Molecular Lattice Clock

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Atomic clock based metrology is at the forefront of high-precision measurements and tests of fundamental physics. On the other hand, molecules offer a range of distinct energy scales that have inspired new protocols in precision measurement and quantum information science. We have constructed a fundamentally new type of lattice clock that is based on vibrations in diatomic strontium molecules, where coherent Rabi oscillations between weakly and deeply bound molecules persist for tens of milliseconds [1]. This clock is made possible by a careful control of molecular quantum states, and by a state-insensitive "magic" lattice trap that weakly couples to molecular vibronic resonances and enhances the coherence time between molecules and light by several orders of magnitude. This enhancement results in a clock quality factor of nearly a trillion. The technique of extended coherence across the entire molecular potential depth is applicable to long-term storage of quantum information in qubits based on ultracold polar molecules, while the vibrational clock enables novel precise probes of interatomic forces, tests of ultrashort-range Newtonian gravitation, and model-independent searches for electron-to-proton mass ratio variations.

[1] S. S. Kondov, C.-H. Lee, K. Leung, C. Liedl, I. Majewska, R. Moszynski, and T. Zelevinsky, *Molecular lattice clock with long vibrational coherence,* arXiv:1904.04891.