current densities and analyze the response in different kinematic regimes. In particular, we show that the tilt generates magnetoelectric terms linear in the tilt velocity: a polarization induced by the magnetic field and a magnetization induced by the electric field.

Key words: Topological insulators, tilted Dirac cones, polarization tensor, Chern–Simons
Acknowledgments: R.M.v.D. was supported by ANID FONDECYT Postdoctorado Grant No. 3260624; R.M.v.D. and L.F.U. by SECIHTI CBF-2025-I-1862; R.M.v.D. and P.C. by Universidad de La Frontera, DIUFRO Project DI24-0044; and L.F.U. by DGAPA-UNAM AG100224.

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A polarimetric probe of θ: antenna arrays as a comparative tool for topological magnetoelectric surfaces

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Abstract

We study the radiation of an array of antennas facing a planar TI, extending the single-antenna case of [1] to N sources [2]. We first find a no-go result: the array factor cancels from the fractional magnetoelectric correction, which depends on the array geometry through its mean distance $\bar{z}$ and no in-phase configuration can enhance the θ-effect. The limitation is one of observable, not of geometry: as the first-order topological field is cross-polarized to the zeroth-order field, their interference survives giving a linear rather than quadratic in α observable.

We discuss this polarimetric route as a comparative probe of TI surfaces, as the quantized Kerr measurements [3].

Key words: Topological magnetoelectric response, antenna array, polarimetric filtering.
Acknowledgments: SECIHTI project No. CBF-2025-I-1862.

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Network of chiral exciton-polariton edge modes in phosphorene/SnSe moiré heterostructures

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Abstract

Topological insulators exhibit protected chiral edge states, offering low-dimensional channels for charge or spin transport. It has been proposed[1] that analogues to these states can be engineered in complex semiconductor nanostructures, involving semiconductor quantum wells and photonic crystals embedded inside optical micro-cavities. In such systems, excitons can strongly hybridise with the cavity photon modes to produce hybrid light-matter excitations known as exciton-polaritons, turned topological by the nontrivial interplay between the photon angular momentum and the discrete rotational symmetry of the nanostructure.

Here, a simpler platform for topological exciton-polaritons is proposed. We show that the strong band anisotropy of phosphorene (P) leads to a nontrivial phase $e^{\pm 2i\phi_{\mathbf{k}}}$ in the $\mathbf{k}$-dependent exciton-photon interaction, producing topological exciton-polaritons with Chern numbers ± 2. We argue that a true topological gap can be opened between the first two polariton branches by placing P on top of the group-IV monochalcogenide SnSe, forming a type-II heterostructure in which the P excitons feel a scalar moiré potential. Our numerical calculations show that two pairs of chiral, topologically protected edge states cross the polariton gap, and in fact run across the entire moiré polariton spectrum, as the two bands of opposite Chern numbers are separated by a wide energy window. The edge states act as ideal unidirectional wave guides along the edge of the 2D system, allowing for topologically protected light transport of potential technological import[2, 3].

Key words: Exciton-polaritons, moiré heterostructures, topological edge states
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Quantum Technologies at Cinvestav-Querétaro

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Recent advances in quantum science have accelerated the transition from fundamental physics explorations to disruptive technological platforms [1]. This talk presents an overview of the research initiatives developed at the Quantum Technologies Laboratory of Cinvestav Unidad Querétaro, highlighting our ongoing experimental and theoretical efforts across multiple frontiers of modern quantum science. Our program encompasses field-deployable quantum cryptography beyond standard laboratory environments, the generation and characterization of entangled beams, and the study of quantum fluids. In parallel, we actively develop high-precision quantum gravimetry, quantum memory architectures for coherent state storage and retrieval, and advanced optical tweezers configurations for micromanipulation and microscopic interaction studies. By discussing the operational principles, core experimental challenges, and current milestones of these complementary lines of research, this presentation provides a comprehensive perspective on Cinvestav-Querétaro's contribution to quantum sensing, communication, and matter-wave control.

