IRAM Newsletter

Number 8 March 18, 1993

Contents

30-m Telescope

IRAM RECEIVERS AT THE 30-M TELESCOPE

The junction of the 2mm SIS receiver lost contact in December ; a new Nb-SIS junction was installed.

As written in the last issue of the Newsletter (January, 1993), we decided to install a new broad band mixer and Nb–SIS junction in the 230 GHz G1 receiver during the November-December 1992 bolometer observation period. We decided for this change because laboratory measurements had shown a good behaviour of this mixer-junction combination. Unfortunately, the installation produced an unstable receiver which was eventually taken out of service. Meticulous search in the Granada laboratory by M. Carter, S. Navarro, H. Hein, and D. John revealed a bad contact in the mixer-IF connector. The fault is repaired, the receiver is installed at the telescope, and regular observations have started.

The change of the 2mm-junction and the modification (and repair) of the new 230 GHz mixer-junction combination resulted, unfortunately, in a loss of knowledge of the behaviour of these receivers and of their tuning lists. A spot measurement (5/3/93) at 230 GHz gave $T_{\rm REC}$ (SSB) = 96 K, 7dB rejection. At frequencies above 240 GHz a magnetic field must be applied for suppression of Josephson noise. We are not yet certain whether the receiver is useful at frequencies above 255 GHz, further investigation is under way. However, we are confident to offer good performance in the frequency range 205–250 GHz (Figure 1).

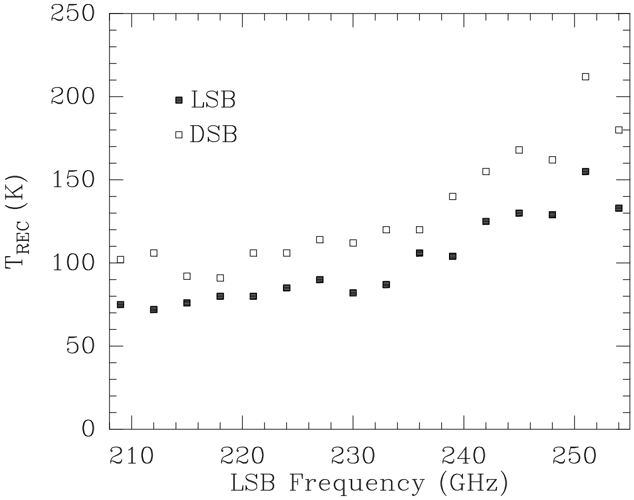

Figure 1: Performance of the new 230G1 receiver

With both receivers we nearly start from scratch as concerns behaviour and tuning lists, and since the receiver group and the operators have to get themselves new experience, we request some patience from the visiting astronomers.

345 GHZ–SIS AND 230 GHZ 7–CHANNEL BOLOMETER OBSERVATIONS

In January-March, we have completed two special, successful, and productive observing runs, i.e. 345 GHz observations (19 Jan – 1 Feb) with the Rothermel open-structure SIS receiver, and 7–channel 230 GHz continuum observations (2 Feb – 9 March) with the MPIfR bolometer array. A map of Virgo A, observed by A. Sievers *et al.*, is shown in Figure 2.

We have had continuous support of H. Rothermel for the operation of his receiver (recycling, tuning, maintenance, explanations, etc.), and also a critical eye on the observations. There are two publications available from H. Rothermel *et al.* (MPI fuer Extraterrestrische Physik, 8046 Garching, Germany) :

