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ANNUAL REPORT

ACKNOWLEDGEMENT

I would like to thank all the IRAM staff for their contributions to this report.

M.J. de Jonge

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Edited by the IRAM Directors

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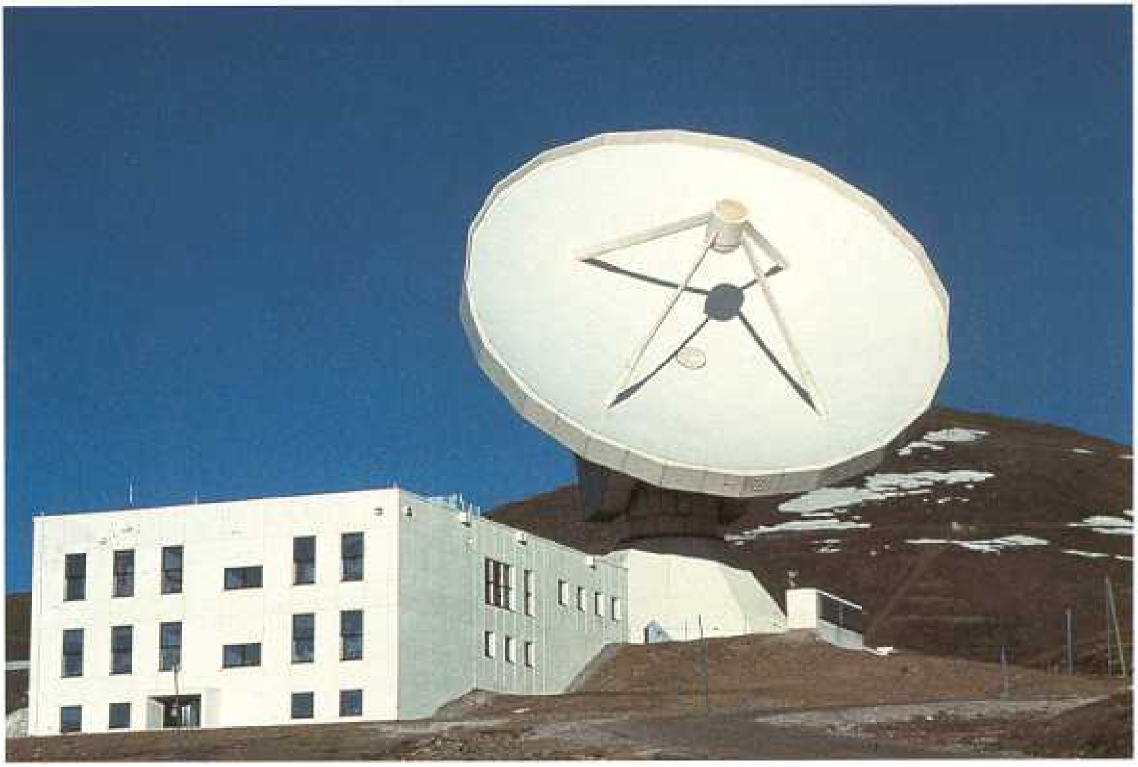


Summary

During 1988, the 30-m telescope was scheduled for astronomical observations more than 70% of the time. Among the numerous astronomical programmes carried out, the observations of CO in quasars and of recombination line maser emission should be mentioned.

Much work was done by the technical staff in Spain to improve the backend situation at the 30-m telescope and to provide the astronomical user community with the unique possibility to observe simultaneously with three receivers.

In Grenoble and on the Plateau de Bure, IRAM's technical activity has been mostly concerned with construction of the interferometer. In addition to instrumentation construction, writing the necessary interferometer software, extensive laboratory tests of the complete interferometer electronics, and single telescope testing on the site, the first interferometry experiments using two telescopes were made.

These activities and experiments resulted in the detection of the first fringe on the 14th of December.

During 1988 IRAM's initial investment plan was completed and the corresponding bookkeeping closed. As of the beginning of 1988, the new 5-year investment plan adopted by the IRAM Council in 1987 was started. This plan includes mm-VLBI equipment, a 4th telescope for the interferometer, and funding for the necessary instrumentation.

Sumario

Durante 1988 el 30 m fue programado para observaciones astronómicas durante 70% del tiempo utilizable. Entre otros muchos proyectos realizados cabe destacar la observación de CO en quasares asi como la de líneas de recombinación en emisión máser.

El personal técnico de IRAM-España realizó un notable esfuerzo para mejorar el equipamiento de backends en el telescopio de 30 m asi como para dotar a la comunidad astronómica con la posibilidad única de observar simultáneamente con tres receptores.

En Grenoble y el Plateau de Bure la actividad técnica del Instituto estuvo fundamentalmente encaminada a la construcción del interferómetro. Independientemente del desarrollo en instrumentación, escritura del soft ware para el interferómetro, test completo del sistema electrónico de la estación y realización de tests in situ del sistema single-dish, se concluyó con éxito la primera serie de experimentos de interferometría con dos antenas.
Estas actividades llevaron a la detección de franjas, por vez primera, el 14 de Diciembre.

Durante 1988 el presupuesto previsto para IRAM se invirtió en su totalidad y se cerró la contabilidad de este ejercicio. A principios de 1988 se comenzó el nuevo plan de inversión quinquenal, adoptado por el consejo de IRAM en el año 1987. Este plan comprende equipamiento para VLBI, una cuarta antena para el interferómetro y financiación para el desarrollo instrumental necesario.

Résumé

En 1988, le pourcentage de temps alloué aux programmes d'observations astronomiques sur le télescope de 30 m a dépassé 70%. Notons, parmi les très nombreux programmes menés à bien, l'observation de CO dans les quasars et celle d'émission maser dans des raies de recombinaison.

Un effort important a été accompli par le personnel technique en Espagne pour améliorer les spectromètres du télescope de 30 m et pour permettre des observations simultanées sur trois récepteurs dans trois bandes spectrales distinctes, une première sur ce genre d'instrument.

A Grenoble, comme sur le Plateau de Bure, l'activité technique a été largement centrée sur la construction de l'interféromètre. Outre la construction proprement dite des instruments, l'écriture du software nécessaire pour l'interférométrie, l'essai poussé en laboratoire des équipements électroniques correspondants et la mise en opération des télescopes sur le site, les premiers essais d'observation interférométrique ont été faits avec deux télescopes. Ils ont conduit à la détection des premières franges le 14 décembre.

Le plan d'investissement initial de l'IRAM et les comptes correspondants ont été clos au cours de l'année 1988. Au début de cette même année a débuté le nouveau plan d'investissement de 5 ans, adopté par le Conseil d'Administration en 1987. Il prévoit l'achat d'équipement VLBI millimétrique, la construction d'une quatrième antenne pour l'interféromètre de Bure ainsi que le financement de l'instrumentation nécessaire.

Zusammenfassung

1988 stand das 30-m-Teleskop für mehr als 70% der Gesamtzeit für astronomische Beobachtungen zur Verfügung. Unter den vielen durchgeführten Astronomie-Projekten sind die Entdeckungen von CO in Quasaren und des Masereffektes bei Rekombinationslinien besonders erwähnenswert.

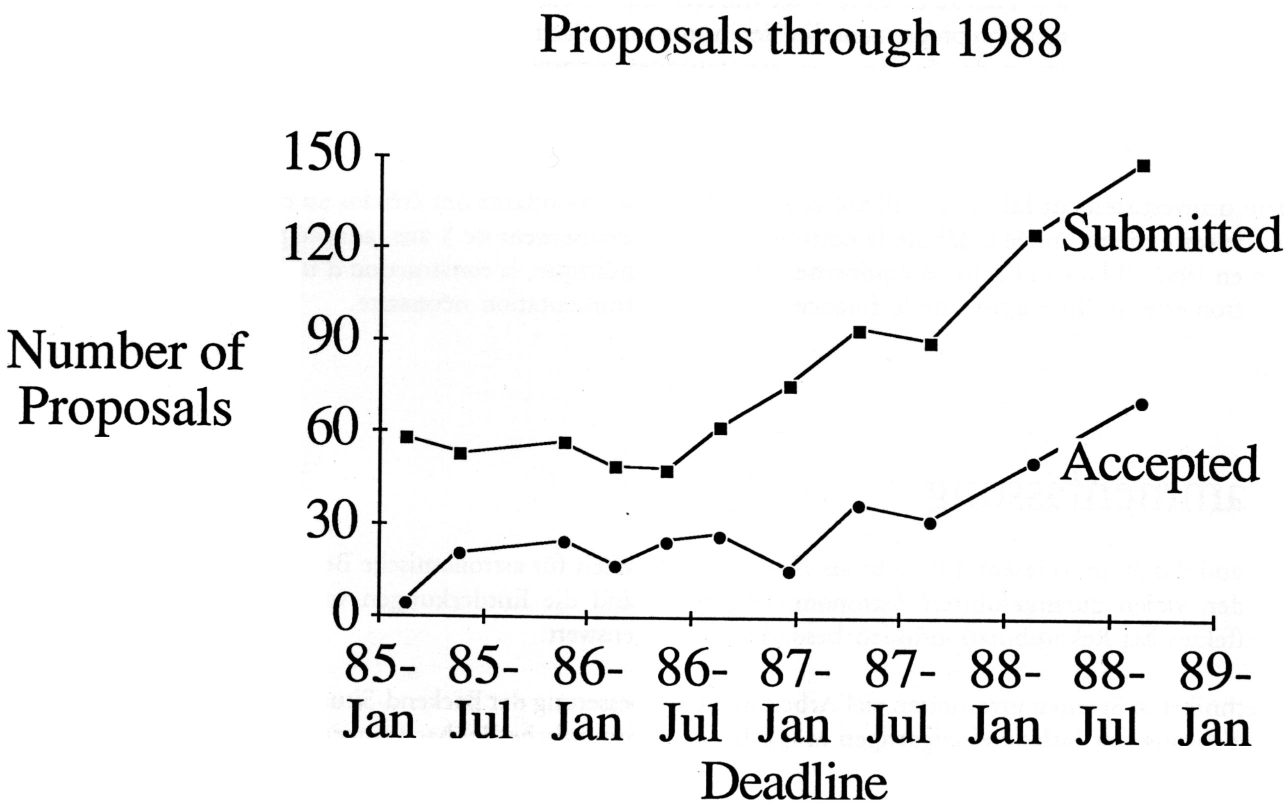
Die Techniker in Spanien investierten viel Arbeit in die Verbesserung der Backend-Situation am 30-m-Teleskop sowie die Einrichtung der bislang einzigartigen Möglichkeit, astronomische Beobachtungen bei drei Frequenzen gleichzeitig durchführen zu können.