Keywords: Quantum technologies, quantum cryptography, quantum sensing, quantum fluids, optical tweezers.
Acknowledgments: The authors gratefully acknowledge institutional support from Cinvestav Unidad Querétaro. This work is also supported by the Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI) and the State Government of Querétaro (Gobierno del Estado de Querétaro) through infrastructure, research, and mobility funding for the Quantum Technologies Laboratory.

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Evolution of the structure of colloidal materials during thermodynamic processes of cooling and heating

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Abstract

Understanding the structural evolution of materials under equilibrium and nonequilibrium thermodynamic conditions is essential for assessing their stability and predicting phase behavior. Despite its fundamental importance, the influence of different temperature protocols on structural transformations remains incompletely understood. In this work, we provide a molecular-level characterization of the structural evolution of a bidisperse colloidal suspension of soft spheres subjected to controlled heating and cooling processes. Using extensive molecular dynamics simulations, we investigate the transformations that occur between equilibrium states at different temperatures and examine how multiple length and time scales govern the system's relaxation toward thermodynamic equilibrium. Our results reveal that rapid temperature variations induce distinct thermodynamic pathways during heating and cooling, driven by different underlying structural mechanisms. We define these protocol-dependent behaviors as thermodynamic asymmetries and demonstrate that their magnitude depends strongly on both the thermal protocol and the composition of the suspension. In contrast, when temperature changes are sufficiently slow, the system follows symmetric and reversible pathways, allowing heating and cooling trajectories to converge. These findings provide new insight into the microscopic origins of thermodynamic irreversibility and establish the conditions under which reversible structural evolution can be achieved in soft colloidal materials.

Key words: colloids, structure, non-equilibrium
Acknowledgments: SECIHTI-Mexico (Grant No. CBF2023-2024-3350).

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Development of Materials for Applications in Phonon Catalysis

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Abstract

Rapid technological advancement worldwide has increased energy demand and intensified environmental problems, particularly the generation of emerging contaminants. These challenges highlight the need for new energy sources and novel methods for environmental remediation and alternative energy production. Among the technologies that have attracted considerable attention worldwide is photocatalysis, which has been extensively studied and primarily uses ultraviolet or visible radiation. However, it still faces significant challenges in efficiency, stability, and industrial scalability. Therefore, exploring new alternatives to address and overcome these limitations is essential. Phonon catalysis is an emerging process that uses infrared radiation to excite phonons, enabling more selective bond cleavage or formation with low energy consumption. The first stage of this project will investigate the mechanism of phonon catalysis and examine a family of materials known as phonon catalysts.

Key words:Phononcatalysis, High Entropy Materiasl, Infrared radiation
Acknowledgments: Universidad de Guanajuato

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Helical Trilayer Graphene

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Abstract
Van der Waals homostructures composed of three vertically stacked graphene layers are characterized using periodic first-principles calculations [1]. These carbon systems —periodic within the plane and finite in the direction perpendicular to the layers— feature a constant angle between consecutive pairs of layers, a clockwise helical axis, and distinct initial stacking configurations between the layers. It is worth noting that this is the smallest, commensurate, strain-free periodic trilayer system that can be constructed theoretically. The numerical results indicate that, in addition to the rotation angle between layers and the number of layers, two other additional parameters as the initial stacking configuration and the external pressure applied normal to the layers, are significant for controlling the electronic and optical properties of these systems. Furthermore, the analysis of the diffraction patterns in reciprocal space reveals the emergence and suppression of symmetries within these systems [2].

Keywords: Graphene, Moiré, DFT, Electronics, Optics

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SECCIÓN DE ABSTRACTS

CÁRTELES

4th School on Physics of Quantum materials

4

Adsorción de H2 sobre cúmulos metálicos soportados carbono templado en zeolita: Un estudio teórico

