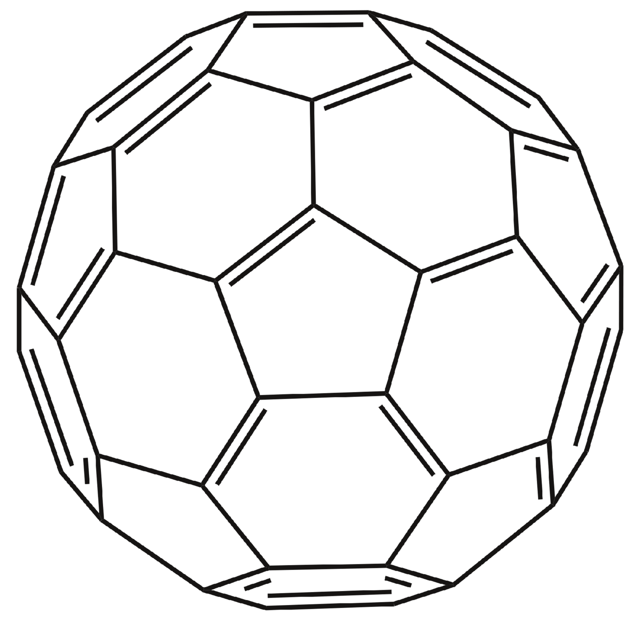
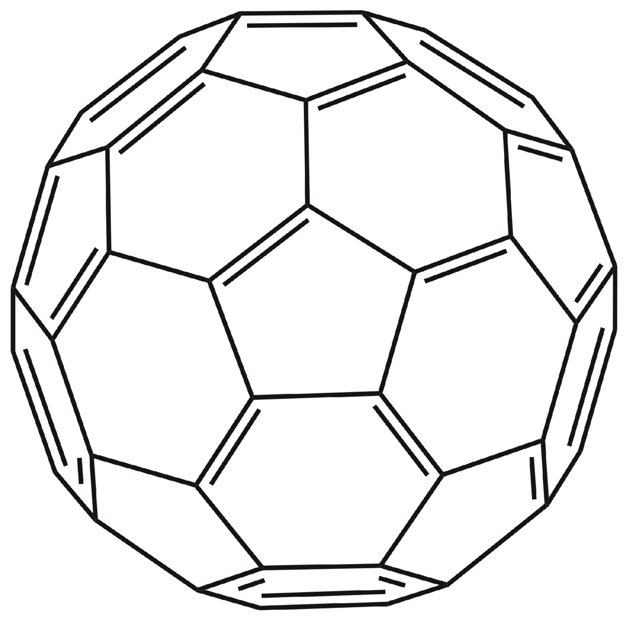


Mid-Infrared Continuous Wave Cavity Ringdown Spectrometer for Acquisition of the High-Resolution Spectrum of C_{60}



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Background

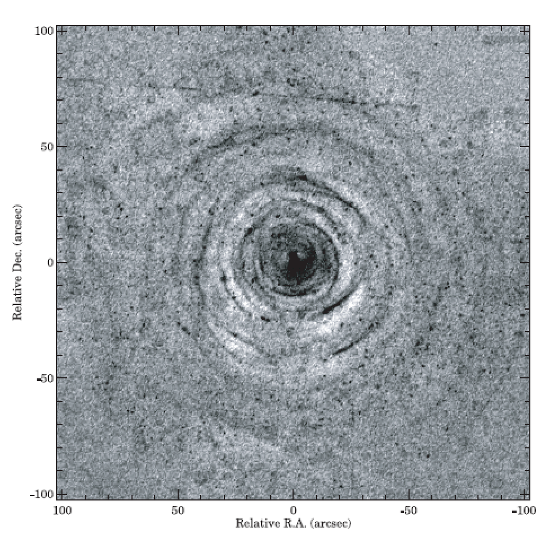
•C_{60} was originally discovered in experiments that attempted to recreate carbon star outflow chemistry[1]

•C_{60} has since been found in an impact crater on an earth orbiting satellite[2] and sediments related to meteorite impacts [3]

•A high-resolution gas phase spectrum of C_{60} has not yet been obtained which can be compared to astronomical observations

•Our goal is to obtain a rotationally resolved gas phase spectrum of C_{60} to aid an astronomical search for this molecule

