# Absence of exponential sensitivity to small perturbations in nonintegrable systems of spins 1/2

Boris Fine[1], Tarek Elsayed[1], Chahan Kropf[1, 2], and Astrid de Wijn[3]

[1]*Instute for Theoretical Physics, University of Heidelberg, Philosophenweg 19, 69120 Heidelberg, Germany*

[2]*Institute of Physics, University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany*

[3]*Department of Physics, Stockholm University, 106 91 Stockholm, Sweden*

The notion of chaos is frequently invoked in the foundations of quantum statistical physics. Yet, the definition of quantum chaos for many-particle systems is still not fully understood. Here we show that nonintegrable lattices of spins 1/2, which are often considered to be chaotic, do not exhibit the basic property of classical chaotic systems, namely, exponential sensitivity to small perturbations. We compare the responses of chaotic lattices of classical spins and nonintegrable lattices of spins 1/2 to imperfect reversal of spin dynamics known as Loschmidt echo. In the classical case, Loschmidt echoes exhibit exponential sensitivity to small perturbations characterized by twice the value of the largest Lyapunov exponent of the system. In the case of spins 1/2, Loschmidt echoes are only power-law sensitive to small perturbations. Our findings imply that it is impossible to define Lyapunov exponents for lattices of spins 1/2 even in the macroscopic limit. At the same time, the above absence of exponential sensitivity to small perturbations is an encouraging news for the efforts to create quantum simulators. The power-law sensitivity of spin 1/2 lattices to small perturbations is predicted to be measurable in nuclear magnetic resonance experiments.

[1] B. V. Fine, T. A. Elsayed, C. M. Kropf and A. S. de Wijn, arXiv:1305.2817