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A New Spectroscopic Facility at Millimetre Wavelengths

(*Report on New Instrumentation Facilities*)

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Abstract. A new millimeter-wave facility is in operation at the Bordeaux Observatory for spectroscopic observations of interstellar and stratospheric molecules. A cooled receiver has been installed on a 2·5m radio telescope. The overall system temperature is in the range 400 to 600 K (single side band) in the operating frequency range 75 to 115 GHz. The relatively broad beam of the telescope (~ 5 arcmin) combined with a sensitive receiver will permit studies of extended molecular cloud complexes.

Key words: instruments—millimeter-wave astronomy

1. Introduction

A new facility for millimeter-wave observations of interstellar and stratospheric molecules has been put into operation at the Bordeaux Observatory under a cooperative effort. The spectroscopic system consists of a multi-channel filter bank and a cooled receiver which has been installed on a 2·5-m Cassegrain telescope. The antenna, with an azimuth-elevation mount, is one of the two antennas of the Bordeaux mm-wave interferometer which has been extensively described by Baudry *et al.* (1975). The interferometer is operated in the continuum at 8·6 mm. Single dish observations of molecules are now possible in the range 75–115 GHz with a 256 channel spectrometer. The relatively broad beam of the telescope, about 5 arcmin at around 90 GHz, combined with the sensitivity of a cooled receiver, are well suited

for spectral observations of extended molecular dark clouds. This new spectroscopic receiver has been designed so that it can be used with other telescopes in the near future.

2. The equipment

Fig. 1 is a block-diagram of the receiving system. The receiver includes a cooled (20 K) mixer with a GaAs Schottky diode mounted on an integrated circuit. Several GaAs diodes (made by G. T. Wrixon, Cork University) have been matched to mixer mounts and various diodes can be used on the telescope. The first intermediate frequency is at 4·755 GHz. Image rejection is achieved in the mixer by means of a movable dielectric backshort. Rejection is better than 15 dB. The first stage intermediate frequency amplifier is a cooled parametric amplifier followed by a room temperature FET amplifier. The best system temperature is of the order of 400 K (single side band) at 93 GHz.

The first local oscillator is a klystron phase-locked to a highly stable 8 GHz solid state source; both signals are fed into a harmonic mixer with an intermediate frequency of 300 MHz. The 8 GHz source is itself phase-locked to the output of a 110 MHz synthesizer.

A 256-channel spectrometer has been built following the NRAO design (Mauzy 1974; Pace and Payne 1973). The spectral resolution is 100 kHz per channel. At 90 GHz the overall velocity coverage is thus ~ 85 km s^{-1} with 0·33 km s^{-1} resolution.

