NISTTech

Cavity Ringdown Spectroscopy System using Differential Heterodyne Detection

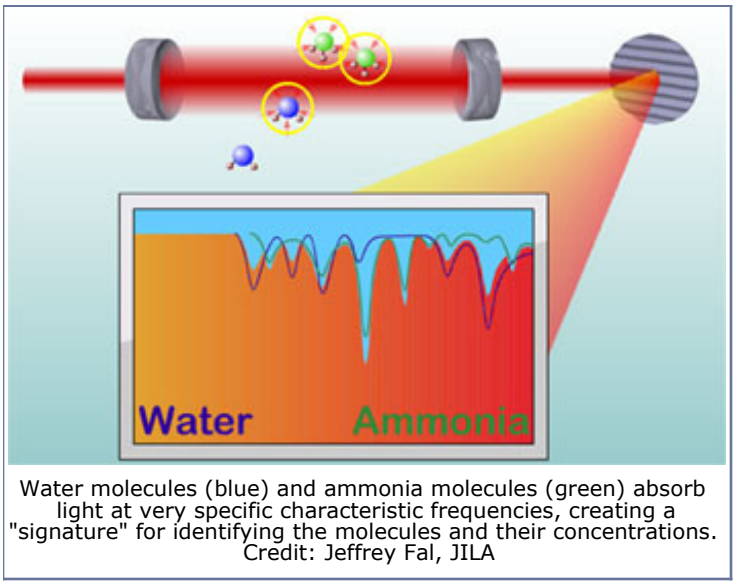
Measures gas concentrations to the parts per trillion

Description

Identifies and measures concentration of gases at parts per trillion sensitivity using only a microwatt level of light power. Incorporating a dual-light source to enhance sensitivity, this cavity ringdown spectroscopy produces an absorption sensitivity on the order of 1 x 10^{-10}. In addition, the system is easy to use and relatively inexpensive.

One beam interacts with the molecules under examination, while the second probes an empty-cavity. Heterodyne detection between the two modes reveals dynamic time constants associated with the cavity and the cavity plus intra-cavity absorption

Images



Water molecules (blue) and ammonia molecules (green) absorb light at very specific characteristic frequencies, creating a "signature" for identifying the molecules and their concentrations. Credit: Jeffrey Fal, JILA

Applications

- **Environmental**
  Measures atmospheric chemistry, carbon and greenhouse gas emissions
- **Medical**
  In-situ gas analysis of a patient's breath to identify diabetes, certain cancers, or other ailments
- **Semiconductor Fabrication**
  Laser gas analyzers for detecting impurities
- **Air Quality**
  Track factory and automobile emissions

Advantages

- **Sensitive**
- **Energy Efficient**
  Low optical power at the microwatt level
- **Available**
  Easy to use and relatively inexpensive

Abstract

A novel AC technique in cavity ringdown spectroscopy that permits IXIO-IO absorption sensitivity with microwatt level light power has been developed. Two cavity modes, one probing the empty cavity and the other probing intracavity absorption, are excited simultaneously, but their intensities are temporally out of phase, with one mode decaying and the other rising. Heterodyne detection between the two modes reveals the dynamic time constants associated with the empty cavity and the additional intracavity gas absorption. The method offers a quick comparison between the on-resonance and off-resonance information, a prerequisite to reaching the fundamental shot noise limit. This simple and yet important improvement of cavity ringdown spectroscopy should lead to enhanced performance in a wide range of applications.

Inventors

- Hall, John L.
- Ye, Jun

Citations

1. J. Ye, L.S. Ma and J.L. Hall. Ultrasensitive Detections in Atomic and Molecular Physics- Demonstration in Molecular Overtone Spectroscopy. J. Opt. Soc. Am. B/Vol. 15, No. 1, Jan 1998.

References

- U.S. Patent # 6,727,492 issued 04-27-2004, expires 05/10/2022
- Docket: 00-005US

Status of Availability

This invention is available for exclusive or non-exclusive commercialization licensing. Collaborative research opportunities are available.

Last Modified: 07/26/2011