Tanya Zelevinsky

Columbia University

High-precision physics and chemistry with ultracold molecules

Abstract: Techniques for controlling the internal quantum states and motion of atoms have led to extremely precise metrology and studies of degenerate gases. Extending such techniques to various types of molecules further enriches the understanding of fundamental physics, basic chemical processes, and many-body science. Samples of diatomic molecules can be created by binding laser-cooled atoms, or by direct molecular laser cooling. We explore both approaches and demonstrate high-precision metrology with an optical-lattice based molecular clock as well as chemistry in the quantum domain.

Bio: Tanya Zelevinsky graduated from MIT in physics and math and received her physics PhD at Harvard University where her thesis work involved precise spectroscopy of helium atoms for testing QED and measuring the fine structure constant. She came to Columbia University in 2008, after spending a few years building and improving the optical lattice atomic clock at JILA in Boulder, Colorado. Her current research interests and work at ZLab involve precision measurements via state-of-the-art optical spectroscopy and quantum manipulation of diatomic molecules. Her group uses laser light to create ultracold molecules trapped in an optical lattice. Lattice-clock style spectral resolution then allows quantum control of the molecules, leading to studies of molecular quantum physics and ultracold chemistry. The latter is investigated via the photodissociation process in the ultracold regime. On a fundamental level, the molecules provide an ensemble of tiny clocks where the vibrations determine the ticking rate. This type of quantum clock allows ZLab to test molecular QED at a high level as well as constrain possible new physics at the nanometer scale. ZLab also explores ways to directly cool molecules in order to manipulate and study them. An exciting future possibility is to apply the ultracold photodissociation technique to produce exotic ultracold gases for a variety of scientific applications. ZLab is also collaborating with University of Chicago and University of Massachusetts to use cold diatomic molecules in combination with optical and microwave techniques to measure time-reversal symmetry violation in atomic nuclei (Cold Molecule Nuclear Time Reversal Experiment, or CENTREX).