Controlling the transverse flow of light in a high-finesse optical microresonator

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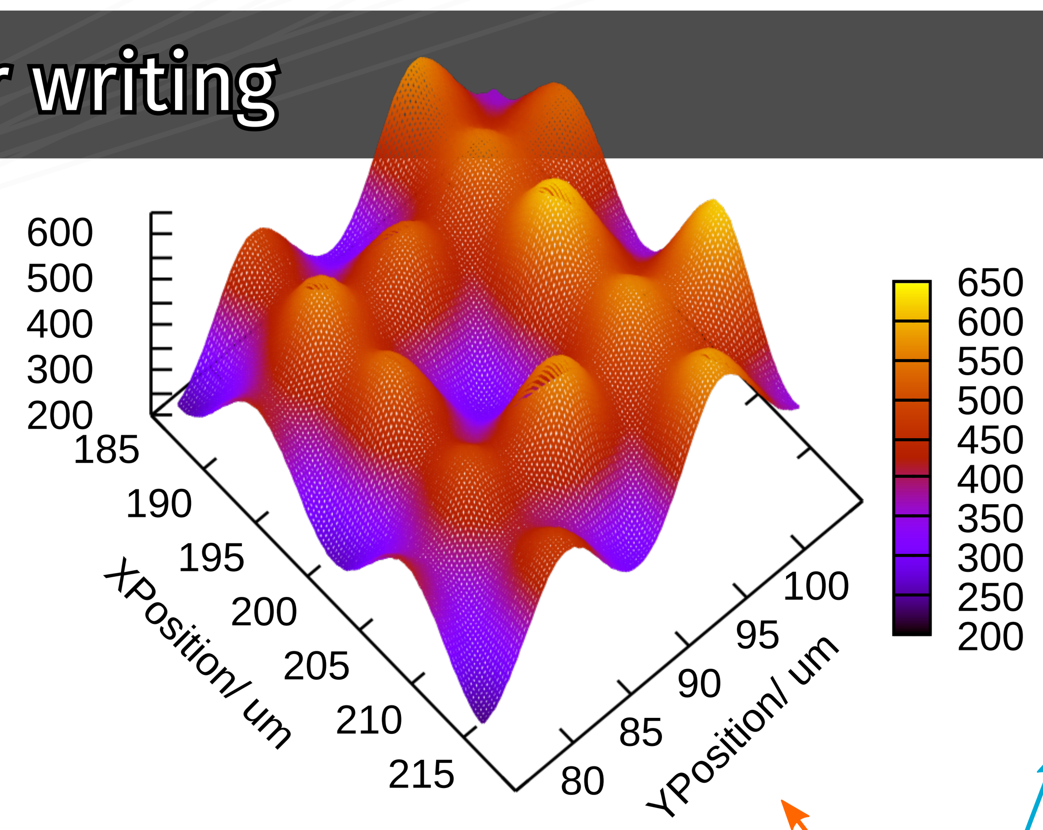
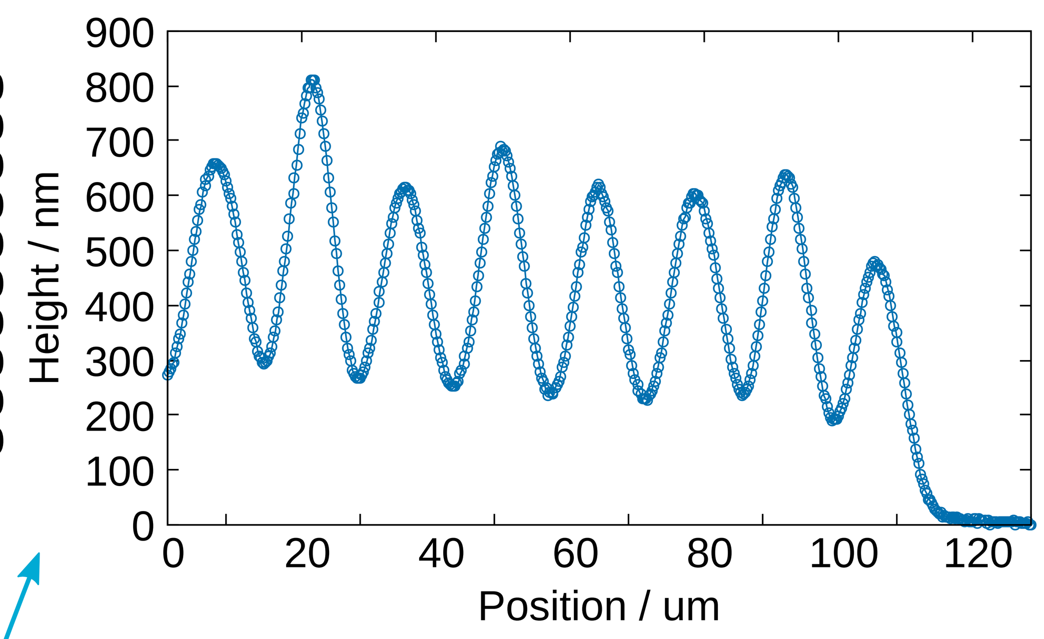
