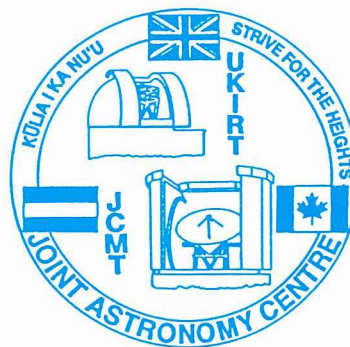
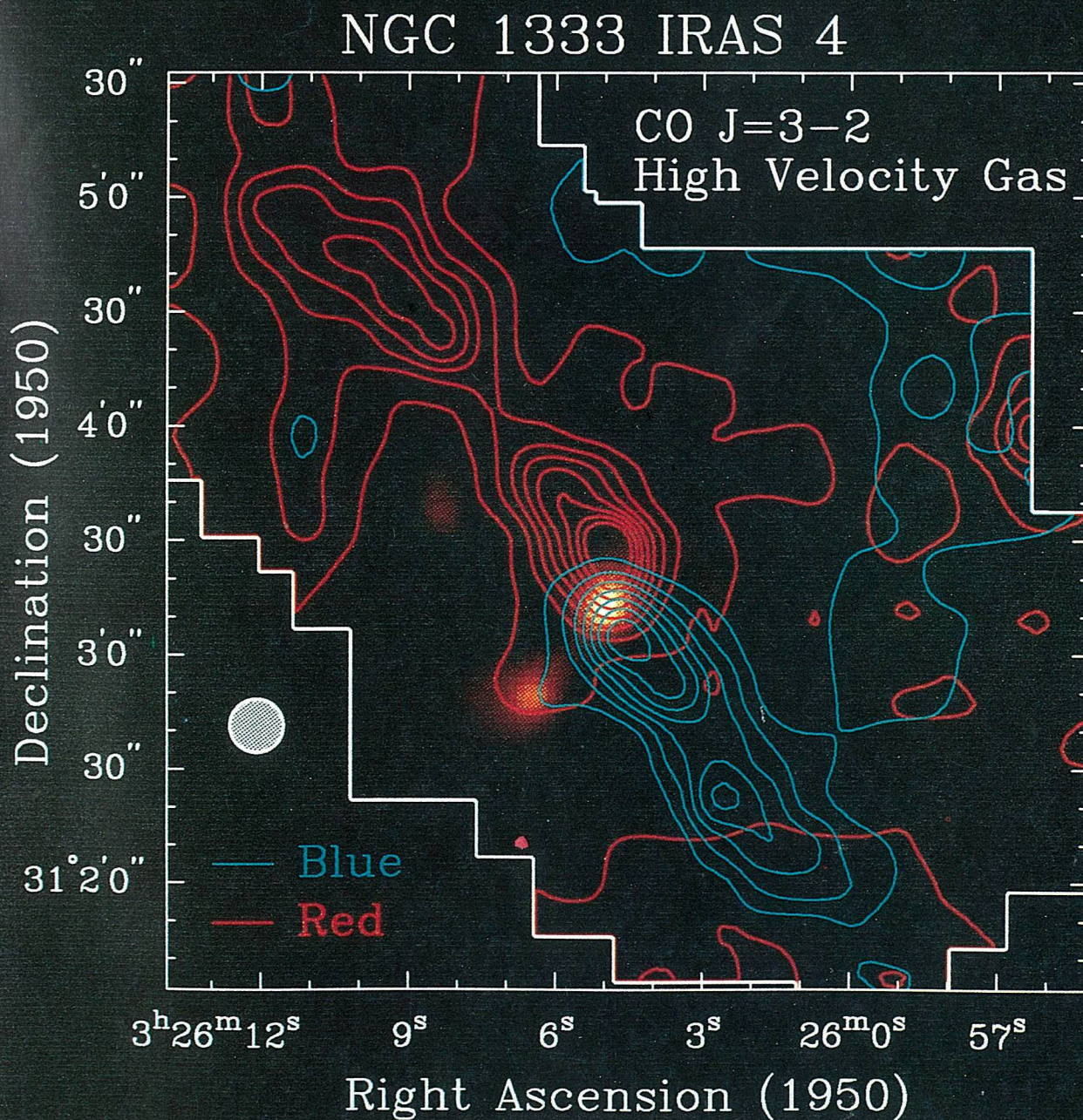


# *The JCMT Newsletter*



Kūlia I Ka Nu'U

Number 1 July 1993





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**Cover Picture:** Red- and blue-shifted CO emission from the IRAS4A and 4B cores in the NGC1333 complex. (see full article in Science section). Note the mirror symmetry between the red and the blue outflow.



# People, Events & Things

## Personnel Changes

**Rob De Haan** has left the JAC having survived many years on the staff of the JCMT. Rob travels back to the Netherlands and takes up a post at NFRA, Dwingeloo connected with the Westerbork synthesis array.

**Wayne Holland** has joined the JCMT team as a Support Scientist with special duties for SCUBA. Wayne has been closely involved with the bolometer development for SCUBA at QMW.

**Ko Hummel** has left the ROE support group where he has been Netherlands liaison officer for the past few years. Ko was largely responsible for getting the data archive operating.

**Chris Mayer** has left the JAC after his tour of duty. Chris returns to RGO to take up a different challenging software position.

**Remo Tilanus** has joined the JCMT staff in Hawaii. Remo comes from Owens Valley but has also been at the IfA in Honolulu where he has used the JCMT several times.

**Colin Hall** has recently left ROE to take up a position at Caltech connected with the JCMT-CSO interferometry work.

**Jane Greaves** has arrived from FCRAO at the JAC as an Affiliate Astronomer. Jane has had extensive use of the JCMT for observing over the past few years.

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## Vehicles with Automatic Transmission

There have been a number of incidents recently where visitors to the Joint Astronomy Centre have experienced brake failure whilst driving the JAC's Ford Bronco that is equipped with automatic transmission.

After careful consideration, the JAC's Safety Committee has concluded that vehicles with automatic transmission might be a safety hazard if they are not driven in the correct manner and has recommended that only vehicles equipped with manual transmission should be used on the road from Hale Pohaku to the summit of Mauna Kea. This recommendation has been endorsed by Senior Management at the JAC and accordingly the automatic Ford Bronco has been exchanged for a manual transmission Ford Explorer.

Anyone who is unable or unwilling to drive a manual (stick shift) vehicle should contact his/her

Support Scientist at the JAC so that alternative arrangements can be made.

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## ASTRA

The Association of Scientific Telescope Research Associates was created in 1992 to codify, solidify and legitimize telescope operating as a career profession, and to assist its members in upgrading and maintaining their skills in regard to the ever changing systems and instrumentation associated with telescopes. This is a professional organization, and not a union, therefore we are not involved in salary issues, labor/management disputes, etc. ASTRA will however attempt to be a voice to represent various issues in common to Telescope Operators of all organizations and to establish basic conditions relating to housing, safety and working environment.

Beyond the scope of the Mauna Kea Observatory, ASTRA seeks association with other organizations within the realm of astronomy and other professional organizations of Telescope Operators at observatories around the world. We seek to share personal and technical information, and to promote goodwill, in the effort to continually upgrade our profession.

We hope that Telescope Operators at other observatories will feel inspired to create their own associations, and correspond with us, as well as visiting us.

Our intention is to meet at least 4 times per year, as near to the solstices and equinoxes as feasible. We shall seek discussions with astronomers, software developers, and engineers/technicians from all areas within the field of astronomy. We seek this to expand our overall knowledge of science and operating systems at different telescopes.

We currently offer full membership to all active Telescope Operators. An Associate membership is available to other technicians, retired Telescope Operators, students, etc. Full membership dues for 1993-1994 are \$25. Associate membership dues are \$12.50. This fee will entitle the member to receive our newsletter, attend meetings and any special functions that may be scheduled.

To get in touch with us or to join, please write to:

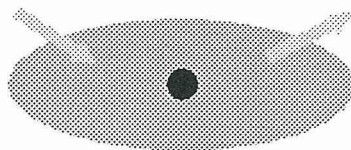
**ASTRA**  
**Post Office Box 10463**  
**Hilo,**  
**Hawaii 96721, USA**



# CIRCUMSTELLAR MATTER 1994

29 August - 2 September, 1994

EDINBURGH, SCOTLAND



The Conference is to be held at the Edinburgh Conference Centre on the Heriot-Watt University campus to the south-west of the city of Edinburgh. The talk sessions will run from Monday morning through Friday mid-afternoon. It is hoped to present a concurrent or recent overview of all features of circumstellar matter. The presentations and posters should lead participants to a better understanding of the processes of star formation, early stellar evolution and the later stages of evolution. The proceedings of this Conference will be published. This work will form the basis for a major review of circumstellar processes.

Some topics to be covered include: formation and evolution of protostars; circumstellar disk formation & subsequent evolution; comparisons between low & high mass young stellar objects; dynamics & chemistry of H-H objects & T Tauri stars; dynamics, chemistry & evolution of outflows, winds & jets; dynamics of evolved & post main sequence stars; mass loss from late-type stars; circumstellar dust, shell & envelope structure & chemistry; envelopes, masers, binaries; dust formation in stellar winds, dust around main sequence stars; mass loss from hot stars: Wolf-Rayet stars, OB & Ae/Be stars, FU Orionis types, etc; instabilities in flows & winds (ie: shocks, blobs, winds, jets); winds from hot & cool stars, winds from massive stars; features of Luminous Blue Variables; role of magnetic field in star formation and early stellar evolution; symbiotic stars and novae.

For further details and information contact Graeme Watt (ROE): tel: (031) 668 8310; fax: (031) 662 1668; e-mail: REVAD::GDW (Starlink) or GDW@STAR.ROE.AC.UK (InterNet) or 19889::GDW (SPAN).

The next PATT deadline for JCMT applications is:

## 21st September 1993

To ensure prompt processing, please ensure that your applications are sent to the correct establishment. Applications for JCMT time should be submitted to the national TAG of the Principal Investigator (PI) or, if the PI is not from one of the 3 partners, to the national TAG of the first named co-investigator on the application who is from one of the partners. International applications (those with no applicants from one of the partners) should be submitted to the UK national TAG. Members of the JCMT staff in Hawaii count as International (not members of the 3 partner countries) unless they are the PI on an application when it should be forwarded to the appropriate national TAG.

Country paying salary of Principal Investigator		
Canada	Netherlands	UK or Other
JCMT Time Allocation Group, Herzberg Institute of Astrophysics, 100 Sussex Drive, Ottawa, Ontario K1A 0R6 CANADA	JCMT Program Committee, Leiden Observatory, P O Box 9513, 2300 R A Leiden, NETHERLANDS	PATT Secretariat, SERC, Polaris House, Swindon, SN2 1ET, UNITED KINGDOM



## Message from the Director

This edition sees the return of the Newsletter dedicated solely to the JCMT, a suggestions originating at the JCMT Advisory Panel in April and endorsed by the JCMT Board in May. To that end I am keen that we identify the user community in the widest sense and Graeme Watt is compiling a list of users who wish to receive the Newsletter. We are also investigating using an electronic information system for the future.

I have taken the opportunity to organise the JCMT staff in Hawaii in a more project oriented structure. To recognise the importance of the telescope in terms of continuing upgrades I created a Telescope Group, headed by Richard Prestage. The function of this group is to monitor the performance of the telescope and to manage projects to ensure that it not only continues to meet our specifications, but that these are improved to meet the requirements of the new higher frequency instruments. The most major projects at the current time are surface accuracy and pointing. Per Friberg heads up the Receiver Group, who have successfully commissioned the new receivers and are now planning for the arrival of SCUBA and RxB3.

There have been a number of milestones achieved during the six months since the last Newsletter. Receiver C2 was successfully commissioned in May and has proven to be both extremely sensitive and highly reliable. Already some very impressive data have been obtained. Very recently, the DAS was commissioned in most of its modes and appears to be working well. Bill Dent reports on this along with RxC2 later in this Newsletter.

The major project undertaken by the Telescope Group was the change in focal length of the JCMT. This has been a major step and the results are extremely encouraging. The details of this excellent project are reported by Richard later in this Newsletter. In terms of pointing, although there are still occasional problems, the performance is normally excellent, with rms values of 1.7 arcseconds or better in each axis under stable observing conditions. The telescope operators are required to report all instances of errors exceeding 5 arcseconds during stable conditions as these should be very rare if only attributable to our pointing model and might be telling us of other areas of difficulty such as the tertiary mirror unit for example.

The prototype for the new SMU digital servo was successfully tested and work on the new system is now well under way.

As one of his top priorities the new Chief Engineer, Phil Moore, has been focussing major effort since

the start of the year on the problems with the power and grounding of the JCMT. Joseph Fletcher was given responsibility for investigating the wiring systems and ground currents, and along with a consultant electrical engineer from RAL, has managed to reduce the currents significantly. Further work will be needed after the consultant's report has been received.

At the beginning of the year the carousel bogie side-thrusters began to fail, a fault which we had thought had been cured two years previously. Extensive investigations of the loadings on the side-thrusters were undertaken by Simon Craig and Phil Moore, and these tests showed that excessive loadings were being inflicted, causing them to fail. The bogie re-alignment work continued alongside an investigation by John White of the track lubrication process. It was believed that the dry lubricant had a lengthy lifetime in terms of allowing the bogey rollers to slide. However dramatic evidence in the form of load curves from a number of side thrusters demonstrated conclusively that the lifetime ranged from a few hours to a couple of days. New lubricants were tried and at the time of writing, a grease lubricant seems to have a lifetime of around a month before loads double from their initial values. Work on this area is ongoing.

The JCMT has started to move towards UNIX; there are now three SUN workstations in Hilo for use by support astronomers and a further two in the terminal room for visiting astronomers.

In this day of electronic communications, I determined that as soon as possible, the JCMT should produce an electronic information system. Henry Matthews was given responsibility for organising this and he reports in detail below. Furthermore, I expect that the bulk of this Newsletter will be made available in electronic form, and in due course, we will have the effort available to have the diagrams also included, providing thereby a fully-electronic Newsletter. We intend to make the JCMT\_INFORM system the main means of communications regarding the JCMT. It should be consulted frequently, the information will be updated at least monthly and it should be the key area for information regarding proposals for the coming semester. In the meantime, we will produce a reduced version of the Newsletter for e-mail transmission, containing information from the project and details about instruments for the next semester. You are probably reading such a version now. Please try the INFORM system and let Henry know of any problems or suggestions.

*Ian Robson, Director JCMT*



# Expected Availability of Instruments during Semester 94A

## Introduction

Semester 94A (1 February 1994 - 31 July 1994) instrument availability and sensitivities are summarized below. Additional details can be found in 'The James Clerk Maxwell Telescope: A Guide for the Prospective User', which is available through the JCMT Section of the Royal Observatory Edinburgh, by contacting the JCMT Group at the Herzberg Institute of Astrophysics in Canada or the NFRA at Dwingeloo, The Netherlands, or from the Joint Astronomy Centre in Hawaii.

## Spectral Line Observations

Three SIS mixer receivers form the core of the heterodyne program, A2, B3i and C2. One other receiver (G) is available via collaboration with the MPE, Garching group. A summary of the properties of this instrumentation is given in Table 1 below.

Receiver temperature values ( $T_{rx}$ ) are typical numbers for each receiver; there are significant changes as a function of frequency. The efficiencies (where measured) are accurate to at least 10%. The beam can be slightly elliptical and may depend somewhat on frequency. Two bands for G are included, since they are significantly different; for G the amount of power arising in near sidelobes is significant (about 30% within a 30-40" error beam).

### (1) Receiver A2

A2 is a single-channel receiver. Its excellent low-noise performance results in a total system temperature ( $T_{sys}$ ) of better than 350K across most of the band under normal conditions. The Schottky receiver A1 has been taken out of service.

### (2) Receiver B3i

B3i (also a single-channel device) is one of the best receivers available in this band in the world. The DSB receiver temperature response is not constant with frequency, and ranges from a best value of near 160 K at 355 GHz (even better values have been recorded below 310 GHz), up to about 265 K at 330 GHz. On the sky, SSB system temperatures below 600 K have been obtained under good conditions. The local oscillator system of B3i permits frequency-switched observations with a recommended maximum switch of 150 MHz.

The dual channel version of B3i, B3, is scheduled to be commissioned at the beginning of 1994, and may be available to users during Semester 94A. The Schottky receiver B2 is no longer available.

### (3) Receiver C2

C2 is a single-channel receiver which covers frequencies from about 450 to 504 GHz. In May 1993 it successfully completed commissioning and has been used for PATT observations since that time, when atmospheric conditions have permitted. Generally this is when the opacity of the atmosphere measured at 225 GHz is less than 0.1 at 461 GHz, and less than 0.06 at 492 GHz.

Two Gunn oscillators (overlapping at 475 GHz) are used to cover the complete frequency band; changing Gunns during an observing night is not recommended. The performance of C2 has considerably exceeded expectations: DSB receiver temperatures of 190 and 220 K are typical near 460 and 490 GHz respectively. Under the excellent conditions encountered during commissioning, total SSB system temperatures were sometimes less than 1000 and 2000 K respectively at these frequencies. Typical system temperatures are usually 2000 and 3000 K under decent observing conditions. Additional details can be found in the report on C2 in this Newsletter.

The bolometer receiver for this frequency, C1, has been retired and is not available as a C2 backup.

