The GBT PRIMOS Project

Searching for Complex Organic Material in the Interstellar Medium using Centimeter Wave Spectral Line Surveys

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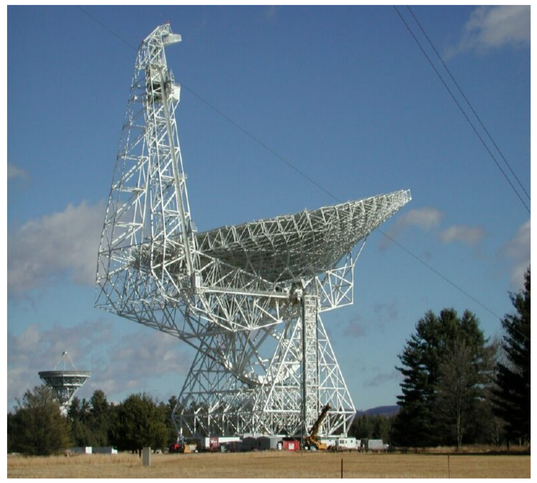
Historical Perspective

Molecular line surveys are studies of the spectra of astronomical sources over a wide, hopefully continuous, range of frequencies, in order to determine the chemical composition (ie. "molecular inventory") , physical properties (temperature, density) and kinematics of such regions. Primarily the lower energy transitions of molecules of astrophysical interest are excited at the cold temperatures of molecular clouds, and these rotational transitions range from the radio to sub-millimeter wavelengths.

In 2007, the Prebiotic Interstellar MOlecule Survey (PRIMOS) was undertaken to provide complete spectral line data between 300 MHz and 50 GHz toward Sagittarius B2(N). Sgr B2(N) is the preeminent source for the study of large complex interstellar molecules and the source of numerous spectral line surveys ranging from the mm to submm (see AAS 352.11). Of the ~170 astronomical molecules detected to date, more than half have been first discovered toward this region. The Sagittarius B2 complex also contains compact hot molecular cores, molecular maser emitting regions, and ultracompact sources of continuum radiation surrounded by larger-scale continuum features, as well as more extended molecular material.

PRIMOS Observations



Observations were conducted from 2007 – 2011 using the National Radio Astronomy Observatory Robert C. Byrd Green Bank Telescope (GBT – see above image). At 17 million pounds, it is the most massive moving structure on land and with a 110m x 100m diameter, provides over 2 acres of collecting area. Towards the Sgr B2(N) complex we used the OFF-ON position switching mode and 4x200 MHz windows affording a spectral resolution of 24.4 kHz

PRIMOS Science

Using Data from the PRIMOS Project, researchers have not only discovered new interstellar species but also unlocked the physical, kinematic and chemical conditions of our Galaxy. The list of journals that reference PRIMOS data include ApJ, PASP, the Journal of Molecular Spectroscopy and the Journal of Physical Chemistry. Research areas specific to astrobiological research include:

1. **Detection of E-Cyanomethanimine toward Sagittarius B2(N) in the Green Bank Telescope PRIMOS Survey** (Zaleski et al. 2013, ApJ, 765, 10L)
2. **The Detection of Interstellar Ethanimine (CH3CHNH) from Observations Taken during the GBT PRIMOS Survey** (Loomis et al. 2013, ApJ, 765, 9L)
3. **Interstellar Carbodiimide (HNCNH): A New Astronomical Detection from the GBT PRIMOS Survey via Maser Emission Features** (McGuire et al., ApJ, 2012, 758, 33L)
4. **Laboratory and Tentative Interstellar Detection of Trans-Methyl Formate Using the Publicly Available Green Bank Telescope Primos Survey** (Neill et al., 2012, ApJ, 755, 153)

This survey provides a complete inventory of known interstellar molecules and their transitions that can be evaluated and synergistically used as multiple probes of physical conditions. This is potentially one of the most important outcomes of this survey. All of our observations, once reduced, are publicly available with no proprietary period. You can find more information, as well as access all of the observations yourself, at:

www.cv.nrao.edu/~aremijan/PRIMOS

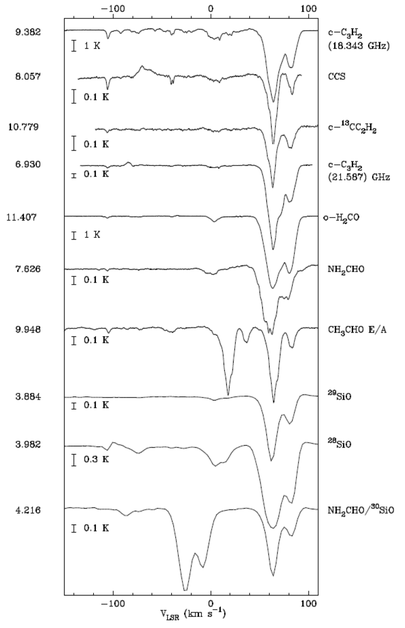


Figure 2. Molecular absorption spectra toward Sgr B2(N-LMH). The molecule is shown in each panel. The abscissa is the radial velocity with respect to the LSR velocity of +64 km s^{-1}.

PRIMOS Outreach

The PRIMOS data has been widely used over the past several years in advertising the advances in molecular astrophysics in a variety of venues. In In 2012, an undergraduate research team who had never worked in laboratory or observational astrochemistry detected a possible building block to the nucleotide adenine using the spectroscopic data available in the PRIMOS survey (right image). The team detected E-cyanomethanimine, more commonly known as HCN-dimer (Figure 3.)

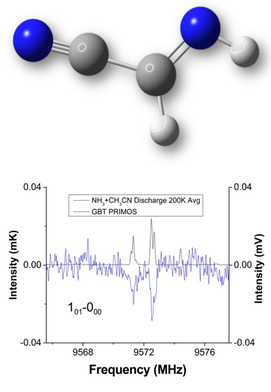
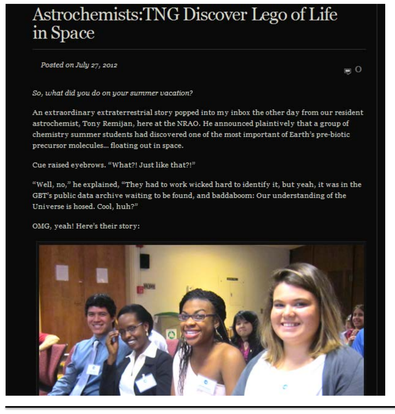
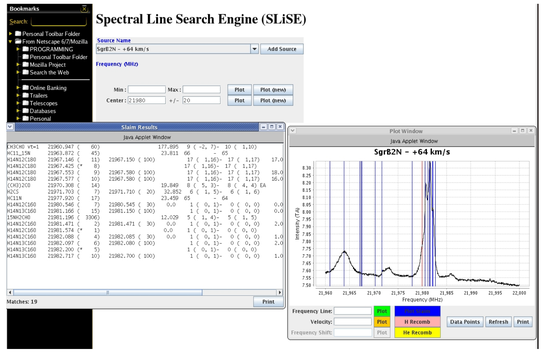


Figure 3. E-cyanomethanimine structure (top) and associated J=1-0 Spectrum (bottom) from the GBT and Lab measurements.



PRIMOS Data Access

Any interested researcher can access the data. Our team has made every effort to make the data available to the community through the Spectral Line Search Engine (SLiSE). SLiSE is a data display tool that contains all the fully reduced and calibrated archived data taken as part of the PRIMOS project. SLiSE is fast, easy to use and contains the necessary functionality to display the data taken from spectral line searches.



The PRIMOS Website is accessible via the following QR code.

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