Open Path Quantum Cascade Laser based Sensor for detecting Nitrous Oxide leaks from backscattered light

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Nitrous Oxide is a greenhouse gas which can be naturally emitted or emitted through industrial processes and has a global warming potential of 300 times that of carbon dioxide over a span of 100 years [2]. Therefore the Environmental Protection Agency through its Clean Air Act has made it a requirement to keep concentration standards for this gas [1].

By observing the gas absorption spectrum of Nitrous Oxide (N2O), the location of the absorption lines of N2O was found according to frequency of light as shown in figure 1(A). The Quantum Cascade Laser (QCL) utilized in this project emits infrared light within the range shown in figure (1). We identified the frequencies with strong N2O absorption lines or peaks and tuned the frequency of the QCL, using a temperature controller unit, to those identified. The laser temperature selected was 16.5 degrees Celsius to detect Nitrous Oxide. The QCL used has a wavelength around 7.78 microns and has 200ns pulse duration with a .4% duty cycle.

This project is focusing specifically at detecting leaks of nitrous oxide. Nitrous Oxide concentrations were detected in this project using an open path Quantum Cascade Laser based system shown in figure 1(B). To obtain the concentration of N2O from a leak we used a gas cylinder to leak small amounts of N2O into the infrared path. The infrared transmitter beam was directed toward a gold lambertian target and was scattered back from the gold target. The Newtonian telescope collects the light scattered with a solid angle field of view after it hits the gold target and focuses the light onto the infrared detector. The signal was recorded using the acquisition software LABVIEW. The recorded data from LABVIEW was processed in MATLAB using the least squares fitting technique to obtain the path-averaged concentration of the nitrous oxide in the air that was present during the leak.

Figure 1. (A) Gas absorption spectrum of N2O. One of these absorption lines will be seen on LABVIEW on the computer depending on the wave number the laser is emitting. At 16.5 degrees Celsius the peak at around 1295.6(cm-1) can be detected on LABVIEW. (B) The open path quantum cascade laser based system used at CCNY for this project.