IRAM Newsletter

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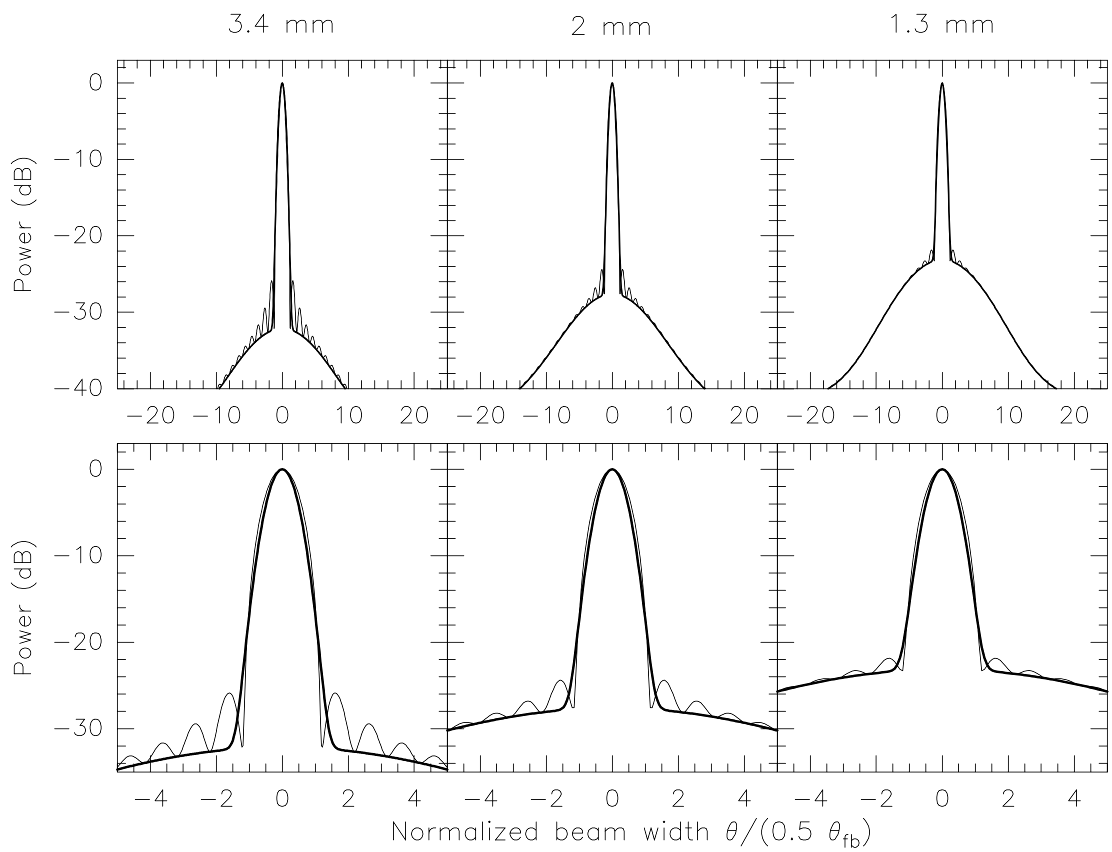
Number 38 January 27th, 1999

Cover Picture



IRAM 30-m telescope beam pattern calculated from scans across the limb of the Moon after the July 1997 surface re-adjustment. The heavy lines show gaussian approximations to the main beam and error beams. For each pattern, the profile is normalized to half-width of the full beam (from *Greve, Kramer and Wild 1998, A&A Suppl.* **133**, 271; see also this Newsletter pp. 16-17).

Calendar

March 8th, 1999 24:00h (MET): Deadline for the submission of observing proposals for the period May 15, 1999 to November 15, 1999

April 8-9th, 1999 Program Committee meeting

April 12th, 1999 Next IRAM Newsletter deadline

April 29-30th, 1999 IRAM SAC meeting (tentative date)

June 17-18th, 1999 IRAM Executive Council meeting

Introductory review: Receivers

an overview for non-specialists

Introduction

The purpose of a receiver is to collect efficiently the astronomical signal that has been concentrated by the antenna near its focal point, and to amplify it with a minimum of extra noise to a level suitable for further processing by the spectrometers or continuum detectors. Figure 1 shows the main subsystems of a receiver, that we will discuss below.

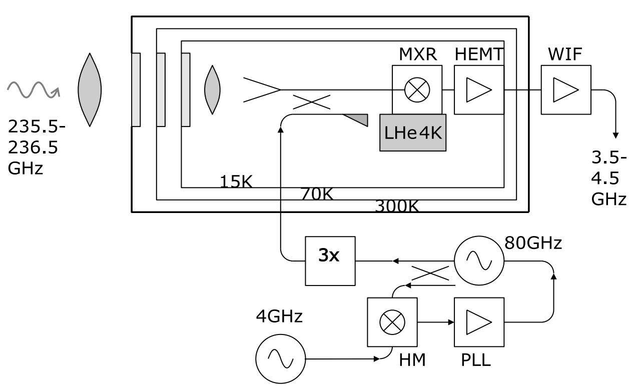


Figure 1: Synoptic diagram of a typical receiver. This diagram is grossly simplified; for instance, the optics involves mirrors, elliptical and planar, and also grids; the LO/PLL system is actually more complicated than shown.

Coupling optics

Up to and including the antenna, the astronomical signal propagates in free space. On the other hand, the first signal processing unit —the mixer— requires the electromagnetic energy to be confined by metallic walls, in a waveguide. The transition between these two modes of propagation occurs at the *horn*.

Assume for a moment that the horn would be placed at the Cassegrain focus of the antenna. Good matching would be difficult to achieve because the field amplitude from a point source (Airy pattern) exhibits radial oscillations alternating between positive and negative values, and has a scalesize proportional to wavelength.

These problems are avoided by coupling —via suitable relay optics— the horn to an *image of the aperture*. This fulfills the condition of *frequency-independent illumination*. In other words, imagine that we propagate the horn mode back to the antenna aperture as if we were dealing with a transmitter, then the illumination pattern is independent of frequency. Using suitably designed corrugations on the inner wall of the horn (see fig. 2) the TE10 mode of the rectangular waveguide couples to a mode at the aperture of the horn whose amplitude has circular symmetry, and whose polarization is pure linear.

Why we need heterodyne receivers

In the present context, *heterodyne* refers to receivers where the frequency of the input signal is shifted to lower frequencies. This is done by adding to the (small) input signal a (relatively) strong monochromatic signal, called the *local oscillator* and passing the sum through a non-linear device, whose output contains (among other) the difference frequency. Although a non-linear device is involved, the transformation from input to output is linear for the small signal. This process is called mixing or downconversion. The output signal is called the *intermediate frequency*. Actually the complete signal processing at a radiotelescope can involve up to four heterodyne conversions.

The first reason why heterodyne downconversion is needed is that only few signal processing devices exist at millimeter frequencies, and definitely not the fully parallel spectrometers (as opposed to multiplex devices such as FTS) that are routinely used for spectroscopic observations.

Then arises the question of where in the signal processing chain to make the down conversion. Basically we have no choice, because hardly any amplifiers are available in the millimeter range, except in the 3mm band, where they do not match the low noise properties of SIS mixers (to be discussed below). So we *must* perform a downconversion before we can amplify the signal.

Local oscillator system

All the local oscillators in the IRAM telescopes use Gunn oscillators. A Gunn diode is a semiconductor device that exhibits negative dynamic resistance over a suitable range of frequencies. Output powers of the order of 10–50mW can be obtained between 60 and 120 GHz. To achieve oscillation at a precise frequency, two means are combined. First, the Gunn diode is coupled to a coaxial cavity that defines the oscillation frequency, and whose high quality factor provides a good spectral purity. Its resonant frequency can be adjusted mechanically; this allows the desired frequency to be approached within ≈10 MHz. Secondly, a fraction of the millimetric radiation from the Gunn oscillator is used to produce a beat with a reference microwave oscillator at a frequency of a few GHz; actually, the Gunn oscillator signal beats with a harmonic (n=17–65, depending on the systems) of the reference frequency. The beat signal is used to "servo" by electronic tuning the Gunn oscillator to a multiple of the reference. Actually, not only the frequency, but also the phase of the local oscillator is locked to the reference oscillator, which is essential for interferometry, whether connected-array or VLBI. This description of the *phase-lock* system is over-simplified.

Local oscillator frequencies above 120GHz can generally not be generated directly by Gunn oscillators. In that case, the Gunn power is fed to a *frequency multiplier*, which is a non-linear device like the mixer, but based on non-linear capacitance, and optimized to produce a certain harmonic (×2, ×3 or ×4 in the case of IRAM systems) of the input frequency. The efficiency of the multiplication process is typically a few percent.

Local oscillator injection

As mentioned above, the local oscillator power must be added to the astronomical signal before it enters the mixer. When the mixers were based on Schottky diodes (10 years ago and more), they required an LO power of almost a mW. As a consequence, the LO power was coupled via a *diplexer*, which is like a frequency-selective coupler, allowing the mixer to be coupled with close to unity efficiency to *both* the input signal and the LO. With the advent of SIS mixers, and due to their modest LO power requirements (read below), a new method can be used, based on frequency-independent couplers. A fraction f (typically 1%) of the LO power is coupled into the signal path; the rest is wasted! The fraction f must be kept small because the same amount f of room-temperature blackbody noise is also coupled into the signal path. The coupler requires no adjustment and is located close to the receiver, inside the *cryostat* (discussed below).

Photon-assisted tunneling

All mixers in IRAM receivers are based on SIS junctions. An SIS junction consists of two layers of superconducting metal (Niobium) separated by a few nanometers of insulator (Aluminium oxide). The insulator is so thin that charged particles can tunnel through the barrier. The area of a junction is typically one to a few μm^2. SIS junctions operate at the boiling temperature of He: 4.2K (at sea level).

Two kinds of charged particles can exist in a superconductor: a) ordinary electrons; b) so-called Cooper pairs, consisting of two electrons interacting and weakly bound together by the exchange of phonons (lattice vibrations); breaking a Cooper pair costs an energy 2Δ. Correspondingly, two kinds of currents can flow across the junction: the Josephson current, consisting of Cooper pairs, and the so-called quasi-particle current, consisting of "ordinary" electrons (presumably "electron" did not sound fancy enough). To keep this digression into SIS physics short, let's just state that the Josephson current can be ignored. At the operating temperature of the mixer, and in an unbiased junction, the population of quasi-particles is virtually negligible. But, if the bias voltage is raised to the *gap voltage*

$$V_g = 2\Delta/e$$

the flow of quasi-particles across the junction becomes possible because the energy gained across the drop of electrical potential compensates for the energy spent in breaking a Cooper pair. See in Figure 3 the "LO off" I-V characteristic.

In the presence of electromagnetic radiation, the situation is modified as follows. If a RF photon is absorbed, its energy $h\nu$ can contribute to the energy budget, which can now be written as:

$$eV_{\text{bias}} + h\nu = 2\Delta$$

or, equivalently:

$$V_{\text{bias}} + h\nu/e = V_g$$

In other words, the onset of conduction occurs at $V_g - h\nu/e$. The region of the I-V curve below the gap voltage where photon-assisted tunneling occurs is called the *photon step*. See the "LO on" curve in Figure 3. Figure 3 is based on actual measurements of a 2-junction series array: the voltage scale has been scaled $\times\frac{1}{2}$ to illustrate a single junction. SIS junctions and their interaction with radiation will be analyzed in more detail in a review by K. Schuster to appear in the next IRAM Newsletter (April 1999).

So far I've shown you qualitatively that an SIS junction can function as a total power detector. The responsivity (current generated per power absorbed) can even be estimated to be of the order of one electron per photon, or: $D \approx e/h\nu$. How does that relate to frequency downconversion? Assume that a power detector is fed the sum of a local oscillator (normalized to unit amplitude for convenience) $v_{LO} = \cos\omega_{LO}t$ and a much smaller signal at a nearby frequency: $v_S = \epsilon\cos\omega_S t$. Assume this functions as a squaring device and discard high-frequency terms in the output:

$$v_{\text{out}} = (v_{LO} + v_S)^2 \longrightarrow \frac{1}{2}\epsilon\, cos(\omega_{LO} - \omega_S)t$$

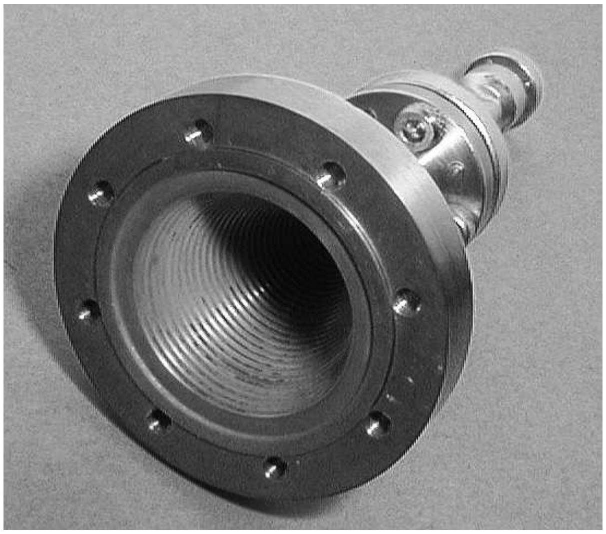


Figure 2: A corrugated horn for the 150GHz band. The phase-correcting lens normally present at the aperture has been removed to reveal the corrugations. The diameter of the aperture is about that of a typical coin (1DM/100Ptas/1F). All the waves collected by the 30-m antenna converge to the horn with a precise phase relationship and are then squeezed into a waveguide 2×1mm across.

