Speaker: **Boris Fine, University of Leipzig**

Title: **Fate of periodic classical trajectories in many-spin systems: their stability and connection to quantum scars**

Date: **Friday, July 18th, 10:00 am**

Place: **Seminar room 915**

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We numerically investigate the stability of exceptional periodic classical trajectories in rather generic chaotic many-body systems and explore a possible connection between these trajectories and the exceptional nonthermalised quantum eigenstates known as "many-body quantum scars". The systems considered are chaotic spin chains with short-range interactions, both classical and quantum. On the classical side, the chosen periodic trajectories are such that all spins instantaneously point in the same direction, which evolves as a function of time. We find that the largest Lyapunov exponents of these trajectories have surprisingly strong and nontrivial dependencies on the interaction constants and chain lengths. In particular, we identify rather long spin chains, where the above periodic trajectories are, actually, Lyapunov-stable on a many-body energy shell overwhelmingly dominated by chaotic motion. We show that the above phenomenology can be quantitatively described based on the translational invariance of the relevant Lyapunov problem. We also find that some of the Lyapunov-unstable periodic trajectories spontaneously develop into an extremely long-living non-ergodic regime exhibiting a nearly quasiperiodic motion. We put forward an argument that the latter regime is a manifestation of Arnold diffusion in the vicinity of integrable dynamics. On the quantum side, we numerically investigate the dynamics of quantum states starting with all spins initially pointing in the same direction: these are the quantum counterparts of the initial conditions for the above periodic classical trajectories. Our investigation reveals the existence of many-body quantum scars for numerically accessible finite chains of spins 3/2 and higher. No evidence of quantum scars was observed for spin-1/2 chains, while spin-1 chains were found to be transitional in this respect. The dynamics dominated by quantum scars exhibits a slow-down of the dynamic thermalisation process.

Preprint:

I. Ermakov, O. Lychkovskiy, B.V. Fine, "Periodic classical trajectories and quantum scars in many-spin systems", arXiv:2409.00258