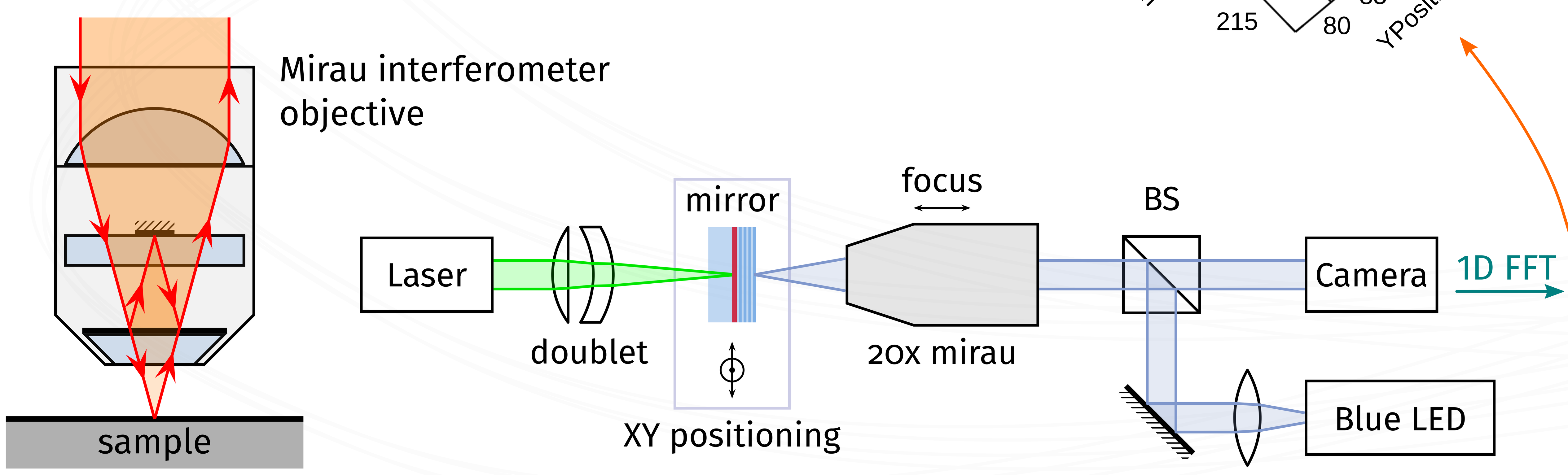
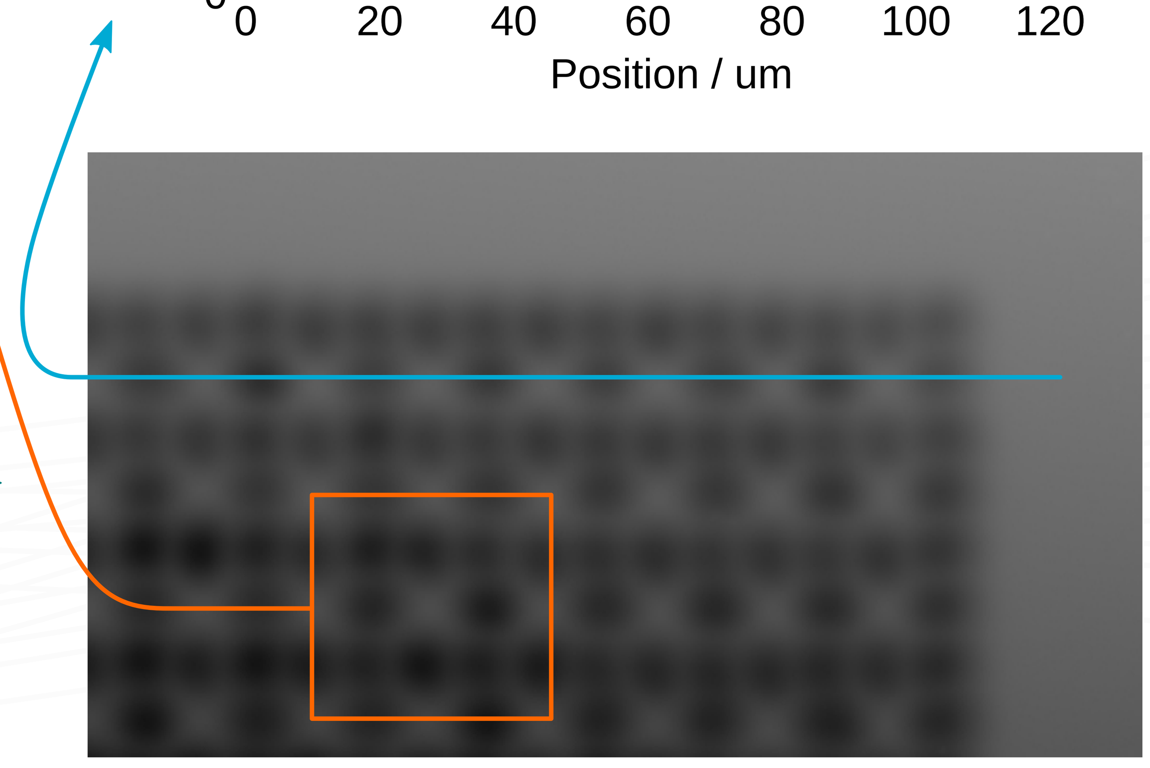
Nanostructuring of mirrors with direct laser writing

