DOCTORAL THESIS ABSTRACT

Phase Matching as an adjustable mechanism of information transfer between light and quantum memory

This doctoral thesis focuses on the issue of phase matching in a quantum memory operating on a cold cloud of ^{87}Rb atoms, where non-resonant Raman scattering is used as an interface between light and atoms. Experimental results and considerations for controlling the memory readout process by using the Zeeman effect, ac-Stark effect, controlling the laser beam geometry, or using an optical ring cavity are presented.

Chapter 2 introduces the theory of the interaction between light and atoms in a three-level Λ system. The influence of factors such as beam intensities, beam offsets, beam geometry, or optical density on the readout rate and efficiency, as well as losses due to decoherence, or light absorption are analysed.

Chapter 3 presents the generation of a fictitious magnetic field using the ac-Stark effect with spatial resolution. Using it, the spatial precession phase of spins oscillating in an external magnetic field was modulated. The results obtained in the experiment show that the control of the spatial phase allow us to turn on or off the quantum memory readout.

Chapter 4 presents the experimental modulation of the spatial phase of spin waves in quantum memory using the ac-Stark effect. The possibility of compensating directly on the spin waves for any aberrations of the imaging system is presented. Using interference measurements on a near-field camera and direct measurements on a far-field camera, the operation of the spatial spin wave phase modulator is also characterised in detail.

Chapter 5 shows the combination of a GEM with spatial phase modulation. An experimental implementation of a very high resolution spectrometer (20 kHz ~ 83 peV ~ 6×10^{-7} cm^{-1}) adapted to narrowband atomic emission is presented. The relationship between resolution, bandwidth and spectrometer efficiency is also analysed.

Chapter 6 proposes a possible implementation of a mod converter enabling the conversion of spin waves stored in different spatial modes of our quantum memory onto a sequence of pulses coupled into a single-mode optical fibre. Results of numerical simulations of the memory readout inside an annular optical cavity are presented, as well as the manipulation of the photon emission direction using a readout beam with a controlled angle of incidence on the atomic cloud.