In Grenoble und auf dem Plateau de Bure waren die technischen Aktivitäten auf die Konstruktion des Interferometers ausgerichtet. Ausser der Konstruktion der Instrumente, dem Erstellen der Software für das Interferometer, ausgedehnten Labortests der gesamten Elektronik für das Interferometer und den Tests der Einzelteleskope wurden auch die ersten astronomischen Tests des Interferometer-Systems mit zwei Teleskopen durchgeführt. Der Erfolg aller dieser Arbeiten zeigte sich am 14. Dezember durch die ersten Fringe-Messungen.

1988 lief der erste Investitionsplan für IRAM ab, und die Buchführung wurde demgemäss abgeschlossen. Anfang 1988 trat der auf fünf Jahre befristete neue Investitionsplan in Kraft, den der IRAM-Verwaltungsrat 1987 beschlossen hatte. Dieser Plan umfasst die Ausrüstung mit mm-VLBI, ein viertes Teleskop für das Interferometer und die Mittel für die notwendige Instrumentierung.

Scientific Research with the 30-m Telescope

The following table gives an overview of the usage statistics for the 30-m telescope since its opening in 1985. As of 1988, the telescope could be scheduled for astronomy 71 per cent of the available time. The principal users are the IRAM associates, namely, CNRS, MPG, and IGN. As external astronomers have mainly used the telescope in cooperative programs with astronomers from CNRS, MPG, and IGN, the statistics are given by two accounting methods: in the upper part of the Table, the cooperative programs are simply counted as CNRS, MPG, or IGN time; in the lower part of the Table, the origins of the users are listed.



The key programs with the 30-m telescope in 1988 have been mainly in the extragalactic domain, in particular mapping the spiral arms of the galaxy M51 in the CO(2-1) line at 230 GHz with a resolution of 12.5'' and the search for CO emission from starburst galaxies and quasars with high infrared fluxes as measured with the IRAS satellite. The latter search has resulted in a number of detections of cool CO, presumably in the host galaxies in which the quasars are embedded. Other highlights have been the detections of CO in elliptical galaxies, which up to now have been thought to be gas poor and containing mostly stars, the detection of a number of different molecular species in nearby galaxies, and the discovery of a strong recombination line maser.

Statistics for the 30-m Telescope to 31 December 1988

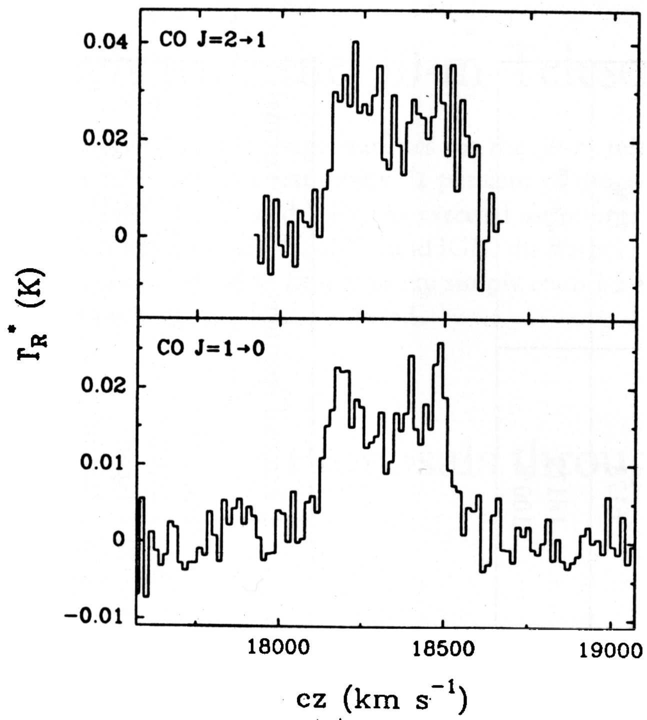
A. External partners included with CNRS, MPG, IGN:

Year	CNRS + Partners (hours)	MPG + Partners (hours)	IGN + Partners (hours)	Pure External (hours)	Yearly Total (hours)	Astronomy Time (per cent)
1985*	714	645	384	0	1743	20%
1986	2187	2218	607	0	5012	57%
1987	2334	2635	277	0	5246	61%
1988	2630	2609	570	370	6178	71%
Total	7865	8107	1838	370	18179	62%**
Per cent	43%	45%	10%	2%	100%	

* In 1985, the telescope was available for only four months.
** Relative to 29,200 hours available.

B. External partners counted separately:

CNRS (hours)		MPG + German Universities (hours)		IGN + Spanish Universities (hours)		External (partners + Pure external) (hours)	
Obs. de Bordeaux	118	MPIfR, Bonn	4806	IGN	1659	India	49
Ecole Normale Supérieure	1021	MPIE, Garching	301	University of Alcala	22	Japan	97
Obs. de Grenoble	2250	IRAM	1837	University of Granada	24	Mexico	6
Inst. d'Astrophys., Paris	276	University of Bonn	76	Inst. Astrofisica de Andalucia	25	Netherlands	220
IRAM	1837	University of Cologne	30			Puerto Rico	56
Lille	42	Hamburger Sternwarte	269			Sweden	292
Obs. de Marseille	81	Landessternwarte Heidelberg	216			United Kingdom	82
Obs. de Meudon	1042					U.S.A.	1410
Obs. de Pic du Midi	11						
Saclay, Service d'Astrophys.	24						
Total	6702		7535		1730		2212
Per cent	37%		41%		10%		12%

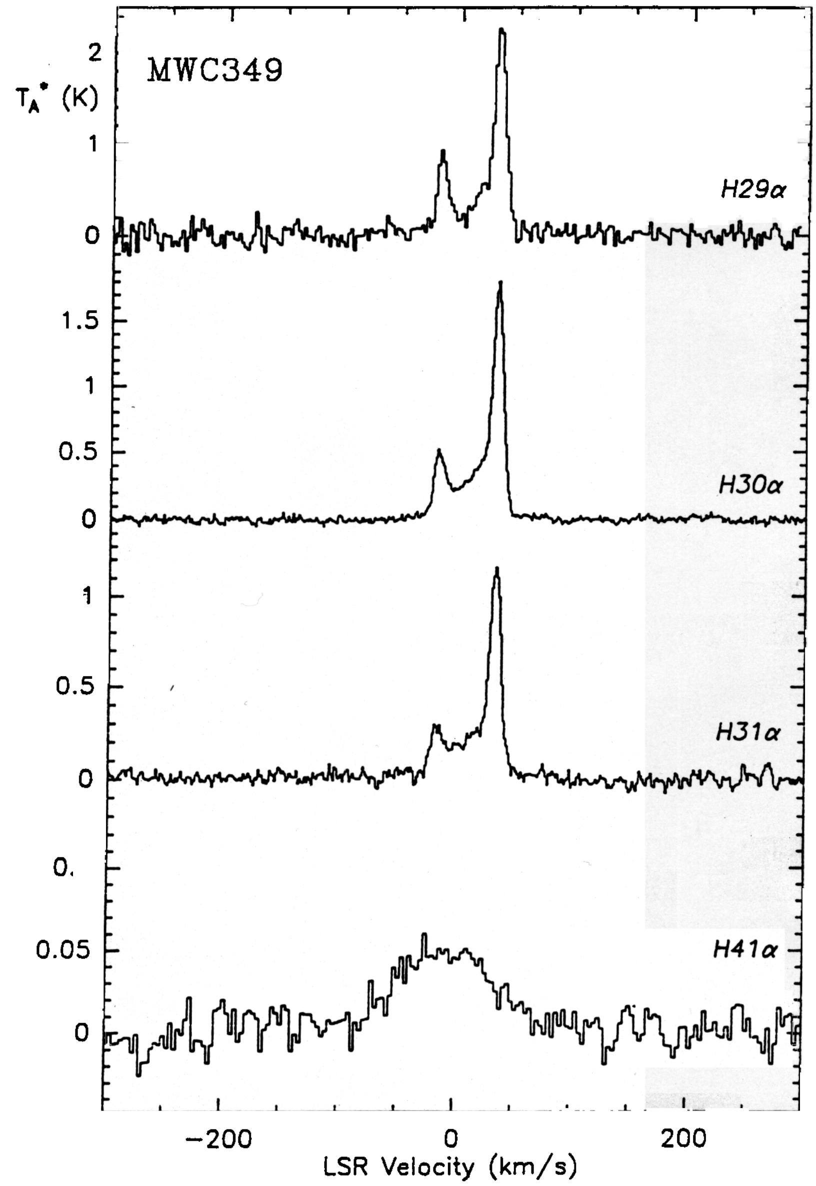


—Observed CO spectra for I Zw 1, smoothed to a resolution of 15 km s^{-1}.

Cool CO molecules are seen in quasars.

As part of a key program of searching for CO in quasars, Seyfert galaxies, and Markarian galaxies by a large consortium of investigators at the 30-m telescope, a number of new detections have been made. Alloin et al. detected the CO(2-1) and (1-0) lines in the radio quiet quasar I Zwicky 1 at a redshift of 18,000 km/s. The line ratio indicates that the CO is cool and it is extended on the same scale as the optically visible disk of the host galaxy of the quasar. The profile shape is double-peaked and symmetric like those seen in the rotating disks of spiral galaxies. The ratio of CO to IR luminosity is the same as for IRAS galaxies, suggesting that the far infrared emission of the quasar is thermal emission from dust, and not synchrotron radiation (Ap. J. Letters, 337, L69).

