Neural Quantum States for Time Evolution - Challenges and Opportunities

Report of Contributions

Contribution ID: **1** Type: **not specified**

Variational dynamics of continuous-variable quantum rotor models

Monday 18 November 2024 14:00 (45 minutes)

Time-dependent variational Monte Carlo (t-VMC) has emerged as a powerful method of simulating real-time dynamics of correlated quantum systems in the recent years. With wider adoption of variational states based on neural networks, these methods have started to reach experimentally relevant time scales. However, despite rapid progress and growing interest, the t-VMC method is still relatively difficult to control and implement in high-parameter regimes of interest. After introducing the method, in this talk I will outline open problems in the field on a specific example of the quantum rotor model where the method has been successfully applied to a problem with continuous degrees of freedom.

Presenter: MEDVIDOVIĆ, Matija

Contribution ID: **2** Type: **not specified**

Solving quantum and classical dissipative dynamics with artificial neural networks

Monday 18 November 2024 14:45 (45 minutes)

We develop a variational approach to simulating the dynamics of open quantum and classical many-body systems using artificial neural networks. The parameters of a compressed representation of a probability distribution are adapted dynamically according to the Lindblad master equation or Fokker Planck equation, respectively, by employing a time-dependent variational principle. We illustrate our approach by solving the dissipative quantum Heisenberg model in one and two dimensions for up to 40 spins and by applying it to the simulation of confinement dynamics in the presence of dissipation. Also, we use normalizing flows to variationally solve diffusive classical dynamics in high dimensions.

Presenter: GÄRTTNER, Marti

Contribution ID: **3** Type: **not specified**

Reinforcement learning for quantum error correction

Monday 18 November 2024 16:15 (45 minutes)

TBA

Presenter: BUKOV, Marín

Contribution ID: **4** Type: **not specified**

Positive Operator Valued Measures Neural Networks for simulation of light-matter coupled systems

Tuesday 19 November 2024 20:00 (45 minutes)

TBA

Presenter: LAGNESE, Gianluca

Contribution ID: **5** Type: **not specified**

Fermions in Motion: A New Approach to Quantum Dynamics

Tuesday 19 November 2024 08:45 (45 minutes)

Describing the real-time evolution of many-electron quantum systems is crucial for understanding the dynamical properties of condensed matter, molecular systems in quantum chemistry, and the behaviors of complex materials. However, the real-time evolution of non-equilibrium quantum electronic systems poses a significant challenge for theoretical and computational approaches. This work introduces a variational approach for fermionic time-dependent wave functions, surpassing mean-field approximations by capturing many-body correlations. Our methodology introduces a parameterization of the time-evolving quantum state, enabling an accurate approximation of its evolution. We utilize the time-dependent variational Monte Carlo technique to efficiently compute optimal time-dependent parameters. Additionally, we introduce a new time-evolution method based on Taylor-root expansions of the propagator, enhancing the accuracy and efficiency of our simulations. The results showcase the ability of our variational approach to accurately capture the time evolution of quantum states, providing insight into the quantum dynamics of interacting electronic systems, beyond the capabilities of mean-field.

Presenter: NYS, Jannes

Contribution ID: **6** Type: **not specified**

Real-time quantum dynamics of thermal states with neural thermofields

Tuesday 19 November 2024 09:30 (45 minutes)

Solving the time-dependent quantum many-body Schrödinger equation is a challenging task, especially for states at a finite temperature, where the environment affects the dynamics. Most existing approximating methods are designed to represent static thermal density matrices, 1D systems, and/or zero-temperature states. In this work, we propose a method to study the real-time dynamics of thermal states in two dimensions, based on thermofield dynamics, variational Monte Carlo, and neural-network quantum states. To this aim, we introduce two novel tools: (i) a procedure to accurately simulate the cooling down of arbitrary quantum variational states from infinite temperature, and (ii) a generic thermal (autoregressive) recurrent neural-network (ARNNO) Ansatz that allows for direct sampling from the density matrix using thermofield basis rotations. We apply our technique to the transverse-field Ising model subject to an additional longitudinal field and demonstrate that the time-dependent observables, including correlation operators, can be accurately reproduced for a 4×4 spin lattice. We provide predictions of the real-time dynamics on a 6×6 lattice that lies outside the reach of exact simulations.

Presenter: DENIS, Zakari

Contribution ID: **7** Type: **not specified**

Dynamics of quantum matter with classical networks and neural quantum states

Tuesday 19 November 2024 11:00 (45 minutes)

Neural quantum states have emerged as a novel promising numerical method to solve the quantum many-body problem both in and out of equilibrium. In this talk I will discuss recent developments and challenges. I will also highlight potential ways to solve for some of these challenges.

Presenter: HEYL, Markus

Contribution ID: **8** Type: **not specified**

Diving beyond t-VMC with state compression and tailored integration schemes

Monday 18 November 2024 17:00 (45 minutes)

TBA

Presenter: VICENTINI, Filippo

Contribution ID: **9** Type: **not specified**

Solving the (time-dependent) Schrödinger equation

Tuesday 19 November 2024 14:00 (45 minutes)

Simulating the time evolution of interacting quantum systems is in general a very hard problem. Quantum simulation experiments, such as cold atoms in optical lattices, are naturally well suited to study closed system dynamics. A bottleneck for these setups are slow data taking rates, which enable experimentalists typically only to get a limited number of projective measurements at a limited number of time steps. In this talk, I will (i) demonstrate how limited, noisy, experimental data can be useful in a hybrid approach for ground state searches using neural quantum states (NQS); and (ii) introduce a new NQS based method to simulate the time evolution of interacting quantum many-body systems.

Presenter: BOHRDT, Annabelle

Contribution ID: **10** Type: **not specified**

Quantum-gas microscopy of Hubbard systems

Tuesday 19 November 2024 14:45 (45 minutes)

Neutral atoms trapped in optical lattices are a versatile platform to study many-body physics in and out of equilibrium.
Quantum gas microscopes provide an excellent toolbox to prepare, control and detect such systems at the level of individual atoms.
First, I will present our recent work on realizing long-range interacting Ising and Hubbard models for Rubidium atoms in optical lattices. Using off-resonant coupling from ground to Rydberg states, we induce tunable interactions via the excitation light. We probe interactions in different experiments on frozen spin systems and the itinerant regime, where they stabilize initial out-of-equilibrium states. In particular, we also observe the buildup of density-density correlations when probing a one-dimensional extended Hubbard system near equilibrium.
Second, I will introduce a new strontium setup that combines large-scale optical lattices with local control achieved through tweezer arrays. I will present our efforts on loading, cooling, and imaging individual strontium atoms in optical tweezers and lattices, where we obtain high-fidelity and low-loss imaging performance using repulsive Sisyphus-cooling. Combining optical tweezer arrays with lattices opens new perspectives to scale tweezer-based quantum simulators to larger system sizes and offers an alternative preparation route of assembled Hubbard systems in optical lattices with the prospect of combining analog and digital quantum simulation capabilities.

Presenter: ZEIHER, Johannes

Contribution ID: **11** Type: **not specified**

TBA

Wednesday 20 November 2024 08:45 (45 minutes)

TBA

Presenter: RIGO, Jonas

Contribution ID: **12** Type: **not specified**

Neural network simulation of a spin glass dynamics transition

Wednesday 20 November 2024 09:30 (45 minutes)

I will explain a recent experiment about the simulation of nonequilibrium dynamics of a magnetic spin system quenched through a quantum glass phase transition and our attempt at using neural networks to simulate the dynamics seen in the experiment.

Presenter: CARRASQUILLA, Juan