cide to participate in one of these GA Symposia only, and not in the entire GA, as is the case in some other international scientific unions.

Whatever the outcome, future IAU General Assemblies are likely to be different.

Next IAU General Assembly

The General Assembly accepted with acclamation the Dutch invitation, most eloquently presented by Prof. H. Habing, to hold the 22nd IAU General Assembly in The Hague, the Netherlands, during the month of August 1994. The exact dates and the duration will depend upon the outcome of the discussion in the IAU Executive Committee about the future format of the General Assemblies, as mentioned above.

How Hot are the Molecular Clouds at the Galactic Centre?

M. GERIN[1,2], N. BEL[1], C. TCHOBROUTSKY[1,2] and Y.-P. VIALA[1,2]

[1]Observatoire de Paris, Section de Meudon, France; [2]Laboratoire de Radioastronomie, ENS, Paris, France

1. Introduction

The refinement of infrared and radio technology and the new ground-based facilities have allowed to penetrate the interstellar gas which hides the Galactic Centre in the UV and optical light. These observations have revealed the complex nature of the central parts of our Galaxy and have raised some puzzling questions. In particular, the heating mecanisms of the Giant Molecular Clouds are not understood; the molecular hydrogen density is high (although not so high as in the hot cores of galactic clouds) and it seems that a pervading high temperature could be found irrespective of the galactocentric distance. Many estimates of these temperatures have been attempted; for example, Wilson et al. (1982) [1] found a rotational temperature of metastable levels of NH_3 as high as 175 K (and this is an underestimate of the kinetic temperature); Morris et al. (1983) [2] found uniformly high temperatures 30–60 K over a few hundred parsecs around the Galactic Centre. A high level of the kinetic temperature is confirmed by the detection of emission lines of SiO as seen in our previous observations (see the report by Sandqvist, 1989) [3] and Gerin et al. [4]. The molecule SiO has been searched in several galactic molecular clouds; it has been observed only toward sources with a kinetic temperature greater than ~ 30 K (Ziurys et al., 1989) [5]. Here, we report on recent observations of the 20 and 50 km/s clouds and we shall focus on the determination of the temperature through a large part of the clouds.

2. What We Observe

We used the 15-m radio telescope SEST operated conjointly by ESO and Sweden. The observations were done in March 1991 with good weather conditions. The 3-mm receiver system consists of two cooled Schottky mixers covering the frequency band 80–115 GHz with an SSB receiver temperature of about 300 K; the image band is attenuated by more than 10 dB. The 1-mm receiver is built in the same way with a receiver temperature of about 700 K. The observer tunes the receiver from the control room with a friendly tuning programme in less than ten minutes in most cases. The spectra are analysed simultaneously by two acousto-optic spectrometers of high (0.04 MHz) and low (0.7 MHz) spectral resolution. The first one is of limited spectral range (80 MHz) and is useful to study the line profiles while the second one has a larger bandwidth (500 MHz). All results are reported in T^*_A, the antenna temperature outside the atmosphere.

