Classification of the universal dynamics in two-dimensional strongly ferromagnetic superfluids

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Abstract: Scale invariance and self-similarity in physics provide a unified framework to classify phases of matter and dynamical properties of near- and far-from-equilibrium many-body systems. To address universality, we monitor the non equilibrium dynamics of a two-dimensional ferromagnetic spinor gas subjected to quenches of the quadratic Zeeman coefficient. This allows to dynamically cross the underlying second-order magnetic phase transitions triggering spin-mixing. Within the short time-evolution we observe the spontaneous nucleation of topological defects (gauge or spin vortices) which annihilate through their interaction giving rise to magnetic domains for longer timescales where the gas enters the universal coarsening regime. This is characterized by the spatiotemporal scaling of the spin correlation functions and structure factor allowing to measure corresponding scaling exponents which depend crucially on the symmetry of the order parameter and belong to distinct universality classes. Our experimental observations are in excellent agreement with the predictions of the truncated Wigner method accounting both for quantum and thermal fluctuations in the initial state. These results represent a paradigmatic example of categorizing far-from-equilibrium dynamics in quantum many-body systems and reveal the interplay of topological defects for the emergent universality class.

About the speaker: Simeon Mistakidis is an assistant Professor at the Department of Physics Missouri S&T leading the Quantum many-body dynamics and technologies group. He was an ITAMP (Institute for Atomic Molecular and Optical Physics) postdoctoral fellow at Harvard University conducting research on the engineering of entanglement-based processes and magnetic phenomena appearing in many-body multicomponent atomic systems ranging from quasiparticles and droplets to long-range interacting settings. He received his PhD with distinction (summa cum laude) at the University of Hamburg, Germany, in the field of Atomic Molecular and Optical Physics. He received a PhD Scholarship named “Hamburgisches Gesetz zur Forderung des wissenschaftlichen und kunstlerischen Nachwuchses” and he was also granted with the Lenz-Ising Award for outstanding junior scientists. Simeon has co-authored more than 90 scientific publications, serves as a reviewer in more than 10 international peer-reviewed scientific journals and he is a topic editor in 2 of those. His research is devoted to non equilibrium quantum many-body dynamics of atomic and molecular platforms. An emphasis is placed on correlation phenomena, nonlinear excitation processes along with the ensuing pattern formation and turbulent response as well as applications to quantum information processing.