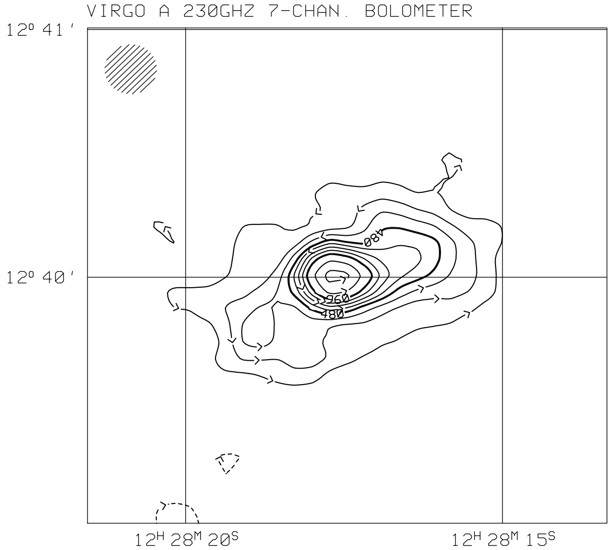

Figure 2: Virgo A mapped with the MPIfR 7–channel bolometer at the 30-m telescope in February 1993 (observed by A. Sievers *et al.*). The contour interval is 120 mJy up to 960 mJy and then 240 mJy/12″ beam. Compare this figure with Salter *et al.* 1989 (A&A 220, 42 (1989))

- Tests and calibration of a 345 GHz open-structure SIS receiver at the IRAM 30-m telescope.
- A 345 GHz open-structure SIS receiver at the IRAM 30-m telescope.

The MPIfR bolometer was operated by the well-known team of E. Kreysa, G. Haslam and R. Lemke.

Both observing runs were supported by the IRAM local staff and Grenoble staff.

DISTRIBUTION BOX

The IF - backend distribution box is nearing completion and we expect installation at the telescope middle - end of April. Thereafter, some time is required to install the software for addressing the distribution box from **OBS**. When done, the correlator will be available in all modes, in particular in split–mode.

Because of a broken synthesizer we have taken the spectral expander out of operation.

Albert GREVE

Interferometer

ANTENNA 4

Despite a number of problems (for example, the receiver compressor had to be exchanged twice in two weeks), antenna 4 is now undergoing final tests. First fringes were obtained on March 6. Final inclusion into the array is scheduled for end of March, depending on weather conditions and results from first holographic measurements.

While final checks continue on antenna 4, for the new projects, the "long baseline" B2 configuration with 4 antennas will be simulated by two 3-antenna configurations (W12-N20-E24 and W09-N20-E24).

OBSERVING PROJECTS

Observing projects during the period November 1992 to January 1993 have been affected by a synthesizer problem. The main interferometer synthesizer was out of lock, giving a slight frequency change (up to 0.3 MHz, depending on observing frequency), and a frequency jitter of 150 kHz. This unfortunately affected several projects for which the lines were too weak for a precise velocity check.

The Hi–Q cable of Antenna 1, which carries the LO reference and the IF from the receiver, was damaged and had to be replaced. Intermittent phase and amplitude problems may affect all projects during the last period. Observers should check the `CABLE_PHASE` variable in CLIC to assess the data quality. This check should be done on uncompressed data, since fast variations only are critical.

DATA REDUCTION

WARNING: because of an offset in the phase lock loop which was not compensated for in the software, *old spectral correlator data* are shifted by 97.656 kHz. Velocities must be corrected downwards (blueshifted) for lower side band, upwards (redshifted) for upper side band.

Improved computer facilities in Grenoble allow several data reductions to be carried out simultaneously. Investigators are requested to contact S.Guilloteau to schedule the data reduction in Grenoble. Because of unusual hardware problems mentioned above, **investigators should schedule a stay longer than 7 days in Grenoble for each project**, with ample time for discussion with IRAM astronomers.

PHASE CALIBRATORS

We have started a project to investigate the use of weaker phase calibrators. Our list now includes more than 200 sources, all of which are apparently usable as calibrators below 100 GHz. We also consider using systematically two phase calibrators for each project, in order to improve astrometric accuracy and to protect against baseline errors.

Stéphane GUILLOTEAU

VLBI

The proceedings of the mm-VLBI workshop will appear in a later issue.

Cornelius SCHALINSKI

Backends

BACKEND GROUP ACTIVITY

The new correlators are routinely operated now. Maintenance interventions uniquely consist of replacing the failed chips. The investigation held by the manufacturer for determining the cause of failures is still in progress.

