NCTS Theoretical Physics Symposium 理論物理論壇

(2025/1/15)

Afternoon session 13:30 – 16:00
Chair: Jeng-Da Chai (NTU)
Location: NSYSU

No.	Time	Name	Title of talk
1	13:30 – 13:40	Jeng-Da Chai (NTU)	Present Status of NCTS-Physics
2	13:40 – 14:10 (Remote Talk)	Yueh-Ning Lee (NTNU)	How nonideal magnetohydrodynamics regulates the formation and evolution of young protoplanetary disks
3	14:10 – 14:30	Jun-Yi Wu (TKU)	Entanglement-efficient distributed quantum computing
4	14:30 – 14:50	Kuo-Chuan Pan (NTHU)	Multi-Messenger Signals from Magnetized Core-Collapse Supernovae
5	14:50 – 15:10	Horng-Tay Jeng (NTHU)	First-principles calculations: A powerful tool for exploring novel condensed matter physics and potential quantum materials
6	15:10 – 15:30	Liang-Yan Hsu (AS)	Non-Adiabatic Quantum Electrodynamic Effects on Electron-Nucleus-Photon Systems: Single Photonic Mode versus Infinite Photonic Modes
7	15:30 – 16:00	Shin-Liang Chen (NCHU)	General characterization of quantum temporal correlations

[1]
Present Status of NCTS-Physics

Jeng-Da Chai
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The present status of NCTS-Physics (e.g., organization structure, operation mode, major programs, and academic achievements) will be presented, as an opening of the National Center for Theoretical Sciences (NCTS) Theoretical Physics Symposium in the 2025 TPS Annual Meeting. More up-to-date information can also be obtained on the NCTS-Physics website: https://www.phys.ncts.ntu.edu.tw/ .

[2]
How nonideal magnetohydrodynamics regulates the formation and evolution of young protoplanetary disks

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[2]Center of Astronomy and Gravitation, National Taiwan Normal University

Many mechanisms have been proposed to alleviate the magnetic catastrophe, which prevents the Keplerian disk from forming inside a collapsing magnetized core. Such propositions include inclined field and non-ideal magnetohydrodynamics effects, and have been supported with numerical experiments. Models have been proposed for typical disk sizes when a field threads the rotating disk parallelly to the rotation axis, while observations at core scales do not seem to show any correlation between the vectors of angular momentum and the magnetic field. I will present a generic model that considers an inclined magnetic field threading the disk and discuss the influences of the nonideal magnetohydrodynamic effects on the protoplanetary disk size. Such model has been confronted to a sample of observed protoplanetary disks and this has clearly suggested a transition of regime where the magnetic braking starts to be important and the disk size becomes self-regulated.

[3]

Entanglement-efficient distributed quantum computing

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In noisy intermediate-scale quantum (NISQ) computing, the scalability of a quantum processor unit (QPU) is limited by the number of qubits and their connectivity. To scale up quantum computing, one needs to employ entanglement-assisted distributed quantum computing (DQC) to implement a large quantum circuit over distributed small-size QPUs. Since entanglement is an expensive resource, we need to save the amount of entanglement consumed in DQC. In this talk, an entanglement-efficient DQC protocol called embedding-enhanced distributing will be introduced. With the help of graph theory, we develop an algorithm to find an entanglement-efficient strategy for distributing a given quantum circuit over two QPUs. The method will be then extended to modular DQC over multiple QPUs.

[4]

Multi-Messenger Signals from Magnetized Core-Collapse Supernovae

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Core-collapse supernovae (CCSNe) are among the most explosive events in the universe and are the birthplaces of neutron stars and stellar-mass black holes under extreme conditions. CCSNe are also ideal multi-messenger sources, as they are expected to be detected not only through electromagnetic waves but also via neutrinos and gravitational waves.

In this talk, I will present the latest findings from our multi-dimensional supernova simulations with self-consistent neutrino transport and general relativistic corrections. In particular, I will focus on how magnetic fields and stellar rotation affect the explosion engine, jet launching, and gravitational wave emissions. In addition, I will also comment on potential future searches for gravitational wave signatures from nearby core-collapse supernovae under the LIGO-Virgo-KAGRA network.

[5]

First-principles calculations: A powerful tool for exploring novel condensed matter physics and potential quantum materials

Horng-Tay Jeng[1]

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First-principles calculations based on Density Functional Theory (DFT) is a powerful computational method used extensively in physics, chemistry, and materials science to study the electronic structures of many-body systems, including atoms, molecules, and condensed matter phases. In this talk, various applications on condensed matter physics and materials science including strongly correlated transition-metal oxides, magnetic materials, 2-dimensional systems, topological, superconducting, charge density wave, and thermoelectric materials, will be discussed.

[6]

Non-Adiabatic Quantum Electrodynamic Effects on Electron-Nucleus-Photon Systems: Single Photonic Mode versus Infinite Photonic Modes

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We investigate quantum-electrodynamic non-adiabatic emission (QED-NAE), a radiative-assisted vibronic de-excitation process driven by electromagnetic vacuum fluctuations. We develop the QED-NAE rate theory from a single cavity photonic mode to a continuum of photonic modes and compute the rates for 9-cyanoanthracene at a first-principles level. Our findings highlight three critical factors influencing QED-NAE rates: light-matter coupling strength (mode volume), mass-weighted orientation factors, and photonic density of states. Mode volume is the dominant factor distinguishing single-mode cavities from infinite-mode free space. In a cavity, a small mode volume and strong light-matter coupling significantly enhance QED-NAE rates, while in free space, weak coupling and a flat, quadratic photonic density of states result in substantially reduced rates. The mass-weighted orientation factor contributes only an $8\pi/3$-fold increase when transitioning from a single mode to free space. Our results demonstrate that cavities dramatically amplify non-adiabatic QED effects, whereas in free space, such effects can be safely neglected.

[7]

General characterization of quantum temporal correlations

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In this talk, we consider a scenario where an observer measures an initial quantum state and sends the post-measurement state to the other observer. We present a framework for characterizing correlations obtained in such a scenario. We show that there are some applications under this framework, such as computing the maximal value of a temporal Bell inequality, the maximal successful probability in a scenario of quantum random access code, minimum temporal steerability, and the minimum fidelity of the quantum state preparation.