

Quantum simulations with atoms in nano-structures

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Many-body quantum systems are very hard to simulate with classical computers, as the running time increases exponentially with the size of the system. Quantum simulation offers a way to circumvent this problem. A quantum simulator is a system where interactions can be engineered, such that its dynamics correspond to the ones of the system one wants to emulate. Ultra-cold atoms in optical lattices can be used for that purpose; in particular, to simulate many-body problems that appear in strongly-correlated systems. In this talk I will briefly review the field of quantum simulations and show how photonic crystal structures can be used to design subwavelength optical lattices in two dimensions for ultracold atoms, achieving a better performance than current experimental set-ups. Furthermore, guided modes can be used for photon-induced large and strongly long-range interactions between trapped atoms, giving rise to quantum simulations which cannot be performed with other systems.