Nonlinear optics in atomic-vapor-filled photonic-crystal fibers

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Alkali-metal atomic vapors are a working horse for optical pumping experiments for nearly 70 years. In early 2000s, the systems experienced revival of interest after (re)discovery of various quantum-coherence optical phenomena, such as slow and fast light, light storage, electromagnetically induced transparence and absorption, etc. This research also led to the development of techniques significant contributing to metrology, i.e., magnetometry.

Despite advantages of the vapors, new media supporting efficient generation and manipulation of quantum states in atom(-like) systems are being continuously sought for. One of the alternative to the bulk atomic-vapor systems (vapor cells) are photonic crystal fibers, which, due to their unique construction, support light guidance through lower refractive index (typically air) material. The core provides good light confinement, and in the case of hollow core enables filling the fiber with foreign media, e.g., alkali-metal atomic vapors. This leads to very strong light-atom coupling and hence opens means for manipulation of atoms, through nonlinear optical phenomena, at extremely low light intensities (single photons regime).

In the presentation, we discuss experimental setup enabling observation of nonlinear optical phenomena in rubidium-vapor-filled photonic-crystal fiber. After brief introduction into such hybrid systems, we discuss construction of experimental setup for optical studies, particularly concentrating on experimental challenges associated with operation with such systems. Starting from basic light absorption in rubidium-filled fiber, through such effect as light induced atomic desorption, to the two-photon absorption and superluminal light propagation, we show a broad spectrum of measurements that can be performed in such systems. In particular, we demonstrate control over group velocity of light pulse propagating through the system, including larger then *c* pulse propagation, and deformation of the “artificially” generated light pulse due to two-photon Rabi oscillations.