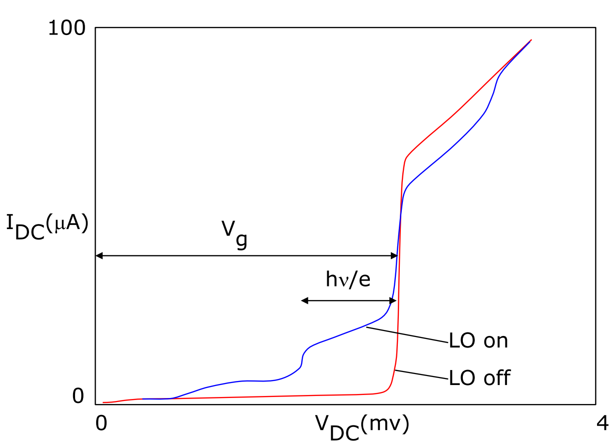


Figure 3: Current-voltage characteristics of an SIS junction operating in a mixer. The two curves were measured without and with LO power applied (frequency 230GHz); they have been slightly idealized (for pedagogical reasons, of course).

So, a power detector can also function as a frequency downconverter (subject to possible limitations in the response time of the output).

The LO power requirement for an SIS mixer can be estimated as follows. A voltage scale is defined by the width of the photon step: $h\nu/e$. Likewise, a resistance scale can be defined from R_N, the resistance of the junction above V_g; junctions used in mixers have $R_N \approx 50\Omega$. So, the order of magnitude of the LO power required is:

$$P_{\rm LO} \approx (h\nu/e)^2/R_N$$

about 20 nW for a 230 GHz mixer. This makes it possible to use the wasteful coupler injection scheme discussed above.

Because the insulating barrier of the junction is so thin, it possesses a capacitance of about $65 fF\,\mu m^{-2}$. At the RF and LO frequencies, the (imaginary) admittance of that capacitance is about 3–4× the (approximately real) admittance of the SIS junction itself. Therefore, appropriate tuning structures must be implemented to achieve a good impedance match (i.e. energy coupling) of the junction to the signals.

The minimum theoretical SSB noise for an SIS mixer is $h\nu/k$, 11K at 230GHz; the best IRAM mixers come within a factor of a few ($\approx 4\times$) of that fundamental limit. These numbers are for laboratory measurements with minimal optics losses; practical receivers have a slightly higher noise.

Mixer

A sketch of a mixer is shown in Figure 4, again grossly over-simplified. The junction is mounted across the waveguide, in the direction of the electric field. One side of the junction is connected to the outside of the mixer block, both to bring out the IF beat signal, and to provide the DC bias. That connection is made through a low-pass filter to avoid losing precious RF energy.

One end of the waveguide is the input of the mixer; the other end must be terminated somehow. At the zero-order approximation, one would like the junction to "see" an open circuit when "looking into" the rear end of the waveguide. More generally, the junction should see a pure imaginary impedance, so that no energy is wasted. A simple calculation shows that a transmission line having a length l, and terminated into a short-circuit, has an apparent impedance:

$$Z_{BS} = j\, Z_0 \tan(2\pi l/\lambda)$$

where Z_0 and λ are respectively the propagation impedance and wavelength in the waveguide, and l is the distance to the short-circuit. In particular, for $l = (\frac{n}{2} + \frac{1}{4})\lambda$, the apparent impedance is an open circuit. More generally, by adjusting l, an arbitrary imaginary impedance can be placed in parallel with the junction. Together with

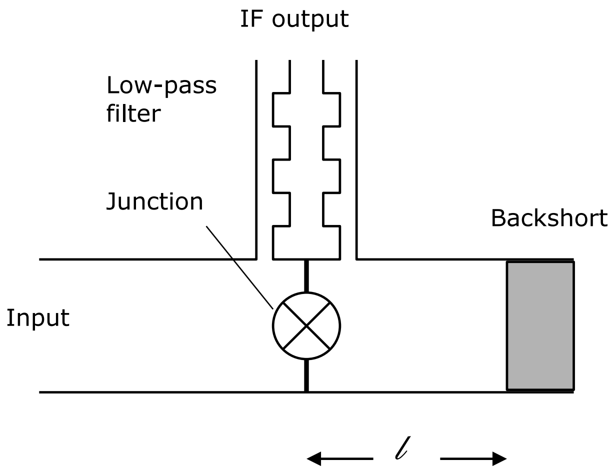


Figure 4: Rough sketch of the main elements of a mixer

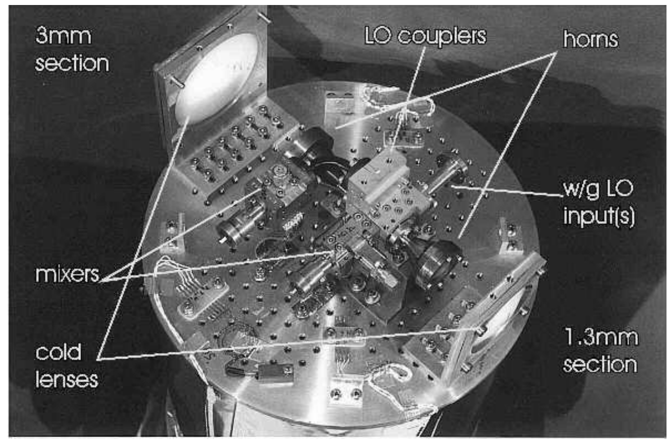


Figure 5: The cold RF assembly for a dual-channel receiver used at the 30-m telescope.

the tuning structures mentioned in the previous section, such an *adjustable backshort* contributes to achieve the best possible match of the junction impedance.

For various reasons (one of which is reducing the noise contribution from the atmosphere) it is desirable that the mixer should operate in *single-sideband* mode. We explain how this is achieved with a crude zero-order model. Assume that the best impedance match of the junction is obtained when the apparent impedance of the backshort seen from the junction is an open circuit. Assume we observe in the lower sideband at a frequency $\nu_L = \nu_{LO} - \nu_{IF}$, and want to reject the upper sideband $\nu_U = \nu_{LO} + \nu_{IF}$. That condition can be achieved if, at the frequency ν_U, the junction is short-circuited. So, we must meet the two conditions:

$$l = (\frac{n}{2} + \frac{1}{4})\lambda_L \quad \text{lower sideband}$$
$$l = (\frac{n}{2} + \frac{1}{2})\lambda_U \quad \text{upper sideband}$$

for some integer n; we gloss over the distinction between free-space and waveguide wavelengths. The two conditions (one unknown) can be *approximately* met for some l close to

$$l_{\text{reject}} = \frac{1}{4}\frac{c}{\nu_{IF}}$$

In practice, single-sideband operation in the 100 GHz band requires additional tricks, because the IF frequency of the current 100 GHz mixers is relatively low (1.5 GHz).

Returning to practicalities, tuning a receiver requires several steps (which used to make astronomers a bit nervous at the 30-m telescope when all was done manually). First the local oscillator must be tuned and locked at the desired frequency. Then the backshort is set at the appropriate position, and the junction DC bias voltage is set. Finally the LO power is adjusted to reach a prescribed junction DC current (of the order of $20\mu A$). These adjustments are made by a combination of table lookup and optimization algorithms under computer control. Altogether this involves between 11 and 13 adjustments, mechanical or electrical, yet this process takes only a few minutes with the current systems.

Cryostat

As mentioned earlier, the SIS junctions in the mixers operate at the boiling temperature of He. Therefore, at the heart of the cryostat lies a reservoir of ≈4 liters of liquid He. However, if that would be exposed to ambient conditions, several undesirable things would happen. First, conducted heat would quickly evaporate the helium. Second, a big icicle of water, nitrogen, oxygen, etc... would condense around the reservoir. Conduction and condensation are avoided by operating the receiver in a vacuum enclosure (labelled 300K in figure 1). But infrared radiation must also be blocked. Your body is receiving about 700W from the surroundings! (and radiating back about the same amount). A typical 4-liter reservoir of liquid He, exposed to the same flux, would evaporate in 2 minutes! Yet the hold time of a cryostat is one to several weeks, four orders of magnitude more. This is achieved via the two radiation screens labelled 70K and 15K in figure 1, as well as by reducing to a minimum all conduction losses. The radiation screens are kept cold by a closed-cycle cryogenic machine involving the compression and expansion of helium gas. The 15K stage is also used to cool the first stages of IF amplification. Future receivers will feature fully closed-cycle cryogenics, including the 4K stage.

Actual receivers

Figure 5 gives you a chance to peek at the cold RF assembly of one of the dual-channel receivers in operation at the 30-m telescope since May 1998.

Figure 6 shows the performance of one of the Plateau de Bure 230GHz receivers. The present LO/IF system dictates a 1.5GHz IF, therefore, these receivers are operated

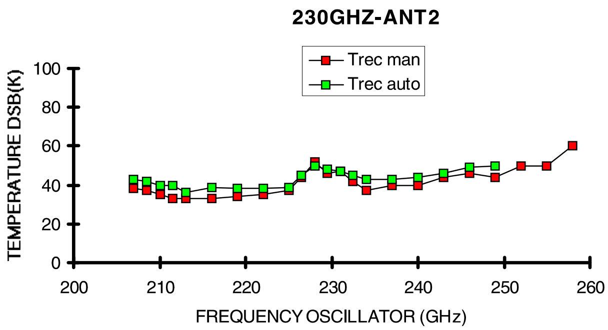


Figure 6: DSB noise performance of one of the 230GHz receivers in operation at the PdB interferometer

in DSB mode; in the interferometer, the sidebands can be separated due to their different fringe rates.

B.Lazareff

News from the 30-m telescope

Experience with the new receivers and the refurbished receiver cabin

After the big refurbishment of the 30m receiver cabin in September/October 1998 (see Newsletter No. 37), first operational experience has been gained during the past months. The new receivers (now called A100, A230, B100, and B230 according to the dewar and band center frequency) are a clear improvement of the observational possibilities. For parameters like receiver temperature, sideband rejection etc... we refer to the call for proposals in this issue of the Newsletter.

The relative alignment of the different receivers (which has sometimes been a problem in the past) is stable and within 2″. A major improvement is also the fully remote tuning (from the control room) and the reduced tuning time. It is well possible to tune 4 receivers within 10 minutes.

At present, four new receivers (plus the ″old″ 2mm receiver) are installed. Four more receivers, two for the 2 mm band (named C150 and D150) and two for the high 1.3 mm band (called (C270 and D270) are under construction and will be installed probably in summer or autumn 1999. News updates will be published in this Newsletter and/or in the IRAM web pages.

Remote observing from IRAM Grenoble and Granada

Further technical tests and some shorter projects have been carried out using remote observing from IRAM Grenoble. This mode of observing works well, in particular for shorter and uncomplicated projects, and is now open for use both from the Granada and Grenoble offices by experienced 30m observers. If interested, please contact either W. Wild (wild@iram.es) or C. Thum (thum@iram.fr) in order to discuss the suitability of a specific program and arrange for an introduction.

Table 1: Transport to the 30m Telescope: Winter 1999 schedule (subject to modification on short notice due to operational reasons)

	Departure from Granada Office	Departure from the Telescope
Monday	08:15	10:45
Tueday	08:15	10:45 and 16:15
Wednesady	No transport	No transport
Thursday	7:00 or 10:00*	16:15
Friday	08:15	10:45 and 16:15

* depending on operational constraints by the skiing company, consult IRAM Granada (Javier Lobato).

Winter transport to the telescope

The old ratrack has been replaced by a newer model with a modern cabin (and good heating !). Because of the rather limited amount of snow and space for both skiiers and the ratrack (basically sharing some slopes) and the associated risk of accidents, IRAM has been urged by the skiing company CETURSA to limit the transports to the absolutely necessary minimum. This means that special transports (e.g. on weekends or at a special hour) *will not be possible* for the time being. Visitors to the 30m telescope will be informed should some of the previous flexibility be regained. For the moment observers are requested to arrange their travel to Granada and the telescope in a way that allows to take one of the scheduled transports (see table). Please note that on Thursdays the transport may already leave at 7:00 instead of 10:00 (inquire beforehand).

Wolfgang Wild

Airline tickets for travels from Paris to the 30-m telescope

We would like to remind those of you living in the Paris area that IRAM has an account in a Parisian travel agency. Those entitled to reimbursement by IRAM of their travels to the 30-m telescope are asked to buy their tickets at this agency. This would minimize our paperwork. Please contact Mrs. G. Marcoux for details (marcoux@iram.fr).

Thanks for your comprehension.

G. Marcoux

Future control system for the 30-m Telescope

We are working on plans for a new control system for the 30-m telescope.

In the near future many hardware components of the control system for the 30-m telescope will be replaced by more modern equipment. We take this as an occasion to consider very broadly the desired features of a new system including:

1) observing modes and telescope control, as well as
2) data acquisition, processing, and archiving;
while maintaining the many successful features of the current system.

Our goals are to:

a) improve current observing modes in terms of flexibility, convenience, and data quality;
b) design and implement new observing modes,
c) optimize observing modes for mm-wavelength observations with a large single-dish telescope;
d) improve the efficiency of the telescope;
e) prepare the system for foreseeable new hardware.

We expect that there will be a "core" of high priority features which will form essential parts of the new system. At this time it appears likely that this core will include:

1) observations with focal-plane arrays, including bolometers and heterodyne receiver arrays;
2) observing modes using the full parameter space of the "wobbler", e.g., scanning with the wobbler;
3) continuous data taking, e.g., fast on-the-fly observations, which can be combined with other observing modes and options, like frequency switching and wobbler switching;
4) remote observing, service observing, and flexibility of observing and scheduling.

Linked to these core features is a need to:

a) foresee very large data rates;
b) optimize the standard observing modes and make them easy to use;
3) automate where possible.

All users of the 30-m telescope are invited to critically follow our discussions and plans as they evolve, and to let us have their comments and suggestions.

