Simulating Quantum Materials

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In recent years, physicists, chemists and engineers have been engaged in a race towards the elaboration of a new class of materials, displaying quantum effects over a large range of energy and length scales, with the objective of revolutionising the development of computing devices, memories and sensors. These quantum materials, which include superconductors, quantum spin liquids, topological insulators and cold atomic gases, derive their properties from the subtle collective interplay of a large number of strongly interacting electrons or atoms. While these materials hold the key for the development of novel applications, one of their fundamental characteristics, the presence of strong interactions, renders them notoriously difficult to study both analytically and numerically. In fact, quantum materials are widely regarded as one of the greatest challenges posed to modern many-body physics. I will present here an overview of the matrix product states method which has, in recent years, established itself as one of the most powerful numerical methods in the study of low-dimensional quantum lattice systems.

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