



## Synchrotron reaches for the stars

Space is not only vast, it is filled with alcohol.

That was one of the earliest findings when radio astronomers first started detecting the spectroscopic fingerprints of molecules in clouds of interstellar gas, where alcohol – specifically methanol – and a host of other ‘organic’ compounds occur in nebulae produced by the death throes of massive stars; the same clouds that become the building blocks for new stars, planets and (in the case of Earth, at least) life. The excitement generated by the discovery, however, soon gave way to frustration: methanol was so prevalent, with such a wide chemical spectrum, that it was drowning out the spectral signals of rarer compounds.

“We started to call it an interstellar weed,” says Ronald Lees, a professor emeritus at the University of New Brunswick. “It’s so rich and found in so many sources that it chokes out the signals from the rarer, exotic molecules that we’re also interested in.”

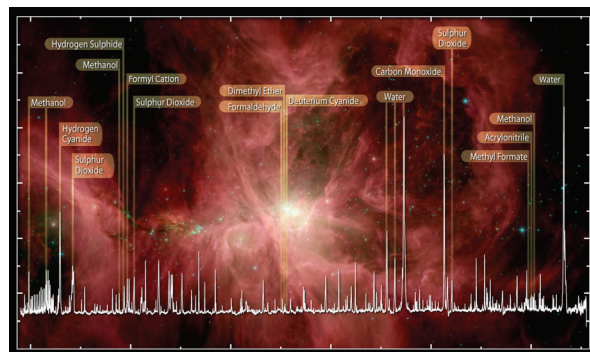
With the recent start of observations by advanced space-based infrared telescopes like the Herschel Space Observatory and radio telescopes like the Atacama Large Millimeter Array, astronomers more than ever need to be able to prune weed molecules from their spectra – and the Canadian Light Source is helping them do it.

The best way to deal with the “weed problem” is to mathematically scrub the spectral lines created by methanol from the data recorded by radio and infrared telescopes, leaving the signals left by more exotic chemicals. To do this, scientists must first have good spectral fingerprints of the weeds, using data collected by measuring their infrared and microwave spectra or using computer models to predict their spectra based on the likely vibrations and movements of atoms in their molecular structure.

Several factors, however, complicate this solution. First, methanol and many of the other weed molecules have complex spectra that don’t lend themselves to modelling. Second, the new telescopes are making their observations at higher resolution using frequencies that have not been detectable before—requiring more precise measurements and predictions of the weeds’ molecular contortions (the source of the spectra) that are now possible using far infrared synchrotron light.

Lees and other researchers are using the CLS to help build “spectral atlases” of several isotopic species of methanol (molecules made up of different isotopes of constituent atoms) and other weed molecules, using the synchrotron’s Far-IR beamline to record the spectral fingerprints in higher resolution across broader stretches of the infrared spectrum than ever done before. Their work has gained a lot of attention in the scientific community, with a paper they published last year in the *Journal of Molecular Spectroscopy* with CLS data making the list of the “Top 25 Hottest Articles” in a series of issues of the journal.

“Methanol is an important molecule, astrophysically and in terms of how molecules vibrate,” explains Lees. “If we can understand how all the atoms in a molecule move around and affect each other not only can we better identify them in deep space, we can also use the same information to predict how those molecules will behave and move during chemical reactions in a lab here on Earth.”



Infrared spectrum of the Orion Nebula (background)—the first taken by the Herschel Space Observatory’s HIFI spectrometer in March, 2010. Infrared spectra taken at the CLS is helping astronomers make sense of spectra obtained by Herschel and other new telescopes.  
Source: European Space Agency, HEXOS and the HIFI consortium. [www.esa.int](http://www.esa.int)

### Fast facts:

- Interstellar clouds and other astronomical features are rich sources of organic chemicals. However, the pervasiveness of some molecules, such as methanol, drown out the spectral fingerprints of more exotic chemicals.
- With a new generation of space observatories and radio telescopes coming online, astronomers are plumbing the chemical depths of space with greater detail than ever before. But they have to be able to weed out the signals from methanol and other common molecules in order to see the rarer chemicals that may be out there.
- Using the CLS, researchers are building high-resolution spectral fingerprints of methanol in all its isotopic forms that can be applied to astronomers’ incoming data.

**Reference:** R.M. Lees, R.-J. Murphy, G. Moruzzi, A. Predoi-Cross, L.-H. Xu, D.R.T. Appadoo, B. Billingham, R.R.J. Golding, S. Zhao. 2009. Fourier transform spectroscopy of the CO-stretching band of O-18 methanol. *Journal of Molecular Spectroscopy*, 256, pp. 91-98. DOI:10.1016/j.jms.2009.02.015

