Efficient Coupling of Atomic Tweezer Arrays to Light

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Arrays of atoms trapped in optical tweezers have emerged in recent years as some of the most prominent platforms of quantum science and technology. Efficient coupling of such tweezer atomic arrays to light is then crucial for a variety of quantum applications of these platforms, from state-readout, quantum memories and networks, to the generation of entangled states of light. Nevertheless, efficient interfacing of light to tweezer arrays is severely limited: this is since the tweezer array lattice spacing typically exceeds the relevant wavelength of light, leading to large scattering losses to lattice diffraction orders. In this talk I will discuss several practical solutions we devised for this basic problem, taking advantage of collective light-matter effects. Based on our recent universal formalism for atom-array quantum interfaces [1], showing that the reflectivity of the array quantifies its coupling efficiency, we develop several solutions for efficient interfacing: (i) eliminating the scattering losses: using multiple array layers such that scattering losses from different layers destructively interfere [2]; (ii) enhancing the coupling over the losses: using a cavity to enhance the coupling to the desired photon mode [3]; For all of these solutions, we derive analytical theories and design principles, showing favorable scaling with finite resources (*e.g.* atom number).

References

[1] Y Solomons, R Ben-Maimon and E Shahmoon, PRX Quantum **5**, 020329 (2024)

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[3] Y Solomons, I Shani, O Firstenberg, N Davidson and E Shahmoon, Phys. Rev. Res. **6**, L042070 (2024)