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NITheCS COLLOQUIUM:

Probing the nature of many-body entanglement in quantum spin liquids: insights from lattice field theories

Dr Aniekan Magnus Ukpong (University of KwaZulu-Natal)

Monday, 13 November 2023 | 16h00 – 17h00 SAST

Venue: in person* and online

** Neelsie Cinema, Stellenbosch University*

--- Cheese and wine will be served at the venue ---

ABSTRACT

The quantum spin liquid (QSL) is an intriguing state of quantum matter in which spins do not align into an ordered, long-ranged, pattern even at absolute zero temperature. Nonetheless, the disordered spins remain highly entangled with strong quantum fluctuations. It is believed that the QSL state can host spinons, anyons, skyrmions, and topological order, making their host materials useful as potential building blocks for the design of quantum communication and topological quantum computation technologies. From a fundamental perspective, the QSL state offers the ideal modelling framework for understanding quantum many-body entanglement in strongly correlated systems, such as high-temperature superconductors, the Kondo effect, the Quantum Hall Effect, etc. It is challenging to model such systems using mean-field theories because of their neglect of correlation effects between individual particles and their associated fields, while density functional theory completely fails to capture the interplay between the entanglement of spin states, fractionalization of excitations, lack of a local order parameter, and the absence of broken symmetry. In this colloquium, I will discuss our ongoing attempts to understand the QSL state within the framework of lattice field theories and highlight the materials modelling challenges that are associated with capturing the many-body physics of quantum entanglement. I will also present some new results from our recent computational experiments on the Heisenberg model on the Kagome lattice and the Kitaev model on the honeycomb lattice, as toy models for understanding the QSL ground state. With beneficial hindsight from these models, I will conclude on the nature of the many-body entanglement by drawing insights from quantum chaos and many-body localization in the wavefunction of the Sachdev-Ye-Kitaev model, which has potential consequences in other physical systems that are accessible beyond condensed matter theory.

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BIOGRAPHY

Dr Aniekan Magnus Ukpong teaches Physics at the University of KwaZulu-Natal, specializing in Theoretical and Computational Condensed Matter. He received a C3 rating from the National Research Foundation (NRF) in 2018 and was honoured with an Outstanding Reviewer Award from the Institute of Physics (IOP) in 2019. Since 2016, he has been serving as a Principal Investigator with the Centre for High-Performance Computing (CHPC). His research primarily focuses on developing and implementing computational models for understanding quantum phenomena in materials. His contributions have encompassed a broad range of fundamental models for the description of advanced materials, leading to an enhanced understanding of the physics of broken symmetry and topologically ordered quantum states in condensed matter systems.

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