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Abstract
El almacenamiento eficiente de hidrógeno en fase sólida representa uno de los principales retos para la consolidación de las tecnologías de energías limpias. En este trabajo se analiza la adsorción de H_2, mediante cálculos de Teoría de los Funcionales de la Densidad (DFT) implementado en el código ORCA 5.0.3, el efecto de dopaje con heteroátomos en la estructura de carbono templado en zeolita ($C_{39}H_{15}$) y la modificación de la superficie usando cúmulos metálicos de Pd_5M (M = Ti, V). Los cálculos se realizaron utilizando el funcional revPBE con correcciones de dispersión empírica de Grimme (D3BJ) y el conjunto de bases def2-TZVP para los átomos de C,H, B, N, Ti y V, y def2-ECP para el paladio. Se evaluaron los estados fundamentales geométricos y de multiplicidad de espín de los cúmulos Pd_5M (M = Ti, V) y soportados sobre $C_{39}H_{15}$. Mediante un algoritmo docking se determinaron las configuraciones iniciales del sistema Pd_5M/ $C_{39}H_{15}$. Los resultados confirmaron que la incorporación de Ti y V rompe la simetría del clúster de Pd_6, redistribuyendo la densidad electrónica interfacial con la red de carbono y favoreciendo la adsorción de moléculas de H_2.

Key words: Hydrogen storage, Density Functional Theory (DFT), Bimetallic clusters, Zeolite-Templated Carbon (ZTC), Palladium alloys, ORCA software.
Acknowledgments: Se agradece al Tecnológico Nacional de México / Instituto Tecnológico de Valle de Etla y a la Universidad San Sebastián por el apoyo institucional y las facilidades otorgadas para el desarrollo de esta investigación, así como al uso de la infraestructura de cómputo de alto rendimiento.

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Cadenas monoatómicas en nitruro de boro hexagonal

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Abstract
Este trabajo tiene como objetivo mostrar que un mecanismo de intercalación de metales de transición en bicapas de nitruro de boro hexagonal permite la formación de líneas conductoras para el transporte de carga electrónico de anchura atómica, tomando como punto de partida los resultados obtenidos por el trabajo de Galván y García, y colaboradores [1]; y por el trabajo de Lin y colaboradores [2]. Los resultados presentados son sustentados por medio de cálculos numéricos de energía total con la Teoría del Funcional de la Densidad (DFT, por sus siglas en inglés) implementada en el código SIESTA [3] (Spanish Initiative for Electronic Simulations with Thousands of Atoms). Las líneas conductoras en estos sistemas tienen la peculiaridad de estar constituidas por átomos de escandio entre dos monocapas aislantes de nitruro de boro hexagonal. El factor de llenado de escandio en las bicapas y la orientación de estas cadenas monoatómicas son determinantes para la formación de las mismas. Vale la pena mencionar que este estudio permite la estabilización de sistemas metálicos monoatómicos dentro de plantillas aislantes, y protectoras, de nitruro de boro para el transporte de carga e información en la nanoescala.

Key words: nitruro de boro hexagonal, Teoría del Funcional de la Densidad, líneas conductoras, escandio
Acknowledgments: este trabajo se llevó a cabo gracias al financiamiento parcial del Departamento de Materia Condensada (IFUNAM), proyecto DGAPA-PAPIIT (UNAM) IN114926: Heteroestructuras de Van der Waals helicoidales, y el proyecto CONAHCYT CF-2023-I-336: Estudio ab initio de cristales no convencionales de van der Waals presurizados. Agradecimiento al actuario Carlos Ernesto López Natarén por su apoyo en la realización de los cálculos numéricos con el cluster Holiday del IFUNAM.

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Electromagnetic Response of Two Interacting Topological Insulator Spheres in External Fields

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Abstract

We study the static electromagnetic response of two spherical topological insulators embedded in a dielectric medium and subjected to a uniform external electric field. The gapped surface states are described by a piecewise constant axion field, which induces a topological magnetoelectric coupling localized at the spherical interfaces. The electrostatic problem is solved at zeroth order using bispherical coordinates, allowing for an exact treatment of both parallel and perpendicular orientations of the external field relative to the center-to-center axis. The resulting mode expansions are determined by three-term recurrence relations, which are solved perturbatively for nonoverlapping spheres. The axion-induced response is then computed to leading order in the fine-structure constant. The induced sources are purely interfacial and generate distinct magnetostatic field configurations in the parallel and perpendicular geometries. Closed-form series representations for the induced vector potential and magnetic field are obtained in terms of the zeroth-order electrostatic coefficients. These results provide an analytically controlled description of axion-induced magnetostatics in multi-sphere topological systems. *Key words: Axion, Classical mechanics, Condensed matter physics, Topological Insulator*
Acknowledgments: J.C.G. was supported by the SECIHTI fellowship No. 1165841