More information and regular updates can be found on new WWW pages for this project; the main page is: http://www.iram.es/FutureControl30M/Main.html

Hans Ungerechts, ungerechts@iram.es

News from the interferometer

Weather conditions and observations

The interferometer recorded a high observing efficiency during the months of November and December: 40%, more than twice the efficiency of the previous two years and with excellent prerequisites for 1.3mm observations. As far as A-rated projects are concerned, we are quite confident that most of them will be brought to completion during the current winter period. However, even if the weather conditions have been substantially better than those from early last winter and even if the backlog has now been substantially worked off, we expect that only a small number of B-rated projects, essentially those falling in a favorable LST range, is likely to be observed. The most extended antenna configurations (A and B2) are scheduled for the weeks to come and will probably be worked off before the end of March.

Investigators who wish to check the status of their project, may consult the interferometer schedule on the IRAM Web page.

Antennas

The subreflector on antenna 3 was replaced with a new generation subreflector made from a solid block of aluminum. The antenna efficiency was extensively tested upon replacement and was found to be comparable to the other antennas.

Surface adjustments and optimization of the receiver alignment have also been carried out on all antennas last autumn.

The 6th antenna is currently assembled in the hangar on Plateau de Bure. The construction of the antenna is progressing well: the pedestal is finished, the transporter will be terminated in a few days from now, and the assembly of the receiver cabin will probably be tackled in the weeks to come. We will keep you informed about the progress in the coming Newsletter editions.

Summer maintenance

Extensive maintenance work is foreseen during the coming summer period. The interferometer will be operated in the 4-antenna mode for at least 4 months. As last year, we plan to start the maintenance by the end of May, at the latest, and to operate the Plateau de Bure array in 4 antenna configurations between June and September.

New Web page

A Web page now sums up all the information needed to prepare the submission of proposals on the Plateau de Bure interferometer and to prepare the reduction of the interferometric data. Just CLIC on:

http://iram.fr/PDBI/bure.html

Roberto Neri

Call for proposals

ELECTRONIC PROPOSAL SUBMISSION

Astronomers interested in proposing observations with IRAM instruments may now use the new Web-based electronic submission facility. The previous ways of submitting proposals, postal mail and fax, are still available. We intend to replace these in the near future by electronic submission, following the procedure described below. Note that submissions by ordinary e-mail will not be accepted.

One of the main advantages of electronic submission is that proposals can be faithfully copied on paper. Proposals using greyscale figures are notoriously difficult to copy, particularly when sent by fax. It is stronly suggested that such proposals be submitted electronically. The program committee who was surprisingly tolerant in the past when confronted with unreadable figures may be less indulgent now.

All three types of proposal submission have the same deadline:

March 8, 1999 24:00 (MET)

The principal investigator of each proposal will be notified shortly after the deadline by the scientific secretary that his/her proposal has been properly registered.

You will find all the instructions for the electronic proposal submission facility on the following Web-page:

http://iram.fr/submission/submission.html

The electronic submission facility will be enabled from the date of publication of this Newletter until the submission deadline.

Roberto Neri, Alain Perrigouard, Clemens Thum

CALL FOR OBSERVING PROPOSALS ON THE PLATEAU DE BURE INTERFEROMETER

Observing proposals are invited for the IRAM Plateau de Bure Interferometer (PdBI) for the period May 15, 1999 to November 15, 1999. The deadline for applications is March 8th, 1999 24:00h (MET)). Applications may now be submitted via the World-Wide-Web using the new *electronic proposal submission* facility.

IRAM expects to schedule and complete between 30 to 50 projects in this period, with an elapsed time of at least two months between start and end of any given project. Selection will be based on scientific merit, technical feasibility, and adequacy to the instrument.

Details of the PdBI and the observing procedures are given in the document "*An Introduction to the Plateau de Bure Interferometer*". A copy can be obtained from the address below via Internet (use IRAM's home page at `http://iram.fr`). Proposers should read this document carefully before submitting any proposal.

Applications sent by fax or postal mail should be addressed to:

IRAM Scientific Secretariat
Interferometer Observing Proposal
300 Rue de la Piscine
F-38406 Saint Martin d'Hères Cedex
FRANCE

Proposal templates and the Latex style file (proposal.sty) may be obtained by anonymous ftp from `iram.fr` (directory `dist/proposal`) or via the Web at http://iram.fr/proposal/proposal.html. In case of problems, contact the secretary, Cathy Berjaud.

We encourage the use of the electronic submission facility. Proposals sent by e-mail, however, will *not* be accepted. *Do not use characters smaller than 11pt*, which could make your proposal illegible when copied or faxed. For the same reasons, also avoid sending by fax figures with grey scale maps. In case your proposal reaches us in time, but is incomplete or unreadable when copied, we will try out best to contact you. The Principal Investigator will receive by return mail an acknowledgement of receipt and the proposal number.

The scientific aims of the proposed programme should be explained on 2 pages of text *maximum*, plus up to two pages of figures, tables, and references. Proposals should be self-explanatory, clearly state these aims, and explain the need of the Plateau de Bure interferometer.

In all cases, indicate on the first page whether your proposal is (or is not) the *resubmission* of a previously rejected proposal or the *continuation* of a previously accepted proposal. In case of a resubmission, state very briefly in the introduction why the proposal is being resubmitted (e.g. improved scientific justification).

For this call for proposals, please note the following specificities.

Backup Projects for the May-Nov. 1999 period

Because of heavy antenna maintenance, not all the backup projects for the summer period will be scheduled. *We urge proposers to re-submit them* unless they have explicitly been notified of their effective scheduling.

Proposal category

Proposals should be submitted for one of the five categories:

1.3mm: Proposals that ask for 1.3mm data *only*. 3mm receivers will be used for pointing and calibration purposes, but cannot provide any imaging.

3mm: Proposals that ask for 3mm data *only*. 1.3 mm receivers can still be used to provide either phase stability information or purely qualitative information such as the mere existence of fringes.

dual freq.: Proposals that ask for dual-frequency observations (i.e. simultaneous observations at 3mm and 1.3mm).

time filler: Proposals that have to be considered as background projects to fill in periods where the atmospheric conditions do not allow mapping, or eventually, to fill in gaps in the scheduling, or even periods when only a subset of the standard 4 and 5-antenna configurations will be available. These proposals will be carried out on a "best effort" basis only.

special: Exploratory proposals: proposals whose scientific interest justifies the attempt to use the PdB array beyond its guaranteed capabilities. This category includes for example non-standard frequencies for which tuning cannot be guaranteed, non-standard configurations and more generally all non-standard observations. These proposals, if accepted, will be carried out on a "best effort" basis.

The proposal category will have to be specified *on the proposal cover sheet* and should be carefully chosen by the proposers.

Configurations

Standard configurations for the summer period are:

5 antenna configurations	
Name	Stations
D	W05 W00 E03 N05 N09
C1	W05 W01 E10 N07 N13
C2	W12 W09 E10 N05 N15
B1	W12 E18 E23 N13 N20
B2	W23 W12 E12 N17 N29

Part of the projects will have to be scheduled during the maintenance period (June–September) where only 4-antennas will be available. These projects will be properly adjusted in observing time and uv-coverage.

The following configuration sets are available:

Set	Configs	Main purpose
D	D	"Low" resolution at 1.3 mm
CD	D, C2 or C1	3.5″ resolution at 3mm, 1.8″ resolution at 1.3 mm
CC	C1, C2	Slightly higher resolution than CD.
BC	B1, C2	2″ resolution at 3 mm
BB	B1, B2, C2	Better sensitivity than BC

There is a possibility of choice between CD and CC arrays when the C2 configuration has been performed for sources in which the resolution choice is unclear. At a higher resolution level, a similar choice between CC and BC or BB is possible. Note that configuration A *will not be scheduled* for the summer session.

Finally, enter ANY in the proposal form if your project doesn't need any particular configuration.

Receivers

All antennas are equipped with fully operational dual frequency receivers. The available frequency range will be 82 GHz to 116 GHz for the 3mm band, and 210 to 245 GHz for the 1.3 mm band. The 3mm and 1.3mm receivers are aligned to within about 2″.

Below 110 GHz, receivers offer best performances in LSB tuning with high rejection (20 dB): expected system temperatures are 100 to 200 K (T_R^* scale) for the summer time. Above 110 GHz, best performances are obtained with USB tuning, low rejection (4 to 6 dB): expected system temperatures are 300 K at 115 GHz. DSB tuning is possible over the whole frequency range, but the system temperature may degrade significantly.

The 1.3 mm receivers give DSB tuning with typical T_{REC} below 50 K. Expected SSB system temperatures are 400 to 500 K. The guaranteed tuning range is 210-245 GHz, but it may be possible to reach lower frequencies for specific cases. Higher frequencies are not feasible because of limitations in the triplers.

1.3mm band observations

Experience based on the past years shows that 1.3 mm observations are seldom feasible in summer time, and that such observations are possible only for objects transiting during the night of the August to October period. Accordingly, 1.3mm or dual-frequency projects for other objects will be considered as "Category 4" proposals, i.e. will be carried out on a best effort basis only, weather permitting.

Note that the field of view at 1.3 mm is very restricted (about 20″).

Atmospheric phase compensation

Software is available to provide real-time atmospheric phase compensation on spectral and continuum data, as well as a-posteriori processing for continuum data. Experience shows that a final phase noise below 30 degrees at 230 GHz is obtained under favorable circumstances.

Signal-to-Noise ratio

The rms noise can be computed from

$$\sigma = \frac{J_{\rm pK} T_{\rm SYS}}{\eta\sqrt{N_{\rm a}(N_{\rm a}-1)N_{\rm c}TB}} \qquad (1)$$

where

- $T_{\rm SYS}$ is the system temperature in T_r^* scale (150 K below 110 GHz, 300 K at 115 GHz, 500 K at 230 GHz)
- $J_{\rm pK}$ is the conversion factor from Kelvin to Jansky (22 at 3mm, 30 at 1.3mm)
- η is an efficiency factor due to atmospheric phase noise (0.9 at 3 mm, 0.6 at 1.3 mm)

- N_a is the number of antennas (4 or 5), and N_c is the basic number of configurations (with 5 antennas 1 for D, 2 for CD, 3 for BC)
- T is the integration time per configuration in seconds (3 to 8 hours, depending on source declination)
- B is the channel bandwidth in Hz (500 MHz for continuum, 40 kHz to 2.5 MHz for spectral line, according to spectral correlator setup)

Coordinates and Velocities

The interferometer operates in the J2000.0 system. For best positioning accuracy, source coordinates *must* be in the J2000.0 system; position errors up to 0.3″ may occur otherwise.

Please do not forget to specify LSR velocities for the sources. For pure continuum projects, the "special" velocity `NULL` (no Doppler tracking) can be used.

Coordinates and velocities in the proposal MUST BE CORRECT: A coordinate error is a potential cause for proposal rejection.

Correlator

The correlator has 6 independent units, each being tunable anywhere in the 110-610 MHz band, and providing 4 choices of bandwidth/channel configuration: 160 MHz/64, 80 MHz/128, 40 MHz/256 and 20 MHz/256. For the 40, 80 and 160 MHz bandwidths, the two central channels may be perturbed by the Gibbs phenomenon (depending on continuum strength): it is recommended to avoid centering the most important part of the lines in the middle of the band of the correlator unit.

The 6 units can be independently placed either on IF1 (3 mm receiver) or on IF2 (1.3 mm receiver).

40 KHz resolution

One (and *only one*) of the 6 units has been retrofitted to offer a higher frequency resolution (40 kHz instead of 80 kHz). This is obtained by operating at half clock speed and inserting an anti-aliasing filter of effective bandwidth 8 MHz. Because the filter reduces the input power to the sampler, this unit should be placed near the maximum amplitude of the IF bandpass: band edges must be avoided.

Sun Avoidance

For safety reasons, the radius of the sun avoidance circle has been extended to 45 degrees. Please take this into account for your sources *and* for the calibrators.

Mosaics

The PdBI has mosaicing capabilities, but the pointing accuracy may be a limiting factor at the highest frequencies. Please contact R. Neri in case of doubts.

Data reduction

Proposers should be aware of constraints for data reduction:

- In general, data should be reduced in **Grenoble**. Proposers will not come for the observations, but will have to come for the reduction.
- We keep the data reduction schedule very flexible, but wish to avoid the presence of more than 2 groups at the same time in Grenoble. Please contact your *local contact* well in advance (see below).
- IRAM may consider splitting the data reduction in two phases: intermediate calibration and final mapping. Such a splitting is often necessary for the high resolution images. In such a case, the proposers must be ready to come to IRAM for fast data reduction of the "compact" configurations.
- CLIC is still evolving fast to cope with the evolution of the PdBI array. The newer versions are upward compatible with the previous releases, but the reverse is not true. Observers wanting to finish data reduction at their home institute should obtain an updated version of CLIC, which is now available. Because differences between CLIC versions may potentially result in imaging errors if new data are reduced with an old package, we insist that observers having a copy of CLIC take special care in maintaining it up-to-date.

Data reduction will be carried out on the dedicated HP workstations.

Local contact

A local contact will be assigned to every proposal which does not involve an in-house collaborator. Depending upon the programme complexity, IRAM may require an in-house collaborator instead of the normal local contact.

Technical pre-screening

All proposals will be reviewed for both scientific interest and technical feasibility. Please, help us in this latter task by submitting technically precise proposals. Note that your proposal must be complete and exact: **velocities, position and frequency setup must be exactly specified**.

Non-standard observations

Please contact R.Neri, R.Lucas, or S.Guilloteau in case of doubt about non-standard program feasibility.