The surface of ultra high finesse mirrors composed of a glass substrate, a metallic layer and multiple dielectric layers stacked on top, may be accurately nanostructured by direct laser writing. This enables us to construct precise and uniform height profiles, with a maximum height of up to 1 µm. We verify such structures with high depth resolution using interferometric microscopy.

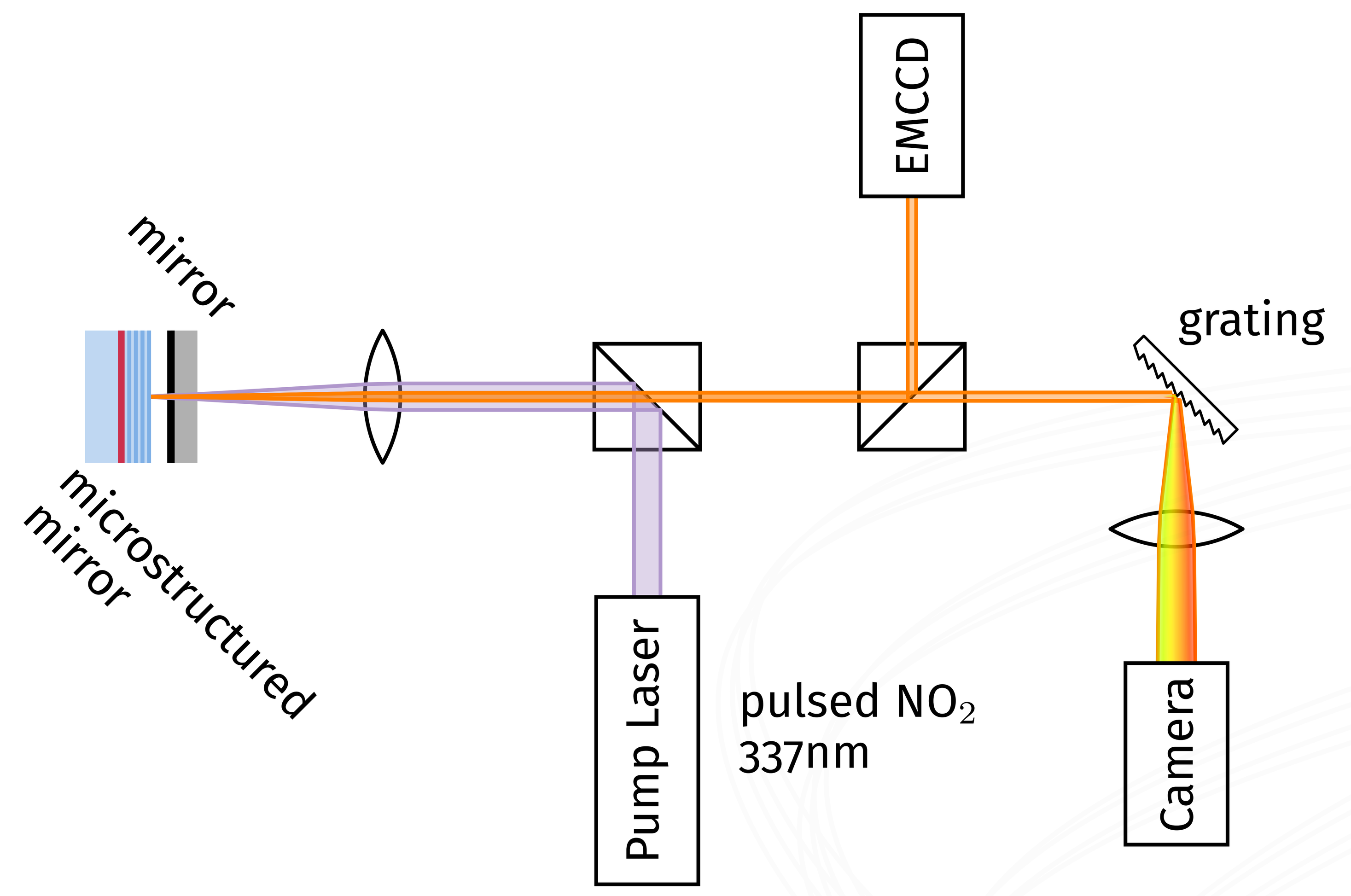




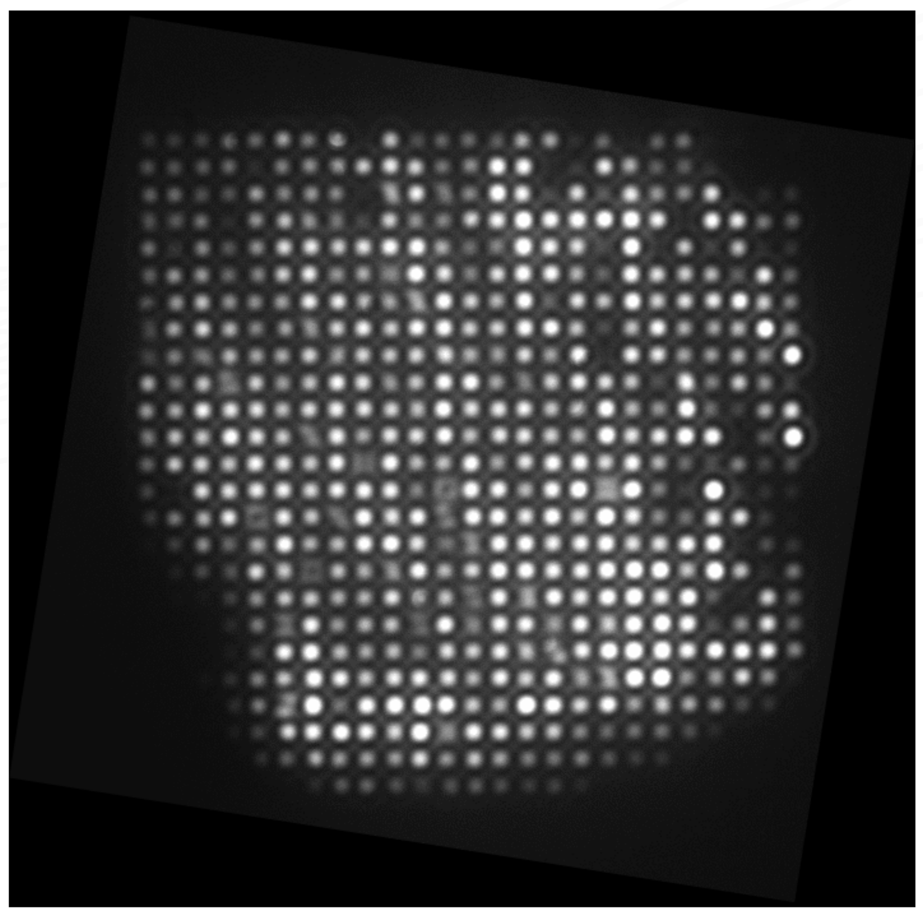




Optically pumping the microcavities

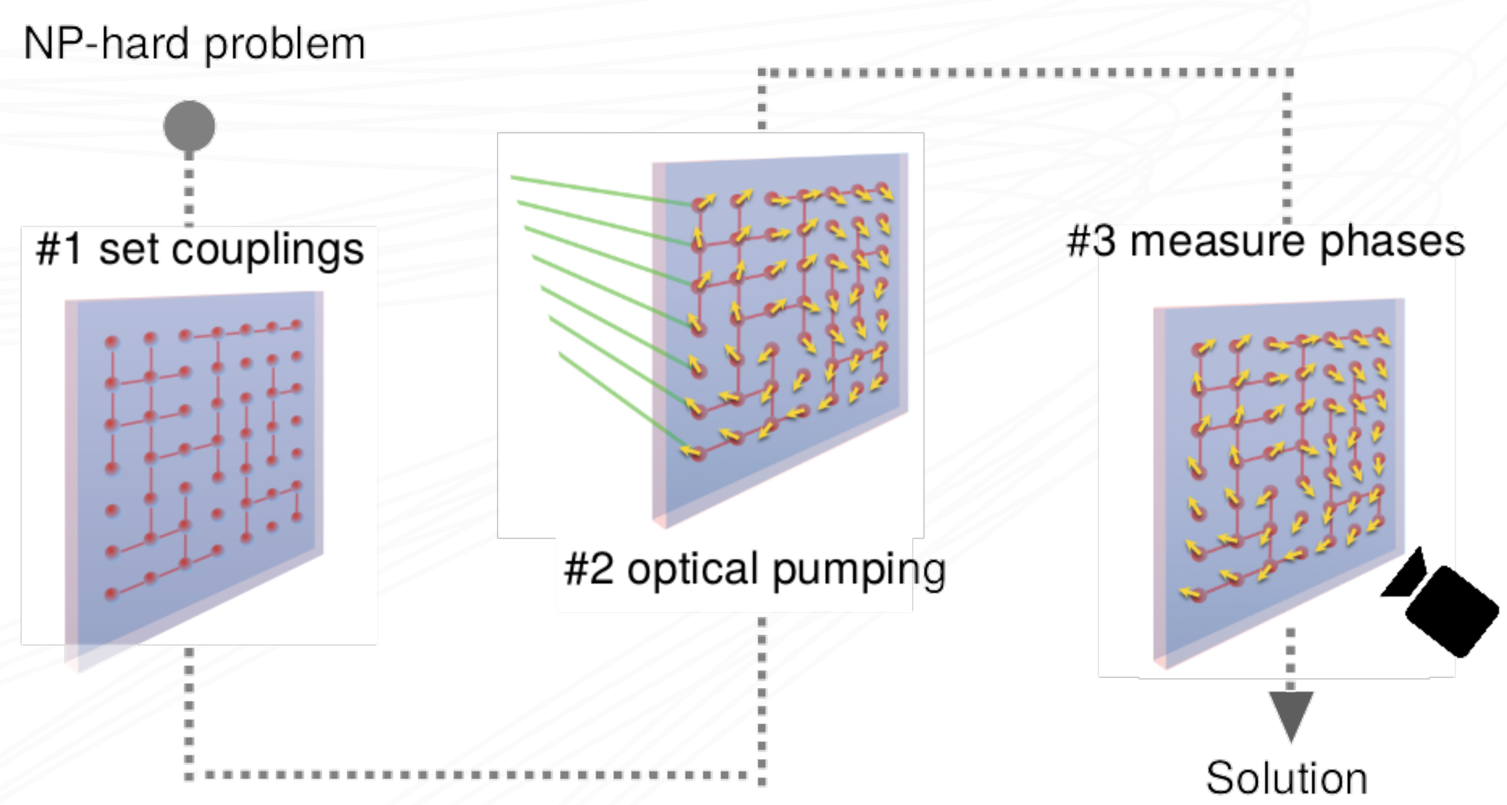


Such microstructured mirrors can be paired with a flat mirror to construct an array of microcavities. Filling the gap with Rhodamine dye and optically pumping with a pulsed UV laser forms photon Bose-Einstein condensates [1] in each microcavity. The BECs from adjacent microcavities interact via tunneling, with coupling constants [2] determined by the previous microstructuring, enabling us to arbitrarily choose the coupling constant between each BEC.



