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Signatures of Quantum Chaos in Many Body Systems

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Quantum Chaos studies how quantum chaotic dynamics emerges from a classical chaotic system when the action can no longer be considered much larger than $\hbar$. In a seminal work, Peres considered a quantity, now called Loschmidt echo, as a measure of sensibility and reversibility of quantum evolution. For quantum chaotic dynamics the decay of the Loschmidt echo with time can be related to the Lyapunov exponent of the underlying classical system. This relation has mostly been explored for systems containing a few degrees of freedom, typically a single particle, where the semi-classical limit is well defined. However, much less is known about the many-body case, where many degrees of freedom strongly interact. In this project, we propose to study signatures of Quantum Chaos in systems containing a few degrees of freedom with a simple semi-classical analog obtained by taking the thermodynamic limit. Perhaps the simplest examples of this class are collective spin models. However, such systems correspond to a single classical degree of freedom and thus lack a classical chaotic regime. A simple generalization which does exhibit chaos is the two coupled collective spins, i.e. SU(2)×SU(2) and for this reason this system is the central subject of this work. The connection between integrable and chaotic behaviour in a mixed dynamics frame is also studied for the spectral statistics of the system.

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