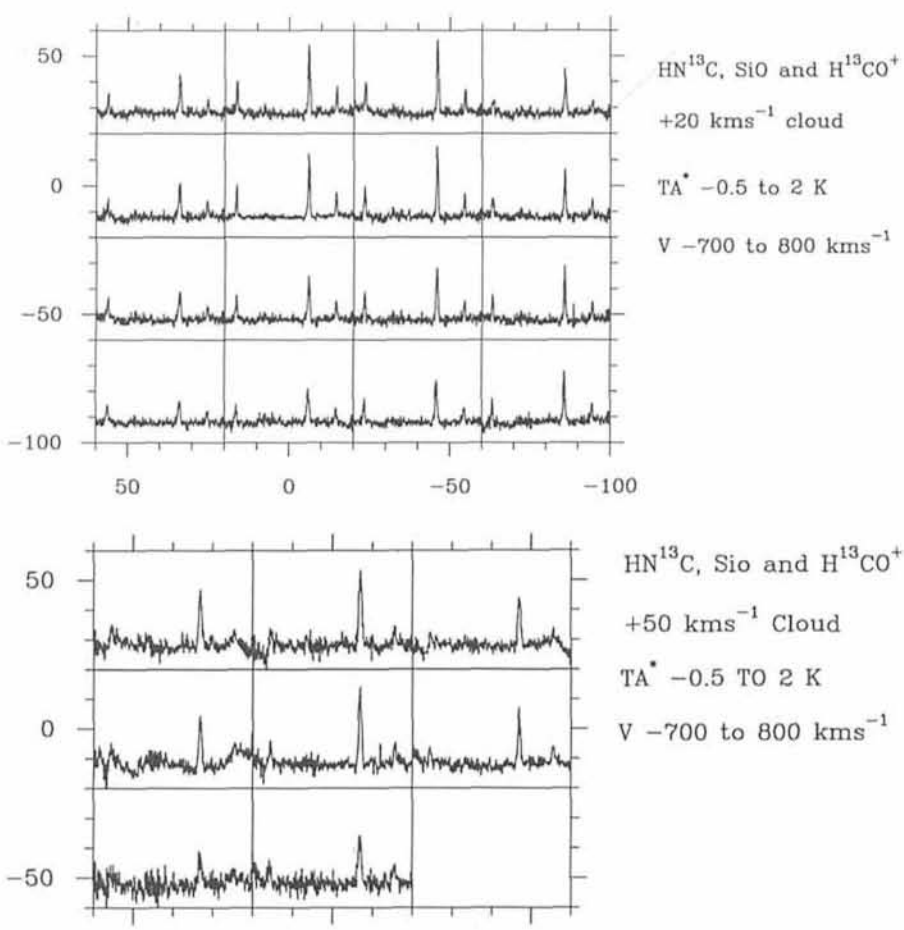

Figure 1 *(a): Spectra obtained for the 20 km/s cloud toward the direction α (1950) = 17h 42m 29.4s, δ (1950) −29°03′31″. (b): Spectra obtained for the 50 km/s cloud toward the direction α (1950) = 17h 42m 40s, δ (1950) = −28°58′20″. All the offsets are labelled in arcseconds. The rest frequency ranges from 87.1 to 86.6 GHz; we see in particular the intense J = 2−1 transition of SiO.*

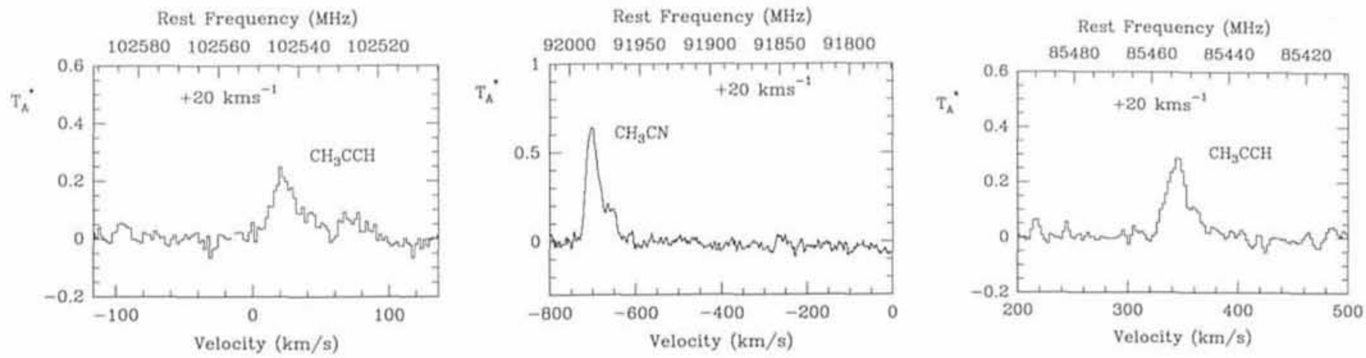

Figure 2: *Some parts of the spectrum obtained for a particular offset (0, +40") toward the 20 km/s cloud. We can see the $J_K=6_K-5_K$ and $J_K=5_K-4_K$ transitions of CH_3CCH and $J_K=5_K-4_K$ transitions of CH_3CN.*

The system temperature varied between 350 and 700 K at 3 mm, with a corresponding noise level of 50 mK in 4 minutes of integration. The sky subtraction was done by switching the telescope between the source and an adjacent position in the sky. First, we moved the telescope to a position known to be free of emission; since this procedure gave bad baselines and a high noise level in some spectra, we preferred to use a rotating mirror to switch the beam to a position 12′ away at a rate of 6 Hz. This procedure gives good baselines but may alter the strong lines if there is some emission in the reference beam. We observed some lines both in the SgrA and SgrB2 clouds to compare with existing line surveys of the SgrB2 cloud and to check the temperature scale. We found general good agreement, except between the line intensities towards our extended sources measured with the SEST and with the IRAM 30-m telescope.

The half-power beam size of the SEST varies from 44" (115 GHz) to 65" (80 GHz), so we chose a map spacing of 40". The observations were centred on the direction α, δ (1950) = 17h 42m 29.4s, −29°03′31" for the 20 km/s cloud and α, δ (1950) = 17h 42m 40s, −28°58′20" for the 50 km/s cloud. The total areas covered in the SiO map are respectively 160"×160" and 120"×120"; assuming a galactic centre distance of 8.5 kpc, these areas are roughly speaking 7×7 pc for the 20 km/s and 5×5 pc for the 50 km/s.