Networks of coupled photon Bose-Einstein condensates as spin glass simulators

Despite large advances in both algorithms and computer technology, even typical instances of computationally hard problems are too difficult to be solved on today's computers. Unconventional computational devices that break with the usual paradigms of digital electronic computers can help to overcome these limitations. In this project, a large-scale network of tunnel-coupled photon Bose-Einstein condensates will be developed and used as experimental platform to perform ultra-fast simulations of classical spin systems. Specifically, the network will be capable of solving the so-called ground-state energy problem in spin glasses (disordered magnets). The latter constitutes a well-known combinatorial problem that can be mapped mathematically to many other computationally hard problems with important applications in electronics, mechanical, chemical, and financial engineering, network design (for traffic, electricity, telecommunication), supply chain management, and scheduling. In a proof-of-principle experiment, we aim at demonstrating that the proposed spin glass simulator can perform this computationally hard optimization problem significantly faster and more energy efficient than any other computer existing today.



References

[1] J. Klaers, J. Schmitt, F. Vewinger and M. Weitz, Bose–Einstein condensation of photons in an optical microcavity, Nature 468, 545 (2010).

[2] D. Dung, C. Kurtscheid, T. Damm, J. Schmitt, F. Vewinger, M. Weitz and J. Klaers, Variable potentials for thermalized light and coupled condensates, Nature Photonics 11, 565 (2017).