### (4) Receiver 'G'

This receiver is a single-channel Schottky device employing a laser local oscillator arrangement. Because of this fact, only certain discrete frequencies can be accessed, in particular in the regions around the CO J=6-5 and 7-6 lines at about 690 and 800 GHz respectively. Typical double sideband receiver temperatures range from 3000 through 4500 K; specifically, at CO(6-5) and  $^{13}\text{CO}(6-5)$  receiver temperatures of 3000 and 3500 K are obtained. The resulting single-sideband system temperatures are extremely sensitive to atmospheric conditions, but are likely to be of the order of 55000 K or more under practical conditions. Receiver 'G' is on loan from the MPE group in Garching and observers interested in using it must contact either Prof. R. Genzel or Dr. A. Harris to arrange collaborative efforts. It is likely that this instrument will only be available during the summer semesters.

### (5) Spectrometer Backends

The Digital Autocorrelation Spectrometer (DAS) has 2048 delay channels having a total maximum bandwidth of 920 MHz in each of two inputs. It is capable of a wide range of configurations, with spectral resolutions of between 0.14 and 1.5 MHz. The widest bandwidth modes are useful only for



receivers (such as C2) with sufficient IF bandwidth. In narrow-band modes it is possible to observe several lines from either sideband with high resolution. Installation of the AGC circuits and a number of software modifications in July 1993 appear to have overcome the earlier problem with baseline matching between 'sub-bands', so that the wider-band modes are now useable.

The AOSC is an acousto-optical spectrometer which offers a resolution of about 330 kHz and a total bandwidth of 500 MHz for a single IF channel. The AOSC serves as a backup for the DAS.

Further details regarding both spectrometers are given in the User's Guide. An article on the DAS also appears in this Newsletter.

#### (6) Approximate rms sensitivities after 30 minutes' integration

Table 2 displays the calculated rms noise in Kelvin after a total observation time of 30 minutes (this assumes 15 minutes on source, 15 minutes on a reference position), for about 1.0 mm of atmospheric water vapour. In parentheses, the expected values of the rms noise are given for 'exceptional' and 'poor' weather conditions (about 0.5 and 5 mm of water vapour respectively). Atmospheric transmission impacts receiver B3, C2 and G observations strongly, and poor conditions render work at the higher frequencies impossible.

#### Continuum Observations

##### UKT14

Contingent on progress with SCUBA (see below), the UKT14 bolometer system will likely be

available during Semester 94A with filters for observations at 2, 1.3, 1.1, 0.85, 0.8, 0.75, 0.6, 0.45 and 0.35 mm. The aperture of the bolometer can be adjusted between 21 and 65 mm. Sensitivities range from typically 0.3 Jy/sqrt(Hz) through to 10 Jy/sqrt(Hz) or more under good photometric conditions. See the User's Guide or March 1992 Newsletter for further information.

##### UKT14 polarimeter

The Aberdeen/QMW polarimeter is available as an optional accessory for the UKT14 bolometer system in step and integrate mode. The effective NEFD of the polarimeter/UKT14 combination is slightly worse than  $NEFD(p) = 2 \times NEFD/P$ , where P is the degree of polarization of the source and NEFD is that for the filter/waveplate in question for UKT14 alone. Observations are possible at 1100, 800, and 450 microns. Additional information appears in the article by Sye Murray in the JCMT-UKIRT Newsletter of August 1991 (p. 19) and in the User's Guide.

##### SCUBA

The Submillimetre Common-User Bolometer Array may replace UKT14 during Semester 94A. An article elsewhere in this Newsletter gives additional information. The SCUBA project plan has it scheduled to arrive in Hilo in December 1993. On this schedule we would anticipate commissioning to commence in February 1994 and for observers to be able to have access to SCUBA for Semester 94A in a limited fashion. The situation is quite fluid and will continue to be updated in the e-mail fileserver system as information becomes available.

Henry Matthews, JAC

Table 1. Summary of spectral line observational data.

	Freq. (GHz)	IF (GHz)	T(rx) (K)	Efficiency			Tel. losses	HPBW (")
				Ap.	Beam	fss		
A2	218-280	1.50	95	0.54	0.72	0.80	0.92	20.8
B3i	310-380	1.50	180	0.42	0.53	0.70	0.89	14.3
C2	450-504	3.94	200	(0.30)	0.43	0.66	0.80	10.5
G	690	1-10	3000	0.23	0.30	0.60	0.65	7.0
G	810	1-10	4000	0.13	0.17	0.60	0.65	6.5

Table 2. Approx. rms sensitivities after 30 mins' integration.

Freq (GHz)	Receiver	T(rx) (K)	T(sys) (K)	dv (MHz)	Rms noise (K)	Notes
230	A2	95	350	0.33	0.02 (0.02, 0.04)	2
270		105	380	0.33	0.03 (0.03, 0.07)	2
330	B3i	265	1000	0.33	0.08 (0.07, 0.38)	1
345		165	650	0.33	0.05 (0.05, 0.16)	1
461	C2	190	1500	0.33	0.12 (0.08, * )	2, 3
492		220	2800	0.33	0.23 (0.16, * )	2, 3
690	G	3000	48300	1.00	2.28 (0.97, * )	3
810	G	4000	78800	1.00	3.71 (1.43, * )	3

Notes: (1) Frequency switching is possible in hardware. Its use reduces the rms noise by a factor of 1.4 for the same total integration time. (2) 'Slow frequency switching' is possible with A2 and C2 via a software procedure. (3) A '\*' means that observations are not possible when conditions are 'poor'; the rms noise is effectively infinite.



# PATT ITAC Report for Semester Y

## Allocations

The individual partner TAGs hold meetings in their respective countries prior to the PATT session to assess applications from their own country. At these meetings informal numbers of shifts are nominated for each application in a priority order. The Chairmen of each TAG bring their respective lists to the PATT where the ITAC combined the awards, include discussion of the engineering and commissioning requirements and assess the international applications. The final allocations of shifts are made by the ITAC.

Applications to be considered	
Appls from University of Hawaii	9
Appls with International status	4
Appls with UK status	45
Appls with Canadian status	29
Appls with Netherlands status	9
<b>TOTAL :</b>	<b>96</b>

The PATT meeting for semester Y was held at the De Montford Hotel in Kenilworth, UK on 9th & 10th June 1993.

Partner application ratio: UK/CDN/NL = 54/35/11

The 'Partner ratio' is defined throughout as:  $X/(UK+CDN+NL)$  where X is the partner award.

All 9 of the University of Hawaii applications were awarded time by the UH TAG.

Awards by country paying salary of PI	16-hr nights
Nights to International	0.5
Nights to UK	71.25
Nights to Canada	35.5
Nights to Netherlands	26.5

International status is given to any application where the only named individual from any partner country is a member of JCMT staff based in Hilo. If that individual is the PI then the application is assessed by the appropriate national TAG. International applications are assessed only by the ITAC members.

16-hr nights requested to PATT: 253  
Nights available for PATT science: 134

Awards (in 16-hour nights)	
No of nights in semester Y	184.00
Christmas Eve - closed:	1.00
Engineering/commissioning	24.25
University of Hawaii (10% )	16.00
Director's discretionary use	9.00
<b>Available for PATT science</b>	<b>133.75</b>

Oversubscription = 1.89

The oversubscriptions for the previous two semesters were 2.15 and 2.36.

Partner award ratio: UK/CDN/NL = 53/27/20

The nights given to Canada include a 2 night payback from the UK quota for past under-allocation.

No of applications requiring line obs: 40  
No of applications requiring cont obs: 27

Several applications require both modes.

The average length of time awarded per application was 3.7 shifts.

For those not familiar with the JCMT formula, the total time requested is divided amongst the PI and collaborators. 50% of the time is awarded to the country paying the salary of the PI. The remaining 50% is divided equally over ALL investigators (including the PI).



Awards by JCMT formula	
Nights awarded to INT	13.9
Nights awarded to UK	63.2
Nights awarded to CDN	31.5
Nights awarded to NL	25.1

Ratio by formula: UK/CDN/NL = 52.8/26.3/21.0

Instrument distribution	
UKT14	41%
RxA	19%
RxB	16%
RxC	24%
RxG	0%

Note the extremely strong interest in use of Rx C2.

The reduction in allocation of time for UKT14 is entirely due to reduced request. Observers are anxiously awaiting the arrival of SCUBA to continue their programmes.

No applications were approved for long term status for this semester.

### Engineering & Commissioning

The engineering & commissioning time has increased as a result of delays in the planned engineering schedule, due to un-planned emergency repair work, but shows a long term decline. Semester X saw the introduction of 'extended days', whereby the telescope is disabled until 9pm and then available for astronomy for the remainder of the night. This is hoped to replace a significant quantity of Heavy Engineering where the telescope would normally be completely closed for up to 5 nights. Significant preliminary work still remains prior to SCUBA commissioning in Semester 94A.

### Service time

This is developing in a reasonably progressive fashion for all partners. Wider distribution of the announcements of opportunity were called for. More use should be made of service mode

observations wherever small quantities of data (up to 1 shift's worth) are required.

Allocations for this semester are:

CDN = 8 shifts allocated  
NL = 6 shifts allocated  
UK = 7.5 shifts allocated

In addition several applications did not have their backup programmes approved. In this case the time becomes service time.

The ITAC awarded small amounts of time to several applications which are to be attempted in service mode. Some other applications were recommended to be observed via remote eavesdropping. The telescope schedule will contain further details of these anomalies.

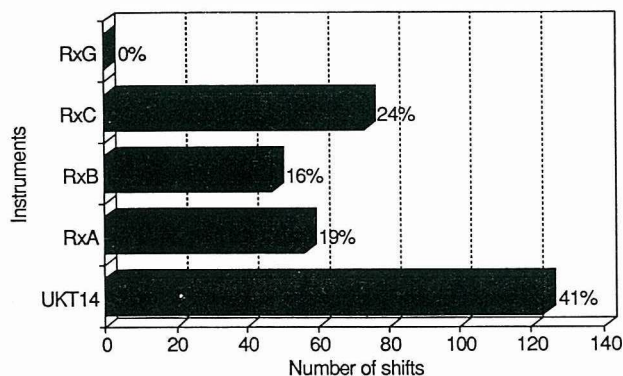
### Naming of the Semesters to follow 'Y'

It has been decided to adopt a more suitable convention for the naming (numbering) of PATT semesters in the future. Each summer semester (February - July) will be numbered 'A', with the appropriate winter semester (August - January) numbered 'B'. In order to make a sensible start to the scheme, there will be no Semester Z. The semester following Semester Y will therefore be designated as Semester 94A.

### Changes in Assessments Procedures

The changes in the assessment and allocation procedures will continue for at least the next semester. Potential applicants for observing time in Semester 94A should check to ensure their applications are mailed to the correct establishment. See boxed item later in the Newsletter for the deadlines and mailing addresses.

*Graeme Watt, ROE*





## Successful JCMT Applications for Semester Y

PATT No.	Principal Investigator	Shifts Given	Title of Investigation
U30	Abada-Simon M	1*	Measurement of submillimetric emission from the magnetic cataclysmic variable AE Aquarii
U28	André P	4	Comparative study of a new class of extremely young stellar objects
N08	Baas F	2	The CO molecular cloud ring in NGC 7331
U13	Bell Burnell S J	2	IR and submillimetre observations of Cygnus X-3
H03	Chambers	2	CO observations of Minkowski's object
U10	Dunlop J S	6	Are radio galaxies at $z > 2$ primæval?
C23	Eales S A	4	A search for protogalactic gas
U23	Emerson J P	6	Millimetre polarisation and dust grain alignment in disks of T Tauri stars
U20	Evans A	3	A CO survey of the environment of GK Per
U21	Evans A	4	Millimetre continuum observations of carbon stars
H07	Evans	8	Submillimetre spectroscopy of high redshift radio galaxies
C28	Feldman P A	4	Search for deuterated methanol towards stars with methanol ice features
C25	Fich M	2	A detailed study of a spectacular molecular outflow
N05	Fridlund C V M	2	Physical properties of the bipolar outflow in L1551
U38	Griffin M J	5	Submillimetre photometry and mapping of Class I IRAS sources
C21	Hajjar R	3	Mapping and photometry of accretion disks around YSOs
C08	Hasegawa T I	2	Observations of extremely hot and dense molecular gas in star-forming regions
N01	Helmich F P	8	The chemical evolution of the W3 molecular cloud
C06	Hesser J E	1*	Search for CO emission from globular cluster M15
U32	Hills R E	5	A search for C <sup>+</sup> emission in high redshift quasars
U01	Hough J H	2	Is Cen A really the nearest blazar?
U09	Hughes D H	8	Submillimetre and millimetre continuum observations of a hard X-ray selected sample of galaxies
U41	Hughes D H	8	Are the cores of lobe-dominated quasars the same as radio-quiet quasars?
C22	Irwin J A	8†	CO observations of NGC 5775
N04	Israel F P	4	CO in NE quadrant of NGC 2403
N07	Israel F P	12	Neutral carbon (C I) in strong CO nuclei of galaxies
C01	Ivison R J	1*	Are there masers in symbiotic Miras?
C03	Kwok S	2	Submillimetre continuum spectra of ultracompact H II regions
H08	Ladd E F	4	Submillimetre continuum observations of stellar density enhancements
H09	Ladd E F	4	Obs of star forming dense cores with rare isotopes of CO
U04	Lawrence A	2	Millimetre CO(2-1) line observations of a complete sample of active galactic nuclei
U42	Lawrence A	4	Energy distributions of ultraluminous IRAS galaxies
N09	Lees J F	4	Submillimetre emission from cold dust in elliptical galaxies
U14	Little L T	3	C I in TMC1: a test for time dependent chemistry
C07	McCutcheon W H	3	A 335-365 GHz line search in NGC 6334 I and I (North)
U24	McHardy I M	2	Shocked jet models for blazars: Simultaneous JCMT/ROSAT/GRO/VLBI/UKIRT monitoring of 3C 273 and 1156+295
U17	MacDonald G H	3	Chemical evolution in the circumstellar structure of B5 IRS1
C27	MacLeod J M	3	A YSO in Taurus, seen through a very dense, warm absorbing screen



## Successful JCMT Applications for Semester Y

PATT No.	Principal Investigator	Shifts Given	Title of Investigation
U03	Mannings V G	5	Pre-main sequence Ae/Be stars: disk masses and grain growth
U05	Mannings V G	4	A 1.1 mm census of circumstellar dust in the Serpens cloud core
U19	Marscher A P	5	Multifrequency monitoring of $\gamma$ -ray bright blazars
C13	Matthews H E	4	Dust properties of Herbig-Haro energy sources
C16	Matthews H E	4	Neutral carbon in optically-thin shells around evolved stars
N06	Miley G K	7	CO observations of a radio galaxy at redshift $z = 2.34$
U02	Minchin N R	6	C I observations of edge-illuminated molecular clouds
C09	Mitchell G F	4	Optical jets, molecular outflows, and neutral winds
C17	Moriarty-Schieven	3	Mapping dense gas in circumprotostellar environments
C18	Moriarty-Schieven	3	Imaging circumprotostellar environments at 450 microns
H02	Owen T	2	The surface of Titan
H04	Owen T	2	Search for gas in circumstellar disks
U31	Padman R	4	'Bullets' in highly collimated outflows
C05	Papadopoulos P P	7	Temperature, density gradients of the molecular gas in Seyferts
U26	Puxley P J	2	Neutral carbon in the starburst galaxy NGC 253
U27	Russell A P G	4	Neutral carbon in the star-forming region DR 21
H05	Sanders D	2	CO(2-1) mapping of nearby starburst/active galaxies
H06	Sanders D	4	The molecular gas properties of normal galaxy nuclei
C20	Scott D	1	Search for C II emission from a damped Ly $\alpha$ absorber at $z=2.8$
U34	Scott P F	4	A search for pre-stellar objects via H <sub>2</sub> O masers
H01	Senay	4	CO emission from distant comets
N03	Stark R	4	Neutral carbon in high latitude translucent clouds
U43	Tamura M T	6	Magnetic fields in the circumstellar disks around T Tauri stars
N02	van Langevelde H	4	The nature and dust content of young stellar objects in Serpens and Corona Australis
I04	Walker C E	1	A study of [C II] towards an optically selected damped Ly $\alpha$ system
U22	Watt G D	5	Search for MgH in C-rich circumstellar envelopes
U35	White G J	6	Neutral carbon (C I) in strong CO Nuclei of galaxies
U36	White G J	6	C I and CO observations of the Orion Nebula
U39	White G J	5	Unbiased multi-point spectral survey of Orion 450-500 GHz
U40	White G J	5	C I and CO observations of the molecular outflow source L1551
C12	Wilson C D	4	A complete map of the M17 molecular cloud in the CO J=3-2 and J=2-1 transitions

\* = observations to be done by JCMT staff

† = 8 x 3/4 shifts awarded; remainder of time goes to Canadian service



## News from the JCMT Board

The JCMT Board met in Hawaii on Monday and Tuesday, May 10 - 11, 1993. It received reports on Operations, Instrumentation Development, Finance and Staffing matters and the report from the JCMT Advisory Panel, and presentations by members of staff on scientific and operational aspects of the JCMT. In addition, members of the Board visited the telescope at night and were able to see observing in progress. The Board met informally with staff on Tuesday afternoon and hosted a reception for members of staff and their families on Tuesday night.

