A FREQUENCY COMB APPROACH TO VIBRATIONAL STABILIZATION OF FESHBACH MOLECULES

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Ultracold molecules can be created from atoms by Feshbach resonance techniques. While these molecules are in the electronic ground state, they are highly excited vibrationally. As a result, these molecules are unstable due to collisional-virational quenching. We present a general and highly efficient scheme for vibration stabilization using a coherent train of weak pump-dump pairs of shaped ultrashort pulses to perform narrow-band Raman transitions between vibrational levels. Although mode-locked lasers emit broadband ultrashort pulses, they can be utilized to perform frequency selective excitation just like narrow-band CW lasers due to their precise frequency comb. This spectral selectivity is explained by the very long inter-pulse phase coherence, which allows for coherent accumulation of the excitation amplitudes from multiple pulses in an excited material system, similar to a generalized Ramsey experiment. The use of weak pulses permits a simple analytic description of the single pulse response within the framework of coherent control in the perturbative regime, while coherent accumulation of many pulse pairs enables near unity transfer efficiency with a high spectral selectivity, thus forming a powerful combination of pump-dump control schemes and the precision of the frequency comb. The feasibility and robustness of this concept is verified by realistic simulations of the molecular dynamics.