Extending the JCMT Spectral Legacy Survey: GBT Observations of W49 from 8 - 22 GHz

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About the JCMT Spectral Legacy Survey

Stars form in the densest, coldest, most quiescent regions of molecular clouds. Molecules provide the only probes which can reveal the dynamics, physics, chemistry and evolution of these regions, but our understanding of the molecular inventory of sources and how this is related to their physical state and evolution is rudimentary and incomplete. The Spectral Legacy Survey (SLS) is one of seven surveys recently approved by the JCMT Board. Starting in 2008, the SLS will produce a spectral imaging survey of the content and distribution of all the molecules detected in the 345 GHz atmospheric window (between 332 GHz and 373 GHz) towards a sample of 5 sources. Our intended targets are: a low mass core (NGC1333 IRAS4), 3 high mass cores spanning a range of star forming environments and evolutionary states (W49, AFGL2591, and IRAS20126), and a PDR (the Orion Bar). The SLS will use the unique spectral imaging capabilities of HARP-B ACSIS to study the molecular inventory and the physical structure of these objects, which span different evolutionary stages and physical environments, to probe their evolution during the star formation process. As its name suggests, the SLS will provide a lasting data legacy from the JCMT that is intended to benefit the entire astronomical community. As such, the entire data set (including calibrated spectral datacubes, maps of molecular emission, line identifications, and calculations of the gas temperature and column density) will be publicly available.

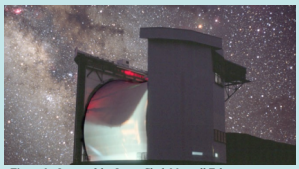


Figure 1 - Image of the James Clerk Maxwell Telescope (JCMT) on Mauna Kea.

A Low Frequency (8 - 22 GHz) Extension to the SLS

The goal of the SLS is to use molecular line observations to help understand the evolution of young stellar objects spanning a range of evolutionary stages and environmental conditions. This will be achieved by obtaining a complete molecular line inventory in three different types of sources: low mass protostars, young high mass sources, and photon-dominated regions (PDRs). Combining these data with detailed chemical and physical models of the sources, the survey aims to improve our understanding of molecular tracers as probes of the astrophysics and evolution of sources. In particular, this survey will:

1) Provide an inventory of the column densities and spatial distributions of the molecular species towards sources of different types and age.
2) Provide a broad-based derivation of the physical and chemical conditions (i.e. temperature, density, velocity, and chemical structure) of the sources on scales both smaller and larger than that of the primary beam.
3) Identify important chemical diagnostics of the physical and chemical processes occurring in different types of sources and different evolutionary states.

Unfortunately a spectral survey over a particular frequency range provides only an incomplete view of molecular inventory of a source and the structure of the source. There are molecules which do not have any transitions in particular frequency ranges. In addition, observing transitions of only a limited range of excitation for some species biases the observations to particular ranges of physical conditions and environments.

The molecular line emission in the centimetre radio region has been relatively poorly explored despite containing numerous lines of important and interesting species - like CH_3CCH, CH_3CN , and HC_3N, which are important thermometers and hot core species. In addition in the frequency range to the observed there are species such as CCS and c-C_3H_2 which may reveal the most quiescent material in the envelopes of these sources. This spectral survey will also provide a basis for searches for as yet undetected heavy, pre-biotic species which will have their low energy transitions in this frequency range.