### Data Rights

The Board reviewed its policy on Data Rights and confirmed that data obtained on the JCMT shall be released into the public domain one year after they were obtained unless Director JCMT has specifically waived this rule. Such waivers, which will be granted only in exceptional cases, may extend the period to release by no more than one year. All data, including cases where an extension to the one year rule has been agreed, shall be released into the public domain two years after they were obtained. The Director JCMT will produce and propagate clear guidelines as to the circumstances in which a waiver would be considered.

(Note: Data obtained during full collaborative observations with other telescopes, specifically VLBI and Short Baseline Interferometry, are excluded from the one-year rule.)

### Receiver W

The Board was advised that the design of Receiver W had evolved such that it could be delivered with both C- and D- band capability, and with polarisation of both bands. The Board strongly supported the delivery of Receiver W with both C- and D- band dual polarisation capability, and warmly welcomed the adoption of this target by the MRAO.

### Receiver C2

Receiver C2 was installed and successfully commissioned since the last JCMT Board meeting, and the Board was shown a very impressive spectrum of the 'first light' on the receiver. The Board congratulated the commissioning and support teams on their efficient and professional execution of the task.

### Service Observing

The Board reviewed its policy on Service Observing. The Board was concerned that the facility of Service Observing should be properly used, and made it clear that duplication of observations was not acceptable unless specifically approved for scientific reasons. In particular, the Board took the view that self-duplication of observations using Service Observing, whether to bring forward observations for which time had been allocated by PATT but which were scheduled later in the semester, or to supplement the time awarded by PATT, was a flagrant abuse of the system and should not be permitted. Sanctions against observers who so abuse the system may include forfeit of their allocated time. The Board agreed that to aid monitoring of observing proposals, all applications for JCMT time will in future be asked to give co-ordinates of all the targets to be observed. Failure to specify the position of the objects precisely could result in a similar observation being undertaken by others as part of a SERVICE programme.

### Guidelines for Commissioning

The Board considered new guidelines for commissioning proposed by Director JCMT and supported by the JCMTAP. The new rules aim to involve the community at the earliest stage to obtain both commissioning and science, recognising both the needs of commissioning and the desire of observers to have earliest possible access to new instrumentation.

### Chairman of JCMT Board

This was the last meeting for Dr Donald Morton, who was a founder member of the Board and has been Chairman since 1991. The Board warmly thanked him for his contribution throughout his membership and Chairmanship of the Board.

Professor Ken Pounds (Vice Chairman; Leicester University, UK) was elected Chairman from 1 September 1993. Professor Harvey Butcher (NFRA, Netherlands) will become Vice Chairman from September. Dr Morton will be replaced by Dr Bryan Andrew (HIA, Canada).

*Rowena Sirey,  
Secretary, JCMT Board*



## Instrumentation Programme Update

### B-band heterodyne array for the JCMT

A long term development plan to equip the JCMT with heterodyne arrays at both B- and D-bands was approved by the JCMT Board in May 1992 with B-band as the highest priority. The Array Programme will consist of four components: the B-band array, Front end, a new IF system, a new Back end and a suite of software. The D-band array Front end will follow as and when resources become available. A major design study by SRON, Groningen for a B-band Front end is almost complete. Studies are under way to define the rest of the system. We are presently looking at ways of cutting the overall costs of the Array Programme. Through the JCMT Advisory Panel, we will solicit comments over the next few months from the User community on the scientific capabilities of the array (size, bandwidth modes etc.) and the overall content of the Instrumentation Programme (upgrades to existing instruments and new components such as a polarimeter for SCUBA).

### RxW

The specification of the new "Wide Band receiver", RxW has been modified to include a total of four mixers; two C-band mixers and two D-band mixers. The receiver will also have single sideband filters which allow the image sideband to be terminated on a cold load. The anticipated delivery date is late 1994.

*Adrian Russell*  
*Head, JCMT Instrumentation Programme.*

## Editor's Bit

Well, here we are! We've graduated again (!) to our own Newsletter. You may recall that there were initially 10 issues of the 'Protostar' which were followed by 5 issues of the jointly produced 'JCMT-UKIRT Newsletter'. The Editors have also changed from Alex McLachlan to Liz Sim to myself. The formatting and editing for the 'JCMT-UKIRT Newsletters' included invaluable assistance from Eve Thomson and Mark Casali who will continue to work on the 'UKIRT Newsletter'.

I am getting more adept at manipulating Word Perfect 5.1 and you may find the occasional piece of editorial artistry as the skills are put into practise. Some of this is necessary to present your text in the two column format, sometimes to ensure the diagrams fit in suitable places, and sometimes because of advice from the printer on the best layout or method of presentation. Any bloopers you may come across are entirely mine.

For assistance with future issues I have requested that Canada and the Netherlands nominate an Associate Editor to collate contributions and aid with distribution within their country. UK and International work falls into my editorship. Final formatting, layout and printing will still remain under my control at ROE. For this issue 1300 copies were printed and distributed to various places across the world.

For simplicity I have just named this issue 'The JCMT Newsletter'. I was tempted to re-use the 'Protostar' title but I thought that a little restricting on the range of objects currently being observed by the JCMT. However, I feel a competition brewing! I would like your suggestions for the title of this new publication. Please send any ideas to me before the deadline for the next issue.

The distribution of each issue is intended to be sufficiently in advance of a JCMT Application Deadline that you have time to read the Instrumentation and Technical data before scribbling out your application for observing time. Since several of the processes involved in producing the document involve finite time period beyond my control, please try to keep to the given deadlines for submitting your articles. The content of the Newsletter is entirely up to you. If you have any comments, suggestions or ideas about format, content or layout in future issues, let me know.

May I thank all of you who have contributed to the current issue. I trust you will have a pleasant read and that many more of you will offer articles for the next issue..

*Graeme*



# The Service Program's Goals and Intentions

Last Autumn, I put a paper to the JCMT Advisory Panel and Board requesting clarification of the rules with regard to the SERVICE programmes. The outcome is reported by Rowena Sirey elsewhere in this Newsletter. Briefly, the Board expressed the view that SERVICE time is for:

- o unfinished programmes requiring small amounts of data,
- o student thesis material,
- o targets of opportunity,
- o test programmes for which later TAG applications might be forthcoming,
- o monitoring programmes.

This list is not meant to be exhaustive.

SERVICE time is not, however, for

increasing the observing time available to TAG- or ITAC- approved programmes in the same semester, observing sources for which others have obtained PATT approval.

There have been a small number of occasions where observers have encroached on sources allocated by PATT to others, but to date these situations have been resolved amicably between the parties concerned. However, notifying an observer that he or she was about to transgress on another party (usually through the SERVICE mode) is not easy: source coordinates are only crudely required on the PATT form, and nowadays there is the confusion over multiple names for the same source.

With the increase in SERVICE observing, and looking ahead to the arrival of SCUBA, the problem of 'illegal scooping' of important observations might be anticipated to increase. Hence, observers will now be asked to specify exact coordinates to help us and the partner SERVICE coordinators to ensure that sources are not duplicated unknowingly to the TAGs.

SERVICE time is a highly valuable aspect of the JCMT and I hope that the users take full advantage of this mode of time allocation.

*Ian Robson*  
Director, JCMT

## UKSERVICE

- what we provide, and how to collect yours.

The UKSERVICE program on JCMT has been in operation for more than a year. Practices have

evolved, hopefully to your satisfaction, but ought to continue evolving to meet your needs. This note is intended to describe the program's *raison d'être* and the current practices of

- o soliciting applications,
- o assessing, approving and prioritizing applications,
- o planning for a particular observing run,
- o obtaining data at the telescope,
- o packaging data for a particular program with appropriate standard measures and calibrations,
- o getting the package to the UKSERVICE client.

We hope that this note will clarify these procedures and stimulate suggestions which may help improve them.

## Soliciting Applications

Information about forthcoming service observing runs and details of how to submit applications for use of the available telescope time are provided to the UK astronomical community by means of NEWS items on the STARLINK network. In addition, e-mail messages are sent to previous applicants and other likely users; requests for inclusion in this direct mailing list are always welcome. Applications can, of course, be submitted at any time on the understanding that, if the programme is accepted, the observations will be made at the earliest opportunity. Special arrangements can be made to observe targets of opportunity.

## Assessment, Approval and Prioritizing

Applications are made on a standard form (which can be extracted from the News item using the NEWS/OUTPUT option) and submitted by e-mail to:

REVAD::JCMTSERV or  
JCMTSERV@ROE.STAR

This may be done AT ANY TIME, although proposals may not be dealt with until the next deadline. Each deadline is normally set around 2-3 weeks before the next scheduled UK Service run.

The scientific assessment of all applications is carried out at ROE by two internal referees (Graeme Watt and Derek Ward-Thompson) and one external referee (currently Rachael Padman of MRAO), and they are ranked in order of scientific merit. All proposals are also assessed by two



technical referees at JAC (Iain Coulson and Bill Dent). On the basis of these assessments the proposals are given a priority rating. Observations are then carried out for the highest ranked proposals, given the usual constraints of source RA, weather and instrument availability.

### Planning an Observing Run

UKSERVICE runs are scattered, perhaps with seeming randomness, through each semester. During a given 8-hour shift only those sources of suitable Right Ascensions may be observed, and the choice of programs may be limited by the (un)availability of particular front-ends. Highest rated programs get preference, although it often makes sense, and makes best use of available time, to stick to one Front-End through a shift rather than lose time changing from one to another with all the extra pointing, focussing and calibration that that entails. Photometric programs in particular require careful standardization, and fragmentation of standard measures ought to be avoided if possible. Despite such planning, the observer on the spot, like regular observers, is faced with adjusting the program to meet changing weather conditions, faults, etc..

### Obtaining Data at the Telescope

Since UKSERVICE is being done by experienced JCMT staff we expect that it will meet the quality you would expect to achieve had you been here yourself. Occasionally we have failed, usually because of misinterpretation of the instructions available to the observer. Understandable though this may be, future solicitation of proposals will request more specific instructions in order to avoid these problems entirely.

What goes unseen from the clients' perspective, and unrequested, are the fundamental startup procedures and system checks that accompany any observing run - the pointing and the focussing and the checking of sensitivities or gains, etc. All this is performed by the observer routinely, and is essential to the quality of the requested service data. If any aspect of these fundamentals need specific attention for your program please include them in your service request.

We aim to provide clients with **ALL** the information necessary to successfully reduce their particular observations. Photometric requests provide perhaps the biggest challenge. You may feel, for instance, that all the standard measures taken during a regular shift of photometry can impact successful reduction of a measure of a target. However, consider an extreme, but likely, case where only one hour of a UKSERVICE run is

given to UKT14 photometry, during which there is only time for a measure of one standard before and one (other?) standard after the measure of the target - all at appropriate wavelengths. Could you analyse this data on your target and get a meaningful result?

The answer ought to be 'Yes', since from two standard measures you can determine, at each wavelength, the gain of the system (converting the flux from the source into measured voltage) and the atmospheric absorption. However, confidence in the result depends upon the air-masses at which the standards and target were observed, the stability of the atmosphere throughout, the availability of other information about the atmosphere during unstable conditions, the linearity of the system as a function of elevation and so on. Careful photometric observers will prefer to measure standards at more airmasses and at more times in order to confirm performance characteristics, but during our hypothetical hour such a comprehensive pattern of calibration is clearly impossible. Unless s/he has specific instructions from the client, which will in any case pre-determine the amount of time to be spent on the program, the observer will make a best-efforts attempt to standardize a solitary measure of a target like this.

Spectroscopic calibrations are usually of the internal kind, as obtained by the familiar CAL command. Spectra of standard sources are occasionally made, but ought to be requested specifically if critical to the program.

### Packaging of Data

We collect together relevant datafiles and other material in 'packages'. Packages for all clients contain the original datafiles for their target and contemporaneous standards. Photometric 'packages' also include the summary photometry of all the photometric standards obtained during each shift, regardless of the distribution of particular targets within that shift.

We now also include a table giving the atmospheric opacity as a function of time through each shift. This data is from the 225 GHz radiometer operated by the Caltech Submillimeter Observatory (CSO) and is provided as a courtesy by our mountain-top neighbours. The data is to be considered copyright of CSO, though it may be used to assist in reducing JCMT data. Please acknowledge the use of the CSO-tau data in any publications arising from its use.

Similar data for the sub-millimeter seeing, as made available to JCMT by the CfA Phase Monitor, will also be routinely included in these packages following a recent request from a client.



The JOURNAL.dat files which summarize a night's observations are normally of great value to each observer, and these too are included, though possibly tailored for each client's needs.

We would welcome suggestions for including other data that may be available to us and which would prove useful to a majority of clients. Otherwise, specific requests will be met where possible.

### Getting It To You

Following months of trial and error, with lots of the latter, and the substantial revamping of the telecommunications links between Hilo and the telescopes on Mauna Kea, a method has evolved for transferring data that has proven reliable.

Like other JCMT data, UKSERVICE data is originally dumped into a subdirectory on the summit computer disks. With other data it is transferred to Hilo for archiving. It is in Hilo that it is divided into packages as described above. The files in a package are BACKUPed (BACKed UP?) to disk save\_sets with names reflecting the assigned UKSERVICE proposal reference number (eg: SW16.bck). Transfer of lots of individual files, and of BACKUP save\_sets, has proven problematic using FTP. Much easier to transfer, or FTP, are compressed versions of the BACKUP save\_set. This compression is achieved (in Hilo) by the command

```
$ LZCMP SW16.bck SW16.cmp
```

where LZCMP, and its inverse, LZDCM, are Starlink commands. These versions of the packages are copied to a subdirectory of the FTP directory of the Hilo (JACH) computers. The subdirectory name will be

```
[FTP.UKSERV.yymm]
```

where yyymm indicates the year and month in which the data was taken. To access your data do the following :

```
$ FTP JACH.HAWAII.EDU   or
$ FTP
FTP>open JACH.HAWAII.EDU
FTP>login
    >anonymous            (username)
    ><your_initials>      (password)
    >cd [ftp.ukserv.yymm] (into subdirectory)
    >dir sw16*             (check existence of
                           data)
    >binary               (may be necessary for
                           transfer)
    >copy sw16.cmp         (get your file)
    >exit
FTP>close
```

You then need to re-create the original datafiles :

```
$ (setup the Starlink commands for
   (de-)compression)
$ LZDCM SW16.cmp SW16.bck
$ BACKUP SW16.bck *
```

If you do not have access to Starlink (de-)compression software you may have to try copying the backup save\_set. In the past this has met with problems regarding incompatibilities of file structures and record lengths. If you have such trouble you should create within the Hilo subdirectory another subdirectory in which you could create the original datafiles by a BACKUP of the save\_set. You could then transfer the files one by one. (We realize that the above assumes users have access to a VAX computer.)

We would appreciate tidiness on the Hilo computer - if you must create directories and files please delete them afterwards.

Notices will be sent to clients of the successful acquisition of data for their programs. However, the FTP sub-directories will always be accessible to the outside world.

We would appreciate return messages to the effect that you have successfully transferred your data, and have read the individual files. We can then tidy up our disk space.

If you encounter other problems in getting your data transferred to your home institution we suggest you contact your local system manager first - and then a member of the UKSERVICE team ... Thanks.

### And Finally

We believe that the JCMT UKSERVICE program provides much to the astronomer:

- an introduction to the sub-millimeter for those without it,
- high quality data from small amounts of observing time, without the hassles of travel,
- testing of astronomical proposals that might otherwise meet resistance at time allocation committees,
- confirmation of critical, previously-obtained results,
- a chance to get that one observation that you'll never get any other way!

If you're a user - we hope you have benefitted from the service so far. If you're not - we would welcome your applications for service time.

*Iain Coulson, Bill Dent, Alex McLachlan & Derek Ward-Thompson*



# The JCMT Electronic Information Fileserver System

## Information

Information on the performance of the JCMT and its receivers is now available via an electronic mail server resident on site at the JAC. The system, FILESERV, is a file distribution service that uses electronic mail facilities to deliver files to anyone with a valid e-mail address. To communicate with FILESERV, send an e-mail message to:

JCMT\_INFO@JACH.HAWAII.EDU (Internet)

Commands are sent in the body of the message you send to FILESERV. Several commands may be sent at one time; just put one command per line. For instance, the one-line message:

help

will reply to you with a message explaining how to use FILESERV, the text of which is similar to the note you are reading here.

Information is grouped within the FILESERV system in 'packages'. Generally, where there is more than one information file within a package, those files will contain related information. A file name consists of a package name and part name, of the form package.part. Commands may be sent to FILESERV as described above to send all or part(s) of a package, or to give descriptions of some or all packages. The commands are:

SENDME package	Sends all parts of the specified package.
SENDME package.n	Sends part 'n' of the specified package.
LIST [pattern]	Gives brief description of all packages matching "pattern". If pattern is omitted, descriptions of all packages are sent.

Commands may be abbreviated. DIRECTORY is a synonym for LIST.

For each request you make, a transaction log is returned to you indicating the status of the request. The status report will indicate whether the request was successfully completed, and when the file was or will be sent. Large files (> 20 blocks or 10 KBytes) are sent only during off-peak hours.

