# Interstellar Spectroscopy at the Madrid DSN Station


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## Host Country Radio Astronomy at MDSCC

The NASA Deep Space Network is a world-wide Network of antennas dedicated mainly to the tracking of NASA's spacecraft. There are three main tracking complexes: in Goldstone (California, USA), Canberra (Australia) and in Robledo de Chavela (Madrid, Spain). The Madrid Deep Space Communication Complex (MDSCC) is operated by INTA/INSA for JPL. Spanish astronomers can use up to 4% of the total antenna time at MDSCC, for radio astronomy observations. This "host-country" time is managed and assigned by the *Laboratorio de Astrofísica Espacial y Física Fundamental* (LAEFF) of the Spanish *Instituto Nacional de Técnica Aeroespacial* (INTA).

## Spectroscopy with DSN 70 m

Nowadays, only the 70m antenna in the MDSCC is technically suited for radio spectroscopy research. We can observe at K-band, with a receiving frequency band between 18 and 26 GHz. The receiver of this antenna is a cooled HEMT. Spectroscopy studies are carried out using a 256-channel autocorrelation spectrometer, with a variable bandwidth between 1 and 10 MHz.

## DSS 63 capabilities

The 70 m antenna at MDSCC is one of the best radio telescopes in the world. Its sensitivity and angular resolution (50'') at K band are close to those of the largest single-dish antennas: GBT and Effelsberg 100m (Figs 1 and 2).

**Fig 1.** The GBT

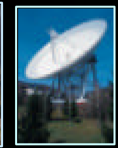

**Fig 2.** Effelsberg radio telescope

**Fig 3.** The 70 m antenna at MDSCC

## VLA + DSN 70 m

Observations with 70m antenna can be used in combination with data taken with interferometers like the Very Large Array of the National Radio Astronomy Observatory to fill the lack of short spacings of interferometers. This is specially useful to study regions of extended emission. At present, we are mapping some star formation regions (e.g. B1-IRS) in ammonia and CCS lines, to combine with different VLA data (de Gregorio-Monsalvo et al. in preparation).

## Surveys

At this moment there are three important research projects that take place during the host-country time:

### Water maser in planetary nebulae

Recently, Miranda et al (2001) discovered the first planetary nebula (PN) with water maser emission. This kind of emission was previously though to be impossible to happen in PN, due to rapid destruction of water molecules. In 2002 a survey for water maser emission towards 27 PNe was started, using the MDSCC 70m antenna, the VLA, and Medicina 32m. The result of this work (de Gregorio-Monsalvo et al. 2003) was a new detection in the source IRAS 17347-3139

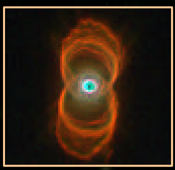

**Fig 4.** Example of PN (HST)

Further simultaneous observations of continuum and water maser emission with the VLA showed a water maser cluster at IRAS 17347-3139 distributed on a ellipse of size ~ 0''.2 x 0''.1, spatially associated with compact 1.3 cm continuum emission (Fig 6).

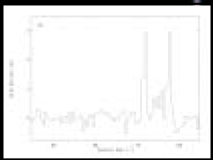

**Fig 5.** Spectrum of water maser emission in IRAS 17347-3139, obtained with the MDSCC 70m antenna.

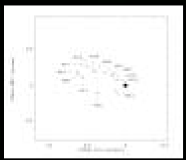

**Fig 6.** IRAS 17347-3139 water maser positions at different velocities observed with the VLA. Circle marks the position of the 1.3 cm continuum emission.

This spatial distribution and the radial velocities of the water masers suggest a rotating and expanding maser ring, tracing the innermost region of a torus formed at the end of the AGB phase. The 1.3 cm peak continuum emission is located at one of the tips of the water maser ring. It is speculated that the continuum emission may trace one of the components of a binary, while the maser emission is associated to its companion.

### CCS survey in star forming region

We are also carrying out a survey of CCS (carbon-carbon-sulphur) emission in star forming regions. The CCS molecular lines are very well-suited to study the structure and the physical conditions in dark clouds because they are not very opaque, they are intense and abundant in dark clouds, and have no hyperfine splitting. All this make them useful for kinematical studies. CCS is a gas tracer whose lines are intense in cold quiescent cores and less abundant when signs of current star formation are manifested. This phenomenon can be explained in terms of chemical cloud evolution, and it can be used as a kind of clock to date the age of dense cores.

**Fig 7.** Example of star forming region (HST image).

In young stellar objects (YSOs) it is very common to find water maser emission, because the physical conditions in disks and shock regions (such as outflows) are appropriate to pump masers (high density and warm temperature). Furuya et al. (2001) found that Class 0 sources are the most likely low-mass YSOs to harbor water masers. The sources selected in our survey were low mass YSOs showing water maser emission. If the proposed CCS chemical evolution in dark clouds is correct, only the youngest Class 0 sources would show significant CCS emission. This study can help to characterize the evolutionary stage of YSOs, as traced by the presence of $H_20$, CCS, and other molecular tracers. This survey has provided four new detections (e.g., Fig 8), and the search continues.



**Fig 8.** CCS spectrum of L1448C

### Water maser survey in Bok Globules

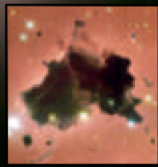

**Fig. 9.** Example of dark cloud

Bok globules are isolated cold dark molecular clouds of small sizes (< 10'). Low-mass star formation can take place in some of them, as supported by infrared and radio observations. They can be in different evolutionary stages, from quiescent dark cores to clusters of Herbig Ae/Be or T Tauristars. Class 0 sources are the youngest evolutionary stage of YSOs, and can present energetic mass-loss processes, manifested as jets, molecular outflows and Herbig-Haro objects.

Because of these energetic processes, the surrounding medium may acquire the physical conditions necessary to pump water masers. We have selected a set of candidate positions in Bok globules from the Clemens & Barvainis (1988) catalog, which shows some sign of ongoing star formation, like the presence of an IRAS source, emission of a tracer of dense gas, molecular outflows, or radio continuum emission, in order to detect possible water maser emission, and use it as a characterization of the physical parameters of the cloud. This survey has provided three new detections (e.g. Fig 10).

**Fig 10.** Water maser spectrum CB101


**References:**

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