Powerful optical centrifuge created to study dynamics of fast spinning molecules

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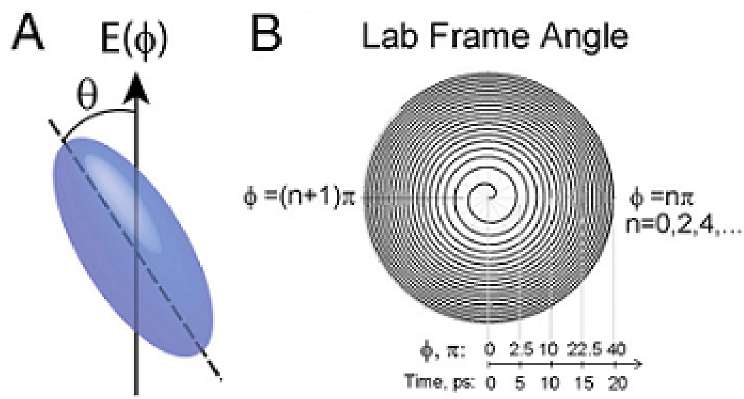

Behavior of molecules in rotationally accelerating strong optical fields. (A) Molecules with nonuniform polarizability tend to align with the electric field vector. (B) Trajectory of the lab frame angle for the electric field during the optical centrifuge pulse, showing the angular acceleration of the field.

(PhysOrg.com) -- High-energy molecules play a major role in the chemistry of combustion, plasmas and the atmosphere. Scientists have been able to generate and investigate molecules with large amounts of vibrational, electronic or translational energy, but methods for producing and studying molecules with large amounts of rotational energy have remained elusive. In the April 5 issue of the *Proceedings of the National Academies of Science*, University of Maryland Chemistry Professor Amy S. Mullin and her research team introduce a new instrument that can both impart extremely large amounts of rotational energy to molecules and study how they subsequently transfer their energy to other molecules.

"The difficulty in generating molecules with extreme amounts of rotational energy," explains Mullin, "is that the energy must be added bit by bit. It's like pushing children on a merry-go-round: you start off slowly, and then each push gets the merry-go-round spinning faster and faster. The trick is finding a method to do the same thing with molecules, and to be able to generate enough of these spinning molecules to study their behavior."

Mullin and her team employed an approach called an optical centrifuge to get the molecules spinning. This method, which was developed by Paul Corkum and co-workers at the National Research Council in Canada, uses a strong laser beam to align molecules and then rotationally accelerate molecules. Mullin's team developed a new optical centrifuge that is a hundred times more powerful than the original instrument. As a result of the added power, they are able to create large enough populations of molecules in extreme rotational states that it is possible for the first time to use spectroscopy to observe their fate.

"We used high-resolution infrared laser spectroscopy to study how the rotational energy is redistributed into other forms of energy through collisions," continues Mullin. "These studies took advantage of time-resolved optical methods to identify the major energy-flow pathways that cause the rotational energy to dissipate into translation, vibration and rotation of other molecules."

The amount of rotational energy that the optical centrifuge imparts to molecules is on the order of the strength of a chemical bond. New types of chemical behavior are therefore likely to occur at such large rotational energies. "The centrifuge allows us to apply large amounts of torque at the molecular level," says Mullin, "and we are now in a position to determine how such torques affect chemical bonds. Practically nothing is known about molecules in this environment, and we are excited to be investigating this new frontier in chemistry."

More information: Dynamics of Molecules in Extreme Rotational States, www.pnas.org/content/early/201 … 669108.full.pdf+html

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