Prof. Dr. Igor Lesanovsky

Universität Tübingen, Institut für Theoretische Physik

Exploring quantum spin systems far from equilibrium – Theory and applications

Understanding and solving quantum many-body problems is among the most pressing challenges of moderns physics. In recent years, cold atomic gases have proven to be versatile platform for emulating and studying non-equilibrium phenomena in quantum many-body systems. Especially systems formed by atoms excited to highly-lying electronic states, so-called Rydberg atoms, have moved into the focus of current research. They form building blocks of the most recent generation of quantum simulators and offer rather intriguing opportunities for exploring strongly correlated quantum dynamics in interacting spin systems.

I will present an overview of the research that our group has conducted on this topic in the past years. I will show that the out-of-equilibrium behaviour of Rydberg gases is governed by emergent kinetic constraints. Such constraints are often used to mimic excluded volume effects in idealised models of glass forming substances and lead to a remarkably rich physics including non-equilibrium phase transitions and localisation phenomena. Moreover, Rydberg gases offer intriguing opportunities for the systematic exploration of the role of competing quantum and classical dynamical effects on non-equilibrium processes.

I will conclude by briefly discussing how the above findings can be employed to gain a new perspective on hyperpolarization methods in nuclear magnetic resonance, which are out-of-equilibrium protocols for enhancing the performance of Magnetic Resonance Imaging applications.