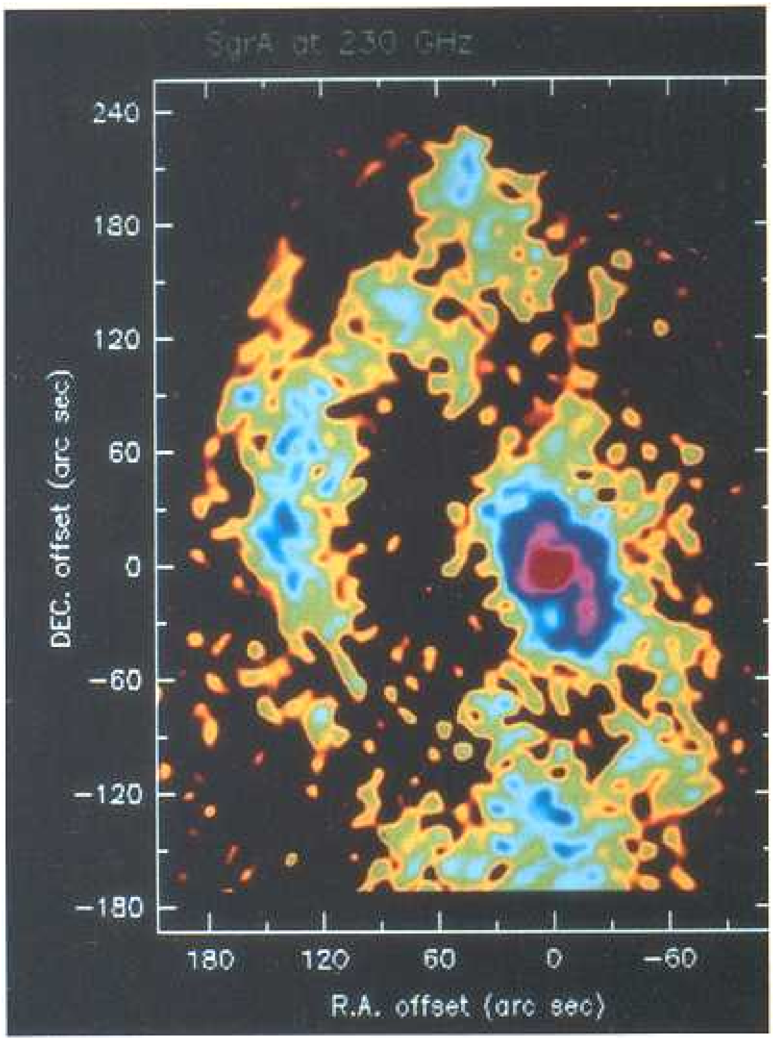
In August and September other groups made further detections in quasars and Markarian galaxies at redshifts out to 39,000 km/s. In general, this work demonstrates (if anyone still doubted it) that radio quiet quasars are bright objects embedded in the nuclei of completely normal galaxies, and adds to the growing body of evidence that the far infrared emission is from dust. The information from CO may place constraints on the radiative transfer as a function of distance from the quasars.



Radio recombination lines observed with the IRAM 30-m telescope toward MWC 349. The H41α line at 3.3 mm shows the thermal emission from the stellar wind with an expansion velocity of 50 km/s. The maser lines are the narrow features that become stronger in the recombination lines of lower quantum numbers (shorter wavelengths).

Discovery of a strong recombination-line maser at 1 mm.

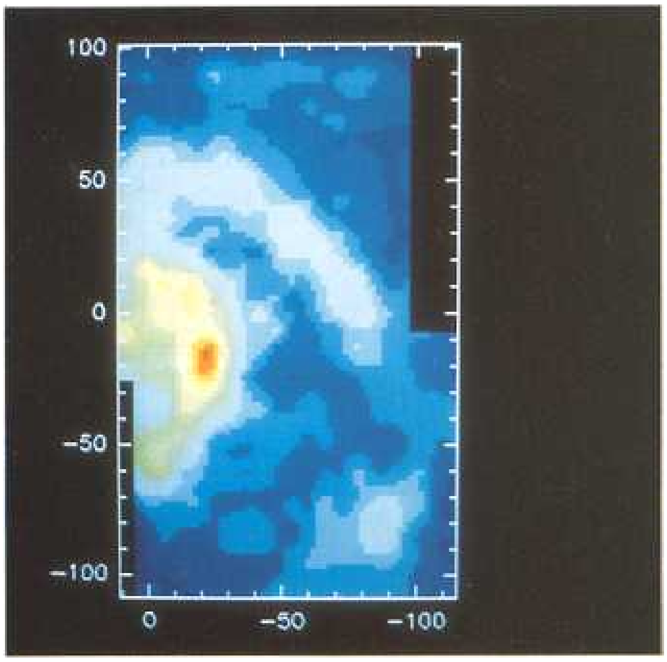
One of the more spectacular discoveries made with the 30-m telescope during 1988 was strong maser action in the hydrogen recombination lines near 1 mm in the stellar wind of the star MWC 349. The maser feature appears in the H31α, H30α, and H29α lines. Its intensity depends strongly on quantum number, becoming undetectable at a wavelength of 3 mm. The strong maser action appears to occur in a medium of electron density 10^7 cm^{-3}, at a radius of 10^{15} cm from the star. With this size its intrinsic brightness temperature would be greater than 10^5 K, making it the strongest recombination line known and one of the rare strong masers found in the 1-mm band.



Map of the continuum radiation from the galactic center at 1.3 mm with 11'' resolution. The map shows the bright nonthermal point source Sgr A, near the galactic nucleus, surrounded by free-free emission from the mini-spiral of Sgr A West, and farther out, the partial shell of dust emission surrounding the synchrotron source Sgr A East.*

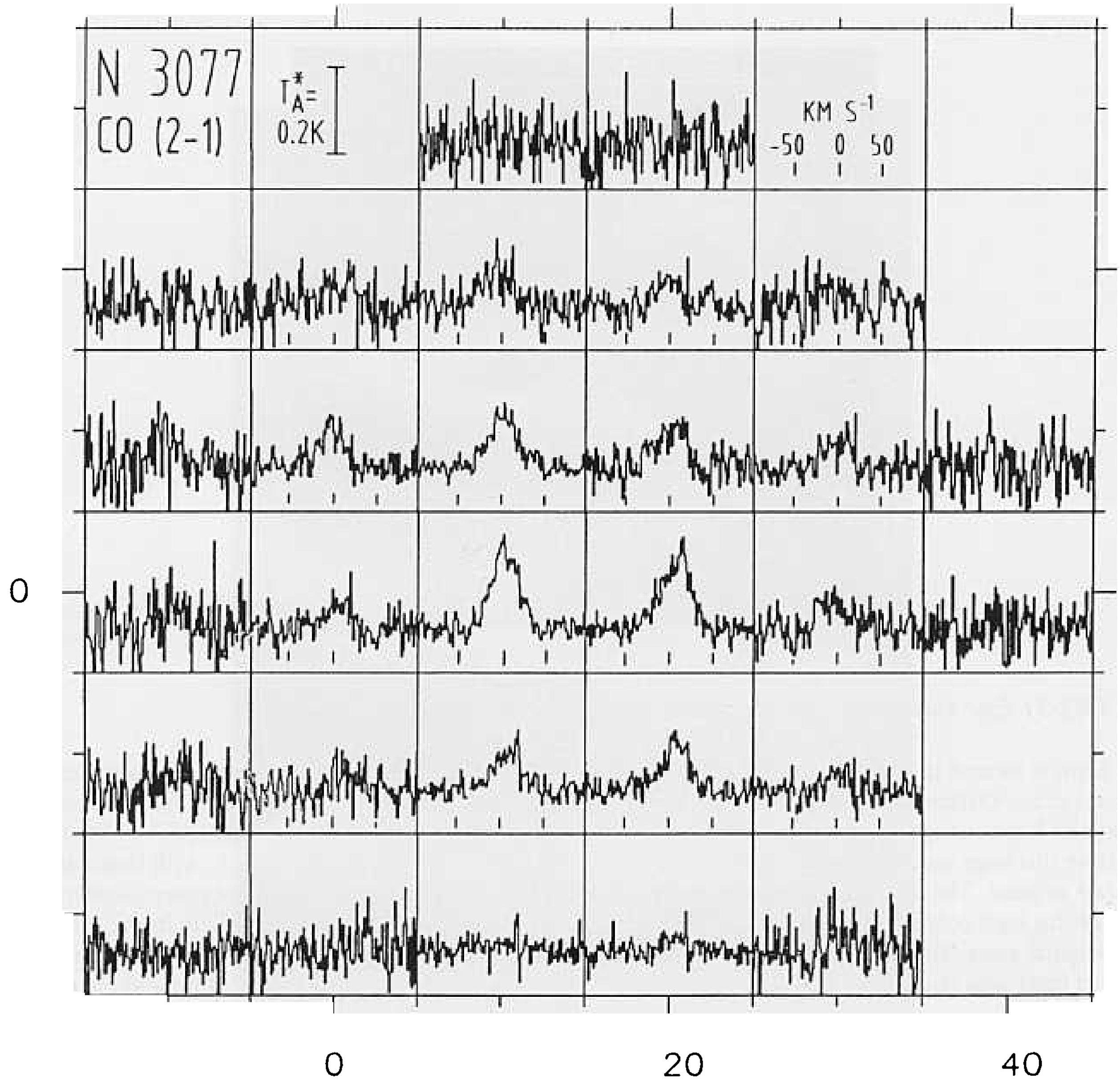
A dust ring surrounds Sgr A East.

Bolometer observations at a wavelength of 1.3 mm and an angular resolution of 11'' show the presence of a dust ring surrounding the synchrotron shell source Sgr A East, whose eastern rim coincides with the region of greatest H_2 density in the molecular cloud, − 0.02 − 0.07, and whose western rim coincides with the circumnuclear disk surrounding the thermal source Sgr A West. The synchrotron shell source and the associated dust shell may be the remnant of an explosion of energy $>4\ 10^{52}$ erg that occurred in a giant molecular cloud.



The CO(2-1) line traces the spiral pattern in the galaxy M51.