V-band (540 nm) image of outflow from IRC+10216, a well known carbon star[4]

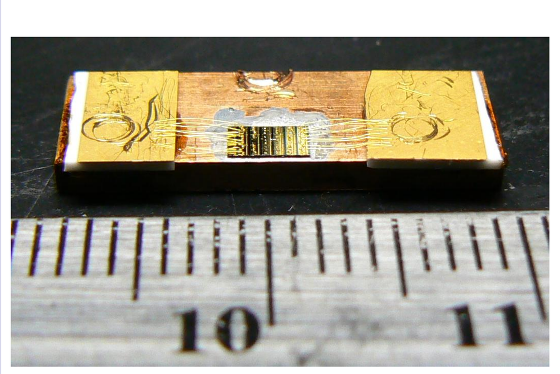


Vibrational Spectroscopy

•C_{60} has no permanent dipole moment (so no rotational spectroscopy) and its electronic transitions are broad and/or forbidden

•Vibrational spectroscopy is the way to go: C_{60} has IR active vibrational modes at 1432, 1185, 577, and 528 cm^{-1}

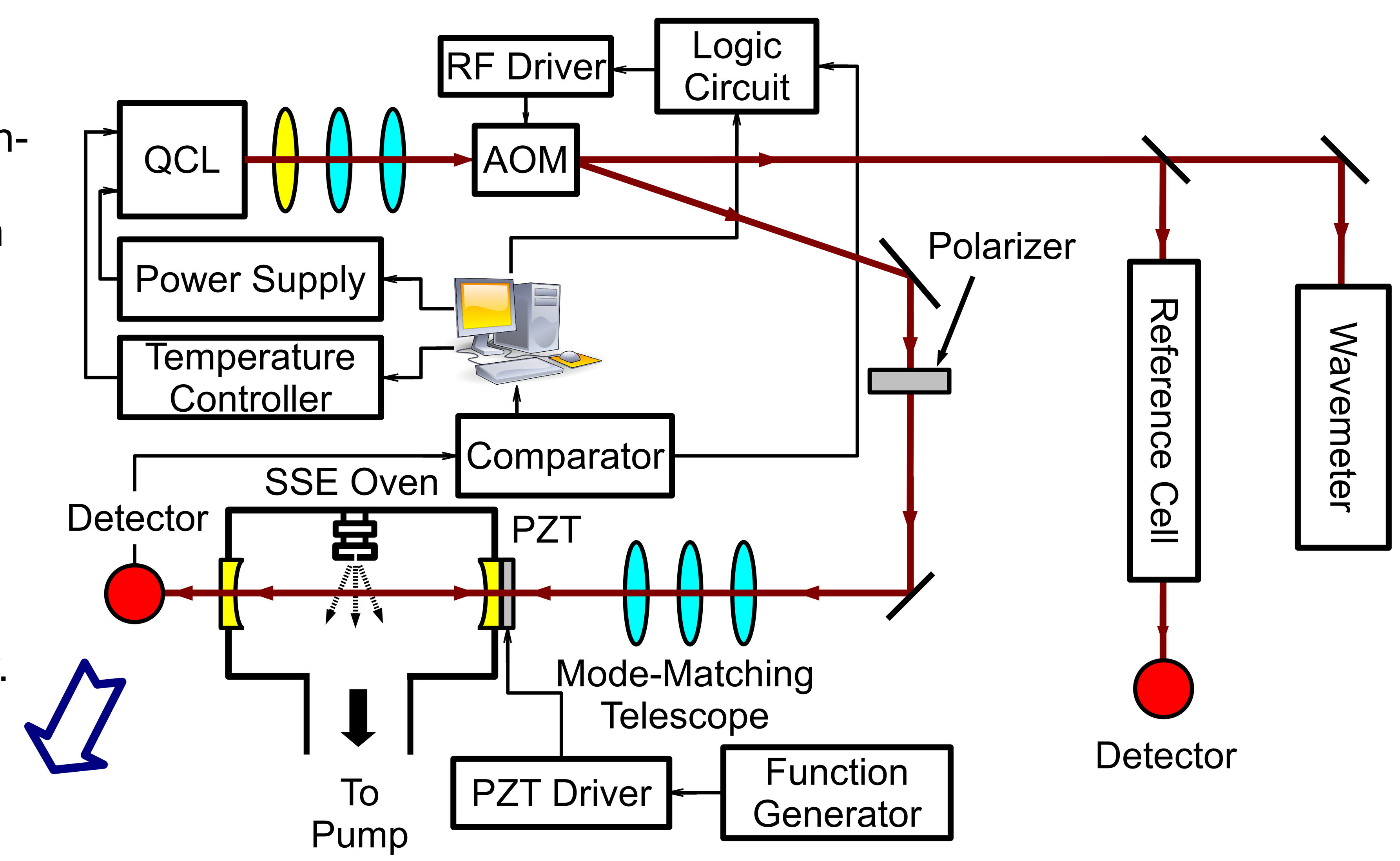
•We are trying to measure the band at 1185 cm^{-1} because it coincides with an atmospheric window, which would enable a ground-based search for C_{60} in the ISM