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Electronic Transport in Tilted Topological Semimetals

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Abstract

Topological Weyl and nodal-line semimetals are three-dimensional quantum materials characterized by band crossings in momentum space. In Weyl semimetals, these crossings occur at isolated points, known as Weyl nodes, whereas in nodal-line semimetals they form continuous closed loops.

Solving the scattering problem using effective low-energy Hamiltonians for each topological material, including symmetry-breaking tilt terms, we study charge transport across each semimetal, with the same material in equilibrium serving as both leads. Following the Landauer–Büttiker formalism presented by Kawabata and Ueda [1], we derive general expressions for the linear and nonlinear conductances, including both longitudinal and Berry-curvature-induced Hall components, and evaluate the resulting conductances at zero and finite temperatures.

Our analytical and numerical results elucidate the dependence of the conductance on the sample width, as well as its strong sensitivity to the tilt terms. This work establishes a unified framework connecting the relativistic Klein tunneling with coherent linear and nonlinear transport in Weyl and nodal-line semimetals.

Key words: Weyl semimetal, nodal-line semimetal, electronic transport, Landauer–Büttiker, conductance, Klein tunneling, nonlinear transport
Acknowledgments: Luis Eduardo Sosa Arias was supported by the SECIHTI fellowship No. 4066288 with CVU No. 1298662. José Alberto Martín Ruiz acknowledges financial support by UNAM-PAPIIT project No. IG100224, UNAM-PAPIME project No. PE109226, by SECIHTI project No. CBF- 2025-I-1862 and by the Marcos Moshinsky Foundation.

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Exact solutions and electromagnetic radiation in homogeneus linear axion electrodynamics

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Abstract

We study the electromagnetic response in the presence of an axion field that is homogeneous and linear in time, ($\theta(t) = \beta_0 t$). By solving the modified Maxwell equations, we derive exact analytical solutions for the electromagnetic fields in the space-frequency domain, applicable to arbitrary source geometries. Using this general formulation we examine

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various radiation scenarios to identify the physical consequences of the topological axion coupling. First, we validate our approach by recovering established results for Cherenkov radiation in isotropic chiral media [2]. Finally, we apply this framework to two additional radiating configurations: radiation induced by the impulsive scattering of a charged particle, and the electromagnetic emission from a pair of short dipole antennas.

Key words: Axion Electrodynamics, Cherenkov Radiation, Short Antennas

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Floquet channel and dissipative structure of a two-level system under periodic driving

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Abstract

The thermal properties of driven quantum dissipative systems are not well understood, this problem is specially relevant in quantum matter under different types of excitations. Here, as a paradigmatic choice, a two-level system coupled to a bosonic thermal bath under periodic driving is studied. The problem is described by using the Floquet-Redfield equation to answer: how many modes participate, which one dominates, and which parameters control them. To respond them, the one-period channel $\mathcal{E}_T$ which maps the density matrix time evolution, is constructed and whose spectrum condenses all the information about the stroboscopic relaxation between the external field frequency. Scans in the coupling α and the frequency ratio $\tilde{\omega}/\omega_0$ reveal that both parameters reorganize the spectrum, but through different mechanisms: α globally contracts all subdominant modes, while $\tilde{\omega}/\omega_0$ acts on the quasienergies and the effective Floquet frequencies, generating a memory maximum near $\tilde{\omega}/\omega_0 \simeq 0.967$ that coincides with a minimum in the quasienergy separation. *Key words: Two-level-system, Floquet, Redfield, channel*

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Gap-controlled anharmonic thermalization in a classical SSH-type lattice

