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**Vibrational Molecular Clock in a State-Insensitive Optical Lattice** CHIH-HSI LEE, STANIMIR S. KONDOV, KON H. LEUNG, Columbia University, CHRISTIAN LIEDL, Humboldt University of Berlin, TANYA ZELEVINSKY, Columbia University, ZLAB TEAM — Techniques originally developed for atomic clocks can be adapted to ultracold molecules, with applications ranging from quantum-state-controlled ultracold chemistry to searches for new physics. Here we present recent experimental results with a molecular lattice clock that is based on a frequency difference between two vibrational levels in the electronic ground state of strontium diatomic molecules. Such a clock allows us to test molecular QED, search for mass-dependent "fifth-force" interactions, and potentially probe the electron-to-proton mass ratio variations. The achieved quality factor for the molecular clock is $Q = 8 \times 10^{11}$. Trap-insensitive spectroscopy is crucial for extending coherent molecule-light interactions and achieving high $Q$s. We have demonstrated a "magic wavelength" technique for molecules by manipulating the optical lattice frequency near narrow polarizability resonances. This technique allows us to increase the coherence time by over a thousandfold and to narrow the linewidth of a 30 THz vibrational transition initially to 30 Hz. Long coherence times of molecular state superpositions are critical not only for fundamental metrology but also for quantum information.

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