Continuous wave cavity ringdown spectroscopy of $C_{60}$ at 8.5 $\mu$m using a quantum cascade laser and a supersonic expansion source

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Introduction

$C_{60}$ was discovered during experiments simulating carbon star outflows\(^1\), and has been found in craters on the Long Duration Exposure Facility (an earth orbiting satellite)\(^2\), and in sediments related to meteorite impacts\(^3\).

$C_{60}$ has 174 vibrational degrees of freedom, 60 quantum-mechanically indistinguishable (spin 0) bosons, and icosahedral ($I_h$) symmetry: 6 five-fold axes, 10 three-fold axes, and 15 two-fold axes. Symmetry restrictions lead to only 4 $F_{1u}$ IR active modes near 1432, 1183, 577, and 528 cm\(^{-1}\).

$C_{60}$ should be readily formed and stable to dissociation in space, but no rotationally cold gas phase absorption spectrum of $C_{60}$ is available for comparison to interstellar observations.

Experiment

We have constructed a spectrometer for continuous-wave cavity ringdown spectroscopy (cw-CRDS) at 1184 cm\(^{-1}\) (8.5 $\mu$m) for the study of rotationally cold gas phase $C_{60}$.

The output of a continuous-wave quantum cascade laser (cw-QCL) is matched to the focal properties of a high finesse cavity. A piezo changes the length of the cavity, and the light couples to the cavity when in resonance. The light is diverted when resonance is achieved, and the intensity exponentially decays with a rate proportional to the cavity absorption. Gas phase $C_{60}$ is produced with a high temperature oven and supersonically expanded into the cavity.

Ongoing Work

We are installing an acousto-optical modulator (AOM) for diversion of the light from the cavity upon resonance so as to eliminate the mode hops induced by the electronic switching. Once installed, we will confirm mode-hop free laser tuning through continued cw-CRDS investigation of $CH_2Br_2$. We will then obtain the $C_{60}$ spectrum with this experimental setup.

References


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