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Abstract

Anharmonic phonon–phonon scattering limits thermal transport in crystals, and the band structure decides which three-phonon channels exist. We study this in a minimal classical model: a Fermi–Pasta–Ulam–Tsingou chain with alternating spring constants $\kappa_1 \neq \kappa_2$ and cubic nonlinearity, whose linear spectrum is the phononic counterpart of the Su–Schrieffer–Heeger (SSH) chain [1], with an acoustic–optical gap set by $\Delta\kappa$. No quantum degrees of freedom are involved. Long-time symplectic simulations show that acoustic–acoustic–optical triads activate the optical branch after $\sim 10^4$ oscillation periods for $\Delta\kappa \leq 1/2$, whereas for $\Delta\kappa > 1/2$ the bands remain isolated. This threshold coincides with the first allowed umklapp process, where two zone-boundary acoustic phonons fuse into a zone-center optical phonon. Boundary conditions add long-lived *sticky* states. The gap thus acts as a tunable, momentum-selective filter for anharmonic energy transfer. The chain is chiral-symmetric with winding number 0 (Zak phase 0) for $\kappa_1 > \kappa_2$, so this threshold is kinematic rather than topological; edge states are not studied here [2, 3].

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Key words: anharmonic lattices, SSH model, phonon gap, umklapp scattering, thermalization, FPUT
Acknowledgments: UNAM DGAPA PAPIIT IN101924; J.A.A. acknowledges a CONAHCyT PhD scholarship.

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Generación de vórtices en flujos electrónicos en conductores de alta movilidad inducidos por la geometría

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Abstract

El transporte electrónico en sistemas mesoscópicos depende fuertemente de la relación entre las longitudes características de dispersión y el tamaño del dispositivo. Cuando las colisiones que conservan el momento entre los portadores dominan sobre los procesos disipativos, los electrones pueden comportarse colectivamente como un fluido viscoso, dando lugar a un régimen hidrodinámico. Este régimen, predicho teóricamente[1], exhibe fenómenos análogos a los de la hidrodinámica clásica, como flujo de Poiseuille [2], efectos viscosos y la posible formación de vórtices de corriente[3]. Recientemente, se ha reportado experimentalmente la formación de vórtices de corriente estacionarios en monocapas de grafeno de alta movilidad a temperatura ambiente mediante magnetometría basada en centros de vacancia de nitrógeno[4].

En nuestro trabajo simulamos un fluido hidrodinámico de electrones en un sistema compuesto por un canal con una cavidad lateral(circular rectangular y triangular), mediante las ecuaciones de Navier-Stokes y de continuidad. Encontramos que la aparición de vórtices en la cavidad está determinada por los parámetros críticos de la longitud de Gurzhi y los parámetros geométricos que describen la cavidad. Este estudio abre la posibilidad de diseñar dispositivos electrónicos basados en fenómenos hidrodinámicos.

Key words: Hidrodinámica electrónica, Vórtices de corriente, Formación de vórtices inducida por la geometría
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Generación de vórtices en flujos electrónicos en conductores de alta movilidad inducidos por la geometría

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Abstract

El transporte electrónico en sistemas mesoscópicos depende fuertemente de la relación entre las longitudes características de dispersión y el tamaño del dispositivo. Cuando las colisiones que conservan el momento entre los portadores dominan sobre los procesos disipativos, los electrones pueden comportarse colectivamente como un fluido viscoso, dando lugar a un régimen hidrodinámico. Este régimen, predicho teóricamente[1], exhibe fenómenos análogos a los de la hidrodinámica clásica, como flujo de Poiseuille [2], efectos viscosos y la posible formación de vórtices de corriente[3]. Recientemente, se ha reportado experimentalmente la formación de vórtices de corriente estacionarios en monocapas de grafeno de alta movilidad a temperatura ambiente mediante magnetometría basada en centros de vacancia de nitrógeno[4].

En nuestro trabajo simulamos un fluido hidrodinámico de electrones en un sistema compuesto por un canal con una cavidad lateral(circular rectangular y triangular), mediante las ecuaciones de Navier-Stokes y de continuidad. Encontramos que la aparición de vórtices en la cavidad está determinada por los parámetros críticos de la longitud de Gurzhi y los parámetros geométricos que describen la cavidad. Este estudio abre la posibilidad de diseñar dispositivos electrónicos basados en fenómenos hidrodinámicos.

