MEASUREMENT AND APPLICATION
OF FAR-INFRARED LASER EMISSIONS

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ABSTRACT
The objective of the proposed research is to measure the frequencies of optically pumped laser emissions generated by the CH$_3$DOH methanol isotope using the three-laser heterodyne technique. Once measured, these lines will be used as sources of far-infrared radiation to investigate the NH radical using the laser magnetic resonance technique.
INTERIM REPORT

As mentioned, the first objective of the proposed research was to measure the frequencies of several optically pumped laser emissions generated by the partially deuterated isotope of methanol, CH₂DOH. This will be accomplished using the three-laser heterodyne system, shown in Figure 1.

![Diagram of the three-laser heterodyne system](image)

Figure 1. The three-laser heterodyne system used for the measurement of FIR laser frequencies.

This experimental system utilizes two stabilized CO₂ laser frequencies to generate a known far-infrared (FIR) difference frequency. This known FIR difference frequency is then mixed with the unknown FIR laser frequency produced by an optically pumped molecular laser. A beat
between the known and unknown laser frequencies can then be observed in the microwave region. The frequency and characteristics of the beat can be accurately measured and are used to extrapolate the unknown FIR laser frequency. With this technique, FIR laser frequencies can be determined to fractional uncertainties of ± 2 × 10^7.

This system was setup during the 2005 spring semester with the assistance of Toby Garrod, Brooke Chuzles and Michael Theisen. This included the alignment and calibration of the following experimental components: the FIR laser cavity, three carbon dioxide (CO₂) lasers and two CO₂ absorption cells. Once complete, the calibration of the entire system was checked by measuring five known FIR laser frequencies generated by optically pumped methanol (CH₃OH).

The measurement of FIR laser frequencies generated by CH₂DOH will be performed during the 2005 summer with the assistance of Toby Garrod, Matt Ramberg and Andrew Stokes. Thus far, the frequencies for the 87.1 and 100.1 μm FIR laser emissions have been determined. The average FIR laser frequency reported for each line is an average of at least fifteen measurements made with four different sets of CO₂ reference laser lines (these frequencies will be tabulated in the final progress report). Figure 2 shows the beat between the 87.1 μm laser line (obtained using the 9R18 CO₂ pump) and the difference frequency generated by the 9P6 and 10P20 CO₂ laser emissions. Once the measurement of FIR laser frequencies from CH₂DOH is complete, these laser emissions will be used to record the NH spectra using the FIR laser magnetic resonance spectrometer system (anticipated to begin in August 2005).
Figure 2. The observed beat between the 87.1 µm laser line of CH₂DOH (obtained using the 9R18 CO₂ pump) and the difference frequency generated by the 9P6 and 10P20 CO₂ laser emissions.
Figure 3. Project participants during the 2005 spring semester and summer. From left to right: Andrew Stokes, Toby Garrod, Dr. Mike Jackson, Michael Theisen, Brooke Chuzles and Matt Ramberg.