The backend group is designing for the interferometer a "Phase Control Unit" to replace the previous aging system, which is quite fuzzy and already limited to 4 antennas. This unit is designed to be expandable to 6 antennas, with 2 active receivers per antenna. It will be similar in physical size to a correlator unit and will use the same computer interface. It will gather all the functions related to LO control, fringe rotation, Walsh switching, cable expansion compensation and time standard monitoring. Its peripherals will be a high-class frequency synthesizer, several home–built modules, a GPS receiver, and, hopefully, an hydrogen maser. The GPS receiver has been ordered. This system will provide to the interferometer a better phase accuracy, a reduced phase noise, and will offer easier service to the operators.

More information on this system has been internally published and is available at IRAM library under the reference WR 215/93.

Marc TORRES

Recent Observations

Observations of comet P/Swift-Tuttle 1992t at IRAM

G. Paubert[1], P. Colom[2], D. Despois[3], J. Crovisier[2], D. Bockelée-Morvan[2], G. Bourgois[2], E. Gérard[2], L. Jorda[2]
1) IRAM, Granada
2) Observatoire de Paris-Meudon
3) Observatoire de Bordeaux
(IAU Circ. No 5653 and 5664.)

Abstract: P/Swift-Tuttle, the comet responsible for the Perseid meteor stream seen each year in August, passed perihelion on December 12, 1992, at 0.96 AU from the Sun. It was at 1.2 AU from the Earth (closest approach) in the first half of November.

The millimeter spectrum of P/Swift-Tuttle was observed with the IRAM 30-m telescope on November 11-14 and 21, 1992, and on January 6-7, 1993. The following molecules were detected:

- HCN, J(1-0) line at 89 GHz;
- CH_3OH, 12 lines around 145 and 165 GHz;
- H_2S, 1_{10}-1_{01} line at 168.8 GHz;
- H_2CO, 3_{12}-2_{11} line at 225.7 GHz.

On November 21, these lines were observed with signal-to-noise ratios ranging from 7 to 30 (figures 3 and 4), representing the best millimeter spectra ever recorded in a comet. HCN, CH_3OH and H_2CO were also observed on January, which will allow a comparison of the molecular productions before and after perihelion. At that moment, the solar elongation of the comet was small and only radio observations were possible.

From the line intensities, we evaluate that on November 21, the abundances of these species relative to water were $5\ 10^{-4}$ for HCN, 0.04 for CH_3OH, 0.003 for H_2S and 0.004 for H_2CO (assuming that all these molecules are directly coming from the nucleus). The water production rate at that moment, estimated from OH observations at Nançay, was of the order of $5\ 10^{29}$ molecules s^{-1} (4 times less than comet Halley at perihelion).

The simultaneous observation of several rotational lines of methanol (figure 3) will permit to constrain the physical conditions within the coma. A rotational temperature of about 80 K is retrieved.

All line profiles are asymmetric with a cusp at negative velocities (figure 4). They are blueshifted by 0.5-0.7 km s^{-1}. The 18-cm OH lines observed at Nançay are consistently blueshifted by 0.8 ± 0.1 km s^{-1}. It is the first time so important line shifts are observed in a comet. These line blueshifts are to be compared with the unusually strong jets observed in optical images. They testify to the important anisotropic outgassing of this comet and to the non-gravitational forces that affect its orbit.

We are grateful to the IRAM staff for scheduling this project on short notice.