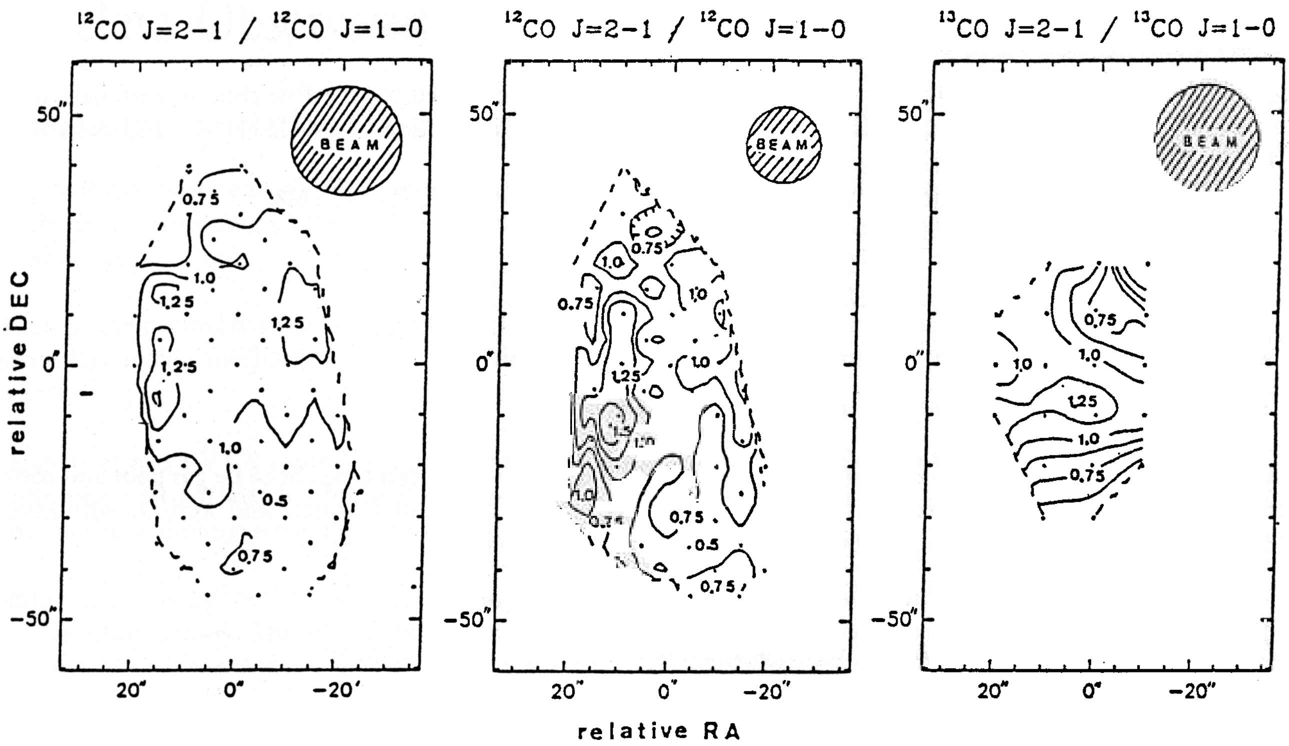
As the Earth is located in the plane of the Milky Way it is not easy to determine the locations of molecules in the spiral arms of our Galaxy. For this purpose, the galaxy M51 is of great interest since it is nearby, face-on to our line of sight, and large enough to be well resolved by the 12.5'' beam of the 30-m telescope at 230 GHz. Preliminary results from this large scale mapping program show that the CO arm-interarm contrast is high, with large variations from place to place. The integrated intensity ratio is 3-6 for the central arm and 10-17 for the inner southwest arm. In spite of this high contrast, narrow-line ($\Delta V \sim$ 6-20 km/s) CO clouds can be seen everywhere in the galaxy between the spiral arms. This study will provide important quantitative data relevant to long term discussions about the ages of molecular clouds and the relative contributions of arm and interarm clouds to star formation in galaxies.



CO (J = 2-1) spectra of the giant molecular complex toward the dwarf galaxy NGC3077. The reference position is α = 9 h 52 m 22.0s, δ = 68° 58' 30'' (1950.0).

Dwarf galaxies have lots of molecular gas.

Observations of dwarf irregular galaxies have shown the presence of large amounts of molecular gas in the extended envelopes of these galaxies. As these objects do not have spiral arms, the observations indicate that giant molecular clouds (and massive stars) can form without the aid of spiral density waves.



a) Ratios of integrated intensities of the 2→1 and 1→0 lines in IC 342, in ^{12}CO. Resolution 21" for both lines.

b) Ratio of integrated intensities of the $^{12}CO(2\rightarrow1)$ and 1→0 maps. The 1→0 map is deconvolved by a maximum entropy algorithm and then reconvolved to the 14" resolution of the 2→1 map.

c) Ratio of integrated intensities of the $^{13}CO(2\rightarrow1)$ and 1→0 maps. The 2→1 map is convolved to the resolution of the 1→0 map. Dots mark the position where measurements were taken. The FWHM beam size is indicated in the upper right.

CO isotopes have been mapped in the galaxies IC 342 and M82.

The ^{12}CO, ^{13}CO, and $C^{18}O$ isotopes have been mapped in the 2→1 and 1→0 rotational transitions in the galaxies IC 342 and M82. In the former galaxy, the ratios are about unity in the nucleus and 0.7 farther out, consistent with optically thick gas. In M82, the ratios are 2.3 over much of the galaxy, indicating optically thin gas at a temperature of about 40 K.

Individual clouds are resolved in the Andromeda galaxy.

New maps have been made of individual giant molecular clouds in the Andromeda galaxy, M31, at a resolution of 13", corresponding to a linear size of 43 pc. The cloud complexes are resolved, having overall sizes of 220 × 70 pc and masses of 1.5 10^6 solar masses.

Tidal stripping is seen in Virgo galaxies.

A study of the interacting pair of galaxies NGC 4435 and NGC 4438, in Virgo, shows that the CO gas is outside the plane of the smaller galaxy; this is interpreted as direct evidence for stripping of the gas from the galaxy by the tidal forces generated when the two galaxies pass near each other.

Further new detections have been made of molecules in galaxies.

After the detection of methanol in 1987, further molecules were detected for the first time in extragalactic sources with the 30-m telescope in 1988. These new extragalactic molecules include CN, C_2H, HNC, and possibly HC_3N, in the following lines and galaxies:

CN (N = 1-0) and 2-1 lines at 113.5 and 226.6 GHz in NGC 253, IC 342, M82;
C_2H (J = 1-0) line at 87.3 GHz towards M82;
HNC (J = 1-0) line at 90.7 GHz towards IC 342;
HC_3N (J = 10-9) line at 91.0 GHz towards M82 and IC 342.

The CO molecule is detected in elliptical galaxies.

CO has been detected in several elliptical galaxies, which have up to now been thought to be gas poor and containing mostly stars. Of particular interest is the detection of cool CO in the giant elliptical and well-known radio galaxy 3C84 (NGC 1275), in both the 5000 and 8000 km/s redshift systems.

Deuterated water is enhanced in hot sources.

Deuterated water, HDO, has been studied in hot, compact sources in our Galaxy. As the direct study of water is blocked by tropospheric absorption lines, except for the maser lines at a wavelength of 1.35 cm, the water in space can be studied by ground-based radio observatories only through its isotopes, $H_2{}^{18}O$ and HDO. On Earth, HDO is 500 times less abundant than H_2O, but observations at 143 and 225 GHz with the 30-m telescope indicate the hot core deuterium abundance is enhanced by a factor of 100 over the terrestrial ratio.

Extensive maps have been made of the galactic center clouds at Sgr B2.

A large program has been started to map the diffuse and hot core components of the giant Sgr B2 clouds near the galactic center, in the molecules of NH_3, CS, HCO^+, HCN, CH_3CN, and the vibrationally excited states of cyano-acetylene, HC_3N. In the hot cores, the line ratios of these molecules indicate temperatures of 250 K, molecular hydrogen densities of 10^7 cm^{-3}, and masses of 4000 solar masses within sources 0.2 pc in size.

Discovery of a new, powerful outflow.

A powerful outflow has been found from the star forming region G5.89-0.39, with a streaming velocity of 150 km/s, a mass in the flow of 1000 solar masses, and a mechanical power of 1000 solar luminosities, about ten times higher than that in the well known outflow from Orion. This source has been studied with the 30-m telescope in the isotopes of CO and CS; the results indicate an unusually high density in the outflow gas, 10^5 H_2 molecules per cm^3.

Astronomical and laboratory detection of the elusive SiC radical.

Both on Earth and in space, the free SiC radical has long defied detection. For many years SiC has been known to be present in the dust grains surrounding carbon stars, where it may condense from SiC molecules in their inner atmospheres. For a long time SiC also eluded identification in the laboratory, and only very recently have transitions between excited electronic states been observed in the near infrared. With the idea that SiC might be easier to detect in astronomical sources than in the laboratory, two several GHz wide bands of the 1.3 and 2 mm spectrum of IRC + 10216, the most conspicuous carbon star envelope, were surveyed with the IRAM 30-m telescope. Two strong unidentified lines were discovered close to the frequencies of the lowest J = 4-3 and 6-5 rotational transition components predicted by ab initio quantum mechanical calculations. Following the discovery at the Harvard spectroscopic laboratory of the way to produce SiC in a spectrometer, the two astronomical lines were detected and conclusively shown to originate from SiC, whose ground state is now completely characterized.

SiC presents a shell like distribution in the IRC + 10216 envelope and must form in situ, probably from the photo-dissociation of SiC_2.

Pico Veleta Observatory

30-m Telescope Operation

No major problems were encountered throughout the year with the routine operation of the 30-m telescope. This good result can be attributed to the weekly 8 hour preventive maintenance period, which has been maintained during the whole year.

In addition to the normal maintenance activity, the lifting platform had to be repaired and an overhaul of the wobbling secondary mirror mechanism, which completed more than 2,000,000 throws in the course of the year, was undertaken.

The change over to a μVAX control computer made the installation of new telescope CAMAC interface necessary. New electronics were constructed for and installed in the elevation servo system and a second CAMAC module for operation of the wobbling secondary was brought into operation.

The compressed air supply of the wobbler was improved. Since this improvement the wobbler is used routinely in spectroscopic observations. The use of the wobbler yields very flat baselines and allowed successfull observation of IRAS quasars.

The detailed schedule telescope usage is given in Annex I.

View of receiver cabin: in the center the optics, on the left the 1.3 mm receiver, and on the right the 0.8 mm receiver.

Receivers

The 1.3-mm receiver, heavily used by visiting astronomers, has been equipped with a new Gunn oscillator, phaselock, and tripler, thus eliminating the expensive and unreliable klystrons and allowing the operators the possibility of tuning the receiver. The tuning range of this receiver was extended to 270 GHz in lower side band. The 2-mm receiver, repaired in Grenoble, was reinstalled and brought into operation and has worked satisfactorily since.

In November the 0.8-mm Schottky receiver, constructed by the MPIfR, was installed, and the first tests at this wavelength showed a DSB receiver temperature of around 900° K and a telescope aperture efficiency of 10%. The receiver has a 1 GHz bandwidth split into two 500 MHz bands.

The 3-mm receiver was repaired but is still not functioning optimally at the CO frequency

The present arrangement in the receiver cabin and the additional IF cables installed allow simultaneous observations with three receivers. This option is offered to the astronomers in two versions: either the 3, 2, and 1.3-mm receivers are used simultaneously, or the 3, 1.3, and 0.8-mm receivers. With the present receivers in use a total of 160 GHz tuning range is covered. To better protect the equipment in the receiver cabin, a new pneumatically activated vertex closure was installed.

Backends

Much work was spent on improving the performance and reliability of the autocorrelator. To permit more efficient tests of the correlator hardware at all shift frequencies, a special pseudo-random noise generator has been constructed. All the power supplies were replaced by more reliable ones, and a new analogue processor was built, installed, and tested successfully. The new analogue processor eliminated all spurious frequencies to a level below the detectability during normal observations. The backplane was rewrapped to create more flexibility, and modifications were made to the data distribution to eliminate cross talk, which permitted the correlator to run for the first time, at least experimentally, at all clock frequencies. Final clean up of the various problems with the correlator is under way.