Key words: Hidrodinámica electrónica, Vórtices de corriente, Formación de vórtices inducida por la geometría
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Emergent Magnetism in Infinite Chains of Alternating Triangulene $N = 2$ Units: A First-Principles Study

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Abstract

Open-shell nanographenes with uncompensated sublattice imbalance constitute one of the most promising platforms for carbon-based magnetism free of transition metals. Among these systems, triangulene $N = 2$ (a triangular graphene fragment with zigzag edges and the molecular formula $C_{13}H_9$) hosts a half-filled zero-mode state that gives rise to a net spin $S = 1/2$, as predicted by the Lieb theorem [1] and confirmed experimentally by on-surface synthesis and scanning-tunneling spectroscopy [2]. When $N = 2$ units are covalently linked into a one-dimensional (1D) periodic chain with alternating connectivity, the inter-unit exchange interaction is mediated by the bridging carbon atoms, yet its sign and magnitude have not been determined from first-principles calculations. Here we report a density-functional-theory (DFT) study of infinite 1D chains of alternating triangulene $N = 2$ units, performed with the SIESTA code using the GGA-PBE functional and norm-conserving pseudopotentials. We compute the total energies of the non-magnetic (NM), ferromagnetic (FM), and antiferromagnetic (AFM) phases, extract the exchange coupling constant J via the energy mapping $J = (E_{\mathrm{AFM}} - E_{\mathrm{FM}})/2S^2$, and characterize each phase through the electronic band structure, total and projected density of states, and real-space spin-density isosurfaces. Preliminary results indicate that the AFM configuration is the ground state, with spin density localized on zigzag-edge carbons and opposite polarization on adjacent units, consistent with kinetic exchange through the covalent bridge. The magnitude of J falls in the range of tens of meV, suggesting these chains as viable candidates for molecular spin-chain devices and quantum-information applications.

Key words: *triangulene, nanographene, edge magnetism, DFT, SIESTA, exchange coupling, spin chain, spintronics.*

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Estados topológicos en una red de Kagomé deformada

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Abstract

En este trabajo se estudia la estructura electrónica y las propiedades topológicas de una red de Kagome sometida a una deformación mecánica uniaxial, utilizando el formalismo del modelo *tight-binding*. Mediante la formulación analítica del Hamiltoniano en las proximidades de los puntos de Dirac y el análisis de la curvatura de Berry, se examina la respuesta topológica del sistema ante la ruptura de simetrías espaciales. Los resultados demuestran que la deformación uniaxial introduce anisotropías direccionales y desplaza los valles de Dirac en la zona de Brillouin, mientras que la inclusión de saltos a segundos vecinos con fase quiral, en analogía con el modelo de Haldane [2], permite modular la apertura de brechas topológicas de energía. Asimismo, se evalúa la robustez del invariante topológico global, estableciendo las condiciones bajo las cuales el sistema transiciona hacia fases con características de aislante topológico.

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Quantum confinement in Chern-insulators quantum dots

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Abstract

This work presents a theoretical study of quantum confinement in circular Chern-insulator quantum dots using effective continuum models. The

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system is described through the Qi-Wu-Zhang model and its continuum limit, considering both linear and quadratic Dirac Hamiltonians with position-dependent mass. The resulting confined states, including topological edge states, are obtained from the corresponding energy spectra. Their probability density, local density of states, azimuthal currents, and orbital magnetic moments are analyzed to characterize the confined states and their topological properties. The results provide a theoretical framework for studying quantum confinement in Chern-insulator quantum dots and their response to magnetic fields, with potential applications in spintronics and quantum technologies.

