Mapping of the Optical Frequency Comb to the Atom Velocity Comb

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Mode-locked, phase-stabilized femtosecond (fs) lasers with high repetition rates produce stabilized wide-bandwidth optical frequency combs [1]. It is possible to directly reference the comb spacing and position to the microwave cesium time standard, thereby determining the absolute frequencies of all comb lines. Such series of secondary reference lines that may be extended across the optical spectrum, brought a revolutionary advance in metrology [2], optical frequency synthesis [3] and spectroscopy [4].

We present the experimental and theoretical study of the resonant excitation of rubidium atoms with fs pulse train in the conditions when the pulse repetition period is shorter than the atomic relaxation time. The velocity selective optical pumping of the ground state hyperfine levels and velocity comb-like excited state hyperfine level populations are demonstrated [5, 6]. Both effects are a direct consequence of the fs pulse train excitation considered in the frequency domain. A simple experimental apparatus was employed to develop a modified direct frequency comb spectroscopy which uses a fixed frequency comb for the ^{85,87}Rb $5^2S_{1/2} \rightarrow 5^2P_{1/2,3/2}$ excitation and a weak cw scanning probe laser for ground levels population monitoring.

The results show that it is possible to directly manipulate the fractional populations of hyperfine ground state levels by varying the comb optical frequency spectrum. This could lead to interesting applications in the field of atomic and molecular switching and finally to quantum computing. Recent experiments with rubidium and cesium will be discussed together with some obvious theoretical predictions.

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