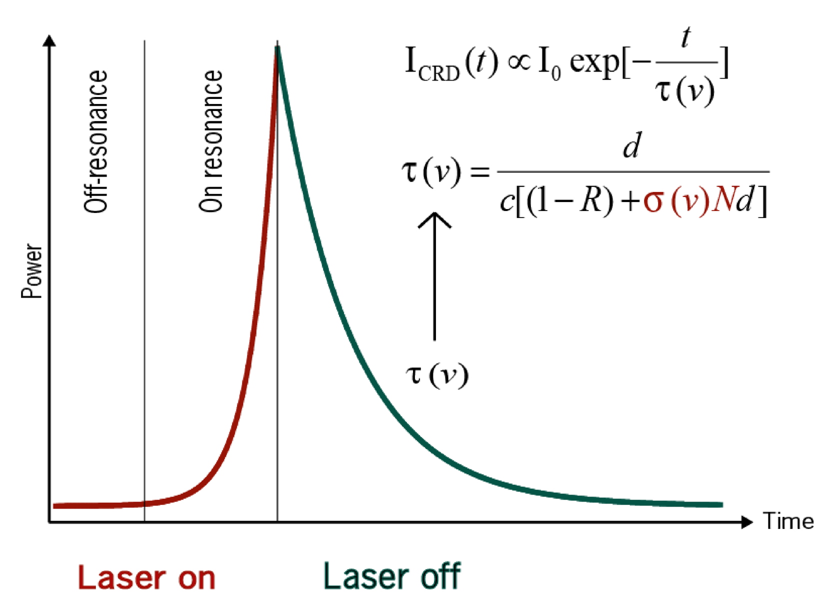


In order to perform high-resolution spectroscopy at 1185 cm^{-1} we use a quantum cascade laser (QCL) provided by collaborators at Princeton

Mid-IR Spectrometer

We have constructed a mid-infrared cavity ringdown spectrometer to record the high-resolution vibrational spectrum of C_{60}. Light from our quantum cascade laser is sent through an acousto optic modulator (AOM) and then into a high-finesse optical cavity formed from two high-reflectivity mirrors. One of the mirrors is mounted to a piezoelectric transducer which allows us to change the length of the cavity.





As the cavity length changes, the laser comes into resonance with the cavity, leading to a buildup of signal on the detector. When the signal reaches a predefined threshold, the AOM is turned off, and the decay of light from the cavity is measured. We place a high temperature supersonic expansion source inside the cavity to generate cold gas phase C_{60} and use our spectrometer to measure the vibrational absorption spectrum.

Generating Gas Phase C_{60}

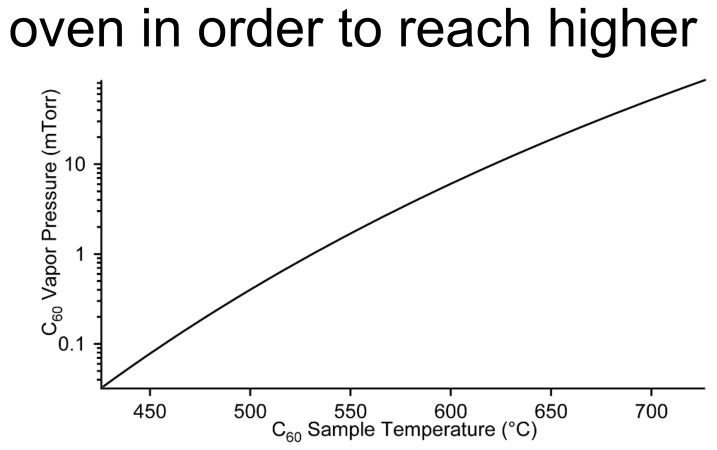
•C_{60} is a solid with a very low vapor pressure, so it must be heated to attain an appreciable amount of gas phase sample