Key words: quantum confinement, Chern-Insulator, quantum dot.
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Room-temperature strong coupling between core-shell inorganic quantum dots and quasiperiodic Fibonacci photonic structures to form exciton-polaritons with positive detuning

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Abstract

We studied the light-matter interaction between core-shell inorganic quantum dots and porous-silicon quasiperiodic structures to form exciton-polaritons with positive detuning. The design was based on tuning an edge photonic state of the Fibonacci quasiperiodic structure with the quantum dots exciton energy achieving a positive detuning between the two corresponding energies. As a result, the formation of two polariton branches (Lower-Polariton, LP; and Upper-Polariton, UP) is observed due to Rabi splitting. Next step is exploring LP Bose-Einstein condensation and exploring possible application in quantum technologies. Fibonacci quasiperiodic structures were fabricated via electrochemical anodization using p+ silicon wafers. After a pre-oxidation of the Fibonacci structure, it was infiltrated with quantum dots via drop casting, controlling the concentration and volume of the solution. Angle-resolved photoluminescence of the structures was carried out using a EKSPLA PL2231-50-SH/TH Nd:YAG pulsed laser system with an excitation wavelength of 355 nm. The emission and reflection of the structures were collected with an optical fiber and analyzed with a UV-VIS spectrometer Ocean Optics USB2000+.

Key words: light-matter interaction, exciton-polariton, porous silicon, strong-coupling
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Structural characterization of YIG films and implementation of a P-MOKE microscope for the study of domain wall dynamics.

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Abstract

Yttrium iron garnet (YIG) is a ferrimagnetic oxide first synthesized in 1957 [1]; since then, it has been the primary material used in the development of spintronic and magnonic devices [2]. It possesses a cubic crystal structure in which yttrium ions occupy dodecahedral sites, while iron ions are distributed across octahedral and tetrahedral sites with mutually opposed magnetic moments [3]. This makes it an ideal material for understanding magnetic domain wall dynamics via magneto-optical Kerr effect (MOKE) microscopy.

In turn, MOKE microscopy involves shining polarized light onto a magnetized surface and subsequently analyzing the reflected beam, which exhibits a rotation in its polarization plane [4]. The direction and magnitude of this rotation depend on the magnetization orientation within the sample. In particular, the polar MOKE configuration (P-MOKE) is employed when the magnetization is perpendicular to the sample plane, as it yields a larger rotation angle [5]. Consequently, the characterization of thin YIG films with perpendicular magnetic anisotropy (PMA) requires the development of P-MOKE systems optimized for observing their domain wall dynamics.

In this work, we study YIG thin films of varying thickness using atomic force microscopy (AFM), scanning electron microscopy (SEM), and superconducting quantum interference device (SQUID) magnetometry to determine the morphological, structural, and magnetic properties of the samples. Furthermore, we present the design and implementation P-MOKE microscope featuring a digital CMOS camera and an electromagnet capable of generating magnetic fields of 2.67 mT/A, aimed at characterizing magnetic domain wall dynamics in YIG thin films.

Key words: YIG, spintronics, P-MOKE, domain wall dynamics
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To the Field and Back Again: A Modular 'Black-Box' Approach for QRNG and Polarization Stability in QKD

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Abstract
This work describes the development of a pair of modulus for a BB84 Quantum Key Distribution (QKD) system designed for real-world optical networks. Transitioning QKD outside the laboratory faces critical barriers, notably environmental polarization drift—which induces unpredictable birefringence and increases the Quantum Bit Error Rate (QBER)—and the security risks associated with pseudo-random generators. To address these challenges, our architecture integrates two essential subsystems: a Quantum Random Number Generator (QRNG) extracting true physical randomness from quantum shot noise, and an Active Polarization Controller (APC) employing a feedback algorithm to dynamically compensate for fiber-induced birefringence using a non-ideal three-waveplate array. We present the experimental validation of the QRNG module, demonstrating that raw and XOR-processed bitstreams successfully pass strict NIST statistical tests. Furthermore, we show how integrating these true random keys with Cascade error reconciliation reduces the initial link QBER from 7.84% to a stable 2.4% over a 1 km commercial fiber link. This modular approach provides a robust framework, marking a significant step toward field-ready quantum cryptographic networks.

Key words: Quantum Key Distribution, Quantum Random Number Generator, Active Polarization Control, BB84 protocol, Birefringence compensation.
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