The filterbanks and IF distribution were modified by replacing the electro mechanical relays by fast solid state switches, designed and constructed in the observatory, which greatly improved the baselines.

In order to implement future backends, the CAMAC interface has been modified to allow simultaneous use of two micro processors in one CAMAC crate. This would permit the use of the filterbanks at the same time as the A.O.S. under construction or other backends.

The design of a new IF distribution system, which could connect under computer control four receivers to as many as nine different backends, has been started. Part of this activity is intended to create a 1-GHz bandwidth system which will become important in the future for extragalactic research.

30-m Telescope control room.

Computer Hardware and Software

The main task of the computer staff in 1988 was replacement of the 8 year old VAX 780 computers by modern μVAX systems, a task already partially prepared in 1987. The VAX 780 computers were sold and three μVAX computers interconnected by Ethernet/Decnet were installed, with reconfigured discs and a terminal server.
The connection of the new μVAX computers to the telescope and auxiliary instrumentation required major modifications in hard- and software, in particular the new interface required for the correlator posed many problems. The new μVAX computers allowed an increase in the speed of the standard display of telescope parameters with a reduced computer load.

In the Granada offices more terminals were installed to allow more local activities and further decrease of the computer load in the observatory. A new laser printer was installed at the telescope replacing the versatec plotter.

At both the telescope and in Granada the CLASS off-line reduction programs, replacing the LAS programme, were installed.

New versions of OBS and RED — very similar to the previous ones, as far as the users are concerned, but internally completely reorganised, compatible with the μVAX processor, and allowing more than two receivers to be used simultaneously — were installed at the telescope. The receiver control software was modified to incorporate control of the 0.8-mm receiver.

Observatory Building and Infrastructure

A number of small repairs in and around the building were executed during the year, in particular all windows were checked and repaired when necessary.

The sewage water treatment posed problems and provisional modifications to the system were made for the winter period 1988-89, awaiting a major overhaul of the system during the summer of 1989.

At the end of the year problems arose with the observatory water supply, essentially caused by the absence of snow, which allowed the supply line to freeze. Improvement of the water supply is an urgent necessity, which hopefully can be undertaken in 1989 if funding allows.

In the Granada offices, the fire detection system was brought into operation and the air-conditioning repaired and improved.

Organisation

The transport to and from the observatory has functioned very well during the winter period. More and more of the staff spent part of their working time in Granada, which improves efficiency and diminishes the demand for board and lodging, thus allowing more visiting astronomers to stay at the telescope. This trend is to be further encouraged, as more and more of the laboratory activities can be handled in Granada, and the telescope and its instrumentation becomes more and more automated and reliable.

Preparation for transport in the snowtrack to the 30-m Observatory

Grenoble Institute

Receiver Group Activity

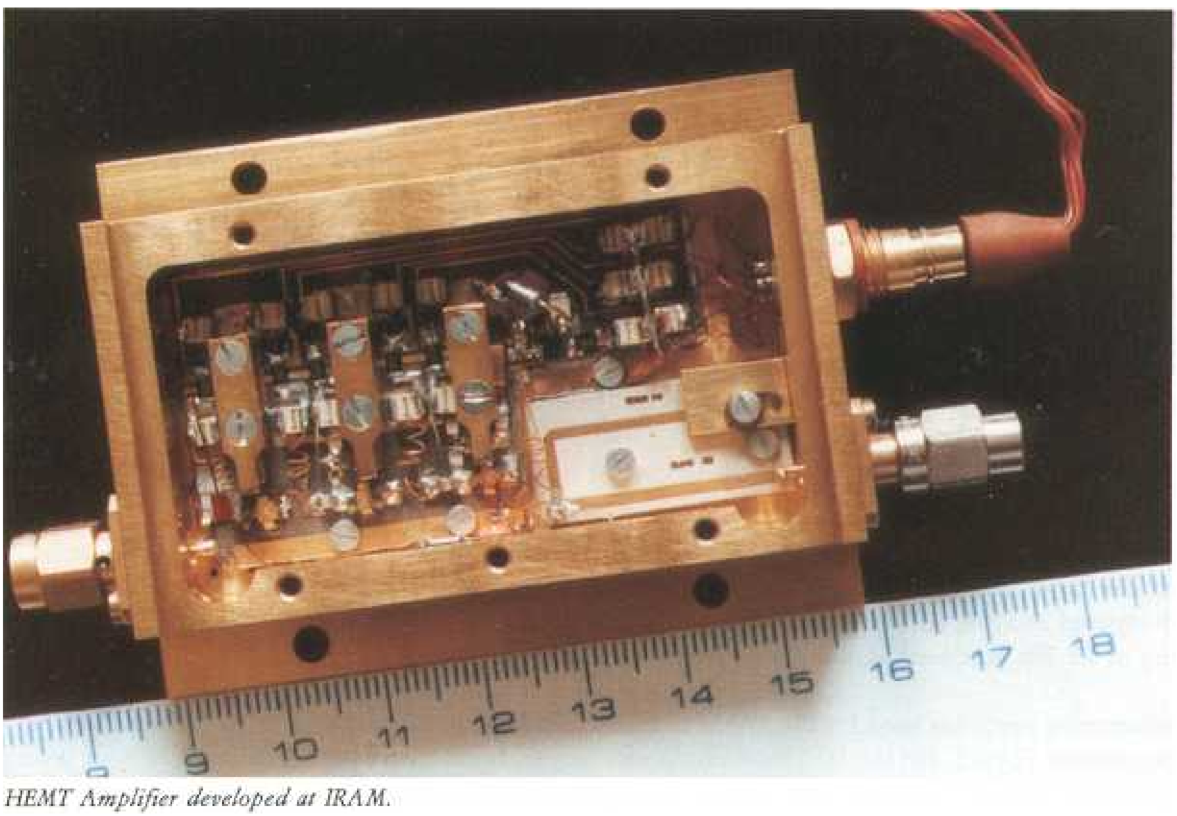
Apart from work on the receivers for the 30-m telescope and interventions in Spain for the repair of the 3-mm receiver, much of the receiver group activity was dedicated to new laboratory developments, the tests of cryogenerators, the remote control of receivers, and the interferometer system test.

Among the laboratory developments that should be mentioned

The design study of a frequency doubler, to be used in conjunction with a Gunn oscillator, as local oscillator source for the 2-mm receiver installed on the 30-m telescope, has been started.

At present the 2-mm receiver is the only receiver left using klystrons, and the new local oscillator source would eliminate the klystrons in this receiver too.

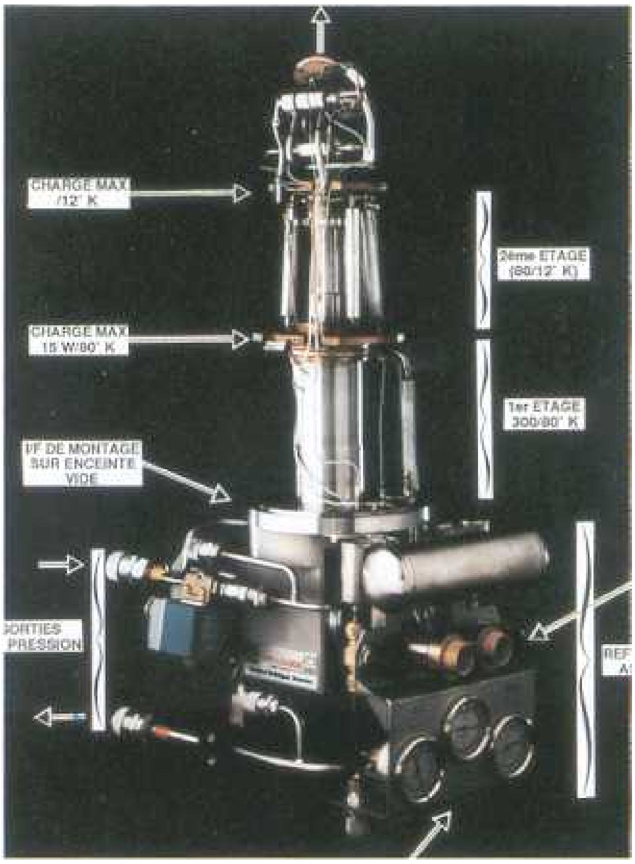
The development of low-noise HEMT amplifiers for the 1.2-1.8-GHz frequency range, the IF frequency of the interferometer receivers.
A number of low-noise HEMT amplifiers with 4.2-GHz centre frequency have been bought for the receivers at the 30-m telescope. In view of the quantity required for the interferometer and given the in house experience with 1.5-GHz centre frequency FET amplifiers, in house development of HEMT amplifiers seems economic and justified.
To speed up the development of these new IF amplifiers, the existing cooled IF test system has been upgraded to allow more accurate and reproducible noise measurements. A theoretical study of the HEMT amplifier circuit has been made for the required frequency range. This study coupled with corrected s-parameter measurements of a number of HEMTs has led to the development of a prototype amplifier with good results.



HEMT Amplifier developed at IRAM.

The development of a 350 GHz SIS mixer was started, but no results are available so far

The remote control of local oscillator systems and mixers is being studied to come to a single design that could fulfill the tuning requirements of both the 30-m telescope and the interferometer.



Prototype 3° K refrigerator.

The prototype cryogenerator, developed under contract by the CENG and Air Liquide, was delivered late 1987 and extensively tested in 1988. At the beginning of the year many problems were encountered, which were overcome by a number of small modifications made by the CENG staff. Towards the end of the year the prototype functioned within the desired specification, and tests to establish that a mean time between failures of more than 1500 hours can be achieved were well under way.

SIS Laboratory

During 1988 the SIS laboratory was extended by a clean room, constructed in the patio between the mechanical workshop and the initial SIS laboratory. In this clean room, the new sputter system and a system for reactive ion etching, both ordered in 1988, will be installed. As soon as these new systems are delivered, tested and operational, manufacturing of all Nb junctions with artificial tunnel barriers can start.

Besides manufacturing junctions used for the IRAM receivers, the laboratory produced 345-GHz junctions for the MPI for Extraterrestrial Physics. For the MPI for Radio Astronomy in Bonn, special junctions with bow-tie antennas were made and work on junctions with logarithmic periodic antennas has started.

View of the SIS laboratory.

