Measurements may help show if constants are changing

Physicists at JILA have performed the first-ever precision measurements using ultracold molecules, in work that may help solve a long-standing scientific mystery--whether so-called constants of nature have changed since the dawn of the universe.

The research, reported in the April 14 issue of *Physical Review Letters*, involved measuring two phenomena simultaneously--electron motion, and rotating and vibrating nuclei--in highly reactive molecules containing one oxygen atom and one hydrogen atom.

The researchers greatly improved the precision of these microwave frequency measurements by using electric fields to slow down the molecules, providing more time for interaction and analysis. JILA is a joint institute of the National Institute of Standards and Technology (NIST) and the University of Colorado at Boulder.

Compared to the previous record, set more than 30 years ago, the JILA team improved the precision of one frequency measurement 25-fold and another 10-fold. This was achieved by producing pulses of cold molecules at various speeds, hitting each group with a microwave pulse of a selected frequency, and then measuring how many molecules were in particular energy states. The apparatus and approach were similar to those used in the NIST-F1 cesium atomic fountain clock, the nation's primary time standard, raising the possibility of designing a clock that keeps time with molecules, instead of atoms.

The JILA team's ability to make two molecular measurements at once enables scientists to apply mathematical calculations to probe the evolution over time of fundamental natural properties such as the fine structure constant, which is widely used in research to represent the strength of electromagnetic interactions. Another research group at the National Radio Astronomy Observatory plans to make similar frequency measurements soon of the same molecules produced in distant galaxies, which are so far from Earth that they represent a window into ancient history.

By comparing precision values for the fine structure constant on Earth and in distant parts of the universe, scientists hope to determine whether this constant has changed over 10 billion years. Because the fine structure constant is used in so many fields of physics, these measurements are a way to test the consistency of existing theories. The JILA measurements could enable any change in the fine structure constant over time to be determined with a precision of one part per million.

Citation: E.R. Hudson, H.J. Lewandowski, B.C. Sawyer, and J.Ye. 2006. Cold molecule spectroscopy for constraining the evolution of the fine structure constant. *Physical Review Letters*. April 14 (Vol. 96, 143004).

Source: NIST