Studying the many-body problem with a few assembled atoms

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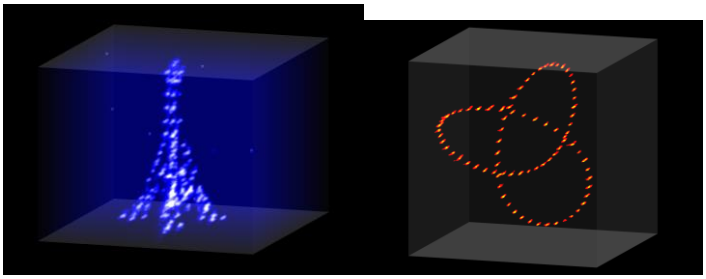
For the last twenty years, physicists have been learning to manipulate individual quantum objects: atoms, ions, molecules, quantum circuits, electronic spins... It is now possible to build "atom by atom" a synthetic quantum matter. By controlling the interactions between atoms, one can study the properties of these elementary many-body systems: quantum magnetism, transport of excitations, superconductivity... and thus understand more deeply the N-body problem. More recently, it has been realized that these quantum machines could perhaps find applications in industrial fields, such as finding the solution of combinatorial optimization problems.

This seminar will present an example of a synthetic quantum system, based on laser-cooled ensembles of individual atoms trapped in microscopic optical tweezer arrays. By exciting the atoms into Rydberg states, we make them interact, even at distances of about ten micrometers. In this way, we study the magnetic properties of an ensemble of more than a hundred interacting ½ spins, in a regime in which simulations by usual numerical methods are already impossible. Some aspects of this research have led to the creation of the startup PASQAL.



Fluorescence images of individual atoms trapped in various optical tweezers arrays. Each point corresponds to an atom.