Speaker: Nicole Yunger Halpern

Abstract: The point of this Simons Center program is that quantum complexity is a useful concept in quantum many-body physics. The point of this talk is that uncomplexity is a useful resource in quantum computation. A state’s complexity quantifies the difficulty of preparing the state from a simple tensor product, or the difficulty of uncomputing the state to a simple tensor product. Uncomplexity is a state’s distance from maximal complexity. The greater a state’s uncomplexity, the more useful the state is as an input to a quantum computation; the more resourceful the state is. Resource theories are quantum-information-theoretic models for agents subject to operational constraints. I will unite the two domains, meeting Brown and Susskind’s challenge to construct a resource theory of uncomplexity. I will define the resource theory, apply it to two operational tasks, and present two monotones (measures of a state’s usefulness). Opportunities for future work involve the resource theory of magic and holography.[1] NYH, Kothakonda, Haferkamp, Munson, Eisert, and Faist, Phys. Rev. A 106, 062417 (2022). [2] Munson, Kothakonda, Haferkamp, NYH, Eisert, and Faist, PRX Quantum 6, 010346 (2025). [3] Haferkamp, Kothakonda, Faist, Eisert, and NYH, Nat. Phys. (2022). [4] Baiguera, Balasubramanian, Caputa, Chapman, Haferkamp, Heller, and NYH,

Speaker: Robert Konik

Abstract: We consider the problem of inferring the presence of multipartite entanglement in a solid state material using both neutron and resonant inelastic x-ray scattering (RIXS). The connection between the scattering response and the presence of multipartite entanglement is found in the quantum Fisher information (QFI) associated to both the material’s density matrix and the operator whose correlation function gives the spectroscopic response. If the QFI associated with a spectroscopic measurement exceeds a certain set of bounds, one can certify the presence of m-partite entanglement. We show that for both scattering techniques, one can use the presence of symmetries to lower (sometimes dramatically) the bounds needed to detect a certain amount of entanglement. We also show that one can associate a QFI to a RIXS measurement despite the operator governing RIXS scattering being non-Hermitian, so detecting, as a test case, bipartite entanglement in the dimer material Ba3CeIr2O9.

Speaker: Jacopo de Nardis

Abstract: Quantum advantage refers to the possibility of performing quantum operations on a quantum computer that would be practically impossible to reproduce on a classical computer, whose memory resources scale only polynomially with the number of qubits. However, present-day quantum computers are affected by external noise, and in the absence of error correction this noise can drive transitions from genuinely quantum behavior, which is exponentially complex to simulate, to effectively classical behavior, which is only polynomially complex. In this talk, I will present two distinct noise-induced transitions from quantum to classical simulability. First, I will show that any noisy quantum system with a noise rate above a finite threshold of order one becomes classically simulable via Monte Carlo sampling. Second, I will discuss how even a small noise rate of order 1/N is sufficient to make local operators efficiently simulable through Pauli-truncation schemes.

Speaker: Kaden Hazzard
Abstract: Much of the basis for many-body physics relies on the short-range character of interactions: such as correlation spreading, exponential clustering of equilibrium correlations, control of diagrammatic expansions, and hydrodynamics. Emerging physical platforms challenge these assumptions. Two key examples are materials in cavities, which mediate an effectively infinite range interaction, and ultracold dipolar interacting systems such as molecules and Rydberg atoms. I will describe our general efforts to understand how the dynamics of correlations are structured in the dynamics of these systems. I will also briefly mention the discovery of a novel type of particle statistics, known as paraparticle statistics, emerging in Rydberg atom chains, which provides a new family of models with exactly solvable dynamics.

Speaker: Giuseppe Di Giulio
Abstract: In the last few years, quantifying the complexity of quantum states has found applications in many fields, including quantum information and computing, quantum dynamics in many-body systems, and black hole physics. Among these measures, the spread complexity roughly quantifies the size of the space of states visited along quantum dynamics. It is obtained through Krylov space methods, which consist of projecting the evolution of a state onto one-dimensional dynamics. In this talk, I will discuss the evolution of the spread complexity after a local quantum quench in conformal field theories (CFT). Interestingly, this quantity depends on the central charge of the considered theory. I will also show that, to get rid of all the non-universal contributions in the leading time behaviour, it is convenient to study another Krylov space quantity, the K-entropy, an entropy measure defined for pure states without the need for a bipartition. These results establish the Krylov space approach as an insightful probe of the universal properties of critical quantum dynamics.