The following packages are available:

HAWAII	General information for visitors
JOBS	Employment opportunities
NEWS	Monthly JAC news
PLANETS	Basic information on planet fluxes
PLANNING	Information to allow planning observing runs
RECEIVERS	Information on JCMT instrumentation
RESERVATIONS	JCMT/HP bookings form
SCHEDULE	JCMT schedule access
SCUBA	SCUBA progress news items
SERVICE	Information on service observing
STATISTICS	JCMT usage statistics
UKT14	Information on UKT14

The contents of the fileserver are being updated and supplemented very frequently at present, since the system is new. In its stable state, updates reflecting new information and changes will be made as necessary. For the moment, however, I particularly welcome comments as to items which should be included. Note that simple ASCII files which have column widths not greater than 80 (and even better, 72) characters are preferred, due to the e-mail nature of the service, and the wide range of terminals on which the information received has to be displayed. This means that LaTeX input (filetype .TEX), standard FITS, and Postscript (.PS) files are acceptable, for instance. It is possible for binary files to be transmitted, but they must be encoded in order to be sent through the mailer and decoded on receipt. No such files are included in the system presently.

Problems, questions, and comments about FILESERV service on this system should be directed to:

JCMT\_INFO-Mgr@JACH.HAWAII.EDU

Queries and comments about instrumental parameters of the JCMT receivers and the like should be sent to HEM@JACH.HAWAII.EDU (Internet). Or phone 808-969-6518 or 808-961-6537.

*Henry Matthews, JAC*



# Confidential Observer Report Analysis

The confidential observer reports were introduced at the behest of the JCMT Advisory Panel and the JCMT Board to monitor the quality of service provided to the users. After almost one semester's worth of reports, the following is a brief (and rather rapid!) analysis of the raw data contained in the 31 Confidential Observer Reports obtained so far by the Director JCMT. These data supply a baseline against which future performance can be measured.

From their home base, 87% of potential observers had access to a copy of 'A Guide for the Prospective User', and 71% were contacted by their Support Scientist, who generally extended a welcome (77%) to them rather than a status report (41%). Some gave both! 29% of observers requested further documentation be sent to them and in all reported cases it was delivered promptly. The majority of prospective observers left their home base adequately informed/briefed (45%), with 39% feeling well prepared. Only 1 individual felt poorly informed!

On arrival in Hilo, 50% were met by their Support Scientist. During their period in Hilo most observers felt they were getting instructive assistance from their Support Scientist on the status of the telescope, administrative details, and tactics to improve their observing programme. A few (<5) noted a lack of instructive assistance.

At HP the data reduction facilities received ratings of 5/14/6/2 for poor/adequate/good/excellent.

Once observing, the Telescope Operators gained highest credit with their knowledge of the telescope, their willingness to give information about the operations and their efficiency at controlling the observations. 65% of observers were very impressed with 35% adequately satisfied. The Support Scientists did almost as well. 75% of observers were ver impressed, 18% were adequately satisfies, but 7% thought they were getting poor service.

The Support Scientists accompanied the observers on their first night 87% of the time with 49% remaining for subsequent nights. For those shifts where the Support Scientists did not remain, 75% of observers felt well able to carry out their observations. All of them mentioned that the TO gace adequate support. All the Support Scientists mentioned that they would be 'on call' if needed and over an average of <3 callouts per observer the response was excellent.

All but one observer managed to perform some, if not all, data reduction on-line. Most people took

their data away on exabyte but seemed reluctant to define their preferred method of data transfer. The scores were:

	transferred	preferred
networked:	6	4
9-track tape:	6	4
other (ie: exabyte):	16	2

Not many observers wanted to stay in Hilo after their run with 68% of those answering the question leaving Hilo within 1 day of coming down the mountain. 85% did not believe they could complete their data reduction in JAC although 94% thought JAC facilities adequate and 59% essential.

Most people failed to find any documentation in Hilo (!). Those that did gace it a 'good' grade. The documentation at the telescope received a 65% good, 23% adequate, 13% excellent. HP fared less well with only 44% good, 26% adequate, 3% excellent, and 26% poor. The grades for accessibility of these documents follow closely these values.

And finally... Most people (85%) managed to complete the form in less than 10 minutes (37% in less than 5 minutes). One poor soul took 20 minutes, and 4 could not manage to answer the question!

## Future Administration Support

The administration at the JCMT is becoming increasingly loaded with more work from a variety of sources. Help from users would be greatly appreciated and the use of the JCMT\_INFO system is one of the ways in which we aim to try and operate more efficiently. In the future, we anticipate that most of the communication will be by electronic mail and that information will be available to the user remotely (see other articles in this Newsletter). One way in which users could assist the administrative staff is to ensure that their bookings for hotels, HP, car hire, etc are received by Donna (DONNA@JACH.HAWAII.EDU) in good time, at least three weeks prior to arrival in Hilo. Also, the JAC is not a travel agency and so bookings for vacations, etc should not be requested through the JAC. The staff are there to support the users of the telescope facilities to the maximum extent. Please try to ensure that you reciprocate by careful and timely preparation and planning for your visit. The Director JCMT also welcomes seminars from visiting astronomers. The contact person is Bill Dent (username DENT), or any of the Support Scientists.

*Graeme Watt, ROE*



## TECHNICAL NEWS

### Polarimetry

It has recently been discovered by Dr Walter Gear and colleagues that there is a bug in the UKT14 polarimetry data reduction software installed at JCMT. It is possible that this bug may have affected the reliability of any results obtained using the 'angle-tracking' facility -- this compensates for the fact that the position angle of the instrumental polarisation arising in the membrane and the telescope rotate with respect to UKT14 at the Nasmyth focus. However, this is only a problem if the reduction programme contained in the command file 'DAT' in the POL directory in the JCMTUSER area was used to reduce the data. Note, 'DAT' stands for 'Do Angle True'. There should be no problems with data taken without using the angle-tracking facility and reduced using the 'DAF' command file ('Do Angle False', -- used predominantly for planetary instrumental polarisation measurements). All PATT observers who used @DAT will have been affected.

The good news is that this error is recoverable and there is nothing fundamentally wrong with the data taken. The cause of the fault lies in the fact that the programme fails to convert correctly from RA, Dec and LST (input as degrees and hours) to angles which need to be in radians in a FORTRAN programme. The result is that the instrumental polarisation is not subtracted at the correct angle from the data when the source Q and U are determined. Depending on the exact position of the source on the sky this may result in a source polarisation either larger or smaller than is actually the case. Of course for sources substantially polarised in relation to the instrumental polarisation the effect of this error will be small, but for sources whose polarisation is of the same order the effect could be very significant.

The software was produced at QMW and the original installed version was extensively tested and found to be bug-free. However the error came about when a new (and improved) version of the polarimetry software produced by QMW was installed. Unfortunately 3 lines of FORTRAN code were misplaced and the error can be corrected with a subsequent change of these 3 lines. If you believe you may have suffered from this problem and require the corrected version of the code, please contact Wayne Holland -- WSH at the JAC.

Our apologies for this unfortunate occurrence.

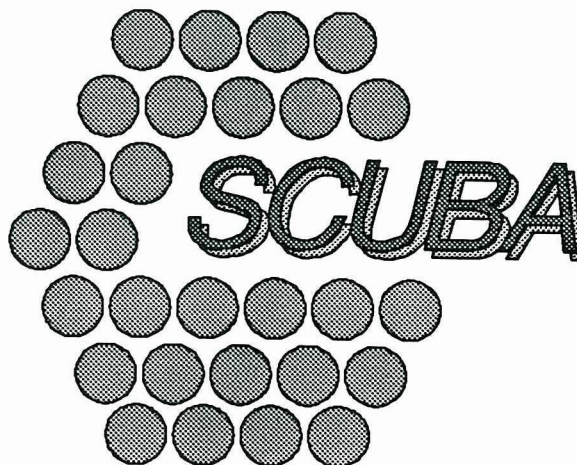
*Ian Robson, Director JCMT*

### Availability of SCUBA

SCUBA, the new submillimetre camera and photometer for the JCMT is currently scheduled for delivery to Hawaii at the beginning of 1994. There will be a period of commissioning lasting approximately 3 months before any astronomical observing can be performed. It is therefore expected that only a limited amount of time will be available in Semester 94A. Because of the possibility of delays to the testing schedule and the fact that any subtleties in taking and analysing SCUBA data will be relatively unknown at that point, no full proposals for the use of SCUBA will be accepted for Semester 94A.

However, in order that users can have early access to SCUBA, the JCMT Board have accepted a proposal from the Director, JCMT for service observing for the User Community during the extended commissioning period. We anticipate that a substantial block of time will be allocated for SCUBA service observing. Prospective users will be able to apply for blocks of time via e-mail through their respective TAGs who will organise refereeing and allocations. A deadline will be announced once dates are confirmed. It is expected that such a deadline will most probably be in February 1994. Prospective users unfamiliar with SCUBA's specifications should read the article by W.K.Gear and C.R.Cunningham in the "Proceedings of the 29th Liege astrophysical colloquium", ESA SP-314 pp353-358. A detailed description of SCUBA's capabilities will also be given in the next JCMT Newsletter and will be resident on the JCMT\_INFO (see this newsletter) mail server, as will information regarding the deadline for service applications.

*Ian Robson, Director, JCMT*  
*Walter Gear, ROE*





## Receiver A2 on the JCMT

As a result of severe torpor, I am rather late in writing an account of the commissioning of Receiver A2 ... by the time this is published, it will have been installed at the JCMT for a year and a half. However, since some developments and improvements have taken place in that time, now is actually a good time to relate the history of the receiver.

Receiver A2 was built in a collaborative project between the Radio Astronomy Group at the University of Kent and the Millimetre Wave Technology Group of the Rutherford Appleton Laboratory. RxA2 is a heterodyne receiver, tunable across a frequency range from 210 - 280 GHz. A single lead-alloy SIS tunnel junction is used as the mixing element, mounted in a reduced-height waveguide mixer block. The receiver is single-channel and is operated in double-sideband (DSB) mode; the intermediate frequency (I.F.) is 1.5 GHz.

Receiver A2 is based upon the prototype SIS receiver tested on the JCMT in May 1989 (see *Protostar* No. 8, September 1989), which was later used in the development of Receiver B3i (*JCMT - UKIRT Newsletter* No. 3, March 1992). It was designed to be uncomplicated and simple to use, ensuring that (a) it was deployed on the telescope in the shortest possible time, and (b) if something does go wrong with it, it will be easier to understand and fix the problem. The people primarily responsible for developing and building Receiver A2 were Steve Davies and Les Little from UKC, Charles Cunningham (before his move to HIA) and Dave Matheson from RAL, with major contributions from various members of the workshop staff at both institutions.

In February 1992, the timely delivery of the receiver to the JCMT was ensured, courtesy of the efforts of Messrs. Jordan and Jarrett. Being rather more accustomed to moving armchairs and boxes

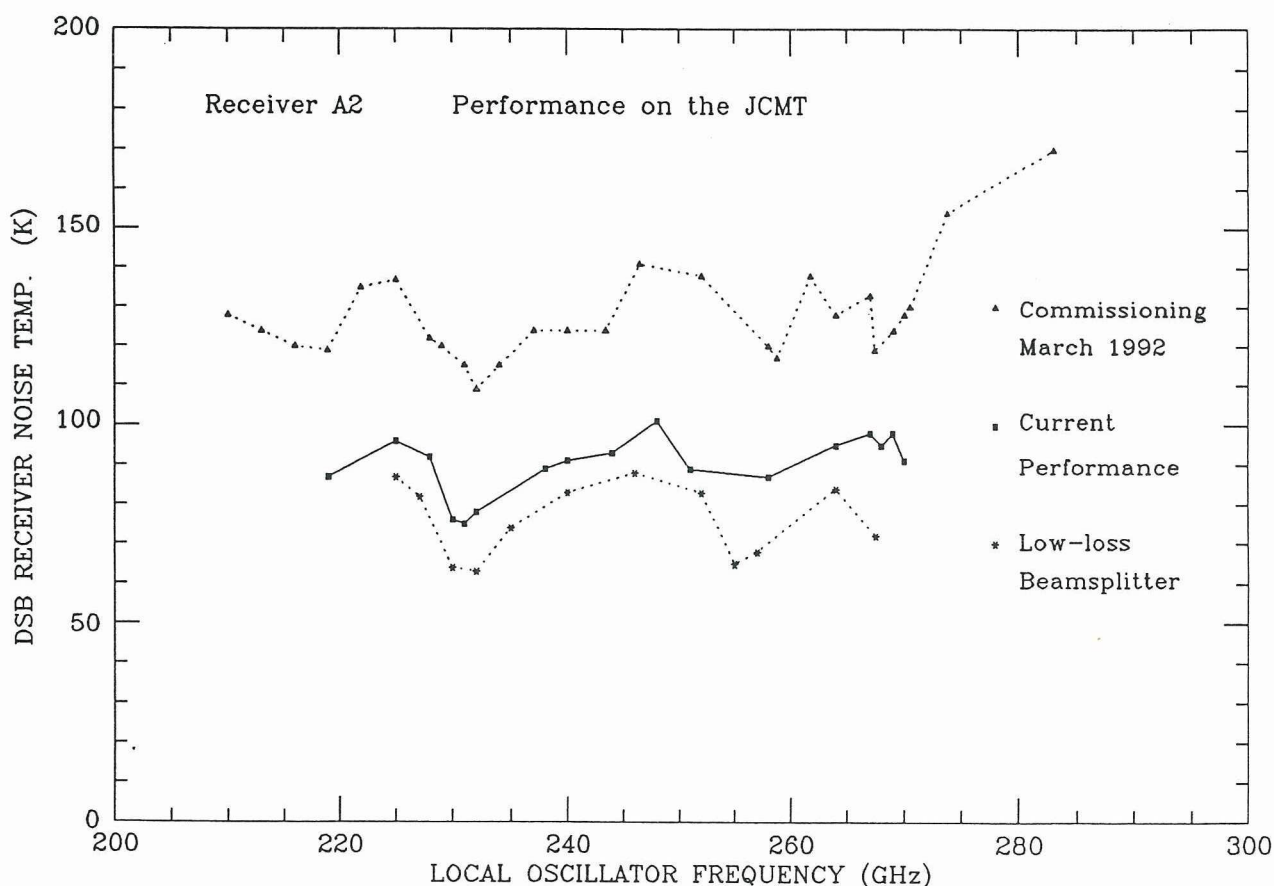


Figure 1. Performance of Receiver A2 at the JCMT (a) at the time of commissioning; (b) at the present time; (c) with a lower loss beamsplitter.

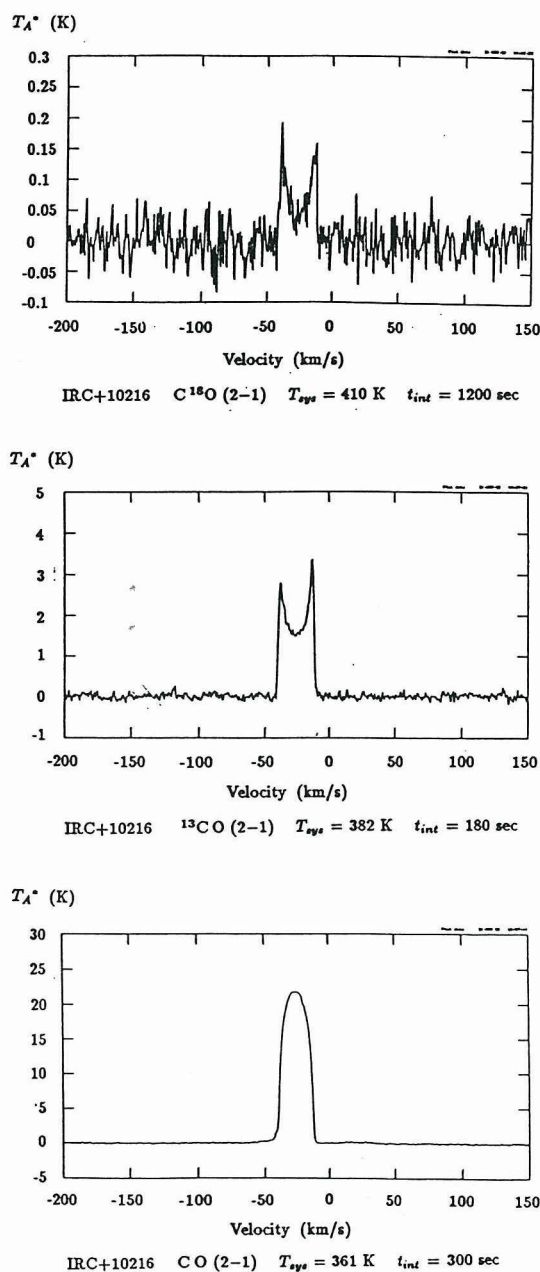


full of crockery from Herne Bay to Folkestone, they seemed to relish this particular task. During commissioning, we worked closely with Per Friberg (Project Scientist, who has looked after the receiver since commissioning) and Phil Williams (Project Engineer), and were ably supported by many other members of the JAC Staff. The unpacking and reassembling of the receiver all went very smoothly. In fact things went so well that the receiver supported its first PATT observations within 30 hours of being bolted into place in the receiver cabin. First light detection was made in the early hours of 10th March 1992, the resulting spectrum clearly demonstrating the great sensitivity of the new receiver.