The documentation for the IRAM Plateau de Bure Interferometer includes documents of general interest to potential users:

- An Introduction to the IRAM Plateau de Bure Interferometer.
- IRAM Plateau de Bure Interferometer: Calibration CookBook.
- IRAM Plateau de Bure Interferometer: Mapping CookBook.
- IRAM Plateau de Bure Interferometer: Frequency Setup.
- CLIC: Continuum and Line Interferometer Calibration.

More specialized documents are also available; they are intended for observers on the site (IRAM on-duty astronomers, operators, or observers with non-standard programs):

- IRAM Plateau de Bure Interferometer: OBS Users Guide.
- IRAM Plateau de Bure Interferometer: Amplitude Calibration.
- IRAM Plateau de Bure Interferometer: Flux Measurements.
- IRAM Plateau de Bure Interferometer: Pointing Parameters.
- IRAM Plateau de Bure Interferometer: Trouble Shooting Guide.

All documents can be retrieved via Internet from the WWWeb IRAM home page `http://iram.fr/`

> Finally, we would like to stress again the importance of the quality of the observing proposal. The technical preparation of observing proposals is unfortunately often insufficient. In the past, proposals were received which did not even include exact observing frequencies or even source coordinates, or worse, with coordinates with the wrong epoch !... The IRAM interferometer is a powerful, but complex and unique instrument, and proposal preparation requires special care. Information is available in the documentation and at http://iram.fr/PDBI/bure.html. The IRAM staff can help in case of doubts if contacted well before the deadline. Note that the proposal should not only justify the scientific interest, but also demonstrate how the Plateau de Bure interferometer will bring new information.

Roberto Neri

CALL FOR OBSERVING PROPOSALS ON THE 30-M TELESCOPE

Summary

The *next deadline* for the submission of observing proposals for the IRAM 30m telescope is March 8th, 1999 24:00h (MET). The scheduling period extends from May 15, 1999 to November 15, 1999, covering roughly the summer period at Pico Veleta. Proposals will be considered only for the observatory's standard heterodyne receivers at wavelengths of 3, 2 and 1.3 mm. Emphasis will be put on proposals for 3 and 2 mm.

Roughly 3000 hours of observing time will be available, which should allow scheduling of a few longer programmes (up to $\sim$ 150 hours).

The main news, proposal formalities, details of the various receivers, and observing modes are described below.

The new receiver cabin

The receiver cabin, which was completely rebuilt last September, has since been used without major problems. In particular, all four new generation receivers (A100, A230, B100 and B230; designated according the dewar A or B they are housed in and according to the frequency, in GHz, they are centered on) perform as expected (see IRAM Newsletter No. 36 and below). The automated tuning available with the new receivers gives fast and reproducible results. Owing to the strong rejection of the image band in all new receivers and to the new calibration unit, the precision of the temperature calibration is now improved.

A backup dual frequency receiver has been built so that it may be expected that two receivers (orthogonally linearly polarized) will always be available for each of the 3 and 1.3 mm atmospheric windows during the upcoming scheduling period. The 2mm window will be served with the old `2MM` receiver.

What else is new ?

In addition to the two traditional ways of submitting IRAM proposals, by normal mail and by fax, we now accept proposals submitted electronically (see two sections above). A new tool is available for estimating the total observing time needed for a given observation. This new Time Estimator is described in the contribution by David Teyssier in the next section of this Newsletter. Use of the Time Estimator which employs the most recent receiver and telescope data is recommended for all technically standard proposals.

Applications

Valid proposals, whichever way they are submitted, consist of the official cover page, up to two pages of text describing the scientific aims, and up to two more pages of figures, tables, and references. The official cover page, in postscript or in Latex format, may be obtained by anonymous ftp from `iram.fr` in directory `dist/proposal`, as well as a Latex style file `proposal.sty`; or on the World Wide Web at URL `http://iram.fr/`. In case of problems, contact the secretary, Cathy Berjaud (e–mail: `berjaud@iram.fr`). *Do not use characters smaller than 11pt*, which could make your proposal illegible when copied or faxed. For the same reasons, also avoid sending figures with grey scale maps except when the proposal is submitted electronically. Applications should be addressed to:

IRAM Scientific Secretariat,
Domaine Universitaire de Grenoble
300, rue de la piscine,
F-38406 St. Martin d'Hères, France.

All proposals must reach the Secretariat before March 8th, 1999 24:00h (MET). Proposals sent by Fax ((33/0) 476 42 54 69) will be accepted, provided they arrive in a readable form. Except for a duplicate of the source list (see below), no proposal should be sent by e–mail. The Principal Investigator will receive by return mail an acknowledgement of reception and a proposal number.

To avoid the allocation of several numbers per proposal, send *only one* copy of your proposal, either by mail or by fax or electronically.

On the title page, you must fill out the line 'special requirements' if you request either spectral line on-the-fly observations, or the polarimeter, service or remote observing, or specific dates for time dependent observations. If there are periods when you cannot observe for personal reasons, please specify them here; beware, however, that such personal restrictions could make your observations difficult or impossible to schedule.

We insist upon receiving, with proposals for heterodyne receivers, a complete list of frequencies corrected for source redshift (to 0.1 GHz) Also specify on the cover sheet which receivers you plan to use.

In order to avoid useless duplication of observations and to protect already accepted proposals, we keep up a computerized list of targets. We ask you to fill out carefully your source list. This list must imperatively contain *all the sources (and only those sources)* for which you request observing time. To allow electronic scanning of your source parameters, your list must be typed or printed following the format indicated on the proposal form (please, *do not hand write*). If your source list is long (e.g. more than 15 sources) you may print it on a separate page, *keeping the same format.*

The scientific aims of the proposed programme should be explained in 2 pages of text *maximum*, plus up to two pages of figures, tables, and references. Proposals should be self-explanatory, clearly state their aims, and explain the need of the 30m telescope. The amount of time requested should be carefully estimated and justified . It should include all overheads (see below).

A scientific project should not be artificially cut into several small projects, but should rather be submitted as one bigger project, even if this means 100–150 hours.

If time has already been given to one project but turned out to be insufficient, explain the reasons, e.g. indicate the amount of time lost due to bad weather or equipment failure; if the fraction of time lost is close to 100%, don't rewrite the proposal, except for an introductory paragraph. For continuation of proposals having led to publications, please give references to the latter.

In all cases, indicate on the first page whether your proposal is (or is not) the *resubmission* of a previously rejected proposal or the *continuation* of a previously accepted 30m telescope proposal. In case of a resubmission, state very briefly in the introduction why the proposal is being resubmitted (e.g. improved scientific justification).

Reminders

A handbook ("The 30m Manual") collecting most of the information necessary to plan 30-m telescope observations is available [10]. The report entitled "Calibration of spectral line data at the IRAM 30m telescope" explains in detail the applied calibration procedure. Both documents can be retrieved through the IRAM Granada web pages (http://www.iram.es). A catalog of well calibrated spectra for a range of sources and transitions (Mauersberger et al. [13]) is very useful for monitoring spectral line calibration.

The On-the-Fly observing mode (OTF) is available for heterodyne observations since more than two years. Considerable progress was made in making the control of the observations and the data reduction user friendly. Documentation is available on the web (http://www.iram.es). Due to the complexity of the OTF observing mode we advise proposers without a demonstrated experience of this technique on the 30m telescope to consult, or if opportune even involve in their proposal, an astronomer with such experience. David Teyssier of the Granada staff (e–mail: `teyssier@iram.es`) serves as the principal contact in OTF matters.

Frequency switching is available. It used to yield satisfactory baselines within certain limitations (maximum frequency throw of 45 km/s, backends, phase times etc.; for details see [8]). At present, up to 3 receivers can be frequency switched simultaneously. Baselines are ordinarily flatter when using one single receiver. Little experience exists however with the new generation receivers.

Many proposers underestimate the time needed to carry out their programme, even under excellent weather conditions. We ask you to pay special attention to this matter as a serious time underestimate may be considered as a sure sign of sloppy proposal preparation. The new Time Estimator tool hopefully helps to avoid such problems.

Observing time estimates

Observing time estimates must take into account:

- integration time on source and comparison field(s), including overheads for ON/OFF telescope motions, deadtime for device switching and data transfer.
- pointing, focus, continuum and line calibrations
- telescope slew motions
- receiver tunings

A technical report explaining how to estimate the telescope time needed to reach a given sensitivity level in various modes of observation was published in the January 1995 issue[1] of the IRAM Newsletter [9]. It has been included in the 30-m telescope Manual [10]. *You are asked to follow the guidelines given in this report (or to justify particular requirements) in your proposal.*

A new Time Estimator is now available on the IRAM web pages. It is described in the contribution by David Teyssier in this Newsletter. This tool handles all spectroscopic observing modes, albeit in slightly simplified forms, available at the 30m telescope. For the simplest, but most frequent observing strategies a realistic total observing time is calculated which includes all relevant dead times, various calibration observations, receiver tuning, and a minimum of other checks. Since the tool uses the most recent receiver and telescope parameters, it gives in most cases the best available estimate of the total observing time. Novice users of the 30m telescope are particularly invited to use this tool in order to avoid the serious underestimation of observing time noted sometimes in previous proposals.

Service observing

To facilitate the execution of short (≤8 h) programmes, we propose "service observing" for some easy to observe (e.g. short, single source) programmes *with only one set of tunings.* Observations are made by the local staff using precisely laid–out instructions by the principal investigator. For this type of observation, we request an acknowledgement of the IRAM staff member's help in the forthcoming publication. If you are interested by this mode of observing, specify it as a "special requirement" in the proposal form. IRAM will decide which proposals can actually go to that mode.

Remote observing

This observing mode where the remote observer actually controls the observations very much like on Pico Veleta, is available from the downtown Granada office as before, but now also from Grenoble. The prospective remote observer receives a quick introduction into the peculiarities of this observing mode, but full time support like on the telescope is not available. Therefore this observing mode is restricted to technically easy projects and to experienced 30m users. Economic aspects suggest that the duration of remote observations from Grenoble should not exceed about 40 hours. The prospective remote observer should note "remote observing from Grenoble or Granada" as a special requirement in the proposal cover sheet.

[1] electronically available by anonymous ftp at `iram.fr`, directory `dist/newsletter/jan95`, or via the WWW at URL `http://iram.fr/newsletter/`

Technical Information about the 30m Telescope

This section gives all the technical details of observations with the 30m telescope that the average user will have to know. See also the concise summary of telescope characteristics published on the IRAM web pages.

Heterodyne Receivers

The optical layout of the new receiver cabin allows simultaneous observations with up to 4 heterodyne receivers like in the past. Table 2 lists the combinations expected to be possible in the upcoming scheduling period. A100 and A230 refer to the new generation receivers centered at 100 and 230 GHz, respectively, and housed in Dewar A. which is served in reflection by the beam divider. B100 and B230 are the orthogonally polarized receivers housed in dewar B. The 2MM receiver is served in transmission.

Table 2: Receiver combinations.

	possible combinations	
receivers	4–Rx	3–Rx
A100	*	
A230	*	
2MM		*
B100	*	*
B230	*	*

The new generation receivers A100 and A230

These receivers, housed in dewar A, admit beams which are, in Nasmyth coordinates, horizontally polarized.

The nominal tuning range of the receiver A100 (H–linear polarization in Nasmyth coordinates) is 83.5 – 115.5 GHz; its IF bandwidth is about 500 MHz. SSB receiver noise temperature is 80 K or less over the entire band; the image side band rejection is at least 20 dB. The receiver may actually tune to somewhat lower than nominal frequencies (down to ∼ 80 GHz), but performance is not guaranteed.

The receiver A230 can nominally be tuned between 200 and 255 GHz. SSB receiver noise temperature ranges between 100 K near 220 GHz and 300 K at the highest frequencies. At 230.5 GHz, values near 150 K were measured. Image band rejection is of the order of 10 dB, the radio frequency bandwidth is $\sim$ 1 GHz at 3 dB[2]. The receiver may actually tune to somewhat higher than nominal frequencies (up to $\sim$ 266 GHz), but performance is not guaranteed.

Both receivers can be tuned entirely from the control room. Tuning is rapid and repeatable, usually not exceeding 20 min for all 4 new generation receivers.

The new generation receivers B100 and B230

These receivers are housed in dewar B admitting (in Nasmyth coordinates) vertically polarized beams. These receivers perform very much like those in dewar A with respect to noise, image band rejection, IF bandwidth, and nominal tuning range. Please consult the Time Estimator for details.

B100 replaces the decomissioned receiver `3MM1` as the standard pointing receiver.

New dewars C and D

The plan for the refurbishment of the receiver cabin forsees installation of two more pairs of new generation receivers housed in dewars C and D. Work on these dewars, which are expected to have each a pair of mixers centered at 2mm and a higher frequency, is well advanced, but not enough to make them available during the next observing session.

`2MM` *Receiver*

This "old" generation receiver still has good and reliable performance over most of its band from 129 GHz to 183 GHz.The instantaneous IF bandwidth is 500 MHz. Receiver temperatures ranges from 70 to 150 K (130 to 155 GHz), and 150 to 400 K (155 to 183 GHz).

Polarimetry

Polarimeters have been constructed by IRAM for measurements of *circular* polarization. They have already been used on the telescope (see e.g. the March 1994 issue of the IRAM Newsletter). These polarimeters have been modified for the optical layout of the new receiver cabin, but no experience of their performance exists yet. In case you consider observations of circular polarization, please contact IRAM (preferentially B. Lazareff or C. Thum) to discuss what might actually be possible.

A new IF polarimeter has been built and will be tested at the telescope soon. This polarimeter which can work at any frequency where two orthogonally polarized receivers are available measures all Stokes parameters for spectra no wider than 20 MHz. Proposals are invited for this polarimeter, but they will be scheduled only if and inasmuch as the tests of the instrument turn out to be positive. Interested observers are invited to check with the undersigned.