Backends and Interferometer Local Oscillator System

During the first months of the year the last electronic circuits for the continuum correlator were finished, which completed this correlator to its full configuration, three antenna inputs, sine + cosine channels, and 500 MHz bandwidth subdivided into ten 50-MHz bands sampled at 100 MHz. The continuum correlator includes the digital delay compensation and phase rotators. The spectral correlator, which shares the IF processors and phase rotators with the continuum correlator, became available towards the middle of the year when the samplers and delay lines were incorporated.

The local oscillator system was completed for three antennas, including spares. The local oscillator references exhibit sufficient spectral purity that any correlation loss is smaller than 5% at 100 GHz.

For both correlators and the local oscillator systems, detailed documentation has been prepared for use on the site and operator training for both use and debugging of the signal processing hardware has started.

Computer and Software Group

As on the Pico Veleta, the Grenoble VAX 780 system was replaced by μVAX computers. Initially many problems were encountered with the new computers but these were cured when an uninterruptable power supply was installed.

Many software packages were developed, tested, and debugged during the year, among them

— data acquisition software for both the continuum and spectral correlators,

— integration of continuum detectors in the data acquisition chain,

— multi-antenna control, which allows simultaneous control of several antennas.

— improved sun avoidance software,

— receiver control software,

— interferometer acquisition and calibration software.

A start was made on modification of the CAMAC drivers to be used on the µVAX that will replace the PDP 11/44 computer, presently on the Bure site, which is insufficient for routine interferometer operation with three or four antennas.
Preliminary tests were made with a new version of the telescope control software to be used with the µVAX.

The Interferometer System Test

Very early in the year it was decided that before installation on the site, the interferometer system hardware and software should be tested in the laboratory and debugged as much as possible.
The test, which required the provisional installation of a computer in an office near the laboratory and needed the participation of virtually all the technical staff, was planned to start on May 2.
The actual test started on May 18 and was performed in steps.

Two SIS receivers in the laboratory during the interferometer system tests.

First the continuum correlator was tested alone, next the correlator with delay cables that simulated the configuration on the site, then the correlator, cables, and the IF system, and finally two complete SIS receivers locked to a single local oscillator source were connected to the correlator via the cables and IF system.

Walsh function demodulation, digital delay lines, phase rotators, phase meters to measure cable electrical length variations, non-linearity corrections for the correlator were all checked in detail.
With each step additional software was brought into operation, and to simulate the actual working of the computer system in real time, both the telescope control and the interferometer software were operated during the tests of the electronics. The first fringes were detected in the laboratory on July 1.

To make the tests more realistic the receivers were mounted in supports that allowed tilting them in elevation in order to check for phase variations as function of elevation, as might occur in the telescopes.

Although these tests demonstrated proper functioning of the electronic systems, a number of items obviously could not be tested, such as fringe stopping and astronomical delay compensation and the effective sensitivity of the correlator, which need testing and astronomical observations at the observatory. The laboratory tests were repeated with the spectral correlator before the equipment was moved to the observatory in the middle of October.

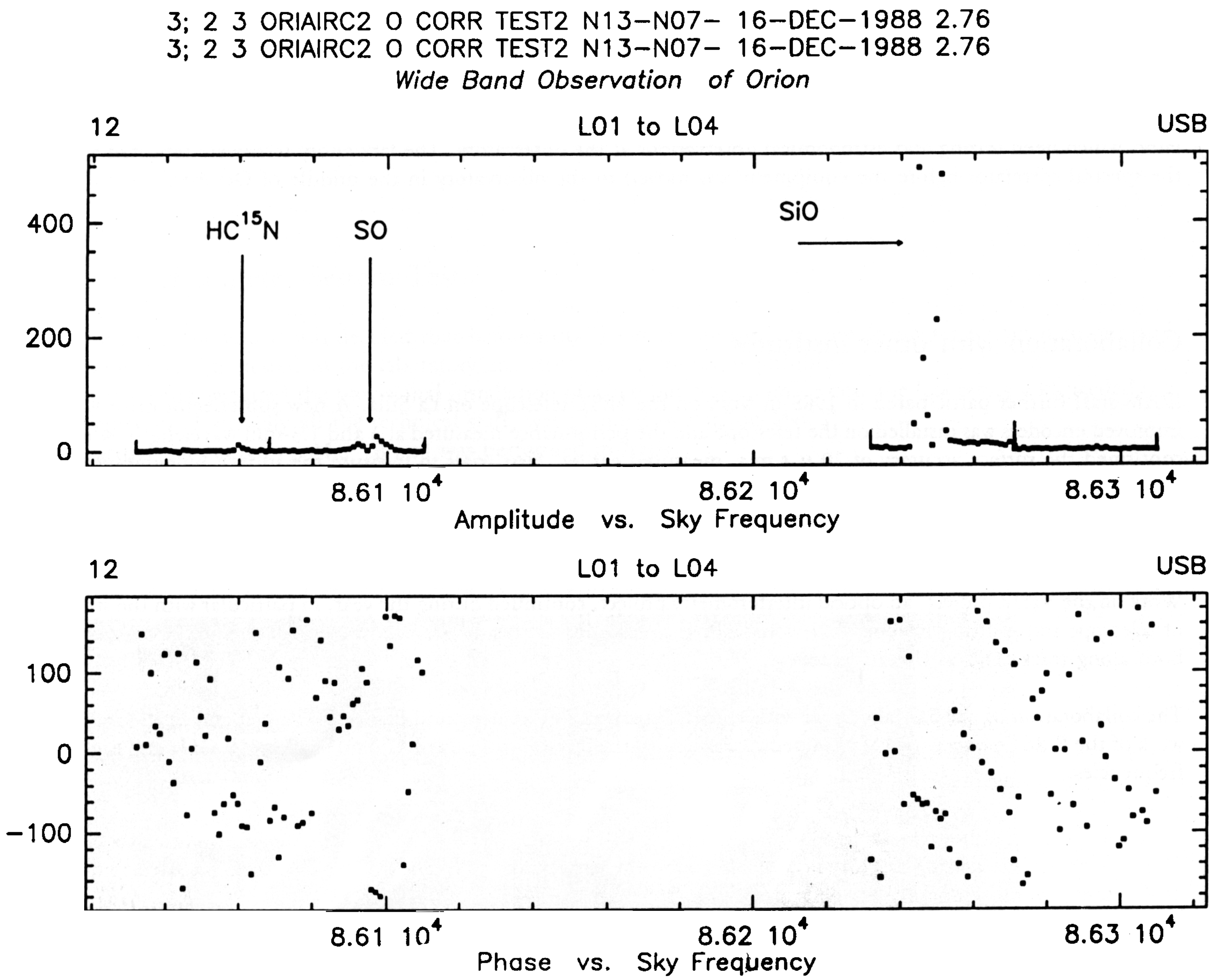
Collaboration with other institutes

IRAM staff further participated in 1988 in work on the SEST telescope on La Silla. A new subreflector drive with improved encoders was installed on the telescope and the performance measured at 3 and 1.3-mm wavelength, which confirmed the surface accuracy of 70 μ r.m.s. measured earlier. First trials to measure the surface holographically were made and a new gain versus elevation curve was measured.

Under contract with INSU, a feasibility and design study for the dome of the THEMIS 10-m solar telescope was prepared.

Work on the VISIR project, an optical interferometry project, continued during the year, in particular with the study of telescope transporting systems that would allow continuous or step-by-step movement of the VISIR telescopes both along tracks and in the x-y plane.

The collaboration of the SIS laboratory with various institutes in Germany and France continued and in the framework of the FIRST project, IRAM obtained a contract for the feasibility study of SIN mixers for 350 GHz and higher frequencies.



First fringes with the two element interferometer.

Plateau de Bure Interferometer

Commissioning of the Second Telescope

The surface accuracy of the second telescope, delivered late in 1987, was measured early in 1988 with the standard theodolite and tape technique. After two iterations, an overall accuracy of about 65 μ r.m.s. was obtained.

The telescope was then equipped with the Schottky receiver also used for commissioning the first telescope in order to eliminate uncertainties in comparing the performance of the first two antennas. The SIS receiver could not be installed in any event since it was needed to make the interferometer system tests in Grenoble.

Telescope performance tests were carried out from early spring until July. The subreflector encoders, which were suspected of causing the erratic elevation pointing errors on telescope 1, were replaced on telescope 2, and no pointing problems were encountered. Both radio and optical pointing are now within 3'' r.m.s. over the whole sky with a pointing model limited to only 5 parameters (zero of azimuth, azimuth collimation, zero of elevation, and axis inclinations). The azimuth collimation is essentially constant, which indicates inclinometers can possibly be used to derive the pointing parameters. This would considerably improve the speed of operation of the interferometer.

No thermal effects on the radio pointing were noted, but the focus shows a systematic day-night effect of about 2 mm. The measured beam and aperture efficiency are in accordance with the measured surface accuracy. Pointing under windy conditions was improved by servo adjustments and upgrading the tracking software. Pointing is now fully accurate to 10 m/sec windpeed, and most of the observations can be made with windpeeds up to 14 m/sec.

Assembly of the Third Telescope

After delivery of all the panels by MAN, assembly started in August under the supervision and responsibility of the same MAN chief mechanic who had already assembled the first two reflectors. During the assembly, the deicing heating element power connections of all panels were modified to improve the insulation between heating element and panel. On both telescope 1 and 2, poor insulation at the power connection of the heating elements had stopped the deicing system from functioning properly.

The assembly work was finished by the end of December and the reflector was provisionally accepted. Surface measurement and deicing system tests are planned for early 1989.

Telescope 1 Tests

Telescope 1 was equipped with an SIS receiver after the laboratory tests of the interferometer electronics. This telescope was also refitted with new subreflector position encoders the first. First radio observations revealed that the elevation pointing problems encountered during the commissioning period have completely disappeared.

The SIS receiver, although sensitive (T_{Rec} = 100° K DSB), was affected by short term instabilities related to thyristor switches in the deicing system and poor IF connections. Moving the hybrid cryostat in elevation affects neither the receiver stability nor the temperature of the mixer.

Back-ends installed in the equipment room on the Plateau de Bure.

Instrumentation

At the end of the interferometer system test in Grenoble, all the equipment was dismounted and transported to the Plateau de Bure.
Reassembly of the correlators went surprisingly well, and as of the first week of November, all systems were operational again on the site. All the software for the interferometer tested in Grenoble, was installed on the PDP 11/44 on the site, and by the end of November, a complete two-element interferometer was available on the site for the first real interferometer experiments.

First Interferometer Fringes

Fringes with the twoelement interferometer were obtained for the first time on the 14th of December 1988.