At the time of commissioning, the Local Oscillator signal was provided by a (frequency tripled) wide-band Gunn oscillator; which could cover a tuning range from 210 - 280 GHz. This oscillator had an unwanted dip in its power versus frequency spectrum, so to ensure sufficient LO power was available at all frequencies, the receiver was commissioned with a high-reflection (10%) mylar LO beamsplitter. The DSB receiver noise temperature as a function of frequency for this beamsplitter is shown in the upper plot of Figure 1.

Well there were a few problems with Receiver A2 after its commissioning ... the hybrid liquid helium cryostat did not have as long a hold time as it was supposed to have, and some of its internal support struts broke, occasionally resulting in unwanted standing waves being seen on spectra. In September 1992, Per and I made some modifications to the cryostat, repairing and improving the errant support struts and making a few other minor changes. This was the time of Hurricane Iniki, and during the storms associated with it the JCMT was struck by lightning, taking down the drive computers for both the JCMT and the CSO but, happily, not damaging the SIS junction at the heart of the receiver. Also the receiver was fitted with an alternative Gunn oscillator which, although not having as wide a tuning range as the original oscillator, did have a flatter power spectrum. This allowed a lower loss LO coupling beamsplitter to be used, reducing the receiver noise temperature by about 30 K. The middle plot of Figure 1 shows the performance of Receiver A2 with this beamsplitter ... this represents the current (June 1993) noise performance of the receiver. At frequencies near 230 GHz, Receiver A2 performs with a DSB receiver noise temperature of 75 K.

The hybrid liquid helium cryostat still had a hold time of only about 7 days ... this was something of a mystery since the nominally identical cryostat of Receiver B3i performed much better. Well, in February 1993 the cold head which drives the refrigerator cooling the radiation shields in the



**Figure 2.** Spectra with a range of line intensities recorded with receiver A2 during its commissioning.

hybrid cryostat stopped working altogether. Per replaced it the cold head and since then the cryostat has performed much better cryogenically, achieving a hold time of about 10 days.

In June 1993 I carried out some experiments using a very low loss beamsplitter. The receiver performance as a function of frequency being shown in the lower plot of Figure 1, a best noise temperature of  $T_{rec} = 63$  K (DSB) being measured at 232 GHz. It was not possible however to obtain sufficient LO power at all frequencies with this



beamsplitter, rendering it impractical for routine use on the telescope. It is possible that an improved Gunn oscillator/frequency tripler combination may become available which would allow this very low loss beamsplitter to be installed permanently on the receiver.

One further possible improvement to the receiver would be to replace the mylar window of the cryostat with a thinner (and hence less lossy) one ... which would reduce the receiver noise temperature by another 10 - 15 K. The mylar is slightly porous however and the long-term cryogenic performance of the cryostat would probably be impaired. The factors described above illustrate the differences between a laboratory receiver system and one for routine use on a telescope, where certain compromises have to be made. If Receiver A2 were back in the laboratory at UKC, I would be measuring a noise temperature of < 50 K. These results highlight the potential still available with lead-alloy based SIS receiver technology.

Under reasonable observing conditions, Receiver A2 should currently perform with a SSB system temperature of 250 - 350 K across the entire frequency range, allowing good observations to be made of very faint sources, previously unattainable. To illustrate what an observer might expect with Receiver A2, Figure 2 shows 3 spectra recorded during commissioning, covering a range of spectral line strengths. Shown are the spectral lines of  $C^{18}O$ ,  $^{13}CO$  and  $CO$ , looking towards the source IRC+10216, having line intensities of 0.15 K, 3.5 K and 22 K respectively.

*Steve Davies, University of Kent at Canterbury*

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### Dixie, D-Mixer: $T_{\text{rx}}(\text{DSB})=850\text{K}$ at 702GHz

Since April 1992, as part of in-house research at HIA, we have been developing an SIS mixer for D-band (620 GHz to 720 GHz). This is the first submillimetre mixer block manufactured at HIA, and despite its simple design, we are measuring good noise temperatures in the lab with a best result to date of 850 K (DSB) at 702 GHz.

The mixer block follows the now conventional design with the SIS device lying across a waveguide, and a single tuning backshort. In Dixie's case, the waveguide is circular which usually means poor RF coupling because of the high waveguide impedance, but we have tried to minimise this problem by oversizing the guide. This results in a waveguide with a slightly lower impedance, and also, manufacturing a larger waveguide and especially a larger backshort is an easier task. One might be concerned that unwanted sidelobe generating modes are allowed to propagate

in the oversized guide, however the central location of the SIS junction inhibits the generation of these modes.

In order to concentrate the received radiation onto the SIS junction, the mixer block features an integrated dual mode horn, often called a Potter horn. This is simply a funnel with a step in it which generates the right forms of propagation (modes) that mix together to create an acceptable beam profile. Our RF measurements haven't yet reached the point where we are measuring beam profiles, but we expect the receiver to have good far-field behaviour with similar E and H plane profiles.

The Josephson current in the SIS device is suppressed in the usual way with magnetic field provided by a coil of super-conducting wire. Additionally, magnetic field concentrators lie on either side of the SIS junction. By squeezing together the magnetic field lines, a reasonable current through the coils creates a high magnetic field across the junction.

For a Local Oscillator source, we are using the Carcinotron from RxB, which was decommissioned in 1991. The signal is doubled in frequency by a multiplier fabricated, and eventually delivered, by Millitech Corp. While waiting for the doubler, we tried pumping Dixie with the solid state LO from the soon-to-be-delivered RxB3. Relying on the fifth harmonic of the frequency quadrupler, the receiver actually showed photon steps at 430 GHz and we measured a double side band noise temperature of 2000 K, which is not bad for a receiver designed to be used at 700 GHz!

Deep in the heart of Dixie is a lead based SIS junction fabricated at the UKC by Steve Davies, who also provided the SIS junctions for RxA2 and RxB3i. There is a lead alloy junction in RxC2 as well (fabricated at RAL). While niobium has now been shown to work well at frequencies up to 700 GHz, we have decided not to abandon lead which has been so successful up to now. With a bit of bismuth added to the lead-gold-indium alloy, the resulting device has a high bandgap. Dixie has been working up to now with a junction that has a bandgap of 2.8 mV. Using modified alloy, the latest junctions have a higher bandgap and we have now mounted a device with a bandgap of 3.2 mV.

Dixie D-Band Mixer was crafted by Luc Martin in the HIA machine shop, and he is presently working on a reduced height rectangular waveguide mixer block. The next generation 690 GHz mixer should have even better performance with the RF match closer to optimum.

*Steve Torchinsky & Charles Cunningham, HIA  
Steve Davies, UKC*



# SIS Detector Developments in Groningen

## Introduction.

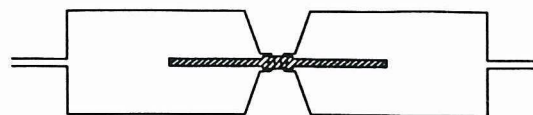
SIS detectors are currently used as the most sensitive heterodyne detectors for frequencies up to 500 GHz and they are in regular use at many groundbased astronomical observatories all over the world, including the JCMT. They consist of tunnel junctions based on lead or the more stable niobium as material for the superconducting electrodes. The SRON-Groningen laboratory has recently shown that excellent sensitivity can also be achieved at frequencies around 700 GHz.

Not only do SIS detectors provide better sensitivity than the more traditional Schottky detectors they also require a much lower level of local oscillator power.

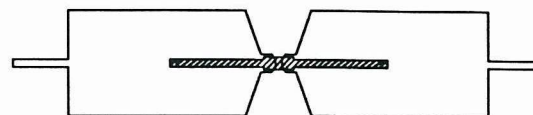
In this paper we will briefly describe a novel fabrication process of niobium tunnel junctions. Next we will describe their application in waveguide mixers as well as their use in planar antennas. Finally we give a summary of Groningen activities for JCMT, including junction fabrication, a design study of an imaging array receiver for the B-band and the development of a 690 GHz waveguide mixer.

## Niobium SIS Junction Fabrication.

The Nb tunnel junctions are fabricated with the use of a novel process (SNOEP Selective Niobium Over-Etch Process). Junctions with areas as small as  $0.8 \mu\text{m}^2$  and a current density of  $12 \text{ kA/cm}^2$  can routinely be made with a high processing yield. The details of this process are described by Dierichs et al. Both, single junctions and arrays of two junctions are used. Arrays of junctions are used to reduce the effective capacitance of the device, thereby improving the RF-coupling. For a further improvement of the RF-coupling the junctions are fabricated with different types of integrated tuning stubs. Such on-chip tuning elements consist of a superconducting stripline connected to the junctions. The big advantage of an on-chip integrated tuning element is the large increase in bandwidth compared to having mechanical tuners only, and the decrease of the dependence on the (critical) tuning of the mechanical tuners. Three types of integrated tuning elements are shown below.



Open ended tuning stub



End loaded tuning stub



Quarter lambda shorted stub

**Figure 1.** Three different types of integrated tuning structures.

## Waveguide Mixers.

The used mixer blocks are scaled versions of the 345 GHz mixer described by Honingh et al. The only difference is the waveguide size: the 345 GHz mixer uses a 50% reduced height waveguide, while the 400-500 GHz and the 750 GHz receiver use full

Freq. (GHz)	Waveguide		Substrate Channel	
	Height	Width	Height	Width
345	150	620	200	220
490	220	440	150	165
750	150	300	100	100

**Table 1.** Overview of the waveguide and substrate channel sizes of the different waveguide mixers. Sizes are in  $\mu\text{m}$ .

height waveguides (see Table 1). The mixer block is placed inside an Infrared Laboratories HD 3 cryostat. The signal and LO-beams are combined by a  $15 \mu\text{m}$  Mylar beamsplitter and enter the cryostat via a 1 mm thick HDP (High Density Polyethylene) window of 3 cm diameter.



The mixer blocks use diagonal horns to achieve a good match to incoming wavefronts with a Gaussian amplitude distribution. Diagonal horns are relatively easy to make and laboratory tests of this type of horn showed a good beam-coupling (side lobes < -15db), equal beamwidths in E-, D- and H- planes and a low cross-polarisation (< -15 dB). Although the dimensions of waveguides and substrate channels become very small at these frequencies, we have developed appropriate machining techniques that provide excellent quality mixerblocks, even for frequencies as high as 700 GHz. The waveguide system can have one or two moving non-contacting shorts (backshort and E-plane tuner) as tuning elements. If an E-plane tuner is used it is placed half a guide-wavelength (at the design frequency) in front of the junction position. A magnet coil made of Nb wire is placed around the horn, in front of the mixer block, to suppress undesired Josephson currents. The LO-power is supplied by Thomson carcinotrons (for 345 and 490 GHz) or Radiometer Physics Gunn and multiplier systems (for 345, 490 and 750 GHz). The noise temperature of the system is measured by using thermal radiation of a piece of 'ECCOSORB' foam at two different temperatures as a calibrated broadband black-body signal source ('Y-factor' method).

The minimum receiver noise temperatures (DSB) achieved for the 370, 490 and 750 GHz mixers using junctions with on-chip tuning elements are 90, 90 and 400 K, respectively. The heterodyne response of the receivers is checked by line measurements using a gas-cell filled with SO<sub>2</sub>. An overview of the measured noise temperatures is given in Figure 2, see for more details de Lange et.al.

Finally, we show in Figure 3 the large increase in bandwidth, obtained by making use of integrated tuning structures. The figure illustrates the instantaneous bandwidth for a structure with and without an integrated tuning structure. A 10 times increase in bandwidth is observed and we may conclude that we have managed to fabricate a **fixed tuned mixer** with a bandwidth of at least 10% of its central frequency.

#### Planar Double Dipole Antennae.

Planar antennas offer some important advantages over waveguide structures when used in conjunction with SIS mixers: they do not require the same delicate machining, while the **absence of moving parts** provides a higher degree of reliability at cryogenic temperatures.

Moreover, they offer good prospects for the construction of imaging array receivers, an important aspect for efficient use of ground-based

as well as space-based submillimeter-wave telescopes. There are also some drawbacks to consider, such as bandwidth limitations, lower beam efficiencies and cross polarization properties.

One such planar antenna or so-called quasi-optical structures is the double dipole antenna. The combination of such an antenna with a thick elliptical lens is described by Skalaré et al. and is illustrated in Figure 4. Two SIS detectors are symmetrically located around the centre of the structure. Scale model measurements at 7, 10 and 14 GHz have shown it to have a -3 dB bandwidth of one octave, and good sidelobe and cross-polarization properties over that band. Measurements at 100 GHz confirmed the good beam pattern behaviour.

In order to get an efficient mixer at 400 GHz, we scaled the antenna down in size and we chose to use a hyper-hemispherical lens, mainly because it can be manufactured to higher tolerances than an elliptical one. The SIS parasitic capacitances were tuned by on-chip stubs, suitable for a series array of two junctions, each with an area of 3 square microns. Like in the experiments with waveguide mixers, we used a superconducting coil magnet to suppress the Josephson effect. Figure 2 includes the DSB noise temperature measurements for such a quasi-optical mixer for the frequency range of 460 to 495 GHz. Best receiver noise temperature was 200 K DSB at 460 and 480 GHz.

#### Summary of Groningen Activities for JCMT.

In Groningen the University group headed by T. M. Klapwijk is supplying niobium junctions for 2 groups of JCMT customers. One group consists of the SRON laboratory and the HIA institute in Ottawa; they focus on 345 GHz junction structures. The other group consists of MRAO in Cambridge and RAL at Chilton, focussing on 460-490 GHz junctions.

Another activity in Groningen is the design study for a B-band array receiver. This activity is concentrated on a 5x5 element array of SIS mixers with fixed tuned bandwidth. The study is about finished and final reports will be available by September 1993 on the following subjects: scientific aspects and design philosophy, construction plan, mixers, bias supplies, IF matching, quasi-optics, control, mapping and data reduction.

Finally, SRON has been asked to develop a 690 GHz D-band mixer for JCMT. The present result of a DSB noise temperature of 400 K at 720 GHz is encouraging.



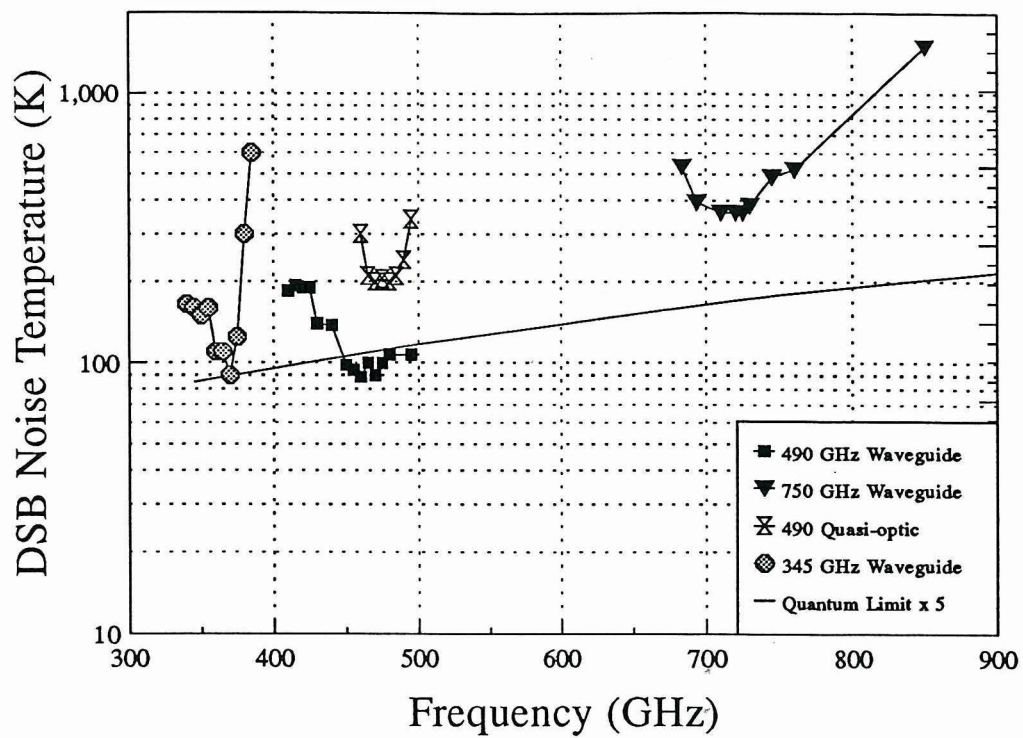


Figure 2. Overview of the receiver noise temperature as measured at SRON.

