Casa abierta al tiempo
UNIVERSIDAD AUTÓNOMA METROPOLITANA
DR. JUAN MORALES CORONA
Jefe del Departamento de Física

CdMx a 11 de noviembre de 2025.

DR. ROMAN LINARES ROMERO
Presidente del Consejo Divisional de
Ciencias Básicas en Ingeniería
P R E S E N T E.

Después de haber revisado el informe de actividades realizadas por el **Dr. Jiang Yu**, durante su periodo sabático, me permito informarle a usted que, a mi juicio, los objetivos se cumplieron de forma satisfactoria.

De esta manera pongo a su consideración que se incluya en la orden del día de la próxima sesión del Consejo Divisional que usted preside la presentación del informe.

Sin más por el momento, quedo a sus órdenes para cualquier duda o aclaración al respecto.

[redacted]

A T E N T A M E N T E
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Casa abierta al tiempo

UNIVERSIDAD AUTÓNOMA METROPOLITANA

CONSEJO DIVISIONAL DE CIENCIAS BÁSICAS E INGENIERIA

INFORME DE PERÍODO SABÁTICO

DATOS GENERALES

Nombre del profesor: Jiang Yu Nº empleado: [redacted]

Departamento: FISICA Área:

Teléfono particular: [redacted] Extensión UAM- [redacted] E-mai [redacted] @xanum.uam.mx

DATOS DEL PERÍODO SABÁTICO SOLICITADO

Nº meses solicitados: 12 Fecha de inicio: 14 de Octubre de Fecha de terminación: 13 de Octubre de 2025

Institución donde se realizará:

Depto., Laboratorio, etc.: Department of Physics, Beijing Normal University

Domicilio de la institución: No. 19, Xinjiekou St, Haidian District, Beijing, China 100875

Teléfono: Fax: E-mail

OBJETIVOS DEL PERÍODO SABÁTICO

Investigar las propiedades de transición de fases en sistemas no-hermitianos

en colaboración con el Dr. Guojian Yang, de Beijing Normal University

METAS ALCANZADAS EN EL PERÍODO SABÁTICO

- ☐ Memorias in extenso en libro de resúmenes*
- ☐ Artículos de investigación en revista indexada*
- ☐ Presentaciones en congresos
- ☐ Libros o capítulos de libros
- ☐ Grado
- ☐ % Avance de estudios de posgrado
- ☐ Otros (especifique):

* Indicar en anexo si se trata de trabajo publicado, aceptado o sometido

[redacted]

TIPO DE ACTIVIDADES ACADÉMICAS DESARROLLADAS

(Indique aquellas relacionadas con las actividades desarrolladas)

- [x] Investigación
- [ ] Docencia
- [ ] Difusión
- [ ] Formación académica
- [ ] Formación profesional
- [ ] Entrenamiento técnico
- [ ] Otros (especifique): ______

RESUMEN DEL PLAN DE ACTIVIDADES ACADÉMICAS DESARROLLADAS

(El llenado de esta sección no sustituye el informe detallado de actividades)

1) Para poder determinar la zona generalizada de Brillouin (GBZ) de un sistema no-hermitiano he desarrollado un método utilizando la suposición de existir un estado conjugado, lo cual nos ayuda definir una extensión de GBZ. Este método nos permita resolver los problemas de volar propio para un sistema en el limite termodinámico con mayor facilitad. He aplicado este método en el estudio de las propiedades de transición topologica de los sistemas no-hermitianos y logre resultados interesantes.

Los otros dos temas 2) y 3) del plan de trabajo aun no he tenido resultados.

PARA USO DEL JEFE DE DEPARTAMENTO

Después de haber evaluado el informe detallado de actividades del período sabático del interesado según los lineamientos establecidos para tal efecto; informo al Consejo Divisional que:

- [x] Los objetivos SE cumplieron satisfactoriamente
- [ ] Los objetivos SE cumplieron parcialmente
- [ ] Los objetivos NO se cumplieron
- [ ] NO se cumplió el propósito del sabático

[redacted]

Firma del Jefe de Departamento

7-Oct-2025

Fecha

PARA USO DEL CONSEJO DIVISIONAL

El Consejo Divisional, en su Sesión No. ______ del ______ sobre el Período sabático del interesado acordó que:

- [ ] Los objetivos SE cumplieron satisfactoriamente
- [ ] Los objetivos SE cumplieron parcialmente
- [ ] Los objetivos NO se cumplieron
- [ ] NO se cumplió el propósito del sabático

______

Secretario del Consejo Divisional

*Además de este formato-resumen, el interesado deberá entregar su Informe detallado de actividades junto con la documentación probatoria correspondiente.

