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Beamlines

Far-Infrared Beamline 02B1-1

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Beamline Overview

Status	Operational – accepting proposals
Source	Bending Magnet: (55×37) mrad^2
Spectrometer	Bruker IFS 125 HR
Spectral range	5 – 1000 cm^{-1}
Flux @ 1000 cm^{-1}	10^{13} photons/s/0.1% b.w.
Brilliance	10^{16} photon/s/0.1% b.w./ mm^2/mr^2
Resolving power	~10^6
Spot size	Diffraction limited

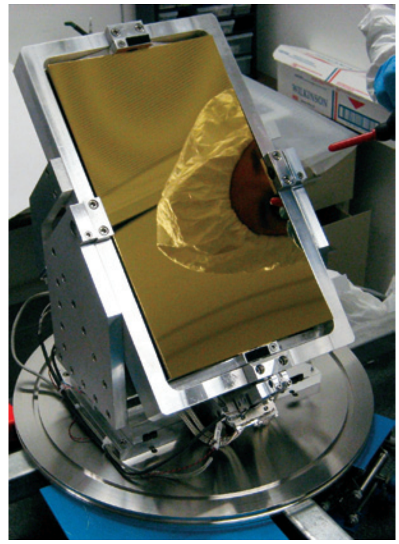

Figure 1: Prototype mirror mount.

Introduction

Beamline 02B1-1 at the Canadian Light Source is the Far-Infrared Beamline (Far-IR). Operating at far infrared wavelengths (5-1000 cm^{-1}), the beamline is used primarily for ultrahigh resolution investigations of gas phase molecules.

Instrumentation

The Far-Infrared beamline is equipped with a Bruker IFS 125 HR spectrometer. The IFS 125HR has a maximum optical path difference of 9.4 m, which allows it to achieve resolutions better than 0.00096 cm^{-1}. Three sample cells are available for use, the choice of which depends on the nature of the sample:

- A 30 cm multi-pass cell capable of reaching path lengths of up to 10 m;
- A 2 m multi-pass cell capable of pathlengths up to 100 meters. Its temperature can be varied to below 200 K.;
- MTEC 300 photoacoustic cell for condensed phase studies.

These cells can be equipped with either KBr or polypropylene windows.

The following equipment is under development:

- Optics to allow the use of diamond anvil cells for high pressure studies.
- A multi-pass electric discharge cell to generate unstable gas-phase species.

New Improvement

In 2009 a prototype for a new mirror mount (Figure 1) was installed on the Far-Infrared beamline. This new mirror mount provides greater stability and reproducibility. In the coming year more of the current mirror mounts will be replaced with this new style of mount. Furthermore an active optic system similar to that currently in use on the Mid-Infrared beamline [1] is being designed to help reduce the source noise experienced by the beamline.

Performance

Figures 2 - 4 show the signal to noise (S/N) advantage that the synchrotron source achieves over a thermal source. In each figure the ratio of the S/N achieved using the synchrotron over that achieved using the thermal source is shown. S/N is estimated by looking at single beam spectra of empty cells.

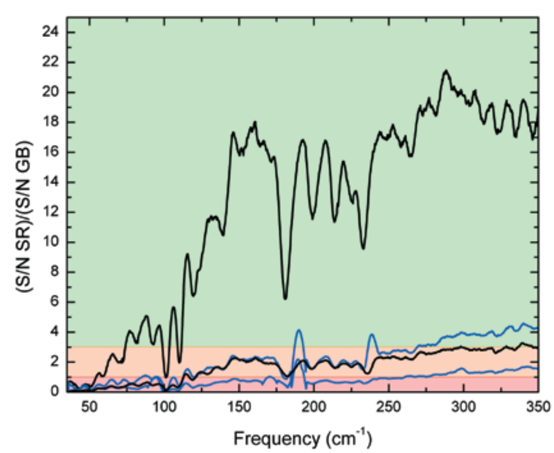

Figure 2: Ratios of the S/N achieved using the synchrotron source over that using a Hg lamp in the 35 – 350 cm^{-1} region. Resolutions of 0.00096 and 0.002 cm^{-1} are shown in black and blue respectively. All data collected with a Si bolometer, 24 m pathlength and a 6 µm beamsplitter. Data collected using the synchrotron with a mirror velocity of 30 kHz is ratioed to that collected using the Hg lamp with velocities of 30 kHz or 5 kHz (upper and lower traces, respectively).