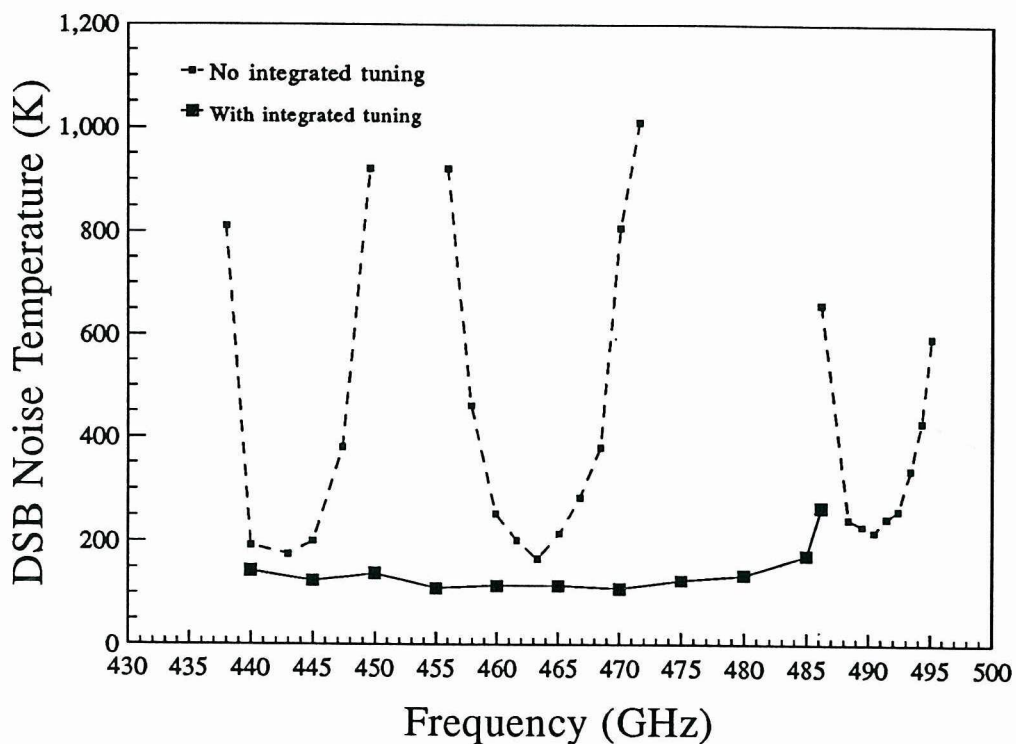


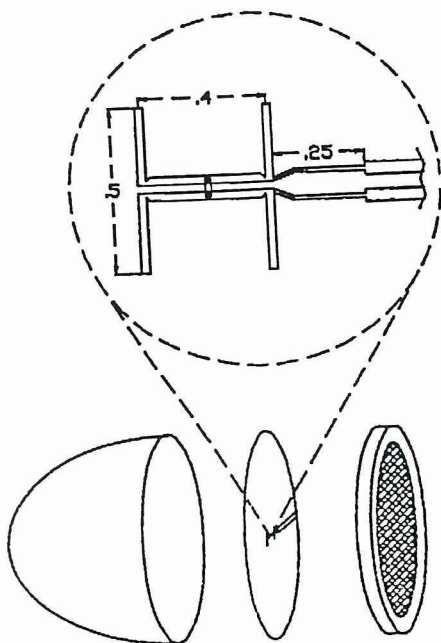
Figure 3. Comparison of instantaneous bandwidth of the 490 GHz waveguide mixer with and without integrated tuning.

#### Acknowledgements.

The junction fabrication work is supported by SERC via the Royal Observatory Edinburgh. The mixer development is supported partly by ESA and the Stichting Technische Wetenschappen of the

Stichting voor Fundamenteel Onderzoek der materie in the Netherlands. We want to mention the invaluable technical support of Harry Schaeffer, Hans Golstein, Marcel Dierichs and Johan Wezelman.





**Figure 4.** The geometry of a double dipole antenna placed between a thick quartz lens and a quarter  $\lambda$  thick quartz slab with a reflector.

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*Th.de Graauw, C.E.Honingh, T.M.Klapwijk, G.de Lange, J.Mees, R.A.Panhuyzen, A.Skalare & H.van de Stadt,*  
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*The Netherlands.*

## Data Archive

All observations continue to be archived at the ROE. Following the disconnection of the dedicated data circuit between the JAC and Edinburgh, Iain Coulson, Ko Hummel and Alex McLachlan have developed efficient ways of transferring the data over Internet. Although the data themselves are protected by the proprietary period rules, the on-line Catalogue is continually updated and can tell you what observations have been taken of particular targets. You can avoid duplication *before* writing your PATT application and, if necessary, contact the original observer without having to wait for the expiry of the proprietary period.

A tutorial on using the query system was published in the last JCMT-UKIRT Newsletter and a User's Guide is available. Here is an abbreviated recipe:

**Access:** Log in as ARCQUERY on to the ROE Starlink cluster: (star.roe.ac.uk on Internet, REVAD on Starlink, 19889 on SPAN). You do not need a password but will be prompted for your initials to identify you to the archive.

**Starting:** Type ARCQHAT (this and other commands are not case-sensitive.)

**Searching:** At the ARCQUERY: prompt, type SELECT. You have to give your search criteria. The most common is by name of the object and you can enter OBJECT\_NAME=HH111 (for example) either on the same line as SELECT or at the SELECT: prompt. You can use \* as a wild card, as in OBJECT\_NAME=HH7\* to get both HH7-11 and HH711, etc. Another common criterion is coordinate range and there are relational operators like .AND. for more selective searches including INSTRUMENT=RXA3\*, for example. You can also narrow down your choice by doing your search in series, as each SELECTION works by default on the most recently produced list. The lists are all kept, so that you can backtrack if you change your mind.

**Reporting:** The SELECT process gives a list of the most recently selected observations. You can read this and the files produced at intermediate steps using the LIST command. You can choose the data reported to you by using the DEFAULT command to edit the format of the LIST report (and view and, if desired, change other defaults like coordinate system and equinox).

All in all, ARCQUERY offers a useful database query system. There is on-line HELP and documentation available. If you haven't done so already, give it a try.

*Peredur Williams, ROE*



## Progress with the JCMT-CSO Interferometer

The most recent trial of interferometry between JCMT and CSO took place in March. Generally it worked well and for the first time the weather was good enough to allow submillimetre interferometry and for us to get a real impression of the instrument's capabilities. The purpose of this note is to show examples of the type of observations that can be made with the interferometer.

First, though, here is a quick review of the important parameters of the instrument. The two dishes are 15 and 10.4 metres in diameter. We use the existing heterodyne receivers but with specially-built LO and IF systems which link the two telescopes via optical fibres. The DAS, operating in its cross-correlation mode, provides the backend for both line and continuum observations. So far we have worked in the JCMT "A"- and "B"-bands spanning 230 to 360 GHz; we hope to extend this to 500 and 700 GHz eventually. The baseline components are 158 m East-West and 43 m North-South giving a fringe spacing of about 1 arcsecond at 345 GHz. It is of course not possible to change the position of the antennas (without taking rather drastic measures!) so we are not able to make standard aperture synthesis maps. The length and orientation of the baseline projected onto a plane perpendicular to the source does vary as a function of hour angle and this may prove useful. But the key point is that the more basic property of an interferometer - the fact that it filters the extended emission from a source and only detects

the compact components - already makes it a powerful tool.

The first figure demonstrates this point. Figure 1a shows the interferometric spectrum obtained after about an hour of integration at 230 GHz on the nearby radio galaxy Centaurus A. The dots in the upper half represent the phase in the range of -180 to +180 degrees and indicate that the continuum emission is coming from the nuclear point source. The lower half of the plot shows the amplitude of the fringes with a resolution of 0.3 km/s. The narrow absorption features are due to CO in the line of sight to the bright nuclear non-thermal continuum source. These features are also present in a single dish spectrum of the object but they are greatly confused by the emission from all the other CO in the telescope beam. Compare the interferometer spectrum with the single dish spectrum in figure 1b; the difference is clear. There are a group of lines near the systemic velocity (~550 km/s on the scale we have chosen here), as expected for material in circular orbits around the nucleus, but there is also an interesting group at about 610 km/s. In principle this could be from gas falling into a black hole at the centre. The narrow linewidth however suggests not; one might have expected tidal disruption to have produced a much larger velocity dispersion. The alternative is that these clouds are further out in the disk structure, which is already known to be highly warped, probably as a result of a merger, but they then imply that it is even more disturbed than had

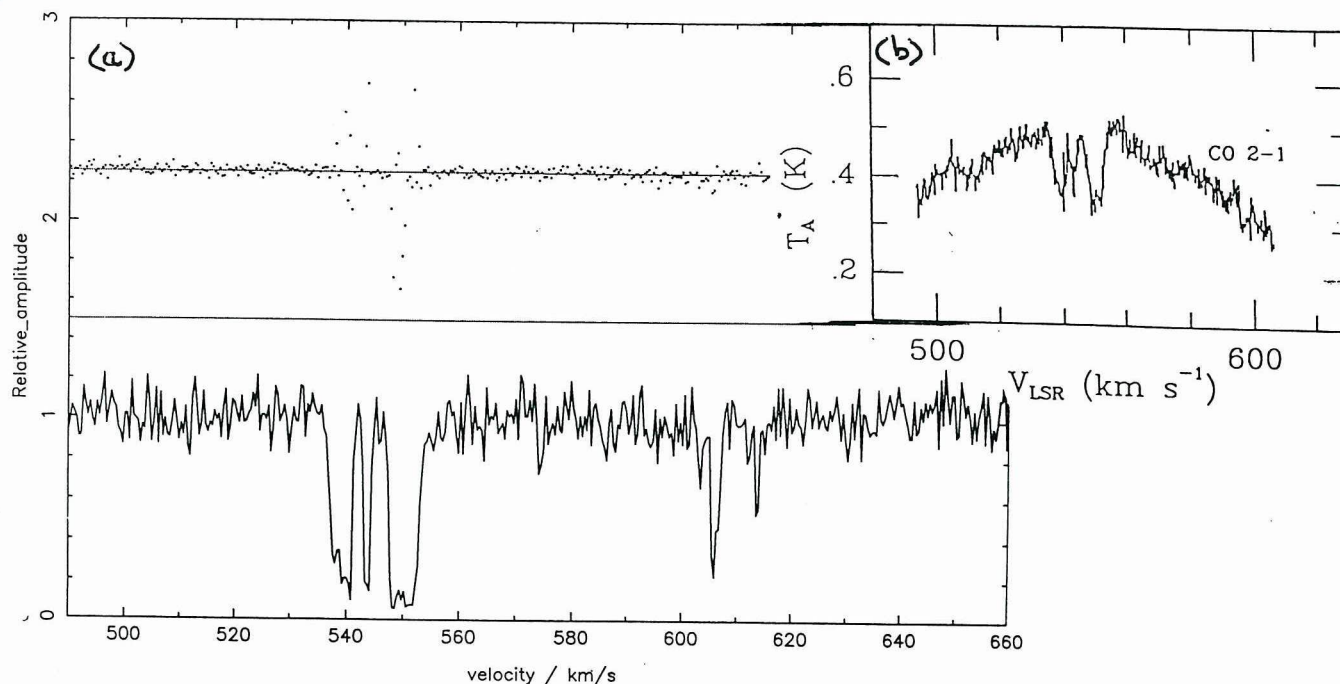
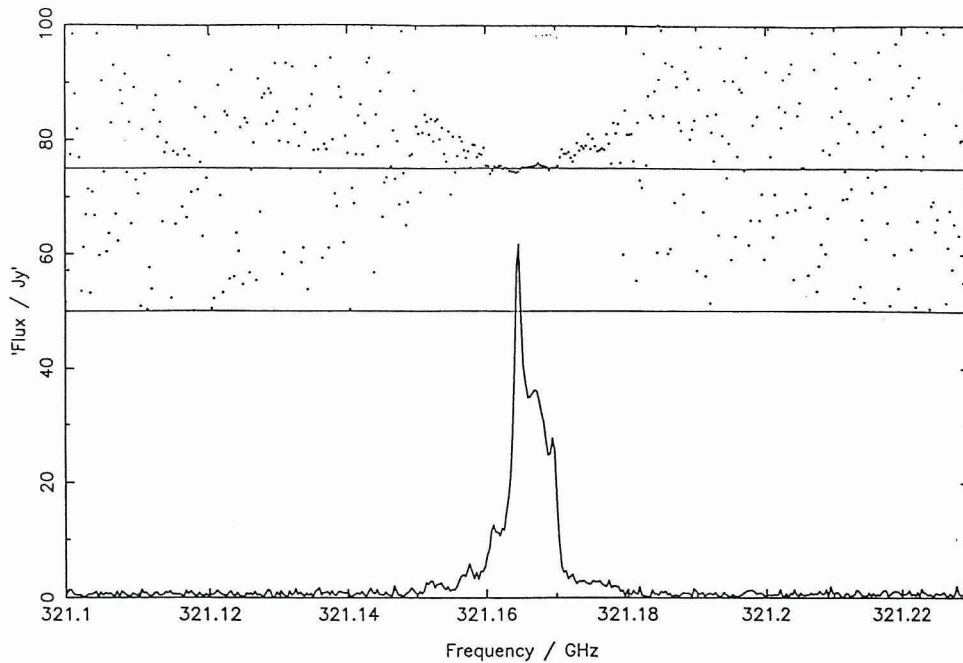
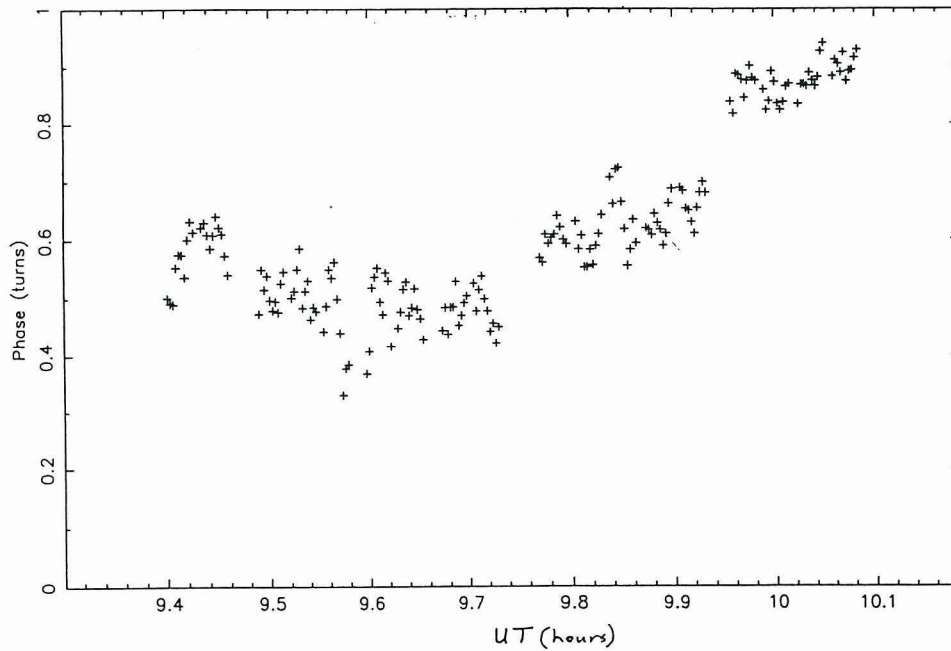


Figure 1 (a). Interferometric spectrum of Centaurus A, CO 2-1, (b) Single dish spectrum for Centaurus A, CO 2-1 (reproduced from Israel et al., *Astron. Astrophys.*, 245, L13, 1991 with permission).





**Figure 2.** *Water maser in VY CMa.*



**Figure 3.** *Interferometer phase versus time for the quasar 3c273.*

previously been thought.

Another useful aspect of an interferometer is its ability to measure relative positional offsets with extreme accuracy. A good example of this is the case of molecular masers, where there are usually a number of spatially distinct sources contributing to the line profile. Figure 2 shows the water maser line at 321 GHz associated with the evolved star VY CMa after integrating for two and half hours.

We believe that the structure in the phase is real and shows positional offsets of just 15 milli-arcseconds for the different velocity components.

The interferometer is in principle capable of observing much fainter sources than these. However to do this we need to be able to integrate coherently for long periods. This requires high phase stability from the electronics and an



understanding of the geometry of the entire system down to the level of a fraction of a millimetre. We spent a large part of the run in March working on this by observing quasars and other bright sources. We now think that we have pinned down the baseline to within a millimetre or so. Life is made more challenging by the totally independent designs of JCMT and CSO; we need to compensate for the extra path introduced by the dishes as they deform under gravity and the for the motions of the subreflectors, as well as accounting for the non-intersection of the elevation and azimuth axes. Figure 3 shows how the phase of the quasar 3C273 varied over an hour or so. Each point represents a 10 second integration. It can be seen that there is a general slow drift which is probably a combination of thermal effects and residual geometric errors. The point to point fluctuations are consistent with the system noise, but structures on timescales of a few minutes can also be seen which are almost certainly due to the atmosphere. Finally, steps in the phase between the different blocks of observations are apparent which are at present unexplained - "software" is the most likely suspect. Poor weather for the first half of the run which produced much larger phase deviations than those shown here hampered our efforts to sort all this out, so a substantial amount of work remains to be done before we can integrate "blind" with confidence on faint sources.

*Oliver Lay & Richard Hills*  
MRAO

*John Carlstrom*  
Caltech

## Adjusting the Focal Length of the JCMT

Regular readers of the JCMT newsletter will know that we have put a considerable amount of effort over the last few years into the improvement of the surface accuracy of the JCMT primary. In July of this year we took this a stage further, by actually making a significant change to the focal length of the telescope. This operation, which required a major adjustment to the primary panel positions, and the removal and replacement of the Secondary Mirror Unit, went extremely smoothly, and is a major step towards obtaining the ultimate possible accuracy from the JCMT surface.

The majority of the surface work over the last year or so has gone into trying to understand the large-scale errors. We still have the problem that the telescope is somewhat non-homologous as a function of elevation apparently because of some unexpected deformation in the backing structure which occurs at low elevations. However, we have set the dish on the basis of out-of-focus beam maps made at intermediate elevations, and as a result of

this the large scale error is rather good at normal observing elevations.

