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ABSTRACT

We present the first results of a systematic (sub)millimeter unbiased spectral line survey performed with the IRAM-30m and JCMT radiotelescopes towards the low-mass protostar IRAS 16293-2422 (IRAS16293). When completed this survey will cover most of the frequency band attainable with the 30m (80-280 GHz) and with the JCMT in the 350 GHz band (335-365 GHz), i.e. 201 GHz.

Key words: ISM: molecules - ISM: abundances - Stars: Formation.

1. INTRODUCTION

Unbiased line surveys are a unique way of determining the molecular content of astrophysical objects. They allow a complete study of the chemistry in and around molecular sources. Among all class "0" protostars observed to date, IRAS16293-2422 (IRAS16293) has the richest and brightest line spectrum. In particular this low mass protostar is the first one where several complex molecules have been observed (Cazaux et al., 2003) but also many deuterated molecules including D_2CO (Ceccarelli et al., 1998) and doubly and triply deuterated methanol (Parise et al., 2002), (Parise et al., 2004). It has been shown recently (Ceccarelli et al., 2000), (Schoier et al., 2002) that the structure of the collapsing envelope around this low-mass protostar has a inner hot core ($r \leq 150$ AU) where the temperature exceeds 100 K and a colder outer envelope. Due to its high temperature and density which excite many transitions not visible from cooler regions, this hot core is responsible for the richness of the IRAS16293-2422 spectrum.

Table 1. Observational parameters

Tel	ν GHz	HPBW $''$	Resol km.s^{-1}	r.m.s. mK
30m	80-115	30.7-21.4	1.2-0.84	6
30m	129-177.5	19.1-13.8	0.72-0.53	8
30m	197-265	12.5-9.3	1.9-1.4	10
30m	265-281	9.3-8.7	1.4-1.3	11
JCMT	330-365	14	0.57-0.51	20

As a consequence IRAS61293 has been selected as one of the key target to be surveyed by the HERSCHEL observatory (HSO). Therefore it was more than necessary to undertake this survey with ground based telescopes and to make it available to the astronomical community before the launch of the HSO. When completed this survey will cover most of the frequency band attainable with the 30m (166.5 Ghz between 80 and 280 GHz) and with the JCMT in the 350 GHz band (330-365 GHz), i.e. 201.5 GHz in total.

2. OBSERVATIONS AND RESULTS

The first observing runs were performed at the IRAM-30m and JCMT telescopes during the winter 2003-2004. About 30% of the full survey has been obtained, i.e. 59.5 GHz at the 30m and 21.5 GHz with the JCMT. The observations were performed in the direction of the "B" source at $\Delta\alpha(2000)$ = 16h 32m 22.6$''$, $\Delta\delta(2000)$= -24° 28$'$ 33$''$.

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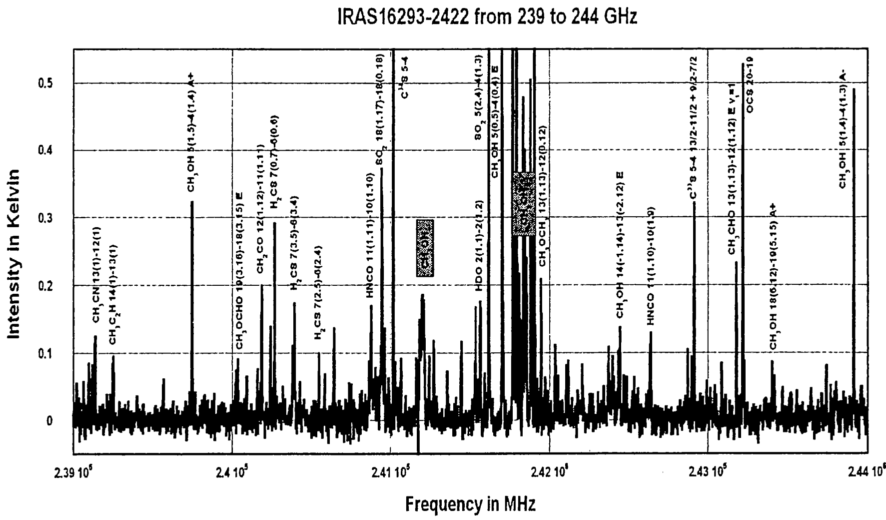

Figure 1. Composite spectrum obtained with the 30m telescope showing the crowding with lines

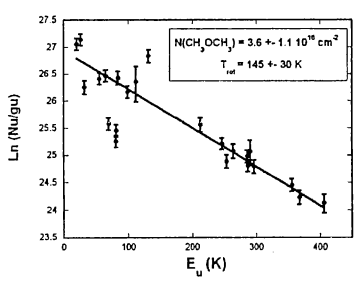

Figure 2. CH_3OCH_3 rotational diagram

The observations with the IRAM-30m radiotelescope were performed in the wobbler switching mode (symmetric throw of 4′) using four receivers at a time connected simultaneously to an autocorrelator and 1MHz filerbanks. Observations at the JCMT were performed with the single-side band dual polarization B3 receiver. Each polarization was connected to a unit of an autocorrelator providing a bandwidth of 500 MHz for a spectral resolution of 625 kHz (0.55 km/s at 340 GHz). The observations were performed in the beam-switching mode (symmetric throw of 3′). All observational parameters are given in table 1.

A first very rough analysis shows the presence of many lines originating from various molecules including complex and deuterated molecules. For example we identified CH_3CH_2OH, CH_3CCH, CH_2CHCN, CH_2DCN, CH_3C_2H, NH_2CO etc.. The density is on the average 30 lines per GHZ at 3 σ. We show here one spectrum (Figure 1) obtained with the IRAM-30m exemplifying the crowding with lines.

One of the first very basic result that can be derived from this data is to estimate the rotational temperature and column density of the various species detected. For example in our partial survey we already detected 23 lines of the dimethyl ether (CH_3OCH_3) molecule with an upper energy up to 400 Kelvin, which lead to a rotational temperature of T_{rot} = 145 30 K and a column density $N(CH_3OCH_3)$ = 3.6 1.1 10^{16} cm^{-2} (Figure 2). Because our regression line is more constrained than the one from (Cazaux et al., 2003) we obtained more realistic values with smaller error bars. This is an important result because the rotational temperature obtained clearly show that this molecule is coming from the internal hot core ($T \geq 100$ K) and not from the colder envelope, a result which was not so obvious from Cazaux et al. paper.

A complete analysis of this spectral survey is in progress and should be published soon. This survey will allow to build a complete census of the molecular content of this object and will permit a modeling of the chemistry governing its core and envelope.

REFERENCES

Cazaux S., Tielens, A. G. G. M., Ceccarelli, C. et al., *ApJ*, Vol 593, L51, 2003.

Ceccarelli C., Castets A., Caux E., Hollenbach D. et al., *A&A*, Vol 355, 1129, 2000.

Ceccarelli C., Castets A., Loinard L., Caux E., Tielens A.G.G.M., *A&A*, Vol 338, L43, 1998.

Parise B., Ceccarelli, C. Tielens, A. G. G. M. et al., *A&A*, Vol 393, L49, 2002.

Parise B., Castets A., Herbst E. Caux E. et al., *A&A*, Vol 416, 159, 2004.

Schoier F.L., Jorgensen J.K., Van Dishoeck E.F. & Blake G.A., *A&A*, Vol 390, 1001, 2002.