[redacted]

Reporte de trabajo 2024-2025

Jiang Yu
(21 de Oct. 2025)

Durante este periodo sabático he realizado los siguientes trabajos de investigación sobre las propiedades topológicas de sistemas no Hermitianos:

1. Para poder determinar la zona generalizada de Brillouin (GBZ) de un sistema no-hermitiano he desarrollado un método utilizando la suposición de existir un estado conjugado, lo cual nos ayuda definir una extensión de GBZ. Este método nos permita resolver los problemas de volar propio para un sistema en el límite termodinámico con mayor facilitad.
2. He aplicado este método en el estudio de los efectos skin no-hermitiano crítico, logre obtener las GBZ en el limite termodinámico, lo cual es difícil calcular numéricamente debido a la dimensión de sistema tiende a infinito.

[redacted]

Real-space study on non-Hermitian skin effects

Jiang Yu

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We present a systematic procedure for investigating boundary states and topological phases in non-Hermitian systems within the framework of tight-binding theory. Taking the determinant of transfer matrix as an indicator we explore various mechanisms leading to the skin effects. Our approach provides a real-space platform for understanding the relationship between the bulk and the edge states in non-Hermitian Hamiltonians. For systems with nonunimodular transfer matrix the Bloch theorem becomes applicable after a similar transformation with decay factor derived the transfer matrix. For vanishing or singular determinants we derive an one-way TB equation to study the anomalous bulk and edge states in real space. In the case of unimodular determinants we show the emergence of the non-Hermitian skin effects due to the underlying symmetry.

INTRODUCTION

Bulk-boundary correspondence (BBC) is a central principle in topological Hermitian systems[1–8]. It reveals a fundamental relationship between the boundary states and the bulk invariants of the Hermitian Hamiltonian. The research progresses in the Hermitian topological systems have inspired attempts to extend the topological concepts, such as BBC, to non-Hermitian Hamiltonians[9–13, 15]. It has been shown that the non-Hermitian systems may exhibit quite different eigenenergy spectra of the bulk states for periodic o open boundary conditions. In particular it is found that, under certain conditions the bulk states may be driven to pile up at the boundaries, exhibiting the unique feature of non-Hermitian systems, which is extremely sensitive to the boundary conditions as well as the intrinsic topologies and symmetries of the systems under investigation.

Recently there have been several proposals to restore the BBC in non-Hermitian Hamiltonians [16–23, 27]. The non-Bloch band theory suggests that in a non-Hermitian system, the Bloch wave vector should be complex, and a non-Bloch band theory is formulated by make a replacement $e^{ik} \to \beta$, where β is defined on a loop (called generalized Brillion zone) in a complex plane[11, 16]. It is also suggested that through an imaginary gauge transformation, which is equivalent to a replacement of the momentum from k to $k - i\log r$ [9, 11, 19–21, 26], one can find the correspopnding topological phases in non-Hermitian systems. However, it remains a challenging task to find the decay factor r, or the imaginary flux $\phi = -\log r$, which may be determined from the boundary condition plus the continuum condition required by the bulk states[11, 16], or is obtained by examining the spectral evolutions [20, 27]. The baisc idea behind those approaches is to relate the decay factors of the left and right edge states to the bulk states parameters, as clearly demonstrated in the definition of biorthogonal polarization[13].

In this work we propose a transfer matrix formalism for studying the non-Hermitian skin effects and the topological phase transition, in real space. This is because the transfer matrix derived from the TB equations provide a natural way for the description of how the state are transfered, from one boundary to the other. It constitutes a complementary tools in addition to the approaches developed in momentum space. The skin effects take place in real-space boundaries, it is appropriate to work out a unified description of non-Hermitian topological properties in terms of real-space eigenfunctions. Particularly when the system operates on or near real-space exceptional points the appearance of defective edge states[9, 10, 23] deserves detailed analysis based on closed-form solutions of the eigenstates.

The transfer matrix method has been widely used in the study of the edge states and the bulk-boundary correspondence in topological phases in Hermitian Hamiltonian. [24, 28, 29]. It also has proved to be a powerful means to treat quantum transports through complex ramified channels[32]. Here we use a modified version of the singular-value decoposition method to decompose the original TB equations into two separate subsystems with only left and right couplings, respectively. Accordingly a transfer matrix can be constructed [25, 26]. Since our purpose is to expand the eigenfunctions in terms of certain orhtoganl basis, we may relax some requirements that the singular value decoposition method should meet, to include more diversified systems. We propose that the decay factor (r) (or the imaginary flux $e^{-\phi} = r$) is given by the transfer matrix, i.e.,$r = \sqrt{\det(M)}$. If $r \neq 1$ non-Hermitian skin effects (NHSE) may appear. In order that the Bloch theorem applies we require that the Bloch cells are identical in both the on-cell potential and the hopping structures, which means that the size of the Bloch cell is equal to the hopping range in the TB equations. This is crucial for the replacement $k \to k - i\log r$ to correctly predict the topological properties of the non-Hermitial system. With the decay factor, one can take the similarity transformation of the eigenfunctions, that is, $\psi_n = r^n\bar{\psi}_n$, where ψ_n, and $\bar{\psi}_n$