Now, with the large and small scale "panel" errors both down at the level of 20 microns or less, we have started to turn our attention to the problem of the panel "scalloping". This has been described in some detail by Richard Hills in the August 1992 Newsletter - basically the problem is that the curvature of the individual panels does not match the curvature of the surface. Perhaps more correctly we should say that the surface does not match the panels, since the panels have a fixed curvature, but we can change the curvature of the surface by changing the telescope focal length - and this is precisely what we are now starting to do.

Richard's article described the origin of the scalloping and its effect on the beam pattern, which is especially pronounced at the shorter wavelengths, producing a diffraction "ring" which contains about 40 per cent of the energy of the main beam at 350 microns. Since Richard wrote his article, we have realised that the focal length has to be decreased, rather than increased (i.e. the dish has to be made deeper) but the required movement is about the same - approximately one inch of focal length change. The size of this effect has two major implications: firstly, to reduce the focal length by 25 mm, the adjusters on the outer edge of the dish have to move up by 12 mm - and this is more than the range of travel of the adjusters (10 mm). Secondly, the change in focal length is more than can be accommodated simply by driving the secondary to a new position using the XYZ translation tables.

Given these challenges, we decided as a first step to move the primary as far as possible using only the range of movement currently available in the adjusters. It turns out that the backing structure itself has considerable irregularities in its shape - so that although the majority of adjusters were near the middle of their range, a significant number were already rather close to one limit or the other. In fact, we determined that we could only raise the outer edge of the dish up by around 2 mm before we started running in to adjuster limits. However, we found we could get another 2 mm of adjustment by moving the inner part of this dish downwards. Despite only doing one third of the total focal length change required, this was still enough to require a movement of the whole SMU assembly downwards, to bring the new focus position back into the range of the Z table's movement.

So, on Monday 12th July, we turned the adjuster electronics on, did some final checks on the adjuster positions on the inner ring, and then simply asked the adjuster micro to move all the adjusters to the positions required to reduce the focal length of the primary by 8 mm, along with a vertex shift



downwards by 2 mm. This went extremely smoothly, although we did notice that some adjusters in sector five appeared to have moved more often than they should have! The process of doing the complete move actually took about four hours - considerably longer than a normal adjustment, and a graphic illustration of how far we were moving the surface. One slight hiccup was that half-way through the adjustment the Vax disk-drives went off line (caused accidentally by people working in the computer room) - first we lost the ability to read the "moves" file, and then the machine crashed! However, we managed to recover from this without any problems. (A good deal of effort had been put into the adjuster software to make it fireproof, but this was a pretty severe test!).

Immediately after the move, we opened up the telescope, pointed at Jupiter and focussed up, and found an offset of almost exactly -10 mm from the previous nominal position. Holography performed that night showed that indeed there was a very systematic error in a number of panels in sector five. In addition, a number of panels in sectors nine/ten had not moved correctly (they appear to have been mechanically binding). However, the fit to the residual phase errors came up with a reduction in the scalloping equivalent to a focal length change of about 6 mm, in good agreement with expectations given the uncertainties in the fit. It was something of a relief when we obtained this result which showed that we had indeed moved the focus in the correct direction!

The remainder of the engineering, although time-consuming, was relatively straightforward. The mechanical staff did an excellent job of pulling back the membrane, removing the secondary mirror, replacing the shims under the "lunar lander" legs with thinner ones, and putting everything back together, all in one day. At the same time, the "focal length change" team moved the rogue panels back to approximately the correct place, using a combination of suggested holography moves, measurements of adjacent panels made with an LVDT unit, and an experienced eye. Further adjustments were made on Wednesday during the day, with a final tweak on Thursday morning.

In pushing the adjustment as far as we could, we ran a number of adjusters into limits. One, in ring two, has hit a bottom limit, so that one edge of the panel is approximately 1 mm too high. We will probably grind down the base of this adjuster to get the panel correctly into its new position. Five adjusters in the outer ring hit their electronic upper limits. For three of these, we carefully drove the adjuster slightly past the limit. For the other two, as an experiment, we loosened the bolts holding the adjusters to the nodes, inserted one quarter inch shims underneath each adjuster, and drove them

back down the appropriate amount. We got both of these correct to within 50 microns by dead-reckoning, in a rather straightforward operation.

The accompanying figure shows "before", "during" and "after" plots of the panel positions (left hand side), and residual surface phase errors (right hand side) for the dish. The one panel which is too high is obvious in the "after" residual plot. The large scale error present in both the "before" and "after" plots is due to the residual problem with homology. Unfortunately, the weather was too poor throughout the whole period to obtain any out-of-focus beam maps, and indeed we have to date obtained very few in-focus beam maps, and no efficiency measurements, with which to characterize the new surface. However, the maps we do have show that we have not introduced any new gross large-scale errors, and so we are confident the the operation has been a success.

We have now removed approximately one-third of the surface error due to the "scalloping" problem. This should have reduced the energy going into the error pattern by more than a factor of two and increased the gain of the dish at the shortest wavelengths quite significantly. To proceed further will require considerably more effort; we will either need to shim a significant number of adjusters, or perhaps we may even need to reset the backing structure. We will be giving this more thought over the next few months, and hope to make further progress on this front in an engineering period in January.

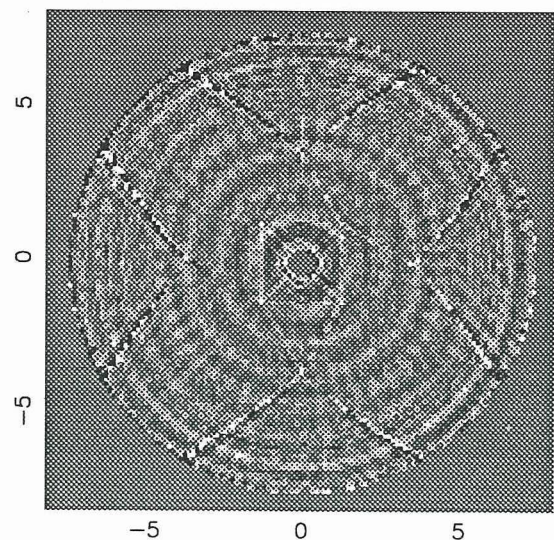
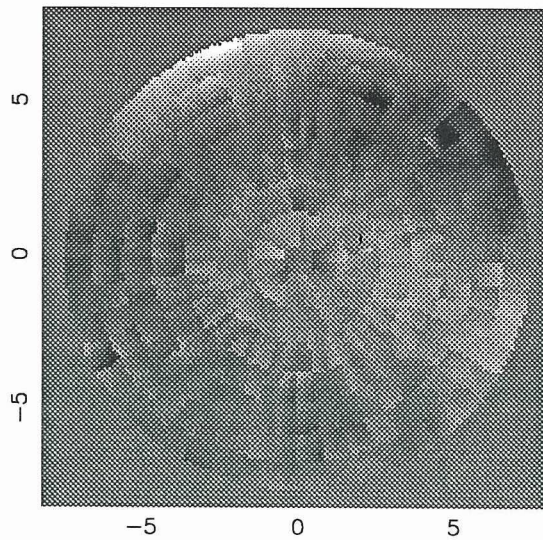
Once again, our thanks to Richard Hills for his invaluable guidance and assistance in the preparation for this work.

*Richard Prestage, JAC*

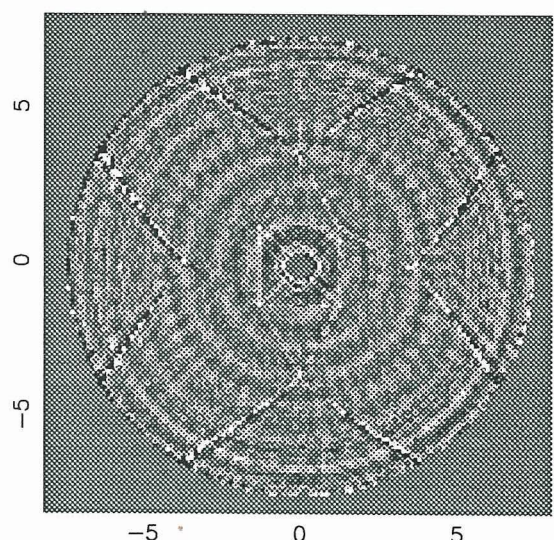
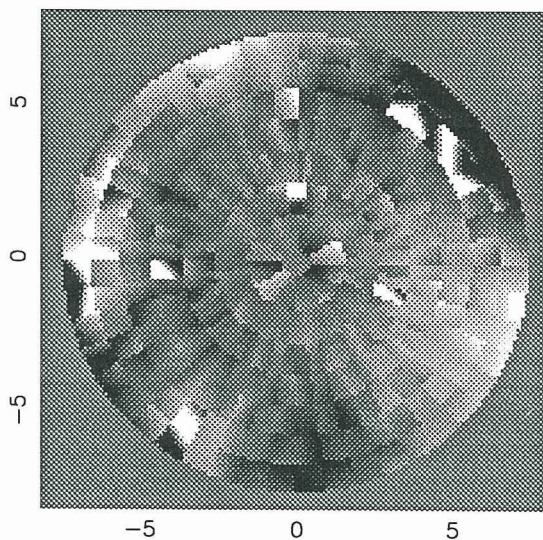


large scale/panel errors  $\pm .10$  mm

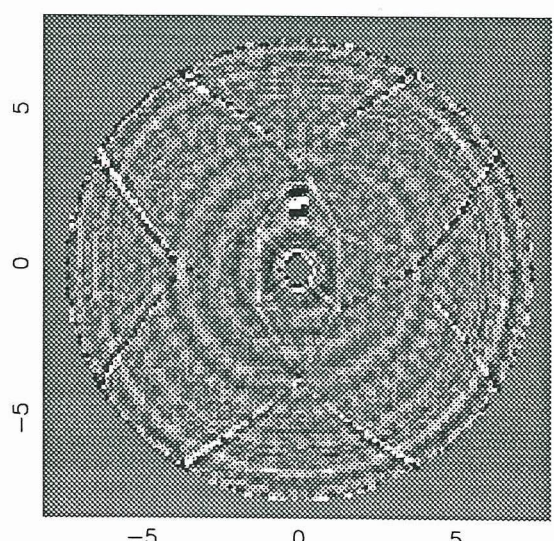
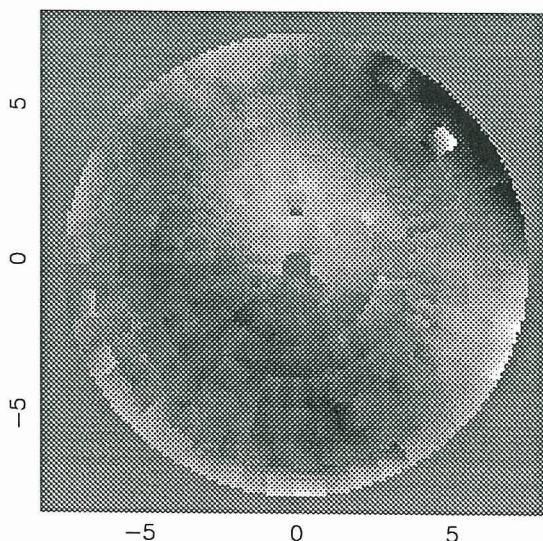
residual errors  $\pm .10$  mm



BEFORE



DURING



AFTER

**Figure.** *The state of the surface of the JCMT before, during and after the focus adjustments. See text for further details.*



## Successful Commissioning of the DAS

The DAS is now installed on the JCMT, and is available to users in all modes. The first commissioning run revealed a major difficulty with baseline merging. The main problem was that the analogue to digital convertors were non-linear. Changes in the input total power (from varying sky, receivers, or IF) resulted in poor baselines; in particular the 'merging' of subbands produced steps and curves in the baselines. This is a difficult problem with wideband hybrid correlators such as the DAS, as good baselines requires a very stable and linear system throughout. The NFRA group were able to manufacture a automatic gain control circuit that keeps the power into the ADC's constant. They were also able to make it small enough to fit into the current box.

The recent July commissioning run on the telescope, and subsequent observations by users have shown that this, combined with several improvements to the software have reduced the non-linear effects by a factor of 10-20. The baselines now are as good and sometimes better than the AOS. In the Figures I show some examples of spectra obtained from the DAS. No 'weird' data 'reduction' techniques have been used, apart from subtracting linear baselines!

Figure 1 shows a spectrum of IRC+10216 in  $^{12}\text{CO}$  J=2-1, with the line on the overlap region. The upper plot shows the same spectrum offset and scaled up by a factor of 10, in order to reveal the typical baseline offsets. These are less than 1% of the peak line intensity, even in the worst case of a bright line being in the centre of an overlap region. Therefore the 'platforming' problems seem to have

been reduced to a very low level. Figure 2 shows a beamswitched spectrum of a wide galaxy taken using RxA2 in the 750MHz mode. The overlap between the two subbands can be seen in the centre, as can the excess noise due to the receiver 'dropoff' at the edges of the passband. In this case, no baseline has been subtracted. Figure 3 shows two raster scans taken through IRC+10216 in  $^{12}\text{CO}$  2-1. An integration time of 5 seconds/point is used, and the telescope tracks continuously through the source. The efficiency of this observing method is very high (about 80% of time is spent integrating on source). In the current system the average of the two end spectra in each row is used as the reference for that row; consequently this only allows raster observations of small sources. However, it is hoped that provision for observations of large sources will be made available in the near future.

### Overview

The DAS provides several substantial improvements over the current backend spectrometer (AOSC). Among these are the capability for observing with a 920 MHz instantaneous bandwidth with Rx2C, and almost 750 MHz with Rx2A and Rx2C. It can give higher resolution with Rx2B3i (down to  $\sim 0.15$  MHz). The 'backend' or channel-by-channel calibration mode normally used gives more accurate calibration over the whole passband, particularly for Rx2B3i and Rx2A. The double buffering allows the DAS to be used for raster (or 'on-the-fly') heterodyne observing.

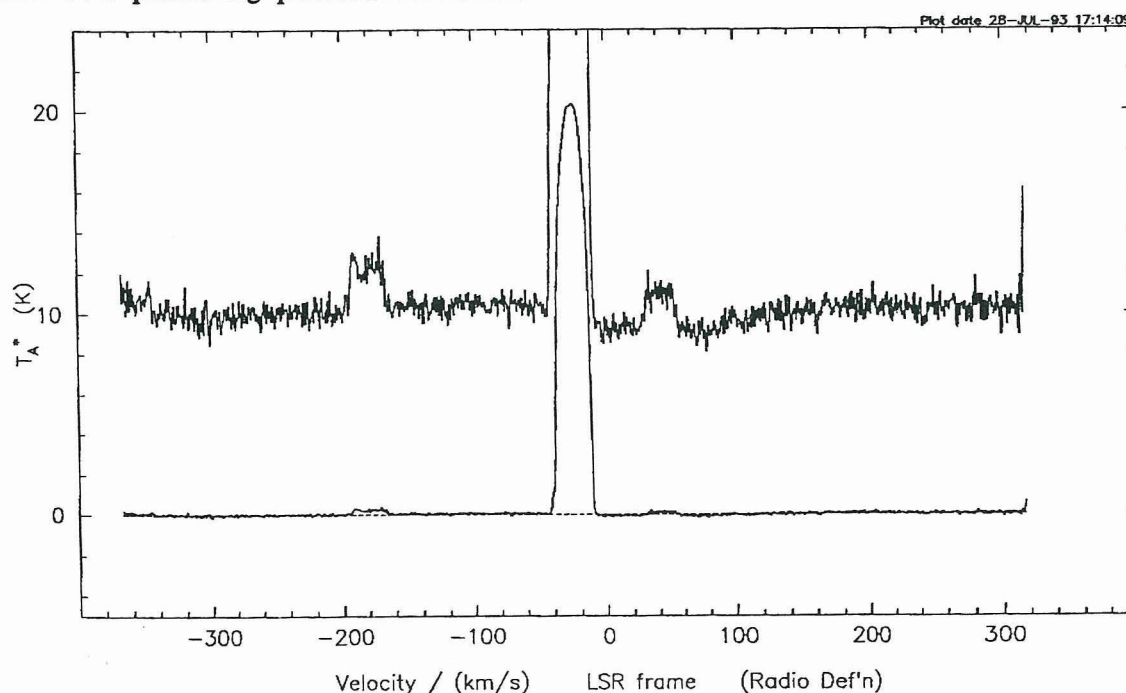


Figure 1.