[2] Note that the 1 GHz bandwidth can presently be used only with the 1 MHz filterbank in 1GHz mode

Efficiencies and error beam

The telescope efficiencies (main beam and aperture efficiency) are given in Appendix A of "The 30m Manual" and the IRAM newsletter No. 18, (November 1994). A one–page summary of the telescope system is on the web (http://www.iram.es/Telescope/systsumm.ps).

At 1.3 mm (and a fortiori at shorter wavelengths) a large fraction of the power pattern is distributed in an error beam which can be approximated by two Gaussians of FWHP $\simeq 170''$ and $800''$ (see [16, 1] for details). Astronomers should take into account this error beam when converting antenna temperatures into brightness temperatures.

The aperture efficiency depends somewhat on the elevation, particularly at shorter wavelengths. This gain/elevation effect is evaluated in [15].

Backends

There are 3 types of spectral line backends which can be individually connected to any receiver.

- The 1 MHz filterbank, consisting of 4 units with 256 MHz each. The units can be connected to different or the same receivers giving bandwidths between 256 MHz and 1024 MHz. The maximum bandwidth of 1 GHz is available for only one receiver, naturally one having a 1 GHz wide IF bandwidth like A230. Connection of the filterbank in 1 GHz mode presently excludes the use of any other backend with the same receiver.
  Other configurations of the 1 MHz filterbank include a setup in 2 units of 512 MHz connected to two different receivers, or 4 units connected to up to four different receivers. Each unit can be shifted in steps of 32 MHz relative to the center frequency of the connected receiver.
- The 100 kHz filterbank, consisting of 256 channels of 100 kHz. It can be split into two halves, each movable inside the 500 MHz IF bandwidth, and connectable to two different receivers.
- The autocorrelator backend with up to 2048 channels. Available nominal resolutions are 10, 20, 40, 80, 320 and 1250 kHz. Nominal bandwidths range from 20 MHz to 2 $\times$ 512 MHz, depending on resolution. The correlator can be split into 8 independent subbands, each of which can be configured individually, shifted inside a 500 MHz IF band, and connected to the same or different receivers. For the larger bandwidths (i.e. more than one subband of 80 MHz) there is often a problem of platforming, i.e. baselines from the different subbands have slightly different power levels.

Pointing / Focusing

Pointing sessions are made every one to two weeks; at present, the fitted pointing parameters yield an absolute rms pointing accuracy of better than 3″ [14]. The relative alignment of the various receivers is of the order of 2″ and is much more stable in the new cabin than it was before. Checking the pointing, focus, and receiver alignment is the responsibility of the observers (use a planet for alignment checks). Systematic (up to 0.3 mm) differences between the foci of various receivers are present. It is recommended to focus on the 1mm receiver when used. The foci should be carefully monitored. Not doing so may result in broadened and distorted beams ([1]).

Wobbling Secondary

- the maximum beam–throw is 240″, but smaller for wobbling frequencies faster than 1 Hz.
- Standard phase duration: 2 sec for spectral line observations, 0.25 sec for continuum observations.

References

[1] *Appendix I: Error beam and side lobes of the 30 m telescope at 1.3 mm, 2 mm and 3 mm wavelength* in: Molecular Spiral Structure in Messier 51, S. Garcia-Burillo, M. Guélin, J. Cernicharo 1993 Astron. Astrophys. **274**, 144-146.

[2] *A Small Users' Guide to NOD2 at the 30m telescope* A. Sievers (Feb. 1993)

[3] *Thermal behaviour of mm-wavelength radio telescopes* A. Greve, M. Dan, J. Penalver 1993, IEEE Trans. Ant. Propag. AP–40, 1375

[4] *Interferometric measurement of tropospheric phase fluctuations at 86 GHz* L. Olmi, D. Downes 1992 (IRAM report 238)

[5] *Thermal design and thermal behaviour of Radio Telescope structures* A. Greve 1992 (IRAM report 253)

[6] *Astigmatism in reflector antennas: measurement and correction* A. Greve, B. LeFloch, D. Morris, H. Hein, S. Navarro 1994, IEEE Trans. Ant. Propag. AP–42, 1345

[7] *Design parameters and measured performance of the IRAM 30-m millimeter radio telescope* J. Baars, A. Greve, H. Hein, D. Morris, J. Penalver, C. Thum 1993, Proc. IEEE 82, 687

[8] Frequency switching at the 30m telescope C. Thum, A. Sievers, S. Navarro, W. Brunswig, J. Peñalver 1995, IRAM Tech. Report 228/95.

[9] *Cookbook formulae for estimating observing times at the 30m telescope* M. Guélin, C. Kramer, and W. Wild; (IRAM Newsletter January 1995 http://iram.fr/newsletter/jan95/jan95.html)

[10] *The 30m Manual: A Handbook for the 30m Telescope* W. Wild 1995, IRAM Tech. Report 377/95, also available on WWW pages.

[11] *NIC: Bolometer User's Guide* D. Broguiere, R. Neri, A. Sievers 1996, IRAM Tech. Report.

[12] *Pocket Cookbook for MOPS software* R. Zylka 1996.

[13] *Line Calibrators at λ = 1.3, 2, and 3mm* R. Mauersberger, M. Guélin, J. Martín–Pintado, C. Thum, J. Cernicharo, H. Hein, and S.Navarro 1989, A&A Suppl. 79, 217

[14] *The Pointing of the IRAM 30m Telescope* A. Greve, J.–F. Panis, and C. Thum 1996, A&A Suppl. Ser., 115, 379

[15] *The gain–elevation correction of the IRAM 30m Telescope* A. Greve, R. Neri, and A. Sievers 1998, A&A Suppl. Ser., 132, 413 – 416

[16] *The beam pattern of the IRAM 30m Telescope* A. Greve, C. Kramer, and W. Wild 1998, A&A Suppl., 133, 271 – 284

These reports are available upon request (see also previous Newsletters). Please write to Mrs. C. Berjaud, IRAM Grenoble (e–mail: `berjaud@iram.fr`).

Clemens Thum, Wolfgang Wild

A NEW TIME ESTIMATOR FOR THE 30-M TELESCOPE

At a time when the receiver hardware at the 30-m telescope undergoes rapid and profound changes, it becomes difficult to prepare adequately an observing session. A Time Estimator tool, which incorporates the most recent receiver and telescope parameters was written to help the preparation of *spectral-type* observations. This tool may be especially useful for observers unfamiliar with the IRAM 30-m telescope.

The Time Estimator, which is available on the IRAM web pages in Spain and France (http://iram.es, http://iram.fr), provides a realistic estimate of the *total* telescope time needed to reach a specified rms noise in a particular observing mode with a specified receiver and backend configuration. In the final output table (an example is shown in Fig. 7), the total telescope time is broken down into several essential components, and the overall observing efficiency (ON source integration time over total telescope time) is calculated.

Figure 7: Final output table of the Time Estimator.

Operation	*Time spent*	*Percentage time*
Receiver tuning (4 receiver(s))	20 minutes	~ 7.3
Preparation time (observation of a Line Calibrator)	20 minutes	~ 7.3
Pointing, focus, calibration	49 minutes	~ 18.1
Effective Position Switching time (5 sources)	3.0 hours with 1.3 hours of ON SOURCE integration time.	~ 66.8 ~ 29.5
Efficiency Ratio	**0.295**	

Since up to 4 receivers can be used simultaneously on the 30m telescope and since many observing modes are available, the number of ways to observe is very large. In

Figure 8: Main input table of the Time Estimator.

Receiver	Line Freq. in GHz	Expected r.m.s. in K in the Ta* scale	Backend	Resolution for Autoco. if used.	Spectral Resolution in km/s, in case of spectral smoothing
A100	109.78	0.05	Autoco.	80 kHz	
B100	110.20	0.05	Autoco.	80 kHz	
C150			1 MHz	10 kHz	
A230	219.56	0.05	Autoco.	80 kHz	
B230	220.39	0.05	Autoco.	80 kHz	

order to keep the Time Estimator manageable and attractive the tool currently handles only the two most used types of spectroscopic observations, namely (i) observations of a number of sources with one single set of frequencies and (ii) observations of one source with several (up to five) frequency sets. All the main observing modes (position switching, wobbler switching, raster mapping, frequency switching, and on–the–fly) are available. The optical compatibility of the requested receivers is checked, and the losses due to the Martin–Puplett interferometers at the specified frequencies are explicitly taken into account. Allowance is made for all relevant dead times, including telescope slew times, pointing, focus, and hot-cold calibrations. The typical time needed for the tuning of the receivers and a minimum of related checks is also taken into account.

The Time Estimator takes input from several templates such as the one shown in Fig. 8. Convenient links to an extensive help page are provided. Input and output are on two separate, but connected web pages. Switching back and forth between these pages allows a rapid optimization of the observational parameters for a given telescope time. A very compact summary text (in LaTeX) can be generated at the end for possible inclusion in a proposal.

A further version of the Time Estimator which covers continuum-type observations with the bolometer array is planned. In the meantime, it is hoped that the current version is widely used and found useful and that the gross underestimations of the observing time occasionally made by observers will be avoided. Please, send your comments on the current version 1 of the Time Estimator to the undersigned (`teyssier@iram.es`).

David Teyssier

LOSSES IN THE MARTIN-PUPLETT INTERFEROMETER DIPLEXERS

In response to questions from observers, and to complement the time estimator described above, the receiver group has prepared some general information about the MPI diplexer that is used with the new dual-channel receivers.

The essential features of the diplexer are described in a short *MPI Guide* that can be found from the `iram.fr` web page by going to *Technical activities*, then to *Receiver group*. A *MPI simulator* is also provided. The essential points worth mentioning here are:

- Diplexing losses are below 2.5% for 90% of random frequency pairs; this refers to losses due purely to the frequency diplexing scheme, over and above other optical losses.
- Try to avoid the following frequency ratios within one cryostat (A or B): $\frac{3}{1}$, giving 15% diplexing loss; $\frac{5}{2}$, giving 5% diplexing loss.
- Diplexing losses are generally small enough that it is not worth to ask the engineer, as in the past, to optimize for just one receiver. If you really want to do this, just assign to the "other" receiver a fictitious frequency such that the ratio of frequencies has, in irreducible form, an even numerator.

B.Lazareff

The beam pattern of the IRAM 30-m telescope

A. Greve([1]), C. Kramer([2,3]), W. Wild([2])
([1]) IRAM, 300 rue de la piscine, F-38406 St Martin d'Hères, France
([2]) IRAM, Nucleo Central, Avda. Divina Pastora 7, E-18102 Granada, Spain
([3]) I. Physikalishes Institut, Universität zu Köln, Zülpicher Strasse 77, D-50937 Köln, Germany
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Total power scans across the Moon around New Moon (mostly day time) and Full Moon (night time) at 3.4 mm (88 GHz), 2.0 mm (150 GHz), 1.3 mm (230 GHz), and 0.86 mm (350 GHz) wavelength are used to derive the beam pattern of the IRAM 30–m telescope to a level of approximately –30 dB (0.1 %) and, dependent on wavelength, to a full width of 1000 – 1400″. From the reflector surface construction and application of the antenna tolerance theory we find that the measurable beam consists of the diffracted beam, two underlying error beams which can be explained from the panel dimensions, and a beam deformation mostly due to large–scale transient residual thermal deformations of the telescope structure. In view of the multiple beam structure of the 30–m telescope, and of other telescopes with a similar reflector construction of (mini–)panels and panel frames, we summarize the antenna tolerance theory for the influence of several independent surface/wavefront deformations. This theory

Table 3: Efficiency parameters of the IRAM 30–m telescope **(after July 1997).**

Wavel./Freq. [mm]/[GHz]	θ_b [″]	θ_{fb} [″]	ϵ_{ap} [%]	B_{eff} [%]	F_{eff} [%]	ϵ_M [%]	$S/T_A{}^*$ [Jy/K]	P_1 ($\theta_{e,1}$) [%] (″)	P_2 ($\theta_{e,2}$) [%] (″)	P_3 ($\theta_{e,3}$) [%] (″)
3.4 / 88	27.5	∼64	61 ± 3	73 ± 3	92 ± 2	94 ± 4	5.9 ± 0.3	3 ± 1 (300)	3 (410)	20 (2500)
2.0 / 150	16.0	∼38	45 ± 3	54 ± 3	90 ± 2	92 ± 4	7.8 ± 0.5	7 ± 3 (175)	8 (280)	25 (1500)
1.3 / 230	10.5	∼25	35 ± 3	42 ± 3	86 ± 2	85 ± 4	9.7 ± 0.9	15 ± 5 (125)	12 (180)	26 (950)
[0.86 / 350	8.5	∼20	16 ± 4	19 ± 4	75 ± 3		22 ± 3	20 ± 5 (85)	20 (160)	30 (580)] *)

Update from the values compiled by Kramer (1997).
The entries of the Table are:
θ_b: beam width (FWHP) (measured); θ_{fb}: full width (to first minimum), $\theta_{fb} \approx 2.4\,\theta_b$ (calculated);
ϵ_{ap}: aperture efficiency (measured & calculated from σ_T^*); B_{eff}: main beam efficiency, $B_{eff} \approx 1.20\,\epsilon_{ap}$;
F_{eff}: forward efficiency (from sky dips), ϵ_M: Moon efficiency (measured);
$S/T_A^* = (2k/A)\,F_{eff}/\epsilon_{ap} = 3.906\,F_{eff}/\epsilon_{ap}$: antenna gain (calculated & measured).
$P_1 - P_3$: relative power of the error beams (calculated). The accuracy of the values is ∼± 5%. The entries of P_1 illustrate the partially transient nature of this error beam. In brackets are given the widths (FWHP) of the corresponding error beams.
* not frequently used frequency and somewhat poorly known telescope performance.
The values valid before July 1997 are published by Kramer (1997) and are found in the 30–m Telescope Manual (Wild).