•We have constructed an oven capable of operating at 600ºC for extended periods of time

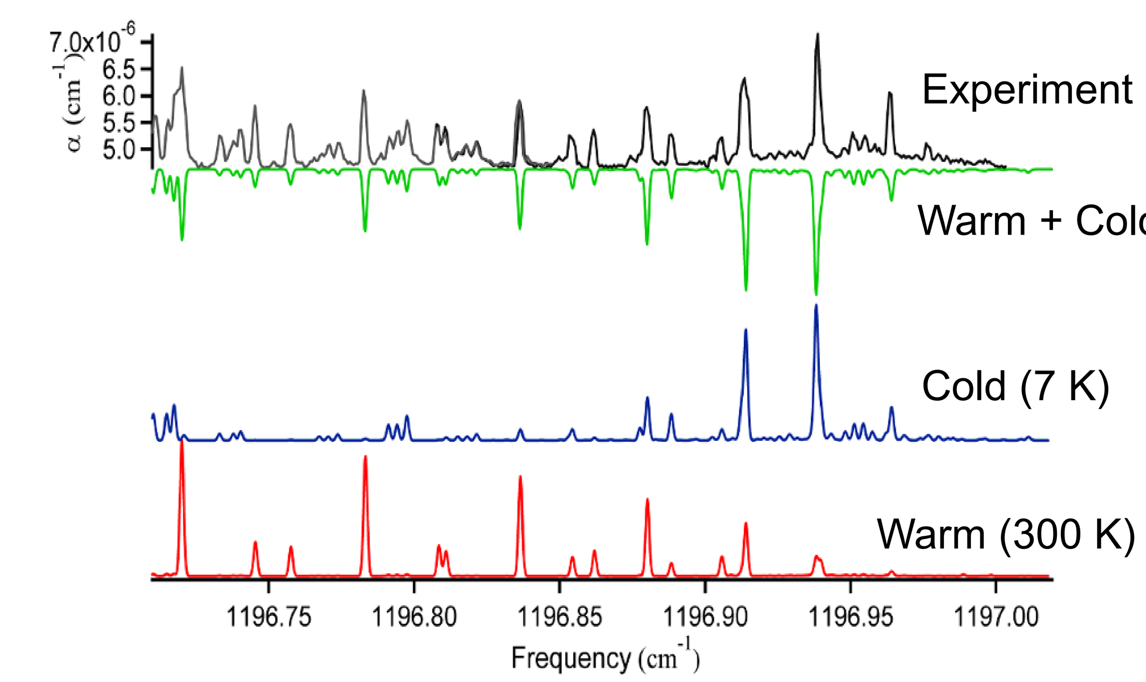
•Hot C_{60} molecules from the oven are cooled by using a supersonic expansion through a pinhole on the front of the oven

•We are currently working on improvements to our oven in order to reach higher temperatures and generate more gas phase C_{60}

Graph recreated from reference [5]



Spectrometer Performance



•We have obtained rotationally resolved spectra of methylene bromide (CH_2Br_2)

•P- and Q-branch lines have been fit to an effective Hamiltonian using Pgopher[6]

•Simulations indicate cold gas (~7 K) from supersonic jet as well as warm background gas

•Spectrometer has a sensitivity of ~5×10^{-8} cm^{-1} $Hz^{-1/2}$

Future Directions

•Install new heaters for the oven to increase the number density of C_{60} in our expansion

•Decouple ringdown mirror mounts from our vacuum chamber to increase cavity stability

•Scan over 1185 cm^{-1} region for C_{60} lines

References and Acknowledgments

[1] Kroto et al. *Nature* **318**, 162 (1985).
[2] Dibrozolo et al. *Nature* **369**, 37 (1994).
[3] Becker et al. *Science* **291**, 1530 (2001).
[4] Leão et al. *A&A* **455**, 187 (2006).
[5] Piacente et al. *J. Phys. Chem.* **99**, 14052 (1995).
[6] Western, http://pgopher.chm.bris.ac.uk

the David & Lucile Packard Foundation
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