Open Positions for MEPs:
Studying Many-body Dynamics on a 50-spin Analog Quantum Simulator

Taminiau Lab, QuTech

A system of interacting nuclear spins around a central electron spin acts as a highly controllable platform for simulating many-body dynamics in solid-state systems. Recently, non-equilibrium phenomena such as many-body localization and dynamic phases of matter such as time crystals (which is also an active area of research in the group [1]) have been observed in systems of NV centers in diamond. The key principle behind the experimental implementation of quantum simulators is the ability to control and modify the native Hamiltonian of the system being studied.

We have a well-characterised cluster of 13C nuclear spins [2] around an NV center that can be individually controlled and read-out. Through Hamiltonian engineering of a sequence of pulses applied on these spins, we can construct an effective Hamiltonian for the system and study a variety of many-body phenomena!

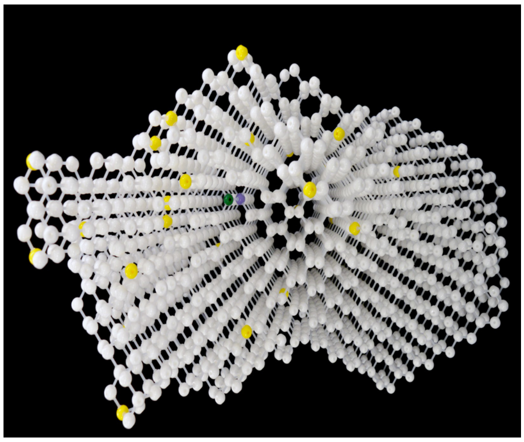

Fig.1 3D model of the 50-spin cluster

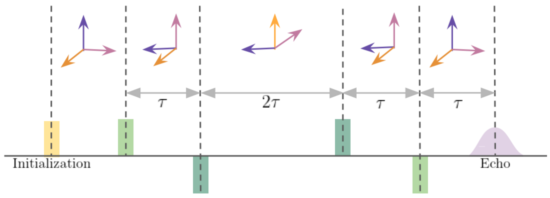

Fig.2 Illustration of an engineered pulse sequence [3]

Potential Project Directions

Numerical Simulations of Nuclear spin clusters: A precursory step to experiments in many-body systems is being able to numerically simulate the dynamics of the system to gain insight into what one would expect as an outcome. Simulating a 50-spin cluster using traditional methods is computationally intractable. We explore other methods, such as tensor networks and cluster expansions [4], to be able to simulate our system.

Exploring entanglement and polarization: We study the possibility of the rapid generation of multi-partite entanglement between the NV electron and a cluster of nuclear spins. We also explore the generation of highly polarized nuclear spin states to implement quantum computing enhanced sensing schemes [5].

Contact:

Madhumati Seetharaman
(M.Seetharaman@tudelft.nl)
Dan Yudilevich
(D.Yudilevich@tudelft.nl)
Christina Ioannou
(C.I.Ioannou@tudelft.nl)

[1] Randall et al., 'Many-Body–Localized Discrete Time Crystal with a Programmable Spin-Based Quantum Simulator'.
[2] van de Stolpe et al., 'Mapping a 50-Spin-Qubit Network through Correlated Sensing'.
[3] Haeberlen and Waugh, 'Coherent Averaging Effects in Magnetic Resonance'.
[4] Onizhuk and Galli, 'PyCCE'.
[5] Allen et al., 'Quantum Computing Enhanced Sensing'.