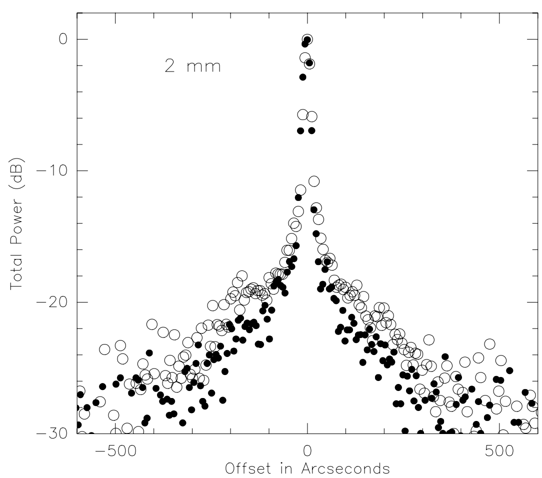

Figure 9: Composite profiles $f_M(u)$ which illustrate the improvement of the reflector surface accuracy; measurements before July1997 (24 Dec 1994): open circles, after July 1997 (19 Nov 1997): solid dots.

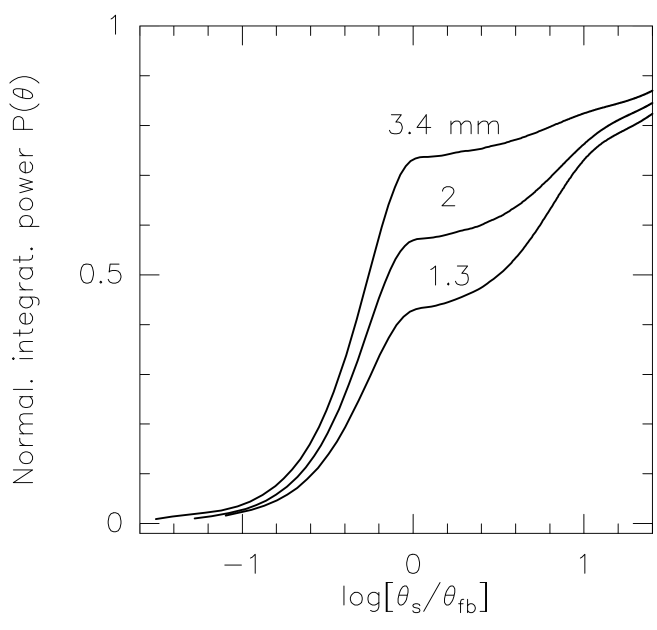

Figure 10: Relative power $P(\Omega)$ (Eq.(24)) received in the solid angle Ω of opening θ_s given in fractions of the full beam width θ_{fb} (Table 2). $P(\Omega)$ at $\theta_s/\theta_{fb} = 1$ is the beam efficiency B_{eff}; the normalization of the curves is made to these values given in Table 1. The values are shown for $\theta_s \lesssim 1000 - 1400''$, i.e. the extent of the profile measurements where also $F_{eff} \approx \epsilon_M$ (Table 1). The remaining energy for larger angles θ_s is mainly in the backward beam and is of the order $1 - F_{eff}$.

makes use of different correlation lengths, which in essence determine the independent error distributions, and of the wavelength–scaling of the diffracted beam and of the error beams.

From the Moon scans we derive the parameters for calculation of the 30–m telescope beam in the wavelength range 3 mm to 0.8 mm as required for the reduction of astronomical observations, in particular of extended sources. The parameters of the beam are primarily for the time after July 1997 when the reflector was re–adjusted and improved to the illumination weighted surface precision of $\sigma_T = 0.065 - 0.075$ mm.

Scientific contribution

The case for a bolometric millimetre camera at the IRAM 30-m telescope

F.–X. Désert(1) and A. Benoit(2)
(1) Laboratoire d'Astrophysique, Observatoire de Grenoble BP 53, 414 rue de la piscine, F–38041 Grenoble Cedex 9 France, e-mail: Francois-Xavier.Desert@obs.ujf-grenoble.fr
(2) CRTBT–CNRS, 25 ave. des Martyrs, BP 166, 38042 Grenoble Cedex 9 France, e-mail: benoit@polycnrs-gre.fr
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We describe here the important astrophysical results that could be obtained by using large format (say 32 × 32) bolometric detectors at 1 and 2 mm with the IRAM 30m telescope: having a confusion–limited 1 mm extragalactic survey containing a large fraction of high redshift objects, mapping star formation regions in our Galaxy at 1 mm, and mapping the Sunyaev-Zeldovich effect at 2 mm in tens of high-redshift clusters. We also show a first optical implementation and the key points of this project.

Scientific goal

The 1 mm source counts

Franceschini et al. (1994, see Burigana et al. 1997), Guiderdoni et al. (1998), Blain et al. (1998a, 1998b) have given number count estimates at the sub–mJy level for a wavelength of 1.3mm, for various galaxy evolution models. It seems that an episode of high rate of star formation is required at high redshift to explain both

- the submillimetre background observed with FIRAS on COBE (Puget et al. 1996, Guiderdoni et al. 1997, Lagache et al. 1998, Fixsen et al. 1998) and with DIRBE on COBE (Hauser et al, 1998)
- and the deep surveys with SCUBA at 850 and 450μm on the JCMT (Hughes et al. 1998, Eales et al. 1998).

We estimate that one can expect to typically observe 1 galaxy per arcmin^2 above a flux of 1 mJy at 1.2 mm. This corresponds to one source per 30 diffraction beams. So a deep survey with the IRAM 30m should aim at confusion–limited maps with a noise per beam of 0.2 mJy. With an estimated sensitivity of 50 mJy.s$^{1/2}$ (see below), this means that the camera field must be observed for 13 hours, to reach that level. In 100 hours of integration, the number of detected sources with flux above 1 mJy (at the 5σ level) can be expected to be about 70. That would be a major breakthrough in order to study the statistics of this population, even allowing for a factor 2 uncertainty in these numbers.

If SCUBA is already finding this population, why should we try to do this in the atmospheric window at 1.2 mm? The answer lies in the now famous positive K–correction that happens for high redshift objects. If SCUBA has a rather strong redshift selection around 3, one can expect a deep 1.2 mm survey to be biased towards redshift 5 objects. Hence, we would probe the evolution of the Universe at large redshifts, for which we know next to nothing. The large collecting area and high angular resolution of the IRAM 30m telescope would give us a substantial advantage in the search of primeval galaxies. At these wavelengths, the galactic cirrus contamination is much less than in the submillimetre domain, because high redshift objects look colder than the high latitude cirrus clouds.

Millimetre interferometers cannot achieve this mapping speed because their field of view is much smaller. Competition with the future LSA/MMA for surveys has to be carefully studied in this research area.

Surveys at 2.1 mm could be quite important as well; see a first BIMA attempt by Wilner & Wright (1997). The confusion limit would be reached at 0.5 mJy (0.4 galaxies per arcmin^2) in probably less time than at 1.2 mm (5σ in a few hours). But this is very much dependent on the assumptions about the very high redshift Universe (z between 4 and 10).

Blank sky surveys should be done in areas where many complementary data have been accumulated. Obviously the HDF, CFRS and deep radio survey fields are prime targets. Mapping fields around clusters seems also a very powerful technique to observe the high redshift Universe, as done with SCUBA by Smail et al. (1997).

Mapping star formation regions

The gain in mapping speed will provide much more information on the cold clouds at the origin of the star formation in our Galaxy and nearby ones but also it will allow to probe the evolution of the circumstellar material around single and multiple young stars.

This is particularly true for some crucial subjects which are today strongly limited by the sensitivity of current bolometer arrays. Among them, one can present here a few major topics:

- *Determination of the initial mass function in nearby star-forming region.* Today many of these studies are performed in the main isotopes of CO in J=2-1 or J=1-0 lines because they are easy to detect. In complement to CO studies, deep and large surveys of the optically thin emission of the dust would strongly improve our knowledge of the clump distribution in cloud interiors (Motte et al. 1998).
- *Sensitive mapping at moderate resolution ($\sim 10''$) of the proto-stars (Class 0 and Class I objects).* These mappings are fundamental because they allow the determination of the total amount of mass surrounding protostars, contrary to mm interferometers which resolve out the extended envelope surrounding these objecs (Gueth et al., 1997).
- *Pre-Main-Sequence Stars (Class II objects)* In the more evolve stage of the TTauri phase, most of the envelope has disapeared and the material is in the form of a Keplerian disk (e.g. DM Tau, Guilloteau

& Dutrey 1998) which remains unresolved by single-dish telescopes. However, sensitive observations of such objects would help to probe the amount of mass in the outer part of the disk and the extended envelope (if any) where the dust escapes the detection threshold of current mm arrays.

- *Young Stars* Finally, we have now several examples of young stars having dusty disks (similar to the Beta Pic disk). Many new objects have been recently detected and mapped at 0.8mm wavelengths with SCUBA around Solar-type and Vega-type stars (Holland et al., 1998). Sensitive surveys of nearby young stars in the northern hemisphere would help a lot to constrain the amount of dust contained in such debris disks.

Mapping the CMB anisotropies

At a wavelength of 2.1 mm, it seems that the measurement of the Sunyaev-Zeldovich effect is the least affected by radio sources and dusty galaxies (see the review by Birkinshaw 1998). Mapping the SZ effect with a comptonisation parameter y sensitivity better than $1.5 \times 10^{-5}\, 1\sigma$ per diffraction beam (20 arcsec FWHM) in the core of clusters would be possible in only ten hours. This would be a factor 10-100 increase in mapping speed as compared to current bolometer experiments like SuZie and Diabolo. This might be crucial for the follow-up of XMM observations (made with a beam of 15 arcsec) of clusters of galaxies. The other Cosmic Microwave Background (CMB) anisotropies at small scales that are and will be detected by other experiments (the Ryle Telescope and the VLA) could receive an independent confirmation–validation at these clean wavelengths. Sensitivity would be the same as quoted above ($\Delta T/T$ units). Millimetre interferometers cannot achieve the sensitivity quoted above for extended sources because of large antennas and the lack of short spacings.

Instrument definition

Requirements

So far, the mapping speed improvements came by adding single elements together. The empirical limit seems to be reached at typically 100 elements. It is limited by the workload (the patience of technicians and engineers: ask SCUBA people for example) of putting things together and by the homogeneity of the array. In general, the worst pixels are pulling down the overall sensitivity of the instrument. Several recent developments in bolometer technology have made integrated arrays possible. Four projects are in various stages of completion: BOLOCAM is an East Coast+Caltech project (Mauskopf & Bock 1998) of 150 integrated 300 mK silicon nitride spider-web pixels with cones separated by one diffraction size to be put at the CSO first and then on the future 50m (at 1 and 2 mm). SHARC (and further) is an operational camera (made by Moseley et al. at NASA–GSFC) of a 24 pixel single line that can be stacked to others in the future, and that works at a temperature of 300 mK and a wavelength of 450 μm at the CSO (Wang et al. 1996). In France, the CEA–LETI–Grenoble (P. Agnese) is developping a 32×32 square array as the baseline for the SPIRE bolometer instrument onboard FIRST (200 to 500μm). It uses the Silicon chip making process to make a fully integrated array. Another development is with the NbSi thin layers by the IN2P3–CSNSM–Orsay (L. Dumoulin).

So if these technologies are available in Europe, what could be the best use of them in the millimetre domain? In what configuration? We argue here that to make full use of the multiplex advantage, the cone for each pixel must be dropped (as is now planned for SPIRE). A cone optimises the f/D ratio and hence minimises the pixel size. In case of lenses, the pixel scale at the focal plane is necessarily larger. A cone also clearly defines the entrance acceptance angle, effectively defining the pupil and reducing sidelobes. So, why dropping the cones? First, the new bolometer technology allows larger pixels without loss in sensitivity (heat capacity is reduced by making thinner bolometers). Then, by using a cold pupil common to all pixels, one can still prevent most of the sidelobes and heatload on the detector.

Moreover, additional problems arise from cones that can be solved by using an appropriate filled array. The most efficient (straight instead of parabolic) cones, as in the best known examples (37 bolometer MPIfR and SCUBA), are packed at a spacing of only twice the diffraction size on the sky, thus mapping at a time, a fraction of 1/4 of the available sky. The sky map must be filled with a drizzle technique using 16 different positions to have a fair sampling. This is a likely source of noise, because the map is not fully acquired at the same time. Another matter of concern is the anomalous refraction which is known to happen at Pico Veleta and at the JCMT. Even a strong source has an apparent jitter in front of a detector, giving a so-called source noise. Calibrations and photometrical measurements are thus more difficult. When reaching the confusion limit, anomalous refraction may be a strong limitation. Therefore, it seems that a cleaner and more efficient solution is to have a filled array of pixels which not only covers the largest possible area of the sky, but also samples correctly this area (i.e. at half the diffraction-size per pixel). This is the current basic design of most infrared cameras. The SHARC experiment is already designed this way.

So far the available arrays are modulated with a wobbling secondary. A total power readout technique could alleviate the use of a wobbler. This is already in use by small bolometer arrays: SuZie, NOBA, and Diabolo at POM2. In the case of a large array, the most promising observing technique is to fix the telescope in local coordinates ahead of the target and let the sky drift with the diurnal motion. Local effects and flat field can thus be disantengled from the real sources.