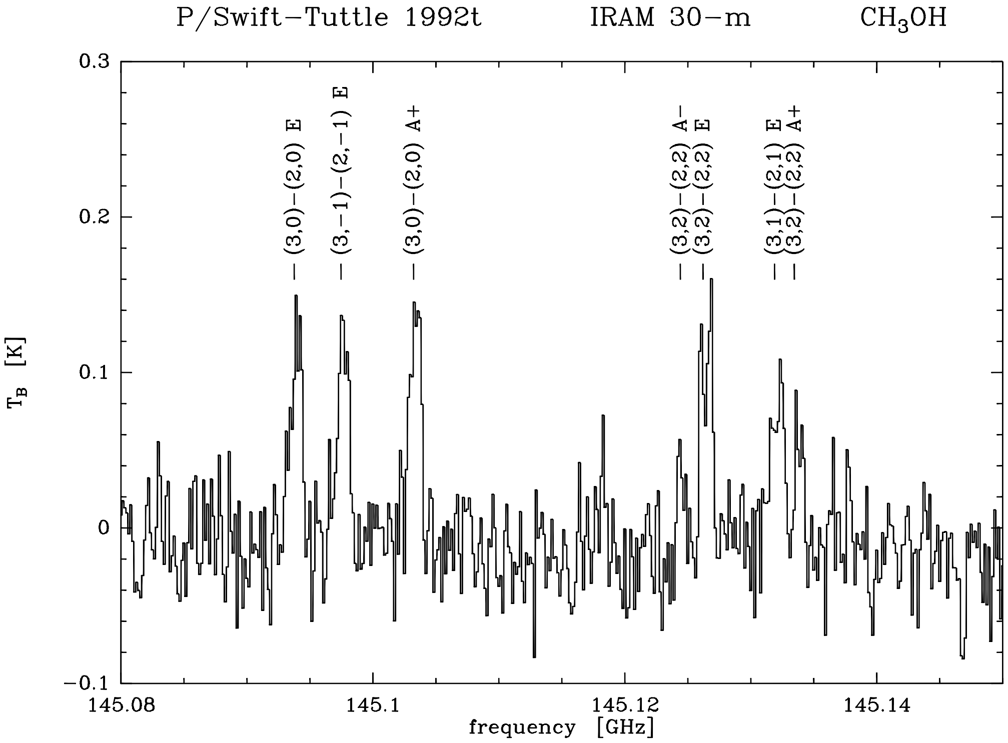

Figure 3: The CH_3OH lines around 145 GHz in comet P/Swift-Tuttle 1992t on November 21, 1992.

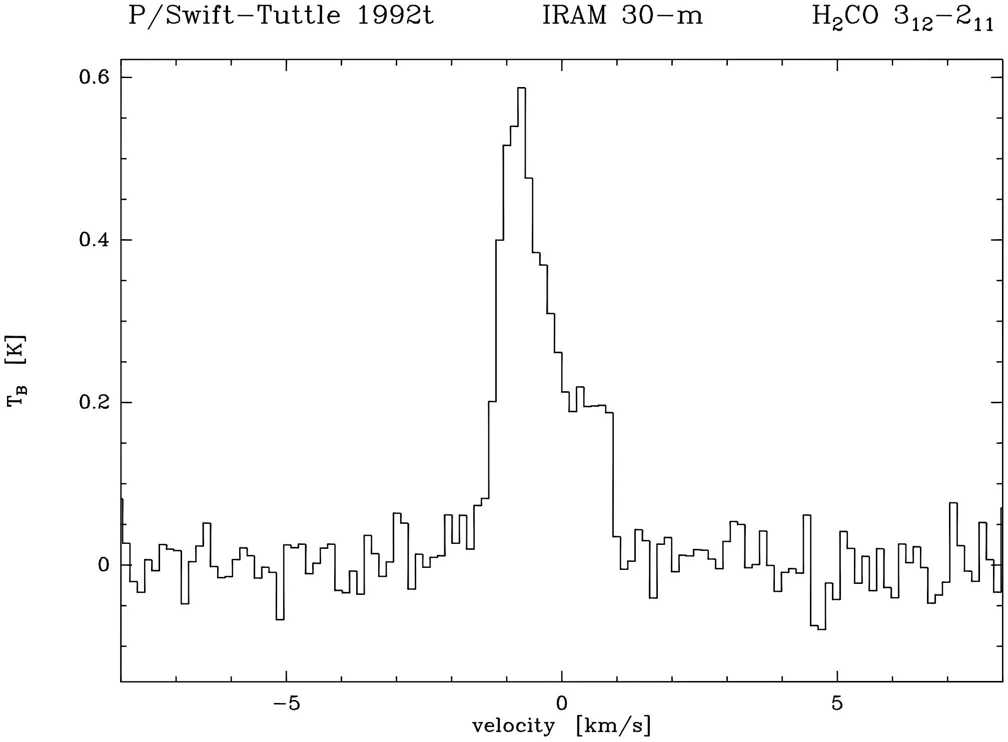

Figure 4: The H_2CO line at 226 GHz in comet P/Swift-Tuttle 1992t on November 21, 1992. The velocity scale is with respect to the comet nucleus standard of rest.

