IR/THZ DOUBLE RESONANCE SPECTROSCOPY APPROACH FOR REMOTE CHEMICAL DETECTION AT ATMOSPHERIC PRESSURE

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A remote sensing methodology based on infrared/terahertz (IR/THz) double resonance (DR) spectroscopy is shown to overcome limitations traditionally associated with either IR or THz spectroscopic approaches for detecting trace gases in an atmosphere. The applicability of IR/THz DR spectroscopy is explored by estimating the IR and THz power requirements for detecting a 100 part-per-million-meter cloud of methyl fluoride, methyl chloride, or methyl bromide at ranges up to 1km in three atmospheric windows below 0.3 THz. These prototypical molecules are used to ascertain the dependence of the DR signal-to-noise ratio on IR and THz beam power. A line-tunable CO_2 laser with 100 ps pulse duration generates a DR signature in four rotational transitions on a time scale commensurate with collisional relaxations caused by atmospheric N_2 and O_2. A continuous wave THz beam is frequency tuned to probe one of these rotational transitions so that laser-induced absorption variations in the analyte cloud are detected as temporal power fluctuations synchronized with the laser pulses. A combination of molecule-specific physics and scenario-dependent atmospheric conditions are used to predict the signal-to-noise ratio (SNR) for detecting an analyte as a function of cloud column density. A methodology is presented by which the optimal IR/THz pump/probe frequencies are identified. These estimates show the potential for low concentration chemical detection in a challenging atmospheric scenario with currently available or near term hardware components.