In Figure 1, we present the spectra obtained toward each offset for the two clouds. The spectral range (87.1 to 86.7 GHz for the rest frequency) is such that the J=1−0 transition of $HN^{13}C$ (87.091 GHz), the J=2−1 transition of SiO (86.743 GHz) and the J=1−0 transition of $H^{13}CO^+$ (86.754 GHz) are selected. On both maps, we can see that SiO is present everywhere and is fairly intense (except in the last offset of Sag A 50 km/s which was not observed); these galactic centre molecular clouds are the unique sources of widespread SiO in our Galaxy. We selected 3 positions in each cloud to observe more molecular lines. As we are interested in the temperature, some examples of the spectra we use for our purpose are presented. Figure 2 gives the $J_K=6_K-5_K$ (K=0−3) and the $J_K=5_K-4_K$ (K=0−3) transitions of CH_3CCH and the $J_K=5_K-4_K$ (K=0−4) of CH_3CN for the 20 km/s; these symmetrical top molecules were chosen because they are supposed to be good thermometers for the interstellar clouds. In each case, only the lines for K=0, 1 and 2 are clearly identified; for K ≥ 3, the signal-to-noise ratio is bad and we have to take the numerical values that we derive with a pinch of salt. Figure 3 gives the same transitions (with same remarks) for the 50 km/s.

3. What We Deduce

Figure 4 gives the rotational diagrams obtained with the transitions $J_K=6_K-5_K$ (full symbol) and $J_K=5_K-4_K$ (open symbol) for increasing values of K, and respectively for the methyl acetylene and the methyl cyanide; these diagrams are given for one particular offset in each cloud. The column density of a level has been obtained with usual hypotheses such as optically thin transition. On Figure 4, it is clearly seen that the dispersion of the points for CH_3CCH is low and is within the uncertainties: the full and open symbols for each K can be considered to be on the same line. The straight lines which are the best fits between the open and the full symbols are almost superimposed and give a unique temperature (the slope of the line is 1/T) which can be considered as a kinetic temperature; we find $T_{kin} \approx 50$ K for the 20 km/s cloud and $T_{kin} \approx 70$ K for the 50 km/s cloud. For CH_3CN, it appears that the representative points of each K-ladder are aligned on nearly parallel lines which lead to a unique rotational temperature, $T_{rot} \approx 10$ K for both clouds. The slopes of the lines which fit the points J=constant are nearly parallel

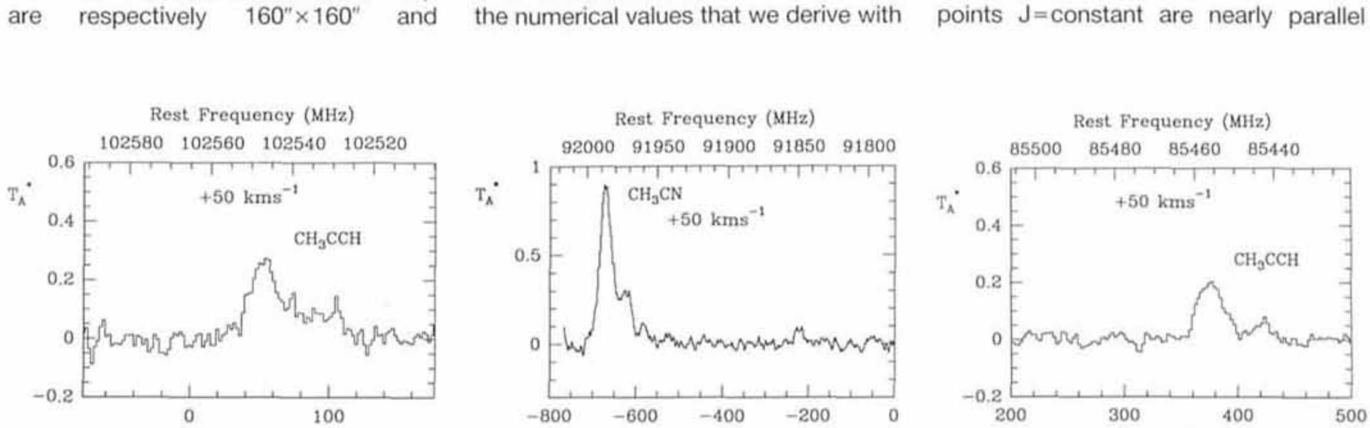

Figure 3: *Some parts of the spectrum obtained for a particular offset (0, +40") toward the 50 km/s cloud which exhibit the same transitions as in Figure 2.*

