INSIGHT SEMINAR: Dynamical Quantum Chaos in Many-Body Systems: An experimental quest for the origin of irreversibility from Loschmidt Echoes to Out of Time Order Correlators

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12:00 to 13:00
Seminar Room

The justification and appropriate description of irreversible macroscopic dynamics of fluids from time reversible mechanics was initiated Boltzmann, Loschmidt, Einstein and Smoluchowski. However, in spite of the impressive experimental advances and clarification of the statistical assumptions, the possibility of an arrow of time has remained a polemic issue. In the last decade, the focus shifted towards the quantum realm, mainly because quantum information processing handles an increasing number of qubits/spins and the AdS/CFT unification of gravitation with quantum mechanics requires quantum chaos in the vicinity of a black-hole [0]. Already Einstein observed that discrete quantum levels of Bohr atoms are not compatible with the classical instabilities conceived by Boltzmann in his ï¿½ stothaltzansatzï¿½. More than two decades ago we realized[1-3], at Cordoba, that Solid-St te Nuclear Magnetic Resonance could serve to identify the quantum signatures in, otherw se ï¿½classicalï¿½, spin diffusion. As pointed by Laughlin and by Larkin and Ovchinikov cl ssical chaos and diffusion of quantum excitations are inextricably tied together [3]. Also, i could implement, for a macroscopic number of (10^{23}) interacting spins, a time reversal procedure, just as suggested by Loschmidt to tease Boltzmann. With this purpose we developed a number of experimental strategies, the Loschmidt Echoes [4]. ï¿½Justiï¿½ by changin the sign of the many-body Hamiltonian, one generalizes the one-body time-reversal o the Hahn´s Spin Echo. This could allow to observe decoherence, irreversibility a d the emergence of hydrodynamic behavior. We also measure different Out of Time Order Correlations (OTOCs) that allows to follow a local excitation as it scrambles throu h the system. I will review our experimental and theoretical quest to improve many-bo y time reversal, whose unsurmountable limitations led us to propose a Central Hypoth sis of Irreversibility [5]. According to this, much as zero temperature residual resistance of metals only depends on reversible collisions with impurities, quantum dynamics of ma y-body systems far from equilibrium becomes intrinsically decoherent, and hence irreversibl , in a time-scale fixed by the reversible interactions. This requires the thermodynamic l mit in which, the time scales of the interaction with the environment, T_S, are much longer than the time scales of the reversed Hamiltonian, T2. Thus, our most recent experiments, [7,8] indicate that hydrodynamical behavior and the arrow of time should result as an emergent property of reversible quantum dynamics.

Hosted by: Prof. Dr. Maciej Lewenstein