At first, fringe stopping did not function, due to sign convention problems in the phase definition, but this was quickly corrected.
After this correction, reproducible fringes were obtained on several astronomical sources: 3C84, 3C273, 3C454.3, and the Orion A SiO maser with both the continuum and spectral correlators.
The side band rejection was measured on the Orion SiO maser, and a first baseline was measured on a 48 meter baseline between two observing stations on the N-S track. The astronomically measured length was consistent with the geodesic measurements to within 2 mm, but the orientation of the measured baseline with respect to North, was wrong by about 1 arc min.

Certainly not all remaining phase and other problems could be identified however, and many more tests and observations will be required.
Tests with the interferometer were stopped on December 22nd to bring telescopes 1 and 2 into the assembly hall for urgent modifications of the deicing system, which were carried out on telescope 2 during the Christmas period.

Asphalting the tracks.

Buildings and Infrastructure

The problems encountered during the winter 1987-88 with the clearing snow from the tracks clearly showed that if the pavement of the tracks was not improved, it would be extremely difficult to keep the tracks available during the whole winter period. As a consequence of this experience, two measures were considered:

— to asphalt the tracks,

— to modify the bogies and to increase the clearance between the rails and the telescope base during transport between the observing stations.

Due to financial constraints only the asphalting could be undertaken in 1988. The asphalting of the tracks, which posed difficult access problems for the asphalting equipment, was completed in August.

What had to be organised to asphalt the tracks.

Personnel and Finances

At the end of 1988, a total of 100 persons were employed by IRAM

Of this total, 88 are IRAM staff members, 9 are thesis students, and 3 are post docs, 1 of whom is financed by the IRAM partners. Not included in the total is the Spanish Co-director, who is delegated to IRAM by IGN.

The geographical distribution of the staff is as follows:

• Grenoble	
• Plateau de Bure	
• Granada .	3
• Pico Veleta	22
Total	88

Even though much time and effort were spent on the problem of reimbursement of value added taxes in Spain, no solution to this problem was found in either 1987 or 1988.

IRAM's financial situation in 1988 and the budget previsions for 1989 are summarized in the tables on the following pages.

Actual expenditure in 1988 was 7.5 Mio FF higher than initially anticipated.
This increase is due to the completion, during 1988, of the construction investments defined in Annex B of the IRAM funding contract between the CNRS and the MPG. These additional expenses were covered by increases of the MPG contribution and IRAM's income. With the increased MPG contribution, both IRAM partners have equally participated in the construction investments. The increase in IRAM's income is related to the end of the reflector contract, as interests for advance payments, exchange rate profits, and penalties can only be determined at the end of the contract.

The construction investments amount to 248.7 Mio FF distributed over the IRAM establishments as follows:

• Pico Veleta	93.4 Mio FF
• Plateau de Bure	142.6 Mio FF
• Grenoble	12.7 Mio FF

During 1988, a start was made with the new 5-year investment plan adopted by the IRAM Executive Council in its September 1987 meeting.
This plan foresees the construction of a 4th telescope for the interferometer, the purchase of mm-VLBI equipment for both observatories, and funding for the instrumentation for the IRAM telescopes.

The total investment — construction and others — reached 286 Mio FF by the end of 1988. Total commitments on 31 December 1988 amount to 6.55 Mio FF.

Budg 988

Expenditure

Budget heading	Budget Mio FF	Actual Mio FF
Personnel	26.070	26
Operations	11.230	94
Investments	10.723	46
alue Ad ed Ta	3.450	50
	51.473	

Incom

udget headin	Budget Mio FF	Actual Mio FF
Contribution CNRS	22.673	66
Contribu MPG	25.150	566
Oth Income	200	
Contribution CNRS for Value ad ed	3.450	
	51.473	

Budget Prevision 1989

Expenditure

Budget heading	Approved Budget
Personnel	27.270
Operations	11.780
Investments	10.030
Value-Added Taxes	3.260
	52.340

Income

Budget heading	Approved Budget
Contribution CNRS	23.775
Contribution MPG	23.775
Other Income	1.530
Contribution CNRS for Value-added taxes	3.260
	52.340

ANNEX I — Record of observing programs at the IRAM 30-m Telescope

IRAM 30-M TELESCOPE OBSERVING PROGRAMS DEC 1987-FEB 1988

Date	Title	Freq. (GHz)	People
Dec 1-5	Nearby Dwarf Irregular Galaxies	115 230	Becker, Appenzeller et al.
Dec 6-7	CO in Elliptical Galaxies	115 230	Henkel, Wiklind, Becker
Dec 8-14	Arm-Interarm Contrast in M51	230	Guelin et al.
Dec 8-14	Edge-on Galaxies	230	Guelin et al.
Dec 12-18	Molecules in the HH 1-2 objects	98 110 115 220 230	Cernicharo et al.
Dec 15-20	Cooling Flows in Galaxies	115 230	Huchtmeier et al.
Dec 18-22	Cyanoacetylene around IRc2	91.9 109.4	Martin-Pintado, Rodriguez et al.
Dec 22-Jan 1	Radio Emission from Stars	250	Altenhoff, Thum, Wendker
(and Jan 4)	Planets	250	Thum et al.
Dec 22, 25	Pluto-Charon occultation	250	Altenhoff et al.
Jan 2-3	Pointing model	90 230	Local staff
Jan 5-11	Dense Core in G05.89	230	Harvey, Forveille
Jan 5-8	IRAS unidentified objects	230	Truong-Bach, Rieu et al.
Jan 9-11	Bright Carbon Stars	230	Rieu et al.
Jan 12-13	Three IRAS Objects	88 98 220 230	Omont, Forveille
Jan 14-16	$^{12}C/^{13}C$ in Circumstellar Envelopes	220 230	Omont et al.
Jan 17-18	H_2S Emission from Evolved Stars	86 216	Lucas et al.
Jan 19-22	Megamaser Galaxies	230	Henkel, Schilke
Jan 23-25	Extragalactic Methanol	95-261	Henkel, Mauersberger, Walmsley, Hein
Jan 25-26	Infrared quasar 13349 + 2438	104	Steppe
Jan 26-28	Turbulent molecular gas	219 220 230	Puget, Perault, Falgarone
Jan 28-29	Deuterated water in compact cores	80.6 225.9	Despois, Jacq, Walmsley, Henkel et al.
Jan 29-Feb 2	Outflow from RNO 14	230	Bachiller, Martin-Pintado, Lazareff
Jan 30-Feb 2	Structure of giant molecular clouds	109 110 115 219	Despois, Puget, Falgarone, Perault
Feb 2-6	Metal molecules in circumstellar shells	214-253	Cernicharo et al.
Feb 6-7	Molecules in the HH 1-2 objects	98 110 115 220 230	Cernicharo et al.
Feb 7-9	CO absorption lines in quasars	80-230	Roland, Radford et al.
Feb 8-9	Molecules in the galaxy Malin-1	106 212	Radford, Bothun
Feb 8-11	CO in the stratosphere of Titan	230	Marten, Lecacheux, Paubert et al.
Feb 9-11	CO and CS study of bi-polar outflow	98 115 230	Torrelles et al.
Feb 12-15	Laser alignment of mirrors, tests	250	Greve, local staff
Feb 16-22	Bipolar flow in a pre-planetary nebula	115 230	Bachiller, Martin-Pintado, Gomez et al.
	Infrared quasar observations	104	Steppe
	Recombination lines in HII regions	85.7 232	Guilloteau et al.
	CO (2-1) from massive OH/IR stars	230	Forveille, Heske, Habing et al.
Feb 23-29	Arm-Interarm Contrast in M51	230	Guelin, Garcia Burrillo et al.
	Edge-on Galaxies	230	Guelin, Dahlem et al.

Date	Title	Freq. (GHz)	People
Mar 1-7	Pointing, autocorrelator tests	90 226	Steppe, Martin-Pintado et al.
Mar 8-11	CO in elliptical galaxies	115 230	Lazareff, Jura, Kim, Lequeux
Mar 8-14	H_2S in Circumstellar Envelopes	86 216	Lucas, Omont, M. Morris
Mar 12-14	$^{12}C/^{13}C$ in C-rich stars	110 115 220 230	Jura, Kahane, Omont, Audouze
Mar 15-21	CO in the nuclei of IRAS galaxies	115 230	Götz, Greve, Steppe, Downes
	CO in the Zeta Ophiuchi cloud	115 230	Le Bourlot, Gérin, Perault
Mar 22-28	Studies of dust features	218 220 245	Mezger, Zylka, Wilson, Mauersberger, Thum
	Bipolar flow from a carbon star	115 230	Kahane, Jura, André
Mar 29-Apr 2	CO in M104	115 230	Bajaja, Hummel, Wielebinski, Dettmar
Mar 29-30	Wobbler, Autocorrelator	115 230	Peñalver et al.
Mar 31	Clouds in the Molecular Ring	115 230	Despois, Falgarone, Pérault, Puget
Mar 31-Apr 2	CO in edge-on galaxies	115 230	Garcia-Burillo, Guélin, Cernicharo, Blundell, Greve, Götz
Apr 2-3	CO in M51	115 230	Guélin, Cernicharo, Downes, Götz
Apr 3-4	Receiver alignment, Pointing	90 226	Hein, Steppe, local staff
Apr 5-11	Virgo galaxies NGC 4432, NGC 4254	115 230	Casoli, Combes, Gérin, Dupraz
	Luminous IRAS Galaxies	115 230	Kazes, Mirabel, Combes, Casoli
	Ring in the galaxy NGC 4314	115 230	Combes, Gérin, Garcia-Baretto, Pismus
	Merging galaxy system Arp 299	115 230	Casoli, Combes, Arnault, Augarde
Apr 12-18	Tidally interacting galaxies	115 230	Casoli, Combes, Dupraz, Pagani, Hummel, Wielebinski, van der Hulst
Apr 19-22	Ultra-luminous galaxy VII Zwicky 31	230	Downes, Radford, Solomon
Apr 23-25	CO (2-1) in selected galaxies	230	Solomon, Radford, Downes
Apr 26-27	Pluto-Charon Occultation	250	Altenhoff et al.
Apr 27-30	PMS Stars/QSOs	250	Guesten, Beckwith, Sargent / Chini et al.
	Pluto, Triple switching, Isoplanicity	250	Altenhoff, Kreysa et al.
May 1	Pluto-Charon Occultation	250	Altenhoff et al.
May 1-2	Pointing model	90 226 250	Altenhoff, Steppe et al.
May 3-9	Baselines	88 220	Morris, Vivekanand
	Molecules in the HH 1-2 Region	97 110 220	Cernicharo, Martin-Pintado et al.
	Spiral Structure in M51	110 115 220 230	Garcia-Burillo, Guélin, Cernicharo et al.
May 10-16	Dense cores in dark filaments	98 245	Güsten, Fiebig, Ungerechts
	Chemical test for MHD shocks	85 98	Cox, Henkel, Güesten, Mauersberger
	Dense cores in NGC 2071 and S140	98 245	Güsten, Evans, Zhou, Mundy, Kutner
May 17-23	^{13}CO and CH_3CN in Orion	220	Wilson, Henkel, Serabyn, Mauersberger
	Orion outflow in H_2CO (3-2)	225.7	Wilson, Mauersberger, Henkel, Walmsley
	Partially-ionized globules	86 98 220 245	Ziurys, Wilson, Henkel, Mauersberger
	^{12}CO and ^{13}CO toward Cas A	110 115 220 230	Olano, Wilson, Walmsley, Henkel, Jacq
May 24-30	M51 Spiral Structure	110 115 220 230	Garcia-Burillo, Guélin, Cernicharo et al.
	Molecules in Sgr B2	98 110 220 225 245	Martin-Pintado, de Vincente, Mauersberger, Wilson, Cernicharo
May 25-27	Line contamination in continuum emission	89-115 230	Mauersberger, Steppe
May 28-30	Star formation in the outer galaxy	111 115	Brand, Wouterlout