Scientific Results

We include in this section abstracts of new scientific results obtained with IRAM instruments. Abstracts should be e-mailed to R. Lucas (`lucas@iram.grenet.fr`); figures may be included as long as they are sent in Postscript code.

Detection of CO emission from massive molecular clouds in the inner disk of M 31

R.J. Allen, Space Telescope Science Institute
J. Lequeux, Observatoire de Paris-Meudon

Abstract: Faint emission in the CO(1-0) and CO(2-1) spectral lines at millimeter wavelengths has been discovered with the IRAM 30-m telescope from dark dust clouds in the inner disk of M 31. These dust clouds are located in regions of the galaxy where there is little evidence of star-forming activity. The CO emission from these clouds is resolved, and comes from roughly the same area covered by the dust clouds (typically 200-600 pc). The line profile widths and sizes imply cloud masses of a few 10^7 $M_\odot$, typical for Giant Molecular Clouds in the Galaxy. However, the observed surface brightnesses are only a few tenths of a Kelvin, and the typical CO(1-0) luminosities are a factor 10 smaller than those of Galactic GMC's of the same size and velocity line width. The cloud temperatures are uncertain; the CO(2-1)/CO(1-0) line ratios are very low, suggesting subthermal excitation, and precluding use of this ratio alone to determine the kinetic temperature. However, there are indications that the kinetic temperatures are significantly lower than the values of $10 - 30$ K typical for Galactic GMC's, and may be close to the 2.7 K cosmic background.

Distribution of molecular gas in the primeval galaxy IRAS F10214+4724

S.J.E. Radford[1], Robert L. Brown[2], Paul A. Vanden Bout[2]
[1]Institut de Radio Astronomie Millimétrique, 38406 Saint Martin d'Hères, France
[2]National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903, USA
IRAM preprint N° 279

Abstract: Using the IRAM interferometer we mapped the distribution of molecular gas in the extremely luminous IRAS galaxy F10214+4724 at $z = 2.3$. Coincident with the radio continuum source there is a small emission region whose CO($3 \rightarrow 2$) flux, $3.5 \pm 0.5\,\mathrm{Jy\,km\,s^{-1}}$, equals the total line flux measured with the IRAM 30 m telescope. This molecular source seems partially resolved by the $2.3''$ beam and extended E-W. The deconvolved size, $(2.5'' \times 1.0'') \pm 1.0''$ or $(10 \times 4) \pm 4h^{-1}$ kpc, is characteristic of an entire galaxy rather than a galactic core. An apparent velocity gradient indicates the gas distribution

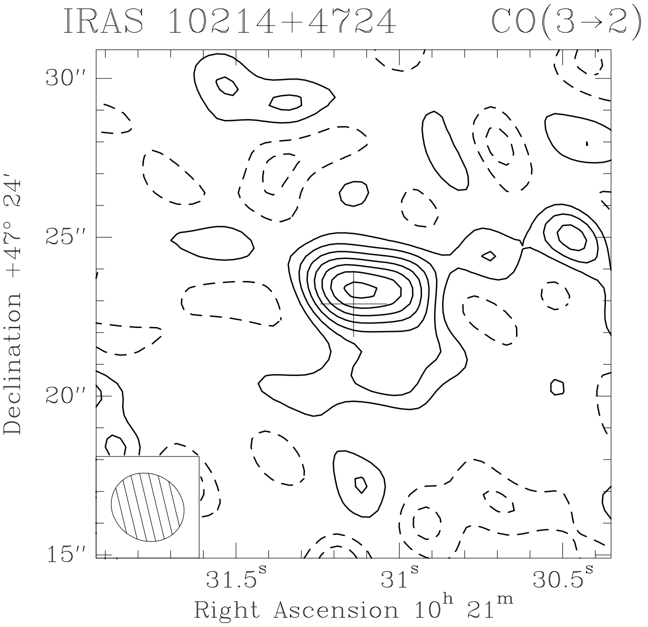

Figure 5: Velocity integrated CO($3 \rightarrow 2$) emission at $z = 2.2858$ from 10214+4724. The velocity interval is $\pm 142.4\,\mathrm{km\,s^{-1}}$, the beam (insert) is $2.3 \times 2.1''$ (FWHM), dashed contours are negative, the zero contour is omitted, and the contour interval is $1\,\mathrm{mJy\,beam^{-1}}$, or $21\,\mathrm{K\,km\,s^{-1}}$ (rest frame). The cross marks the phase center at $10^h21^m31.14^s$ $+47°24'22.9''$ (1950), which is is $0.6''$ SE of the position of maximum emission.

