Experiments with an ultracold molecular lattice clock: subradiance, forbidden transitions, and E1 / M1 / E2 photodissociation

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When a molecule is subjected to laser light tuned above a dissociation threshold, the molecule can break apart into fragments whose angular distribution depends critically on the character of the particular channel by which dissociation occurs. When the initial state is well-defined, the angular distributions of the photofragments at various frequencies above threshold can be fitted to determine the shapes of the final molecular potentials involved as well as the relative strengths of the contributing pathways.

We measure the photofragment distributions of photodissociated state-selected $^{88}Sr_2$ molecules via absorption imaging, with an imaging beam parallel to the probe axis. The molecules are produced via photoassociation from ^{88}Sr atoms cooled to a few μK, trapped in a 1D optical lattice, and probed along the lattice axis. The resulting images show rings of atoms whose angular distributions encode the strength and character of the participating dissociation pathways. We present measurements of one- and two-photon photodissociation of either E1 or M1 / E2 character. The measurements of M1 / E2 photodissociation are achieved by coherently populating a subradiant excited state for which E1 photodissociation to the ground state is forbidden, and can therefore only occur due to higher order processes.

In addition to photodissociation experiments, we present recent work toward the realization of a molecular clock, including: magnetic field-enabled control of highly forbidden (ΔJ = 2,3) transitions between weakly bound rovibrational levels[1]; production and precision characterization of long-lived "subradiant" states, so-called because quantum mechanical symmetries forbid E1 decay to the ground state[2]; and a new method for characterizing the temperature of a cloud of particles confined to a roughly harmonic trap by examining the lineshape produced by "carrier transitions", i.e. those transitions which preserve motional quantum number between initial and final state[3].

References

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