Frequency comb effects for a single photon in one-dimensional waveguides

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Abstract:

We analyse single-photon transport in an one-dimensional waveguide coupled to cavities with embedded two-level atoms, by using a transfer matrix formalism developed from a fully quantum-mechanical theory. We calculate the transmission and reflection amplitudes for waveguides with side-coupled and direct-coupled atoms. Our results reveal that when the photon frequency is comparable to the atom transition energy, perfect reflection frequency windows emerge for direct-coupled waveguide, while a resonant transmission regime is found for side-coupled system. When the waveguide photon frequency is away from atom transition one, we find a comb-like spectrum, which is determined by photon-cavity as well as photon-atom coupling constants. For two serially coupled atom arrays, our numerical analysis demonstrates that side bands show up as a result of competition effects between the two inter-atom spacings.

References and links

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Controlling photon transport in multi-branch photonic quantum circuits

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Employing a tight-binding approximation we derive a transfer matrix formalism for single photon transport through a composite scattering center, which consists of parallel connected resonator optical waveguides. By solving the single-mode eigenvectors of the corresponding Hamiltonian, we investigate the quantum interference effects of parallel couplings on the photon transport. We find that the transport properties are dramatically modified by the number of coupled resonator waveguides. Numerical analysis reveals that by changing atom transition frequency, the window of perfect reflection may shift to cover almost all incoming photon energy, indicating the effective control of single photon scattering by photon-atom interaction.

PACS numbers: 42.50.Ex, 03.67.Lx, 42.50.Pq

INTRODUCTION

Large scale photonic quantum circuit can be built from basic quantum optical devices. One dimensional waveguides such as optical nanofibers[1–8], photonic crystal waveguide[9–18], surface plasmon nanowire[19–21], etc..., provide a natural platform to implement such modular functions. Recent studies have revealed many interesting single photon transport features in such a simple one dimensional quantum circuit. It has been shown that the coupling of atoms or quantum emitters to the optical waveguide offers controllable framework to achieve quantum phton switching, routing, storages and other quantum information operations[22–27]. Since single photon propagation may be used for quantum information processing, the control of single photon transport through photonic quantum devices like single-photon diode, circulator, and router, has beed studies extensively in recent years[100]. Most of such investigations are focused on the photon transport through a single optical waveguide. It is, however, interesting to study the photon propagation in branched optical photonic quantum circuits, where the network consists of both serially and parallel coupled basic modules. In this work we propose to investigate the single photon transport through such a parallel connected optical waveguides. We will show the impacts of parallel photonic circuits on the photon transport properties by analyzing transmission and reflection probabilities.

Currently there are several important theoretical approaches being used to study the photon transport in one dimension waveguide coupled to a chain of quantum emitters, including the real space Bethe anzatz approach[28, 29], Input-out formalism [30, 31], and Lippman-Schwinger scattering-theory approach [32–35]. The tight-binding (TB)formalism has recently been employed to show that the scattering of a single photon inside a one-dimensional resonator waveguide can be ocntrolled by the coupled two-level quantum system[36]. It is demonstrated that a finite-bandwidth spectrum of perfect reflection appears as the detuning between the photon and atomic frequency varies. Single-photon transport properties can be strongly influenced by the number of atoms that interact with the waveguide as a result of multiple scattering between the propagating photon and the quantum emitters, which has been used for controlling the coherent transport of the photons[37–45]. In addition to the effects of the collective interaction with the multiple emitters, the coupling modes between atom and the one-dimensional waveguide also affect the photon transport and result in quite involved, nontrivial dispersion relations that can lead to strong reduction of the group velocity of photons due to the increase of a finite reflection bandwidth[37, 38, 46]. Since the coupling configuration between atoms and waveguide play an important role in determining the transport properties of photons, in this paper we will focus on the coupling effects on the photon transfer through a black-box like scattering cluster, in the context of the tight-binding theory[47]. In the context of the electron transport of multiply-connected structures made of one-dimensional wires, the effects of the junction, where several wires emerge, are described by scattering matrices, whose elements are determined by current conservation and other relevant structural symmetries. On the other hand in the study of quantum interference in multi-branch molecular junctions the bifurcation points are described by connecting matrices, whose elements represent the coupling constant of the branching sites to their nearest-neighbor ones[48–50]. In this paper we will present a transfer matrix approach for single-photon transport through a multiple one-dimensional coupled resonator waveguides which are bound together at two terminals. Our method can be regardes as an extension of the transport through a scattering center of the ring structure to a general two-terminal, multiple internal-branch scattering potentials.

The paper is organized as follows. In Sec. II we derive a general theory for photon transport through a two-terminal interaction box, where multiple waveguides with