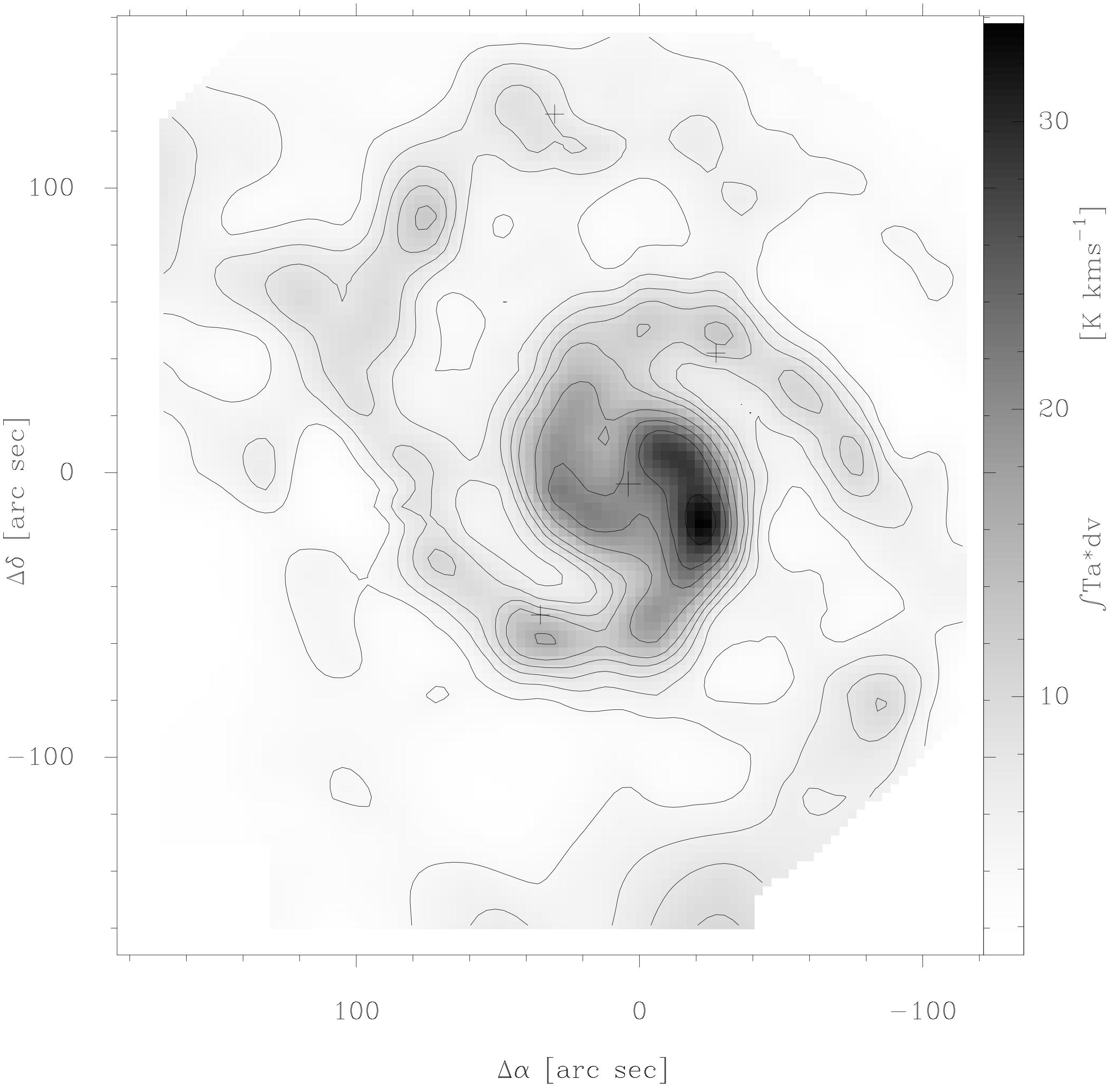

Figure 6: The $I(\mathrm{CO}) = \int T_{\mathrm{A}}^{*}(^{12}\mathrm{CO}\ 2-1)dv$ integrated intensity distribution in M51. Lower and left scales: R.A. and Dec. offsets (in arc seconds) with respect to the adopted center ($\alpha = 13^h27^m46.^s1$, $\delta = 47°27'14''$); right: color scale in K kms^{-1}. The contours are: I(CO)= 4, 6, 8, 10, 12, 16, 20, 24, 30, 36 K kms^{-1}. The cross at $(\Delta\alpha, \Delta\delta)$= $(+4'', -4'')$ marks the position of the dynamical center.

is rotating. The dynamical mass, 8–13 × $10^{10}h^{-1}\,M_\odot$, is consistent with the inferred H_2 mass, $1 \times 10^{11}h^{-2}\,M_\odot$.

Molecular Spiral Structure in Messier 51

S. Garcia-Burillo[1,2], M. Guélin[1], J. Cernicharo[2]
[1]IRAM, 300 Rue de la Piscine, 38406 Saint Martin d'Hères, France
[2]Centro Astronómico de Yebes. IGN. 19080 Guadalajara, Spain

Abstract: The "grand-design" spiral Messier 51 has been mapped in the $J = 2-1$ and $J = 1-0$ transitions of ^{12}CO with the IRAM 30m telescope. The angular resolution in the $J = 2-1$ line is 12″ (HPBW), the highest of any single-dish CO survey. Both maps have been fully sampled (i.e. with steps of 6″ for $J = 2-1$) in the inner 3'×3' region, and the lines accurately calibrated. 40 positions have been re-observed in ^{13}CO(2–1) and (1–0) and 10 positions in ^{12}CO(3–2).

The CO emission, which nicely delineates the two-armed spiral pattern, is weak, albeit ubiquitous in the inner interarm region. The CO arms have deconvolved widths of 20–30" and are broader and stronger than those observed by Rand and Kulkarni (1990) with the OVRO interferometer. They stretch almost continuously from the nuclear "disk" (a molecular condensation