Date	Title	Freq. (GHz)	People
May 31-Jun 4	Shocks in Scorpio-Ophiuchus Region	115	de Geus, Brand
	Wobbler tests		Schraml, Granada staff
Jun 5-6	Pointing		Steppe
	HCN Maser Monitoring	88	Liechti, Guilloteau, Lucas, Omont
Jun 7-13	Isotopic Ratios in Evolved Stars	99-147, 219-225	Kahane, Gomez, Cernicharo, Guélin, Penalver
	Response of Molecular Gas to Compression	109-115, 219-230	Puget, Pérault, Falgarone
	Line Calibration	230-250	Liechti, Despois, Mauersberger, Steppe, Martin
Jun 14-20	Spiral Galaxies in Clusters	115 230	Gérin, Casoli, Combes, Dupraz
	FeO, HCOCN, CH_2D^+ in Interstellar Space	97-238	Gérin, Combes, Salez, Encrenaz, Pauzat, Wootten
	Starburst Barred Spiral NGC 660	115 230	Casoli, Combes, Dupraz, Gérin, Miyaji, Nakai
	Molecular Spiral Arms of NGC 6946	115 230	Casoli, Combes
	Molecular Clouds in M81	115 230	Brouillet, Baudry, Combes, Bash
	Molecular Clouds near the Galactic Centre	86-115, 219-236	Bel, Viala, Combes, Pagani
Jun 21-27	CO Observations of RV Tau Stars	115 230	Bujarrabal, Alcolea, Martin-Pintado
	Recombination Lines from Star Winds	92 230 231	Martin, Planesas, Bachiller, Gomez, Bujarrabal
	Ring, Butterfly, Nebulae and IC418 Maps	90-115, 230	Bachiller, Planesas, Bujarrabal, Martin, Gomez
	Cooling Flows in Galaxies	115 230	Huchtmeier, Bregman, Roberts
Jun 28-Jul 1	Tests		Granada staff
Jul 1-4	CO in Early-Type Galaxies	115 230	Henkel, Wiklind
	CO in Early-Type Galaxies	115 230	Henkel, Wiklind
	CO in galaxies	115 230	Becker, Henkel, Wouterloot, Wilson, Appenzeller, Wiklind
Jul 5-7	$^{12}C^{18}O$ in M82 + $^{18}O/^{17}O$ in Nuclei	110-12, 220-224	Reuter, Wielebinski, Klein, Henkel, Mauersberger
Jul 8-10	Search for Vibrationally Excited Water	96 233	Menten, Melnick, Thaddeus, Walmsley
July 10-112	Molecular Clouds in Dwarf Irregulars	115 230	Becker, Henkel, Wouterloot, Wilson, Appenzeller
Jul 12-15	Molecules in QSO	90 220	Roland, Webb, Douglas, Radford
	CO in Strong IRAS Galaxies	230	Booth, Johansson, Radford
Jul 15-18	Molecular Content of Polar Ring Galaxies	90 220	Radford, Greve
	Molecular Content of Malin 1	106 212	Radford, Bothun
	Recombination Lines of Positronium	80	Vivekanand, D. Morris, Downes, Radhakrishnan
Jul 19-25	Luminous Giants + Circumstellar Envelopes	86-115, 220-230	Schönberg, Engels, Reimers
	Luminous Giants + Circumstellar Envelopes	86-115, 220-230	Loup, Despois, Lucas, Omont
	Line calibration	107-115, 222-230	Liechti, Despois, Mauersberger, Steppe, Martin
	CO Observations of Red Supergiants	230 86	Loup, Mauron, Omont, Forveille
	IRAS Galaxies project consortium		Steppe et al.
Jul 26-29	Tests		Granada staff
Jul 30-Aug 2	Recombination lines from star winds	92 230 231	Martin-Pintado, Planesas, Bachiller, Gomez-Gonzales, Bujarrabal
	$^{12}C^{18}O$ in M82	219.5	Reuter, Wielebinski, Klein
Aug 2-8	Isotopic ratios in evolved stars	99-115 219-225	Cernicharo et al.
	IRAS Galaxies project consortium		Steppe, Chini, Krügel

IRAM 30-M TELESCOPE OBSERVING PROGRAMS AUG-DEC 1988

Date	Title	Freq. (GHz)	People
Aug 9-15	Evolved Carbon + Oxygen Stars	230 115	Cernicharo, Guélin, Bachiller, Martin
Aug 16-22	Molecular Envelope of Mira	several	Planesas, Bujarrabal, Bachiller, Martin, Gomez
	ρ Ophiuchi Cloud Core	96-245	André, Martin, Despois, Montmerle
	Mapping of Evolved AGB Stars	115 230	Heske, Maloney, te Lintel
Aug 23-29	Tests		Granada staff
Aug 30-Sept 6	Magnetic Fields + Molecular Clouds in M31	115	Berkhuijsen, Beck, Bajaja
	Clouds with Magnetic Field Strengths	91 109 110	Troland, Kazes, Crutcher
	CO Mapping of CRL 2688 + IRC 10216	230	Truong-Bach, D. Morris, Rieu, Viala
Sept 6-13	Molecular Gas in Elliptical Galaxies	113-115, 226-230	Jura, Kim, Lazareff, Lequeux
	$^{12}C/^{13}C$ in ^{13}C-rich Envelopes	86-147, 231-245	Jura, Kahane, Omont, Audouze
	HCN maser monitoring	88	Liechti, Guilloteau, Lucas, Omont
Sept 13-19	Planetary Nebula NGC 7027	99 232	Vallée, Omont, Guilloteau, Forveille
	S235 and W40	109 110 115	Guilloteau, Vallée
Sept 20-25	Seyfert Galaxy NGC 6764	115 230	Eckart, Harris
	Starburst Galaxies NGC 2146, 2903	115 230	Jackson, Eckart, Genzel, Harris, Ho
Sept 24-27	CO Observations of Mars	109-115, 219-230	Lellouch, Gérin, Combes, Encrenaz, Paubert
Sept 27-Oct 2	Maintenance Period		Granada staff
Oct 25-31	Oxides and Hydroxides in Star Envelopes	212-253	Cernicharo, Guélin, Penalver, Downes
	IRAS Galaxies project consortium	90 220	Steppe, Blitz et al.
	High-latitude clouds	115 230	Blitz, Falgarone
Nov 1-7	Interstellar Phosphorus-Bearing Molecules	220 240	Schilke, Henkel, Walmsley, Mauersberger
	HDO in Hot Cores	143 225 241	Jacq, Baudry, Walmsley, Henkel, Mauersberger
Nov 8-14	Receiver Installations and Tests		Carter, Baars, Schultz, Güsten, local staff
Nov 30	HCN maser monitoring	88	Liechti, Guilloteau, Lucas, Omont
Nov 30-Dec 3	Young stellar objects	115 230	Bachiller, Cernicharo, Martin-Pintado
Dec 1-5	Clouds in the molecular ring	90-115, 219-245	Despois, Pérault, Stark
Dec 4-5	Lines of CH_3OH masers	84, 95, 132, 147, 229	Menten, Walmsley, Liechti
Dec 6-12	CO in NGC 4449	115 230	Henkel, Klein, Mebold
	Tidal arms + dwarf galaxies near M81	115 230	Becker, Henkel, Wilson et al.
	Envelopes of dwarf galaxies	115 230	Henkel, Becker, Appenzeller et al.
	Star formation in dwarf irregulars	115 230	Becker, Henkel, Wouterloot et al.
Dec 13-19	Mapping in Taurus + Molecular Disks	141 226 246	Lazareff, Monin, Pudritz
Dec 14-16	Autocorrelator tests		local staff
Dec 17-18	CO in ellipticals	113-115, 226-230	Lazareff et al.
Dec 17-19	Molecules near ultra-compact H II regions	98 110 220	Walmsley, Churchwell
Dec 19	Starburst galaxies	115 230	Moles, Gomez, Cernicharo, Masegosa
Dec 20-23	Recombination lines from compact H II regions	85.7 231.9	Churchwell, Walmsley
Dec 24-26	CS in ρ Oph cloud core	98 245	André, Martin-Pintado, Despois et al.
	Deuterated formaldehyde in Orion	111, 128-166, 221, 247	Mauersberger, Jacq, Henkel, Walmsley
	CO in Markarian galaxies	110 115 220 230	Chini, Krügel, Steppe
	Anomalous recombination line	98 147 245	Martin-Pintado, Bachiller, Thum

ANNEX IIA IRAM Publications

140. 3 and 1.3 mm observations of a complete sample of active galactic nuclei. R. Chini, H. Steppe, E. Kreysa, Th. Krichbaum, A. Quirrenbach, C. Schalinski, A. Witzel. 1988, *Astron. Astrophys.*, **192**, L1.

147. New HCN masers in stars. R. Lucas, S. Guilloteau, A. Omont. 1988, *Astron. Astrophys.*, **194**, 230.

148. Thermal control of the IRAM 30-m millimeter radio telescope. J.W.M. Baars, A. Greve, B.G. Hooghoudt, J. Penalver. 1988, *Astron. Astrophys.*, **195**, 364.

149. Deuterated methanol in Orion. R. Mauersberger, C. Henkel. T. Jacq, C.M. Walmsley. 1988, *Astron. Astrophys.*, **194**, L1.

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