An introduction to Many-Body Localization for a simple random spin chain model

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What happens in an isolated quantum system when both disorder and interactions are present ? Over the recent years, the picture of a non-thermalizing phase of matter, the many-body localized (MBL) phase, has emerged as a stable solution, challenging the very foundation of statistical quantum mechanics. In this talk, I will present a basic introduction to MBL, focusing on the paradigmatic example of the quantum XXZ spin-$\frac{1}{2}$ chain Hamiltonian in a random magnetic field. This (apparently simple) model provides a very rich example where unconventional physics emerges. I will also discuss how the use of high-performance computer simulations has been of great help to better understand quantum matter at high energy behaves in the presence of strong randomness. For further reading, see [1, 2, 3].

[1] D. A. Abanin, E. Altman, I. Bloch, M. Serbyn. *Many-body localization, thermalization, and entanglement.* Rev. Mod. Phys., **91(2)**, 021001, 2019. doi :10.1103/RevModPhys.91.021001.

[2] F. Alet, N. Laflorencie. *Many-body localization : An introduction and selected topics.* Comptes Rendus Physique, **19(6)**, 498–525, 2018. doi :10.1016/j.crhy.2018.03.003.

[3] P. Sierant, M. Lewenstein, A. Scardicchio, L. Vidmar, J. Zakrzewski. *Many-body localization in the age of classical computing.* arXiv :2403.07111, 2024.

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