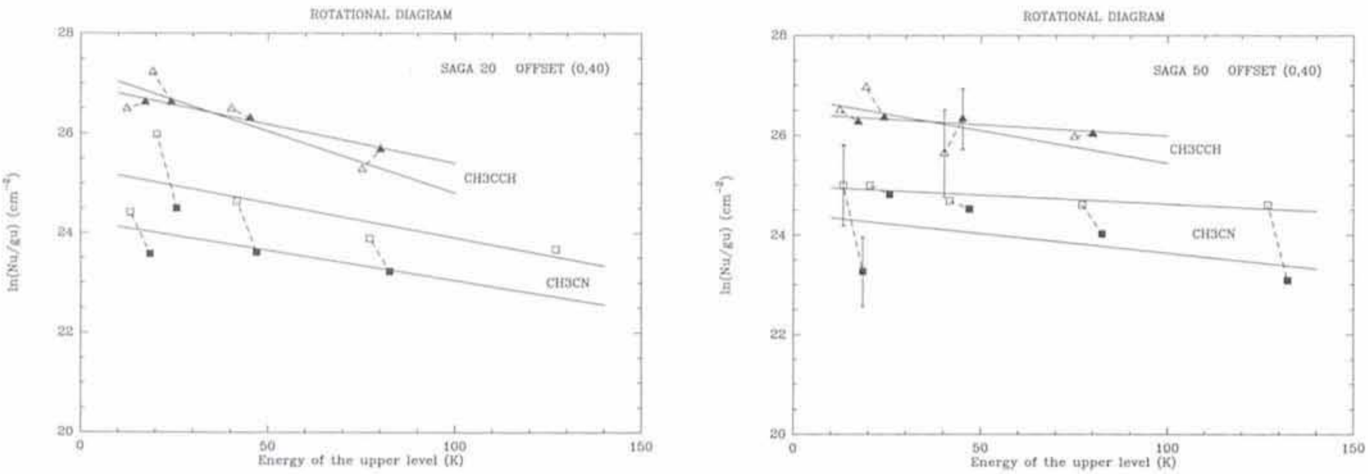

Figure 4: *Rotational diagrams which show the population of the upper level of a transition divided by the statistical weight as a function of the energy level. The full symbols are representative of the transition $J_K = 6_K - 5_K$ while the open symbols are for the transition $J_K = 5_K - 4_K$. K increases from the left to the right from 0 and is the same for each pair of symbols. Some error bars give an estimate of the errors due to the fitting of the line profiles by gaussians.*

and could give an estimate of the kinetic temperature (see for example Turner, 1991 [7]; Churchwell and Hollis, 1983 [6]). Table 1 and Table 2 summarize the results for the 3 offsets in each cloud and also give the average value. One can also find the total column density of each molecule; it has been obtained by using our observations and the partition function computed for the temperature we determined. The magnitude of the CH_3CN column densities of the 20 km/s cloud are of the same order as those obtained by Turner (1991) [7] for Sag B2; for the 50 km/s cloud, the column densities are somewhat higher. In both clouds, the methyl acetylene column densities are of the same order as those found by Churchwell and Hollis (1983) [6] in Sag B2.

Some remarks must be made. CH_3CCH seems more thermalized than CH_3CN, which can be understood if we recall that the electric dipole moment (and as a consequence the probabilities of radiative transitions) of CH_3CN is larger (3.9 D) than that of CH_3CCH (0.78 D): in this last molecule, the level populations are mainly governed by collisions. This is compatible with a numerical molecular hydrogen density $\approx 10^4$ cm^{-3}. Concerning the galactic clouds themselves, the Tables 1 and 2 show that the kinetic temperature must definitely be high in these clouds, $\approx$25–70 K in the 20 km/s, if we take the average value, $\approx$80–90 K in the 50 km/s cloud. On the other hand, this "high" temperature is pervading in a fairly extended part of the clouds (at least 5 pc), which put some constraints on the heating processes.

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SAGA 20

	CH_3CN			CH_3CCH	
Offset	T_{kin}(K)	T_{rot}(K)	$N_{tot}(10^{14})$	T_{kin}(K)	$N_{tot}(10^{14})$
(−80,−80)	66 J=5 99 J=6	11	1,3	82 J=5	9,6
(0,0)	82 J=5 37 J=6	7	0,99	22 J=5 80 J=6	7,7
(0,40)	71 J=5 83 J=6	5	1,5	40 J=5 64 J=6	9,4
Average				25 J=5 77 J=6	8,4

Table 1 *gives for the 20 km/s cloud the rotational and the kinetic temperatures we derived at three offsets and also gives the average value for these three offsets.*

SAGA 50

	CH_3CN			CH_3CCH	
Offset	T_{kin}(K)	T_{rot}(K)	$N_{tot}(10^{14})$	T_{kin}(K)	$N_{tot}(10^{14})$
(0,−40)	196 J=5 502 J=6	11	11	53 J=5 92 J=6	11
(0,0)	163 J=5		6,4	133 J=5 74 J=6	18
(0,40)	278 J=5 126 J=6	6	6,0	76 J=5 64 J=6	11
Average				81 J=5 94 J=6	13

Table 2 gives the values derived for the 50 km/s cloud.