Cold atoms of large optical depth inside a hollow-core fiber

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Quantum information processing typically requires atomic media at large optical depth, e.g. to enable nonlinear effects even at the low light intensity level. Implementations of appropriate methods to provide such media are technologically quite challenging. Loading cold atoms into an optical trap inside a hollow-core photonic crystal fiber exhibits a promising approach to reach the goal. Recent experimental implementations of this technique enabled optical depth (OD) of roughly 180.

In our setup we apply a different magneto-optical technique to guide the atoms into the dipole trap inside the fiber. This allows us to cool the atoms during the transfer and reach higher transfer rates. In first preliminary tests we reached an optical depth of 150 (i.e. already in the range of the best results reported in the literature). Our numerical simulations predict optical depths beyond 1000. This will enable an improvement by an order of magnitude compared to the state-of-the-art. At such densities, our setup will enable nonlinear optics at low light levels and light storage at ultra-long storage times.

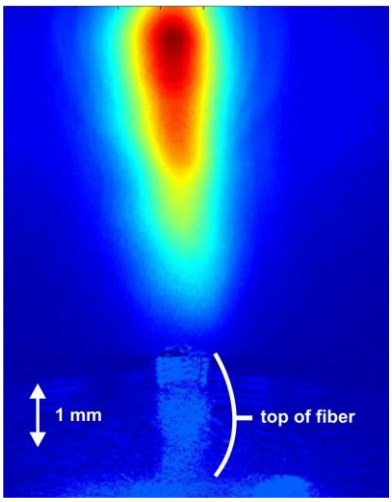

Figure 1: Fluorescence image of cold atoms just before entering the hollow-core fiber.

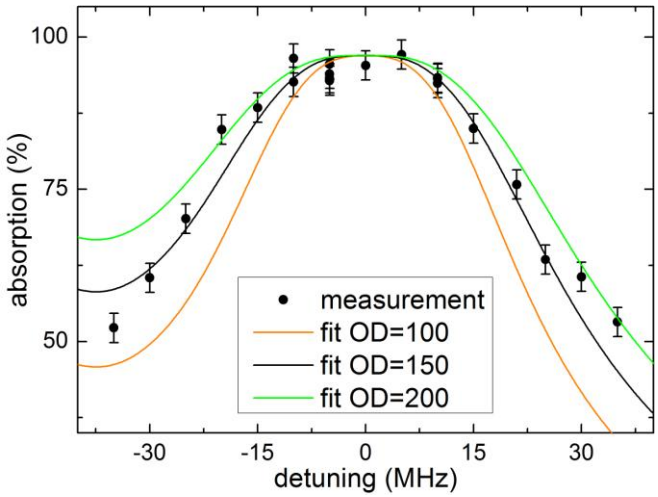

Figure 2: Absorption of cold atoms inside the hollow-core fiber as a function of probe frequency (data points). Solid lines show fits for the optical depth (OD) from numerical simulation.