of radius $r \simeq 1$ kpc), to $r = 8$ kpc (the corotation radius, according to Paper II). The arm–interarm intensity contrast is $3-5$ through most of the inner region and increases to $5-6$ near the 'corotation'. It is larger for the southern inner arm (Arm I) than for the northern inner arm (Arm II).

The rotation curve derived from CO is best approximated by a steeply rising line, reaching $V_{\max} = 200$ kms^{-1} (cos 20°/cos$i$) within 10″ (0.5 kpc), followed by a flat section. The CO velocity field shows large departures from circular rotation. Those consist of 'streaming' motions near the arms and near the center, and of random motions.

The streaming motions in the arms, already reported in previous studies, can now be followed in the interarm region from one arm to the other. These motions have the direction and behaviour predicted by the density-wave theory inside corotation; their line-of-sight component is larger in the SE and NW quadrants and changes sign in the inner edge of the CO arms. The peak to peak variation of this component reaches 60 kms^{-1} in the SE quadrant, most of the variation occuring inside Arm I in less than 10" (460 pc). The streaming motions in and near Arm I could be as large as ±100 kms^{-1}, if they are in the plane of the galaxy and if $i = 20°$.

The streaming motions across Arm II are a factor of 2 smaller. Arm I, which, inside 'corotation', is twice stronger than Arm II in CO and IR emission, is likely to be driven by a stronger response to the density wave.

The gas in the nuclear region also exhibits non-circular motions. Molecular clouds probably follow elliptical orbits and are trapped into a 'bar' aligned with the stellar bar apparent on infrared pictures.

