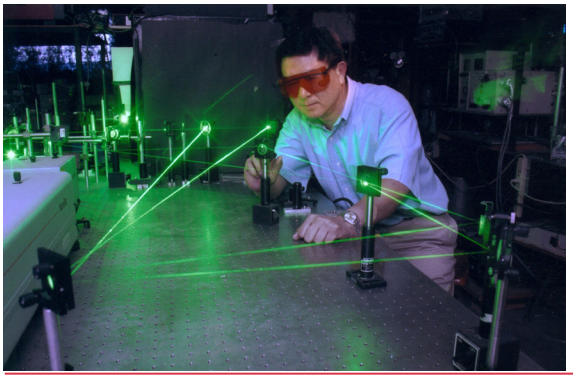
Novel Nonlinear Laser Methods for Chemical Analysis

Approaching single-atom detection with isotope resolution

Novel multi-photon optical methods based on laser wave mixing and dynamic laser gratings offer many advantages compared to conventional optical methods. These simple, compact and robust systems offer excellent detection sensitivity and high chemical selectivity.

Chemical and isotope analyses at trace-concentration levels with Doppler-free spectral resolution have been demonstrated using various atomizers, including flames, discharge plasmas, graphite furnace, and inductively coupled plasma atomizers. Because the signal is a coherent laser beam (unlike fluorescence signal), virtually 100% of the generated signal can be collected and directed into a detector.



The nonlinear signal has a cubic dependence on excitation intensity, and hence, laser power requirements are low, and mW-level continuous-wave lasers and nJ-level pulsed dye lasers can be used for this multi-photon spectroscopic setup. The optical alignment and beam quality requirements are relatively less demanding, and, hence, compact inexpensive lasers, including laser diodes, can be used. Because the coherence time and coherence length requirements are also relatively low, many types of laser sources can be used.

In addition to isotope and hyperfine analyses for gas-phase analytes, sensitive on-column absorbance measurements can also be made for liquid analytes with sensitivity levels comparable to those of fluorescence-based methods. Both fluorescing and non-fluorescing analytes can be detected without tedious labeling processes. The small (pL-range probe volume laser beam overlap zone) allows convenient interfacing of this detection method to capillary-based electrophoresis or chromatography separation systems. Hence, it offers many potential applications.

Advantages

- Coherent laser-like signal
- Highly efficient signal collection and detection
- Comparable or better sensitivity than fluorescence
- Approaching single-atom detection in flow cells
- Measurement of biomolecules without labels/tags
- Native biosample analysis
- Better spatial resolution (small probe)

Applications

- Biomedical, biotechnology
- Chemical sensors on a chip
- Native DNA and protein detection with out labels
- Sensitive absorption detection for chromatography
- Atmospheric and environmental chemistry
- Geochemistry

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