Programmable quantum simulator with Strontium Rydberg atoms in optical tweezer arrays

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Electronically highly excited (Rydberg) atoms constitute a system with controllable long-range interactions which allows to study and simulate many intriguing phenomena, ranging from quantum non-linear optics to quantum magnetism and dipole-mediated energy transport [1]. The underlying dynamics depend on the structure, dimensionality and interaction type of the physical system. Disentangling and controlling their contributions is an open problem, whose solution may empower new technology, including realizing general purpose quantum computers.

Such challenge is addressable by studying model systems in highly controllable experiments that capture their key features. Ultra-cold interacting Rydberg Strontium atoms trapped in reconfigurable arrays of optical tweezers represent such tailored quantum simulator. Strontium provides several sets of atomic states, including metastable ones[2], that are conveniently mappable into magnetic spins or quantum bits. Single- or two-photon excitation pathways to nS, nP and nD Rydberg states allow to engineer and fine-tune dipole-mediated interactions that can picture different spin or energy transport scenarios and also realize quantum gates [3]. I will present our progress with the construction of the setup and outline our planned capabilities, including the creation of up to three-dimensional large structures of optical tweezers with single site addressability and manipulation ability.

References

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