Up to 'corotation', the CO arm emission is tightly correlated with the non-thermal radio-continuum emission and, as found by Vogel et al. (1988), peaks on the dark dust lanes. Although the Hα regions tend to lie further out than the dust lanes and the CO peaks, most lie within the CO arm boundaries. Thermal radio-continuum emission is observed toward the CO peaks showing that visual extinction is important in the arms – as also suggested by the large molecular column densities derived from the ^{13}CO intensities and by the large extinctions measured by van der Hulst et al. (1988) toward 39 HII regions.

The CO arms exhibit a number of discrete emission peaks, spaced by $1.5-2$ kpc and symmetrically located with respect to the dynamical center. A similar pattern is observed in HI and Hα, although the brightest Hα peaks are shifted radially outwards by a few arc seconds. The remarkable symmetry of the CO peaks and the similarity between the CO, HI, and Hα patterns in the inner arms suggest that we are observing complexes of molecular gas, HII regions and HI envelopes, located at resonant positions.

The ^{12}CO $J = 2-1$ to $1-0$ line intensity ratio, corrected for the difference in beamsize, is $\simeq 0.7-0.8$ all over the disk and shows no systematic difference between the arms and the interarm region. The corresponding ^{13}CO ratio, on the other hand, varies from 0.8 in the arms to $\simeq 0.4$ in the interarm region; it reaches 1.2 near the nucleus. The ^{12}CO $J = 3-2$ to $1-0$ ratio is large near the center and in the arms: $\simeq 0.7$. These line intensity ratios are used to derive core-halo models of the molecular cloud complexes, using LVG and Monte Carlo radiative transfer calculations. Different cloud models are derived for the center, the arms and the interarm gas. The mass fraction in the cores is found to increase from the interarm (<20%) to the arms (∼ 50%) and from the arms to the nuclear region (≃60%). The CO cloud models reproduce also the HCN (1–0) line intensities observed by Rieu et al. (1992). Radiative trapping, which is taken into account in the Monte Carlo code, plays a major role in the 2-component models by rising substantially the ^{12}CO and HCN line brightnesses in the halos.

The molecular column densities derived from the cloud models are factors of 3–5 smaller than those calculated with the 'standard Galactic' X= N(H_2)/I(CO) conversion factor of Strong et al. (1988). In particular, X is found smaller for the interarm gas than for the clouds in the arms, which suggests that the H_2 arm-interarm contrast is larger than the CO intensity contrast.

New Preprints

The following preprints are available from IRAM:

277. Dense gas in nearby galaxies
VI. A large $^{12}C/^{13}C$ ratio in a nuclear starburst environment
C. Henkel, R. Mauersberger, T. Wiklind, S. Hüttemeister, C. Lemme, T.J. Millar
1993, *Astron. Astrophys.*

278. Rotation of stars and gas in M82
C.D. McKeith, J. Castles, A. Greve, D. Downes
1993, *Astron. Astrophys.*

279. Distribution of molecular gas in the primeval galaxy IRAS F10214+4724
S.J.E. Radford, R.L. Brown, P.A. Vanden Bout
1993, *Astron. Astrophys. Letters*

280. The molecular cloud content of early–type galaxies
IV. A molecular bar in NGC 4691
1993, *Astron. Astrophys.*

281. Cold dust around high–redshift quasars
P. Andreani, F. La Franca, S. Cristiani
1993, *Mon. Not. R. Astron. Soc.*

The IRAM Newsletter is edited by Robert LUCAS at IRAM-Grenoble (e-mail address: `lucas@iram.grenet.fr`).
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For instance, to obtain a copy of the May 1992 issue, just send the one line message:
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More information may be obtained by sending the one line message:
`HELP`
Note that this file server also contains Postcript files of the proposal forms and of Plateau de Bure documentation.
We also start to compile a list of e-mail addresses of IRAM users (e.g., in order to send warning messages when the Newsletter is available, but also to provide fast information, if needed). If you feel your address should be on this list, please send the one line message:
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Pico Veleta	Instituto de Radioastronomía Milimétrica Estación Radioastronómica IRAM-IGN del Pico Veleta Sierra Nevada, Granada, España	(34) 58 48 02 11	(34) 58 48 08 60

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- IRAM-Granada: `username@IRAM.ES`, or through SPAN: `IRAMEG::username` or `16494::username`

The `username` is generally the last name of the person to be contacted.