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Adiabatic Control of Two-Photon Transitions via Optical Frequency Comb[1]

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An optical frequency comb is recognized as a new and unique tool for high-resolution spectroscopic analysis as well as for controlling ultrafast phenomena in atomic and molecular physics. The investigations have been carried out implementing a femtosecond frequency comb to manipulate ultracold gases. These include a theory on piecewise stimulated Raman adiabatic passage using two coherent pulse trains with pulse-to-pulse amplitude and chirped phase variation to create ultracold KRb molecules from Feshbach states, [1,2]. Here, we demonstrate how to use a single, phase modulated optical frequency comb to control population dynamics aiming at creation of deeply bound ultracold polar molecules, [3]. We model the KRb cooling by the three-level λ-system interacting with a single femtosecond optical frequency comb, that governs the Raman transitions from the Feshbach state to the ground electronic vibrational state. The phase across a single pulse in the pulse train is sinusoidally modulated with a carefully chosen amplitude and modulation frequency. Partial adiabatic population transfer is fulfilled to the final state by each pulse in the applied pulse train providing a controlled population accumulation in the final state. Detuning the carrier frequency and the modulation frequency to less than the frequency difference between the initial and final states changes the time scale of molecular dynamics but leads to the same complete population transfer. Strong dependence of the cooling dynamics is observed on the magnitude of the amplitude of sinusoidal modulation. The proposed scheme demonstrates the robustness of a single optical frequency comb in application to molecular cooling from Feshbach states.

[1] A. Pe'er, E.A. Shapiro, M.C. Stowe, M. Shapiro, J. Ye, "Precise control of molecular dynamics with a femtosecond frequency comb", Phys. Rev. Lett., 98, 113004(4) (2007).
[2] E.A. Shapiro, A. Pe'er, J. Ye, M. Shapiro, "Piecewise Adiabatic Population transfer in a molecule via a Wave Packet", Phys. Rev. Lett., 101, 023601 (2008).
[3] W. Shi, S. Malinovskaya, "Implementation of a single femtosecond optical frequency comb for molecular cooling", submitted.

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