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Quantum Information Theory: Applications and challenges

Abstract: Quantum Mechanics can be used to describe a large variety of exotic phenomena that appear in the microscopic world. During the last years it has been recognized that those phenomena may be used to process and transmit information in a completely different way as the one that is used nowadays. In particular, one can devise new communication protocols which are secure against eavesdropping, or numerical algorithm to solve certain problems that are much more efficient that the existing ones. Thus, a lot of effort has been put into the development of a new multidisciplinary field, the so–called Quantum Information Science, which should be able to build quantum communication and computational devices, as well as to establish the corresponding mathematical framework. In this talk I will first review the most important concepts in this new field, the applications, as well as the experimental situation. Then I will mention some of its most important theoretical challenges. Specifically, I will show how the mathematical techniques that have been developed during the last years in this context can be used and extended to describe many-body systems in an efficient way. Those systems are very hard to describe for a large number of particles, N, due to the exponential growth of the number of parameters with N. The techniques and results presented here have applications in other fields of Physics and Chemistry.