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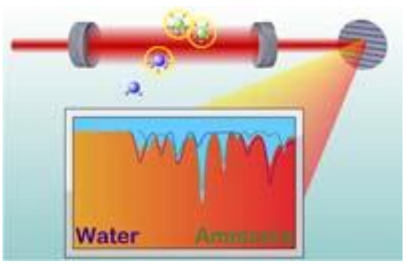
New twist on chem analysis

Physicists at JILA, Boulder, Colo., have designed and demonstrated a highly sensitive tool for simultaneous, real-time analysis of the quantity, structure, and dynamics of a variety of atoms and molecules.

The new technology is an adaptation of a conventional technique, cavity ring-down spectroscopy, for identifying chemicals based on their interactions with light. The JILA system uses an ultrafast laser-based "optical frequency comb" as both the light source and as a ruler for precisely measuring the many different colors before and after the interactions.



Developers: *Researchers at JILA, led by Jun Ye.*
What's new: *A powerful new spectral tool that identifies trace levels of different molecules at the same time.*
How it works: *An optical frequency comb is used as both the light source and as a ruler for precisely measuring the many different colors of light after interactions with molecules.*
Applications: *Analysis of chemicals in many different environments, as well as breath analysis to monitor disease.*
Web site: *www.nist.gov*

Adapting a conventional technique

Cavity ring-down spectroscopy identifies atoms or molecules by the way they absorb laser light as it is repeatedly reflected and dissipated inside a mirrored vacuum cavity.

The JILA system uses a laser that emits a broad range of colors. The laser light is then tuned to the "resonant frequency" of the cavity such that all of the many different wavelengths of light—all "harmonics" of a single basic wave size—fit perfectly between two special mirrors. The distance between the mirrors is adjusted using tiny motors to select the resonant frequency of the cavity. The mirrors inside the laser are then rotated to match the laser frequencies to those of the cavity.

The light is repeatedly reflected inside the cavity until the laser is turned off, after which all of the energy is gradually lost in a few microseconds. If atoms or molecules are placed inside the cavity, they absorb some of the light energy at frequencies where they switch energy levels, vibrate, or rotate, and the light dissipates faster at those frequencies.

A beam of "white light" is emitted from the cavity during the dissipation process and separated into a rainbow of colors, which are detected in sets of color bands. Computer software can then analyze the change in the decay time of selected channels of different frequencies simultaneously. The results are rapidly matched against a catalog of absorption signatures of known atoms and molecules.

"What a frequency comb can do beautifully is offer a powerful combination of broad spectral range and fine resolution," says NIST fellow Jun Ye, who led the work.

"The amount of information gathered with this approach was previously unimaginable. It's like being able to see every single tree of an entire forest. This is something that could have tremendous industrial and commercial value."

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