Initial Results: An 8 - 22 GHz Spectral Survey of W49

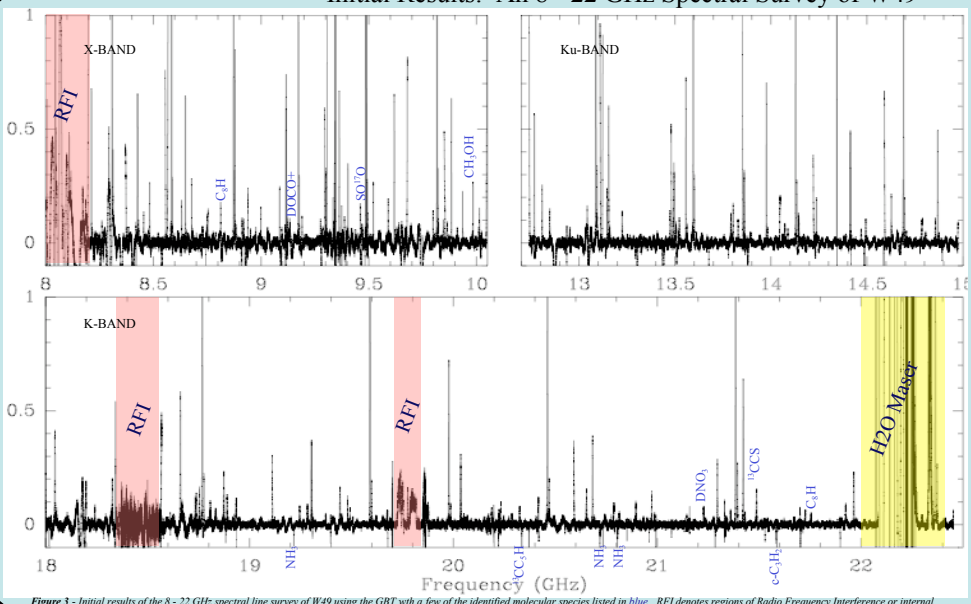


Figure 3 - Initial results of the 8 - 22 GHz spectral line survey of W49 using the GBT wth a few of the identified molecular species listed in blue. RFI denotes regions of Radio Frequency Interference or internal reflections in the system that resulted in bad baselines. The well-known H_2O maser shows up in the signal sideband (centred at ~ 22.213 GHz) and, even with 30 dB of sideband suppression, the image sideband (centred at ~ 22.34 GHz)

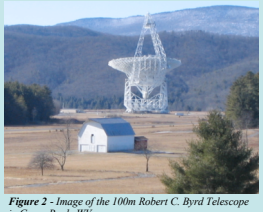
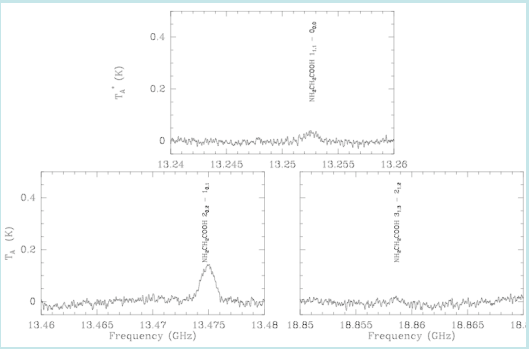


Figure 2 - Image of the 100m Robert C. Byrd Telescope in Green Bank, WV.

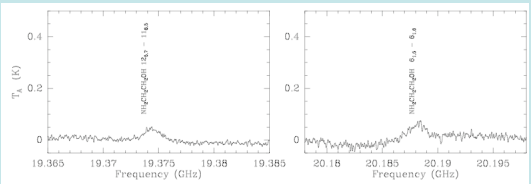
- Data obtained using the 110 m Robert C. Byrd telescope at Green Bank.
- More than 230 spectral lines found.
- All of the strong lines (> 0.5 K) are H, He, or C recombination lines.
- Many molecular species identified (Figure 3 shows a few key species).
- Many more lines yet to be identified (will be using an LTE line modeling approach).
- ID's from SPLATALOGUE (http: phobos.phy.umist.ac.uk splatalogue) which combines the JPL, CDMS, and LOVAS NIST molecular line databases.
- Possible detections of pre-biotic species like NH_2CH_2COOH (glycine) and $NH_2CH_2CH_2OH$ (aminoethanol)

Possible Detection of Pre-Biotic Molecules

Glycine - Conformer I?



Aminoethanol?



- Possible detections of pre-biotic species like NH_2CH_2COOH (glycine) and $NH_2CH_2CH_2OH$ (aminoethanol)
- Glycine is the simplest amino acid and, if discovered in the ISM, may suggest that these interstellar pre-biotic molecules may have helped jump start biological chemistry on Earth (Ehrenfreund et al. 2001).
- Aminoethanol may form on grain surfaces and then evaporate off the grain mantle.
  - Subsequent gas-phase processing leads to the formation of glycine (Kessler-Silacci 2006 and references therein)
- Despite many attempts (e.g. Kuan et al 2003), it has not yet been definitively detected in the ISM (see Snyder et al 2005 and references therein).
- We still need to verify our "detection" of these complex species by confirming that all of the expected strong lines are present in the spectra.

References

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