Deciphering complex quantum systems

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Not many ingredients are needed for a quantum system to turn complex, with the helium atom as the arguably most elementary example. Much as for classically chaotic systems, accurate predictions of the long-time dynamics, or an exhaustive description of the very structure of such a system's state turns quickly prohibitive as the size of state space is increased. This has been a concern of theory for long, and recently receives renewed interest as also quantum optics labs turn "complex", where a stunning level of control over elementary constituents now makes contact with the exponential proliferation of alternative transition amplitudes. To characterise and to certify such systems, let alone to actively control them, we need to identify robust, coarse-grained quantifiers which allow to discriminate their distinctive features, on the basis of experimentally accessible and scalable, yet necessarily incomplete information. We will have a closer look at some exemplary certification problems, with a special emphasis on indistinguishability as a specific source of complexity in many-particle quantum dynamics.