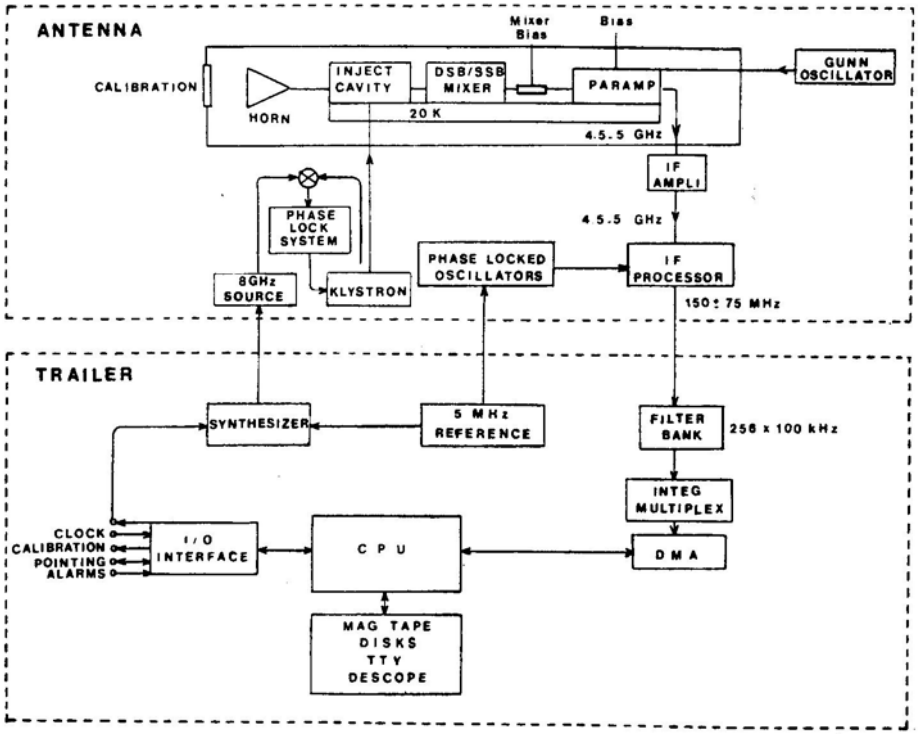

Figure 1. Block diagram of receiving system,

Table 1. Main characteristics of the new spectroscopic millimetre facility.

Antenna diameter	2·5 m
Surface accuracy (rms)	0·05 mm
Beamwidth	5′.4 at 90 GHz
Pointing accuracy	$<\pm 20''$
Frequency coverage	75-115 GHz
System temperature	400 K (SSB) at 93 GHz
Frequency resolution	100 kHz (256 channels)

A PDP 11/34 computer is used for collecting and reducing data in real time and for handling the whole observing procedure. In particular it is linked to another small computer used to drive the 2·5-m telescope. Data are written on disk and/or magnetic tape for further analysis. The PDP 11/34 and its peripheral devices, the back-end, the local oscillator power supply and the stable low frequency oscillators are installed in a controlled-temperature trailer.

The beam width measurement and the focal adjustment were made by observing the centre and the limbs of the solar disk. The pointing has been checked on the sun and on stars by means of a refractor attached to the antenna. It is better than about $\pm 20''$.

The sea level site of the Bordeaux Observatory has been chosen mainly because of the already existing antenna and of the technical assistance available for easy debugging of the system. Table 1 summarises the main characteristics of the new mm-wave facility. Future developments will include a back-end extension with 256×500 kHz analog filters and a spectrum line expander.

3. Preliminary observation

Preliminary observations have shown that many days or nights are expected to give zenith opacities $\simeq 0{\cdot}1$ to $0{\cdot}2$ in the frequency range 80 to 100 GHz. Two modes of operation are currently used: either the receiver is frequency-switched or the antenna is positions-witched. Calibration is obtained by switching between an absorbing movable load in front of the feed horn and the cold sky, in the usual way at millimetre wavelengths.

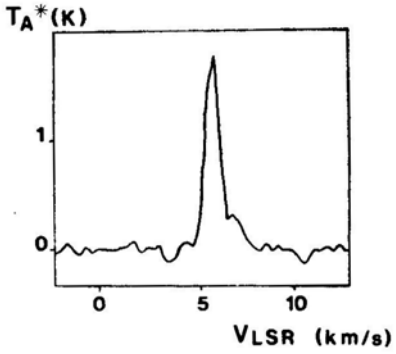

Figure 2. Line profile of HCO^+ observed toward Taurus Molecular Cloud 2 (a = $4^h\,29^m\,43^s$ (1950), $\delta = +24°\ 16'.9$) at positions $\Delta\ a$, $\Delta\delta$=10′, 8′. Spectral resolution = l00 kHz.

The new spectroscopic system briefly presented in this paper has been designed primarily to study the spatial extent of dark molecular clouds and to investigate part of the large scale structure of the Galaxy by observing molecular species other than CO (the latter is observed by the 1·2-m telescope of the Columbia University, see *e.g.* Cohen and Thaddeus 1977). Our very first spectra were obtained in mid-December 1979 and the present observation programmes are mainly devoted to the $J = 1 \rightarrow 0$ transition of HCN and HCO+ in various galactic clouds. Fig. 2 shows the result of an HCO+ observation made towards Taurus Molecular Cloud 2.

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Reference

Baudry, A., Bocchia, R., Delannoy, J., Gérard, F., Lacroix, J., Montignac, G., Poumeyrol, F., Robillot, J. M. 1975, *L' Interférométre Millimetrique Solaire de Bordeaux,* CNRS, Paris.

Cohen, R. S., Thaddeus, P. 1977, *Astrophys. J.*, **217,** L155.

Mauzy, B. 1974, *NRAO Electron. Div. Internal Report* No. 146.

Pace, C, Payne, J. 1973, *NRAO Electron. Div. Internal Report* No. 134.