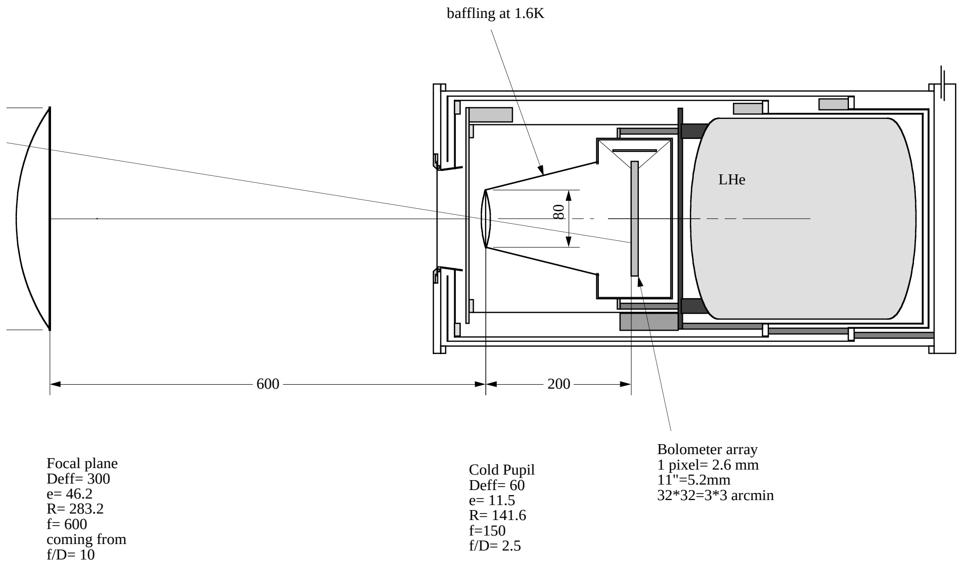

Figure 11: A schematic optical layout

A preliminary implementation

Figure 11 shows a possible optical layout of the bolometric camera at 1.2 mm. It uses one warm lens (assumed here in polyethylene with a n=1.47 index of refraction) at the 30m focal plane and one cold lens at the pupil image of the secondary. This cold pupil lens closes the 1.6K box. Note that the pixel size is here 2.6 mm (i.e. larger than the operating wavelength) and that is samples half a diffraction size. Filters (not shown) have to be placed at the cold pupil or just in front of it at 4 K or higher. The camera at 2.1 mm may require bigger pixels, hence may be 16 by 16 pixels wide. The field of view

Table 4 gives a conservative estimate of the expected sensitivity. For that, we assume a very mediocre state of the atmosphere and the telescope: atmospheric opacity (at the measurement elevation) and temperature of resp. 0.4 at 1.2 mm and 250 K, telescope emissivity and main beam efficiency of resp. 0.1 and 0.25 at 1.2 mm and 0.50 at 2.1 mm. The filtering is assumed to have an overall transmission of 15 percent in a $\delta\lambda/\lambda \simeq 0.30$ bandwidth. The box enclosing the detector must be kept at 1.6K to avoid overloading the detectors. Most of the photon noise is due to the atmosphere, and not to the telescope. The same calculation adapted to the present 37-bolometer array and Diabolo experiments give sensitivities which are slightly above what has been obtained on the sky. The needed detector sensitivity can be achieved with the present technology, on single bolometers, especially with relatively slow time constant. This sensitivity of arrays should be coming soon. Cooling the detector to 0.1 K might be advantageous in this respect.

We list here several open issues that should be dealt with before designing such an instrument.

Table 4: Sensitivity evaluation

Characteristics	units	**1**	**2**
Wavelength	mm	1.2	2.1
Heat load	pW/pix	23	2.5
Photon noise	10^{-17} WHz$^{-0.5}$	17	5
Assumed Pix. noise	10^{-17} WHz$^{-0.5}$	10	5
Point Source 1σ, 1s.	mJy	50	25

- Which array of detectors can we foresee to use?
- Should we use lenses or ellipsoidal mirrors as in SHARC?
- Filtering: use a dichroic to have simultaneously the 1 & 2mm channels (as in Diabolo) or use a filter wheel or make two separate cryostats on a similar design to match the detector to the wavelength?
- The readout technique is not yet settled and depends on the used array. Multiplexing bolometers has not yet been reported.
- Cooling to 0.3 K or 0.1 K, with cryocoolers or a cryostat?
- Stray light should be a major concern at the start. Ray-tracing and Gaussian optics should be used to predict and deal with the biggest sources of stray light and ghost images.

Conclusions

Having a truly mapping millimetre instrument would bring the same qualitative changes as we saw 15 years ago when IR cameras arrived at the telescopes and replaced single element detectors. The modern submillimetre instruments are near or at the confusion limit in extragalactic and galactic environments. Data acquired with arrays having cones may be very hard to exploit. A true camera has a potentially large multiplex gain and cleaner behaviour at the confusion limit. The IRAM 30m user community clearly has to discuss the various options before attempting to build such an instrument. We think the challenge is really worth the efforts and that the time is ripe to start a definition study. We here suggest to continue pre–design studies and then build the instrument which could be soon fitted with prototype detectors of 5 by 5 or 8 by 8 but which would also be compatible with future 32 by 32 bolometer arrays.

We thank P. Agnese, L. Dumoulin, A. Dutrey, S. Guilloteau, J.-M. Lamarre and B. Lazareff for many helpful discussions.

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Scientific results in press

LOW AND HIGH VELOCITY SIO EMISSION AROUND YOUNG STELLAR OBJECTS

C. Codella([1]), R. Bachiller([1]), B. Reipurth([2])
([1]) Observatorio Astronomico Nacional (IGN), Apartado 1143, E-28800 Alcalá de Henares (Madrid), Spain
([2]) CASA, University of Colorado, Campus Box 389, Boulder, CO 80309, USA

Abstract: We present a multiline mm-wave survey of SiO emission towards a sample of star-forming regions associated with molecular and Herbig-Haro outflows. The sample includes sources in the northern and southern hemispheres. We extensively mapped some particularly interesting objects (IRAS00338+6312, HH7-11 and CepA). The high detection rate in the sample (52%) confirms that the SiO emission is closely associated with outflows. There exists a trend so that the more intense SiO sources are associated with higher luminosities, with an average $L_{\rm SiO}/L_{\rm IR}$ ratio of 1.8 10^{-10}.

The SiO lines exhibit a variety of profiles, ranging from narrow lines (1-3 km s^{-1} width) at ambient velocities to broad profiles (10-20 km s^{-1}), with complex profiles consisting of a blend of low and high velocity components as intermediate stages. In the regions where SiO was mapped, the low velocity SiO emission comes from regions definitely offset from the position where the high velocity emission is present, indicating that the *low* and *high* velocity SiO emissions trace two distinct regimes. The SiO abundances are different in those two regimes: we estimate that typical SiO abundances are $\simeq 10^{-9}$-10^{-8} in the high velocity components, but they decrease by two orders of magnitude (10^{-11}-10^{-10}) when SiO is detected at low velocities.

The hydrogen volume densities estimated from the multiline SiO observations are in the range 10^5 to fews 10^6 cm^{-3}, in both the low and the high velocity regimes, indicating that all the SiO emission arises in shock-compressed regions. We argue that the different observed SiO profiles could be caused by an evolutionary effect: the SiO molecules produced at high velocities could be slowed down because of their interaction with the surrounding gas before they stick onto the dust grains. However, the possibility that the low velocity SiO emission is due to slow shocks cannot be ruled out, but this would require the presence of a small amount of silicon compounds on the dust grain mantles.

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e-mail: codella@oan.es
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CARBON-CHAIN MOLECULES AS TRACERS OF TIME-DEPENDENT CHEMISTRY

M. Guélin([1]), N. Neininger([2]), R. Lucas([1]) and J. Cernicharo([3])
([1]) IRAM, 300 rue de la piscine, F-38406 St Martin d'Hères, France
([2]) Radioastron. Institut der Universität Bonn, Germany
([3]) Instituto de Estructura de la Materia, Madrid, Spain

Abstract:

Gas-phase chemical models seem able to reproduce the abundances of organic interstellar molecules, provided the

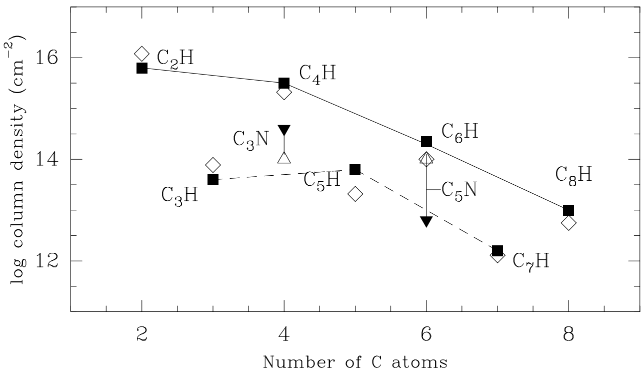

Figure 12: Observed (filled symbols) and predicted (open symbols) column densities of the carbon-chain radicals in IRC+10216 (after Guélin et al. 1997&98). The predicted column densities are taken from Millar & Herbst (1994) and correspond to the peak abundances of the different species.

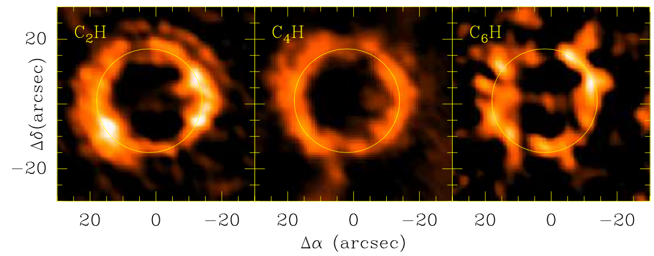

Figure 13: Brightness temperature distribution of the λ 3-mm lines of C_2H, C_4H and C_6H, observed in IRC+10216 with the IRAM interferometer. The intensities (multiplied by 1,1.3, and 7, respectively) have been integrated over a narrow band centred on the star velocity and represent roughly the species' abundance distribution in a meridian plane. Except for the larger noise in C_6H, the 3 maps look very similar; their brightest spots lie all along a circle of radius 16″. Note that the emission from the central star has been removed.

clouds are relatively young (Figure **??**). Age, however, is not observationally constrained in most astronomical sources. An exception is IRC+10216, an expanding circumstellar envelope, where the distance to the central star is also a measure of age. An analysis of the spatial distribution of carbon chains in that source shows that the agreement between predicted and observed abundances is fortuitous.

The current chemical models predict that C_6H forms from C_4H and C_4H from C_2H. C_2H itself results from the photodissociation of acetylene. A lower limit to the formation times of C_4H and C_6H can be derived by using the largest possible reaction rates, gas density and acetylene abundance. It takes ≥ 1000 yr to form C_4H from C_2H and C_6H from C_4H, which means, considering the envelope expansion velocity (14 kms^{-1}) and its distance ($simeq$200 pc), that the abundances of these species should peak respectively $\simeq 14''$ and $\simeq 28''$ further out than C_2H. In contrast, Figure 13 shows that the 3 species coexist spatially within $\leq 2''$ and should form quasi-simultaneously (i.e. within 120 yr).

The very good agreement of Figure 12 is thus fortuitous and a new formation mechanism must be sought. This mechanism could be the desorption from dust grains of weakly attached carbon-chains, under the influence of interstellar UV and/or shocks.

Proc. 3rd Cologne-Zermatt Symposium *The Physics and Chemistry of the Interstellar Medium*, ed V. Ossenkopf.

The jet-driven molecular outflow of HH 211

F. Gueth[1,2] and S. Guilloteau[1]
[1] Institut de Radioastronomie Millimétrique (IRAM), 300 rue de la Piscine, 38406 Saint Martin d'Hères, France
[2] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany

Abstract:

We present high angular resolution (down to $\sim 1.5''$) interferometric maps of the CO J = 1→0 and J = 2→1 emission in the molecular outflow associated with the extremely young HH 211 jet, which is located in the IC 348 molecular complex. At velocities close to the systemic velocity, the CO emission traces the outflow cavities, while an extremely collimated, continuous jet-like structure is observed at high CO velocities. The continuum emission reveals a ~ 0.2 $M_\odot$ dust condensation surrounding the central exciting (Class 0) protostar, clearly resolved and elongated perpendicular to the jet axis. The strong (bow-)shocks observed in vibrationally excited H_2 emission are located at the terminal ends of the jet and the low-velocity CO cavities are precisely situated in their wake. Hence, the overall structure of HH 211 perfectly fits into the picture of a jet-driven flow and strongly supports shock-entrainment models as the formation mechanisms of young, embedded molecular outflows. The shape of the cavities traced by the low-velocity CO emission can actually be (surprisingly well) reproduced by a simple, semi-analytical toy-model of a jet-driven flow, in which prompt entrainment occurs at the head of a travelling bow-shock. The estimated jet mass and mass loss rate yield a timescale of order one thousand years, in agreement with the kinematical age. Finally, we discuss the physical properties of the different parts of the outflow, and especially the actual nature of the high-velocity CO jet.

