NCTS Theoretical Physics Symposium 理論物理論壇

(2024/1/25)

Afternoon session 13:30 – 16:00
Chair: Jeng-Da Chai (NTU)
Location: 中央大學健雄館 S4-202 (2F) Chien-Shiung Bldg., NCU

No.	Time	Name	Title of talk
1	13:30 – 13:40	Jeng-Da Chai (NTU)	Current Status of NCTS-Physics
2	13:40 – 14:10	Fu-Lai Wen (NTUE)	Bridging single cell dynamics to global tissue behavior: Multiscale modeling and experiments
3	14:10 – 14:40	Di-Lun Yang (IOP/AS)	Recent developments of quantum kinetic theory for chiral and spin transport
4	14:40 – 15:00	Wen-Te Liao (NCU)	Gravitationally sensitive structured x-ray optics using nuclear resonances
5	15:00 – 15:20	Hung-Yi Pu (NTNU)	A step-by-step introduction to General Relativistic Radiative Transfer
6	15:20 – 15:40	Tay-Rong Chang (NCKU)	Feature-energy duality of topological boundary states in multilayer quantum spin Hall insulator
7	15:40 – 16:00	Hsuan-Yi Chen (NCU)	Extreme value statistics and noises in stick-slip dynamics

[1]

Current Status of NCTS-Physics

Jeng-Da Chai
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As an opening of the National Center for Theoretical Sciences (NCTS) Theoretical Physics Symposium in the 2024 TPS Annual Meeting, I will report the current status of NCTS-Physics (e.g., organization structure, operation mode, major programs, and academic achievements). More information can also be found on the NCTS-Physics website: https://www.phys.ncts.ntu.edu.tw/ .

[2]

Bridging single cell dynamics to global tissue behavior: Multiscale modeling and experiments

Fu-Lai Wen (温福來)
Department of Science Education, National Taipei University of Education, Taiwan

Tissues consist of many cells that work together to perform a specific function for the organism. Each cell within a tissue can exhibit rich dynamics such as cell shape changes and cell movement. The various cell dynamics generate mechanical forces necessary for tissue shape formation during embryo development and tissue repair in wound healing process. Understanding of how individual cell dynamics orchestrate the global tissue behavior is central to the fields of biology and biomedical engineering, and presents a new frontier in the physics of soft matter since cells can be generally considered as an "active" soft material that is far from equilibrium. In this talk, I will present how physics can address complex problems found in nonequilibrium living systems, such as how tissues acquire their characteristic shape, respond to various mechanical and chemical perturbations of their homeostatic state, and repair properly when they get injured.

[3]

Recent developments of quantum kinetic theory for chiral and spin transport

Di-Lun Yang
Institute of Physics, Academia Sinica, Taiwan

Recently, the anomalous transport associated with quantum anomalies and spin effects has been greatly explored in different physical systems including relativistic heavy ion collisions (HIC), Weyl semimetals, and core-collapse supernovae. In particular, to understand the non-equilibrium anomalous transport, there have been extensive studies upon quantum kinetic theory (QKT) for relativistic fermions incorporating the chiral anomaly and spin-orbit interaction. I will briefly review the recent developments and applications of QKT for massless fermions known as the chiral kinetic theory (CKT) obtained from the Wigner-function approach based on quantum field theory and further extension to massive fermions for understanding dynamical spin polarization of quarks in HIC.

[4]

Gravitationally sensitive structured x-ray optics using nuclear resonances

Shin-Yu Lee[1], Sven Ahrens[2], and Wen-Te Liao[1]
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[2]Shanghai Normal University, Shanghai 200234, China

Einstein's general theory of relativity not only revolutionized our understanding of the universe but also led to numerous gravitational applications on a large scale, such as gravitational-wave astronomy. However, it is still a challenge to find a gravitational application at small spatial extensions on Earth. In this study, we investigate a structured waveguide system that enables the control of an X-ray profile at altitude separations of millimeters or even shorter, utilizing the nuclear resonant scattering of X-rays. Our current findings suggest a potential compact solution for using Earth's gravity as a practical application of X-ray optics [1].

References

[1] S.-Y. Lee, S. Ahrens, W.-T. Liao, arXiv:2305.00613 (2023).

[5]

A step-by-step introduction to General Relativistic Radiative Transfer

Hung-Yi Pu

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2. Center of Astronomy and Gravitation, National Taiwan Normal University
3. Institute of Astronomy and Astrophysics, Academia Sinica

During the presentation, we will delve into the realm of astrophysical radiative transfer in curved spacetime, illustrated through various examples. Additionally, we will explore its practical applications, notably its role in the prediction of imagery such as the black hole shadow.

[6]

Feature-energy duality of topological boundary states in multilayer quantum spin Hall insulator

Tay-Rong Chang

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Gapless topological boundary states characterize nontrivial topological phases arising from the bulk-boundary correspondence in symmetry-protected topological materials, such as the emergence of helical edge states in a two-dimensional $\mathbb{Z}_2$ topological insulator. However, the incorporation of symmetry-breaking perturbation terms in the Hamiltonian leads to the gapping of these edge bands, resulting in missing these crucial topological boundary states. In this talk, I will introduce our recent results on the robustness of bulk-boundary correspondence in the quantum spin Hall insulator via feature spectrum topology. Our findings present a comprehensive understanding of feature-energy duality, illustrating that the aggregate number of gapless edge states in the energy-momentum ($E-k$) map and the non-trivial edge states in the $\hat{S}_z$ feature spectrum equals the spin Chern number of multilayer quantum spin Hall insulator. We identify a van der Waals material bismuth bromide (Bi4Br4) as a promising candidate through first-principles calculations. Our work not only unravels the intricacies of bulk-boundary correspondence but also charts a course for exploring quantum spin Hall insulators with high spin-Chern number.

[7]

Extreme value statistics and noises in stick-slip dynamics

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Stick-slip is common in natural and engineering out-of-equilibrium disordered systems as a yield response to a smoothly varying external force. Friction between solid surfaces, earthquakes on faults, and motion of the contact line between a liquid-air interface and a solid substrate are among the best-known examples. Characterized by intermittent bursts of irregular signals of different amplitudes, durations, and separations that result from the spontaneous depinning of mechanical contacts or local rearrangement of material bonds, one is curious about the possible universal behaviors and universal classes in stick-slip dynamics. In this talk, I will introduce our recent model based on experimental measurements of the statistics of the slip length, the maximal force needed to trigger the local slips, and the local force gradient of the pinning force field for solid friction and contact line dynamics. Our model shows that many small-scale details are not relevant to the statistical features of these quantities. Furthermore, it is possible to classify stick-slip dynamics according to a few properties, such as the inertia effect and range of interaction between the pinning sites. Our model answers some key questions about the stick-slip dynamics at mesoscales.