## Séminaire de physique statistique

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## Quasi-integrable systems are slow to thermalize but may be good scramblers

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Knowing the position of the Earth today will not enable us to predict its position 10 Myrs from now, yet, the planetary orbits in the Solar System are stable for the next 5 Gyrs [1]. This is a typical feature of classical systems whose Hamiltonian slightly differs from an integrable one — their Lyapunov time is orders of magnitude shorter than their ergodic time. This puzzling fact may be understood by considering the simple situation of an integrable system perturbed by a weak, random noise: there is no Kolmogorov-Arnold-Moser (KAM) regime and the Lyapunov instability can be shown to happen almost tangent to the invariant tori. I will extend this analysis to the quantum case, and show that the discrepancy between Lyapunov and ergodicity times still holds, where the quantum Lyapunov exponent is defined by the growth rate of the 4-point Out-of-Time-Order Correlator (OTOC) [2]. Quantum mechanics limits the Lyapunov regime by spreading wavepackets on a torus. Still, the system is a relatively good scrambler in the sense that the ratio between the Lyapunov exponent and $kT/\hbar$ is finite, at a low temperature T [3]. The essential characteristics of the problem, both classical and quantum, will be demonstrated via a simple example of a rotor that is kicked weakly but randomly.

[1] J. Laskar. Chaotic diffusion in the solar system. Icarus, 196:1, 2008.
[2] T. Goldfriend and J. Kurchan. Quasi-integrable systems are slow to thermalize but may be good scramblers. arXiv:1909.02145 [quant-ph], 2019.
[3] J. Maldacena, S. H. Shenker, and D. Stanford. A bound on chaos. J. High Energy Phys. 2016:106, 2016.