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e-mail: gueth@mpifr-bonn.mpg.de
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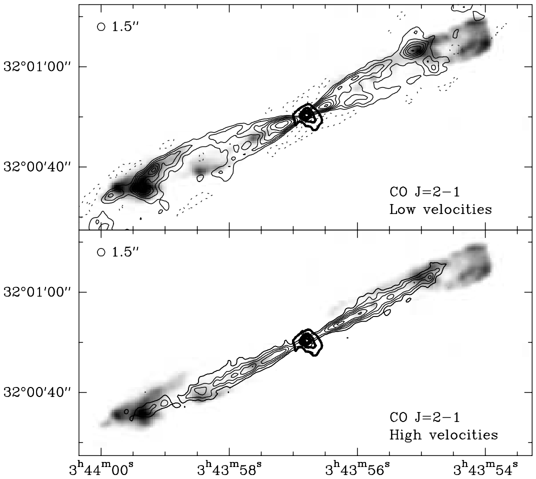

Figure 14: CO $J = 2 \rightarrow 1$ emission (thin contours) integrated in two different velocity intervals and superimposed on the H_2 v=1–0 S(1) emission (greyscale; from McCaughrean et al.1994) and the 230 GHz continuum emission (thick contours; contours are 10, 30, 50 and 70 mJy/beam). The angular resolutions are $\sim 0.75''$ for the H_2, $1.7'' \times 1.3''$ at PA $-50°$ for the CO, and $1.6'' \times 1.3''$ at PA $-46°$ for the continuum observations. *Upper panel:* CO $J = 2 \rightarrow 1$ emission integrated between LSR velocities 2.2 and 18.2km s^{-1} (the systemic velocity is 9.2km s^{-1}); contours are 1.6 Jykm s^{-1}/beam. *Lower panel:* CO $J = 2 \rightarrow 1$ emission integrated for velocities lower than 2.2km s^{-1} and larger than 18.2km s^{-1}; first contour is 1 Jykm s^{-1}/beam and contour step is 1.5 Jykm s^{-1}/beam.

A Strong Magnetic Field in the Disk of MWC 349

C. Thum [1] and D. Morris [1],
[1] Institut de Radioastronomie Millimétrique, Grenoble, France

Abstract:

Using Zeeman observations of the H30α recombination line maser transition at 1.3 mm we have detected a magnetic field which is associated with the corona of the circumstellar disk of MWC 349 A. At a radial distance of 40 a.u.,where the H30α maser is located, the line–of–sight component of the field is approximately parallel to the plane of this edge–on disk, and its average strength is 22 mG. The corresponding magnetic energy density is $\sim$ 70% of the thermal energy density of the plasma where the maser emission originates, very likely making the detected field dynamically important. Spectral fine structure of the detected Zeeman pattern suggests that the field may have a strong radial component, although other models for the field configurations are possible. The strength of the field at such a large distance from the star makes it unlikely that the field is of stellar origin. We suggest that it is generated by a local disk dynamo.

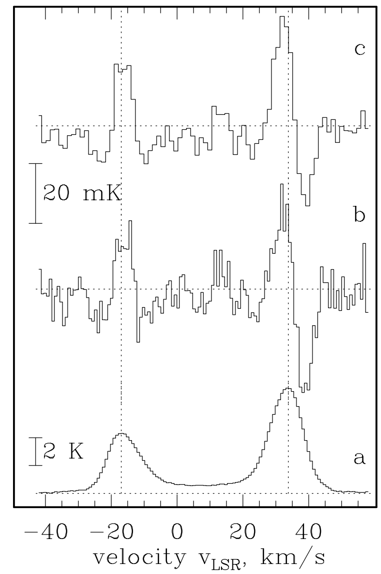

Figure 15: Zeeman observations of the H30α transition in MWC 349 obtained with an autocorrelator backend and smoothed to a resolution of 0.7 km s^{-1}. All data obtained during 23–28 June 1996 have been averaged, representing 245 min of polarization–switched spectra. The three subframes show: (**a**) the total power spectrum (Stokes I), (**b**) the V–spectrum (RHC–LHC), corrected for instrumental polarization, (**c**) same as (**b**), but observed with the filter bank at a spectral resolution 1.3 km s^{-1}. Vertical dotted lines mark the maxima of the total power maser spikes.

Detection of CO(4-3), CO(9-8) and dust emission in the BAL quasar APM 08279+5255 at a redshift of 3.9

D. Downes([1]), R. Neri([1]), T. Wiklind([2]), Wilner([3]) and Shaver([4])
([1]) IRAM, 300 rue de la piscine, F-38406 St Martin d'Hères, France
([2]) Onsala Space Observatory, S-43992 Onsala, Sweden
([3]) Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA
([4]) European Southern Observatory, D-85648 Garching bei München, Germany

Abstract:

We detected with the IRAM interferometer the lines of CO(4-3) and CO(9-8) from the recently-discovered broad absorption line quasar APM 08279+5255. The molecular lines are at a redshift of 3.911, which we take to be the true cosmological redshift of the quasar's host galaxy. This means the quasar emission lines at z=3.87 are blueshifted by a kinematic component of -2500 kms^{-1}, and, along with the broad absorption lines, are probably emitted in the quasar's wind or jet, moving toward us. The CO line ratios suggest the molecular gas is at a temperature of about 200 K, at a density of about 4000 cm^{-3}. We also

detected the dust emission at 94 and 214 GHz (emitted wavelengths 650 and 290 μm). The spectral index of the mm/submm continuum is +3.2, indicating the dust emission is optically thin in this part of the spectrum. The extremely high CO and dust luminosities suggest magnification by gravitational lensing. Using the optical extent and our limit on the size of the CO region, we estimate a magnification of 7 to 30 for the CO lines and the far-IR continuum, and 14 to 60 for the optical/UV. In this interpretation, the molecular gas and dust is in a nuclear disk of radius 90 to 270 pc around the quasar. The quasar is 25 to 100 times stronger than, but otherwise resembles, the nucleus of Mrk 231.

Astron. & Astrophys., in press

Interferometric ^{12}CO observations of the box-shaped bulge spiral NGC 4013

S. Garcia-Burillo(1), F. Combes(2) and R. Neri(3),
(1) Observatorio Astronomico Nacional (IGN), Apartado 1143, E-28800 Alcalá de Henares (Madrid), Spain
(2) Observatoire de Paris, 61 av. de l'Observatoire, 75014 Paris, France
(3) IRAM, 300 rue de la piscine, 38406 St Martin d'Hères, France

Abstract: The nucleus of the box-shaped galaxy NGC4013 has been observed with the IRAM interferometer in the J=1-0 and J=2-1 lines of ^{12}CO. Our maps show the existence of a fast–rotating (130 km/s) molecular gas disk of radius r=110 pc. Several arguments support the existence of a bar potential in NGC 4013. The figure-of-eight pattern of the major axis p-v plot, the ring-like distribution of gas, and the existence of gas emission at non-circular velocities are best accounted by a bar. We have also detected gas at high z distances from the plane (z=200-300 pc). The latter component is related to a system of 4 Halpha filaments of diffuse ionized gas that come out from the nucleus. The galactic fountain model seems the best to account for the Halpha and CO filaments. Although the peanut distortion can be spontaneously formed by a stellar bar in the disk, gas at high z might have been ejected after a nuclear starburst. The Halpha filaments start in the plane of the disk at r=200 pc, and reach several Kpc height at r=600 pc, coinciding with the maximum peanut distortion. Although a link between the bar and the box–shaped bulge in NGC4013 is suggested we find noticeable differences between the results of previous numerical simulations and the present observations. The discrepancy concerns the parameters of the bar generating the peanut. We see in NGC 4013 the existence of a strong ILR region. The inclusion of a dissipative component, which remains to be thoroughly studied, may change the evolution of the stellar peanut: although in simulations the peanut appears initially near a marginal ILR, the inflow of gas driven by the bar, can make two ILRs appear.

Astron. & Astrophys., in press

New IRAM Preprints

489. Widespread SiO Emission in NGC 1333 B. Lefloch, A. Castets, J. Cernicharo, L. Loinard 1998, *Astrophysical Journal*

490. A Molecular Jet from SVS 13B Near HH 7–11 R. Bachiller, S. Guilloteau, F. Gueth, M. Tafalla, A. Dutrey, C. Codella, A. Castets 1998, *Astronomy and Astrophysics*

491. A Three Photon Noise SIS Heterodyne Receiver at Submillimeter Wavelength A. Karpov, J. Blondel, M. Voss, K.H. Gundlach 1998, *IEEE Trans. on Appl. Supercond.*

492. Optimizing Receivers for Ground Based MM–Wave Radio Telescopes A. Karpov 1998, *Proc. ESA Workshop on MM–Wave Techn. & Appl.*

493. A Broad Band Low Noise SIS Radiometer A. Karpov, J. Blondel, P. Dmitriev, V. Koshelets 1998, *IEEE Trans. on Appl. Supercond.*

494. ^{13}CO at the Centre of M82 N. Neininger, M. Guélin, U. Klein, S. Garcia-Burillo, R. Wielebinski 1998, *Astronomy and Astrophysics*

495. CO in Absorption and Emission Toward Compact Extragalactic Radio Continuum Sources H.S. Liszt, R. Lucas 1998, *Astronomy and Astrophysics*

496. Millimeter–Wave Interferometry of Circumstellar Envelopes R. Lucas, M. Guélin 1998, *Symposium IAU 191* AGB Stars Montpellier, France

497. Low and High Velocity SiO Emission around Young Stellar Objects C. Codella, R. Bachiller, B. Reipurth 1998, *Astronomy and Astrophysics*

498. The Jet–Driven Molecular Outflow of HH 211 F. Gueth, S. Guilloteau 1998, *Astronomy and Astrophysics*

499. Depletion of CO in a Cold Dense Cloud Core of IC 5146 C. Kramer, J. Alves, C.J. Lada, E.A. Lada, A. Sievers, H. Ungerechts, C.M. Walmsley 1998, *Astronomy and Astrophysics*

500. Interferometer ^{12}CO Observations of the Box–Shaped Bulge Spiral NGC 4013 S. Garcia-Burillo, F. Combes, R. Neri 1998, *Astronomy and Astrophysics*

501. Detection of CO(4–3), CO(9–8), and Dust Emission in the Bal Quasar APM 08279+5255 at a Redshift of 3.9 D. Downes, R. Neri, T. Wiklind, D.J. Wilner, P.A. Shaver 1998, *Astrophysical Journal*

502. A Strong Magnetic Field in the Disk of MWC 349 C. Thum, D. Morris 1999, *Astronomy and Astrophysics*

Workshop on Millimeter VLBI in Granada

Second Workshop on Millimeter VLBI (1999)

Granada – Spain, 27 - 29 May 1999

Following the successful worshop on mm-VLBI held in Boston 1996, we have decided to organize a Second Workshop on Millimeter VLBI, to be held in Granada/Spain from 27 May to 29 May this year. The meeting will be organized by IRAM–CMVA–MPIfR, and will include a visit to the 30-m telescope.

The workshop will concentrate mainly on technical aspects of mm-vlbi, observations and data reduction, supplemented by presentations of recent scientific results. It is intended to discuss also organisational aspects of mm-vlbi.

The number of participants is limited to 30 – 40 persons.

Tentative Agenda of the workshop

— I. Day —

[Registration, Welcoming Remarks]
DISCUSSION of **SCIENTIFIC RESULTS**
A. 3 mm :
Source Surveys
Imaging and Monitoring of AGNs and Jets
Polarization
Line Observations (Masers, absorption lines)
B. 2 mm and 1 mm :
General Status, Sensitivity, Future Activities, Recent Results
SgrA *

— II. Day —

DISCUSSION of **TECHNIQUES**

Observatory Reports
Transition to Thin Tapes, Transition to MkIV
Data Reduction and Correlator Availability
New Data Reduction Techniques and Software
Atmosphere Correction (opacity, phase correction, calibration)

DISCUSSION of **ORGANISATIONAL MATTERS**
Review of CMVA Activities
Scheduling of Observations, New Observing Facilities (VLBA, HHT, ...)
Time Table of Annual Observing Sessions

Summary of the Meeting: DECISIONS and RECOMMENDATIONS

— III. Day —
Visit to the 30-m Telescope

For further information, please contact A. Greve (IRAM) and T. Krichbaum (MPIfR).

For registration and title of any presentation/poster please send Name, (e-mail) Address, and Title until 15 March 1999 to: Winnie@iram.fr and/or Greve@iram.fr

IRAM	CMVA	MPIfR
Grenoble - France	Haystack - USA	Bonn - Germany
Granada - Spain		

The IRAM Newsletter is edited by Michel GUÉLIN at IRAM-Grenoble (e-mail address: `guelin@iram.fr`).
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Directory	Contents
`/dist/newsletter`	Recent issues of this Newsletter (one subdirectory per issue)
e.g. `/dist/newsletter/jul95`	jul95.ps is the Postscript file for the July 1995 issue.
`/dist/doc`	Documentation on IRAM telescopes and software
`/dist/proposal`	Proposal forms and Latex files to aid proposal preparation
`/dist/soft`	distribution files for reduction software

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  `GET IRAMNEWS JAN99.PS`
  to the above electronic address. You will receive later a mail message containing the IRAM Newsletter in Postscript code. Please discard all the e-mail header information with a text editor, and send the file to a Postscript printer. More information may be obtained by sending the one line message:
  `HELP`
  Note that this file server also contains the proposal forms.

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Please keep M. Guélin informed of any problem you may encounter.

IRAM Addresses:

	Address:	Telephone:	Fax:
Grenoble	Institut de Radioastronomie Millimétrique, 300 rue de la Piscine, Domaine Universitaire, 38406 St Martin d'Hères Cedex, France		
	from abroad:	33 476 82 49 00	33 476 51 59 38
	from France:	0 476 82 49 00	0 476 51 59 38
Plateau de Bure	Institut de Radioastronomie Millimétrique, Observatoire du Plateau de Bure, 05250 St Etienne en Dévoluy, France		
	from abroad:	33 492 52 53 60	33 492 52 53 61
	from France:	0 492 52 53 60	0 492 52 53 61
Granada	Instituto de Radioastronomía Milimétrica, Avenida Divina Pastora 7, Núcleo Central, 18012 Granada, España	(34) 958 22 88 99	(34) 958 22 23 63
Pico Veleta	Instituto de Radioastronomía Milimétrica, Estación Radioastronómica IRAM-IGN del Pico Veleta, Sierra Nevada, 18012 Granada, España		
	starting April 15:	(34) 958 48 20 02	(34) 958 48 11 48

E-Mail Addresses:

- IRAM-Grenoble: `username@iram.fr`
- IRAM-Granada: `username@iram.es`

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