Furthermore, the S/N is calculated in 0.2 cm^{-1} steps across a given spectrum. In all cases the data has been smoothed using the Savitzky-Golay algorithm. Appropriate apertures for the differing resolutions were used, ranging from 1 to 3.15 mm. For convenience each of the figures are divided into three regions along the Y axis. The red region indicates that the thermal source performs better than the synchrotron, the orange that the synchrotron achieves S/N up to 3 times better than the thermal source and the green region indicates that the synchrotron achieves S/N better than the thermal source by a factor greater than 3.

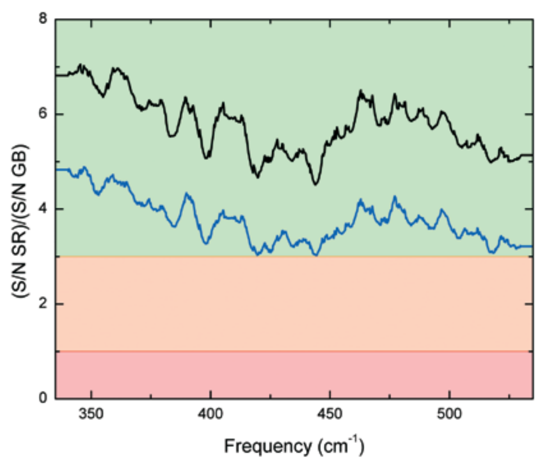

Figure 3: Ratios of S/N achieved using the synchrotron source over a globar in the 335 - 535 cm^{-1} region. Resolutions of 0.001 and 0.002 cm^{-1} and are shown in black and blue respectively. All data collected with a Ge:Cu detector, 24 m pathlength and a 6 μm beamsplitter.

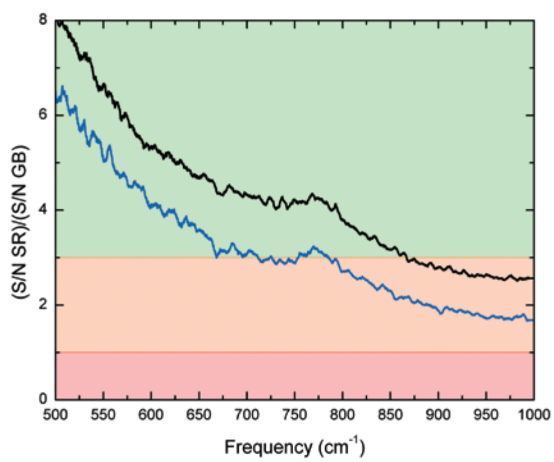

Figure 4: Ratios of the S/N achieved using the synchrotron source over a globar in the 500 - 1000 cm^{-1} region. Resolutions of 0.001 and 0.002 cm^{-1} are shown in black and blue respectively. All data were collected with a Ge:Cu detector, 24 m pathlength and a KBr beamsplitter.

Science and Research Activities

Currently the beamline investigates high-resolution spectroscopy of atmospheric and astrophysical molecules, and complex molecular systems. Future development will allow the study of high pressure materials and unstable species. Furthermore, research continues into using coherent synchrotron radiation as an intense source for studies of the THz region.

Beamline Design and Beamline Teams

Name	Role
A.R.W. McKellar	Beam Team Leader
A. Adam	Beam Team Member
D. Appadoo	Beam Team Member
P. F. Bernath	Beam Team Member
R. Brooks	Beam Team Member
S. Desgreniers	Beam Team Member
T. Ellis	Beam Team Member
W. Jager	Beam Team Member
D. Klug	Beam Team Member
R. Lees	Beam Team Member
H. C. Liu	Beam Team Member
G. Lopinski	Beam Team Member
N. Moazzen-Ahmadi	Beam Team Member
T. Momose	Beam Team Member
I. Ozier	Beam Team Member
A. Predoi-Cross	Beam Team Member
N. Rowell	Beam Team Member
D. Roy	Beam Team Member
D. Tokaryk	Beam Team Member
J. Tse	Beam Team Member
J. van Wijngaarden	Beam Team Member
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Y. Xu	Beam Team Member
B.E. Billinghurst	Beamline Scientist
T.E. May	Beamline Scientist
C. Payne	Controls Lead
S. Chen	Engineering Lead

Conclusion

The synchrotron source allows the Far-Infrared beamline to achieve signal to noise ratios significantly better than can be achieved in a comparable amount of time using a thermal sources. With improvements to the beamline optics that will be undertaken in upcoming cycles this advantage should be increased significantly.

References

1. May, T., Quaroni, L., Bodnarchuk, C., Chen, S., 2007. Active Optics on the Mid Infrared Beamline. Canadian Light Source Activity Report 2007, Ed. Matthew Dalzell, PP. 137.