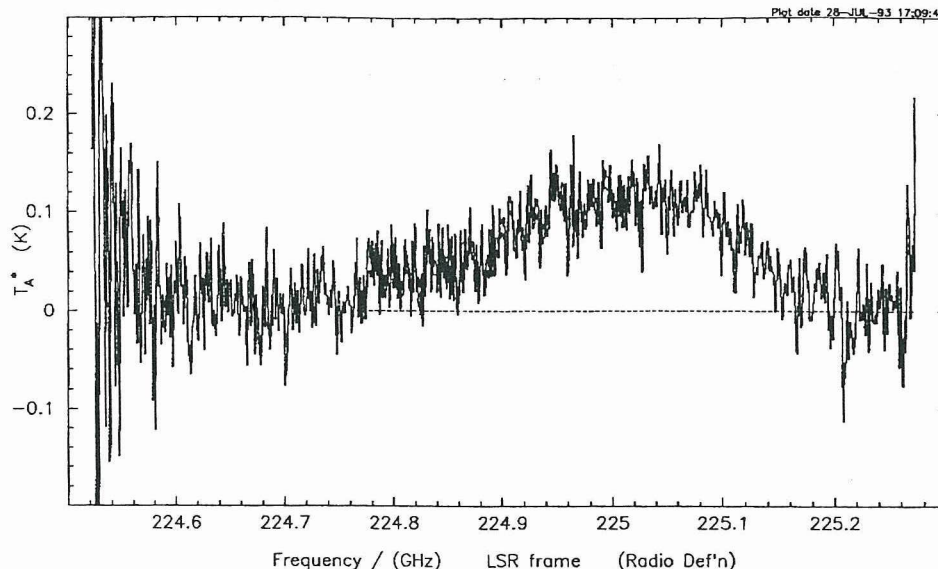


Figure 2.

The correlator is also required for interferometry with the CSO and, in the near future, it will be needed for the new dual-polarisation wideband receivers.

The instrument is highly versatile; the electronics can be re-configured to produce spectra of different resolutions/bandwidths. In addition, the system can be split up to sample different parts of the IF passband(s) at various resolutions. However, there are rules limiting the allowed configurations. The standard bandwidth options depend on the frontend receiver; the more important configurations are listed in the table.

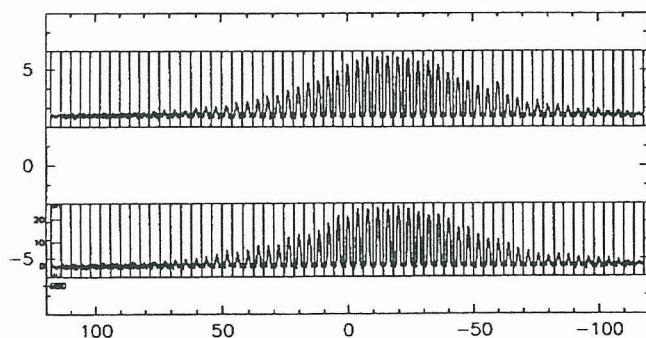


Figure 3.

The DAS produces one or more separate SUBSYSTEMS. A subsystem is a single spectrum, which, when read into SPECX, is put into one layer of the stack. Thus a simple dual-polarisation observation gives two subsystems. However, it is equally possible to configure for two subsystems from a single-polarisation receiver, by sampling two small sections of the passband. The software

will allow the user to choose different rest frequencies for the various subsystems, as long as they lie within the IF bandwidth of the receiver (in either sideband). One example might be simultaneous high-resolution observations with Rx B3i at 345.796 GHz and 342.883 GHz (<sup>12</sup>CO 3-2 and CS 7-6).

A subsystem is composed of between 1 and 8 SUBBANDS. A subband is one section of the correlator, and is 160 MHz wide. However, because of the necessary overlap between subbands to make up a subsystem, only 125 MHz of this is used. To make a single contiguous spectrum from a subsystem, the SPECX MERGE command must be used. This matches the edges of the subbands together to give a single spectral array.

#### DAS commonly used configurations:

Receiver	Bandwidth (MHz)	No of subsystems	Resolution* (kHz)
RxC2	920	1	1250
RxA2/B3i	750**	1	1250
RxA2/B3i/C2	500	1	625
" " "	250	1	312
" " "	125	1	156
" " "	125	2	312

#### Notes:

\* This assumes Hanning smoothing of the ACF. Higher resolution (0.6 times better) can be obtained at the expense of higher sidelobes in the spectrum.

\*\* This mode is obtained by overlapping two 500 MHz subsystems by 250 MHz; the bandwidth of A2 and B3i is typically about 650-700 MHz without substantial excess noise. This extra has essentially been obtained 'for free', as these two receivers were originally not designed for more than 500 MHz bandwidth.



## Acknowledgements

The following people were involved with commissioning of the DAS: Albert Bos, Hans van Someren Greve, Rob Millenaar, Mary Fuka, Chris Mayer, Neal Masuda and Bill Dent. Thanks also to the various engineers and scientists who helped with the construction and testing of the instrument.

*Bill Dent, JAC*

## Successful Commissioning of RxC2

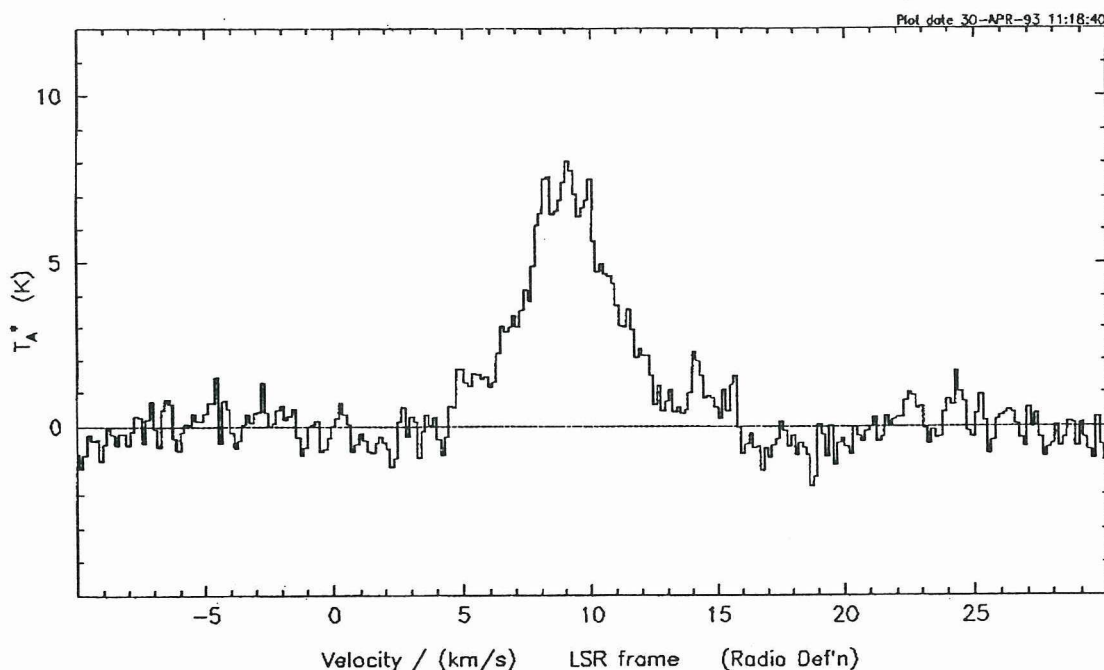
The new SIS receiver (RxC2) was shipped from the Rutherford Labs in the UK in early April, and arrived in Hilo apparently in one piece. Brian Ellison, Stephan Claude and Tony Jones arrived a few days later.

Testing in the receiver prep room went smoothly, with only a few minor software glitches. However, at 7pm on the evening before the receiver was to be installed on the telescope, during a routine tuneup ... catastrophe. The SIS junction went open circuit. A lot of morose receiver builders... It turned out that the mixer backshort had come loose during transit, and snapped the half-mm diameter quartz mounting substrate in the process of tuning. The weekend was spent looking through the 40-plus

receiver was mounted on the telescope. That evening (30th April), in only two minutes integration, we had first light - the fine structure line of neutral Carbon (C I) at 492 GHz. The SSB system temperature of this spectrum was ~2500 K.

During the subsequent commissioning run the weather was excellent, with 225 GHz zenith optical depths of typically 0.04. All of the major receiver parameters were obtained and are shown in the table. In Figure 2, a map of M82 in the C I line is shown. The line is strong ( $T_A^* \sim 0.5$  K) and can easily be detected in 5 minutes. Finally Figure 3 shows a spectrum of OMC1 at 504 GHz. Only a few of the lines can be identified using standard catalogues!

One of the major problems in this frequency band is the unequal atmospheric transmission in the two sidebands. At some frequencies, the image sideband can have zero transmission. As the receiver has no sideband filter, this could cause major calibration problems. However, Chris Mayer included an atmospheric model from IRAM ("ATM", written by J. Cernicharo). From this, we obtain the theoretical optical depth ratio in the band centres between the signal and image sidebands. Using a simple three-load calibration, and a mean  $T_{sky}$ , it is possible to get the effective system temperatures in both the image and signal sideband using a Newton-Raphson fit. The overall system sideband ratio (including receiver and calibration



**Figure 1.** First light spectrum of C I in the Orion Nebula.

spare junctions for a suitable replacement. Mounting the new one was stressful, but successful. It had characteristics very similar to the broken one; in fact it turned out to be somewhat better at 460 GHz. So after a delay of only three days, the

errors) appears to be 1.0-1.2, measured simply by looking at the same line in both sidebands. This calibration system was also installed in the other heterodyne receiver software, and made a significant difference to line temperatures around the edges of atmospheric windows. Observers



should be aware of this when combining new data with previously obtained spectra, especially for lines such as  $^{13}\text{CO}$  J=3-2.

The following gives the nominal receiver performance. Contact your support scientist for the latest values (the efficiencies may be different due to surface changes). There are two Gunns, one covering 450 to ~475 GHz, the second from ~475 to 504 GHz. Changeover should be done by the support scientist during the day, but is not recommended during a normal PATT shift. The noise temperature at other frequencies is shown in the receiver temperature plots elsewhere in this newsletter.

#### Acknowledgements

The following people were involved in the construction and commissioning of the receiver:  
RAL: Brian Ellison, Stephan Claude, Tony Jones;  
JAC: Chris Mayer, Firmin Olivera, Neal Masuda, Bill Dent.

*William Dent, JAC*

RxC2 Parameters		
Frequency range (including 3.94 GHz IF): 450 - 504 GHz		
IF bandwidth (920 MHz is currently useable with the DAS)		1.8 GHz
	460 GHz	490 GHz
Beam efficiency (a)	$0.511 \pm 0.02$	$0.491 \pm 0.02$
Main beam efficiency (b)	$0.461 \pm 0.05$	
Beam shape	11.7" x 10.9"	10.5" x 10.0"
FWHM	10.2"	10.2"
Eta_tel	0.86	0.76
Eta_fss (c)	0.66	
$T_{ra}(\text{DSB})$	180 - 190 K	210 - 220 K
$T_{sys}(\text{SSB})$ (d)	~1000 K ~2500 K	~2000 K ~6000 K

a: measured on Jupiter - size ~42"

b: measured on Mars - size ~4"

c: measured on full Moon, assume  $T_{moon} = 395$  K

d: top value is for best weather; bottom value for 225 GHz  $\tau \sim 0.05$





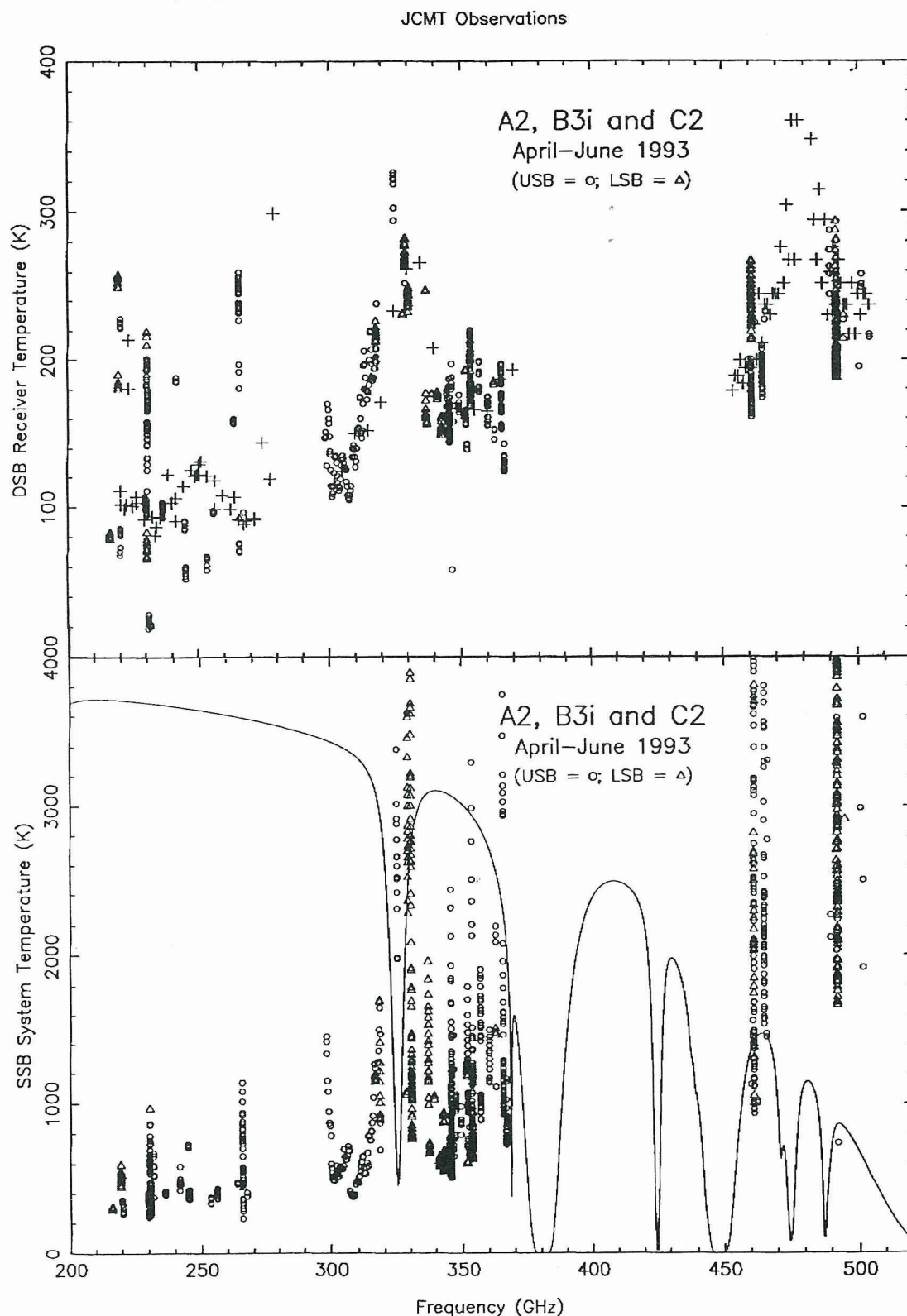


## The Real JCMT SIS Receiver Performance

The upper plot shows the DSB receiver temperatures obtained on the JCMT between April and June 1993. Data from all three SIS receivers are shown. The lower plot shows the corresponding SSB system temperatures, together with the atmospheric transmission at zenith for 1 mm PWV (on a vertical scale from 0 to 1). The data include about 3000 "real" points from PATT observations, DDT and EAC time - no editing has been done!

Various effects such as "clustering" around the most popular molecular transitions, the effect of the atmosphere, the lower boundaries of the system temperature and the reproducibility of receiver performance can all be clearly seen.

W. Dent & H. Matthews, JAC





# SCIENCE HIGHLIGHTS

## Continuum Observations of Nova Cygni 1992 - A New Test of Mass Ejection Models

### Introduction

Nova Cygni 1992 (V1974 Cyg), the brightest classical nova at visual maximum since 1975 and the closest neon nova ever observed, was first spotted in the early hours of 1992 Feb 19 (UT). Continuum observations of Nova Cyg 1992 were first performed during 1992 March 6 and 12 by Hjellming (1992) using the Very Large Array (VLA). The first pair of measurements resulted only in upper limits, but two days later, a total of 24 days after outburst, Tuffs (1992) reported the detection of radio emission from the nova remnant using the Max-Planck-Institut für Radioastronomie continuum receiver mounted on the 30-m Institut de Radio Astronomie Millimétrique dish. After a further 16 days, on Mar 30, the level of emission was high enough for the VLA to determine the shape of the centimetre continuum - a power law of index  $\alpha = +1.5$ , where  $F_\nu \propto \nu^\alpha$ .

Radio emission from classical novae is currently modelled in terms of free-free emission from a spherically symmetric expanding shell of ionized gas. Typically the radio light curves increase steadily in the early stages of outburst during which time the shell is optically thick and the flux density increase is driven by its expansion. As the nebula continues to expand the radio emission eventually peaks at a given frequency as the optical depth falls to unity, finally dying away as the density in the shell decreases. For a number of novae, e.g. V1500 Cyg 1975, FH Ser 1970 and HR Del 1967, the spectral slope during the early stages of the outburst is nearer unity than the +2 expected for an optically thick, geometrically thin shell. This can be explained by invoking density and velocity gradients in the shell which cause some regions to become more transparent towards the higher radio frequencies (e.g. Seaquist et al. 1980). For example, the observed radio light curve of V1500 Cyg 1975 is well accounted for by a Hubble-flow-type model in which a velocity gradient is imparted to a thick, isothermal shell at the moment of ejection.

At centimetre wavelengths the ejecta are at least partially optically thick until long after mass loss has ceased so that details of the ejection mechanism operating cannot easily be obtained. Submillimetre observations of novae, however, allow the investigation of the nebular remnants during the earliest stages of outburst when the ejecta are optically thin at these wavelengths. In addition, the free-free emission from the expanding shell of material is uncontaminated by emission from dust,

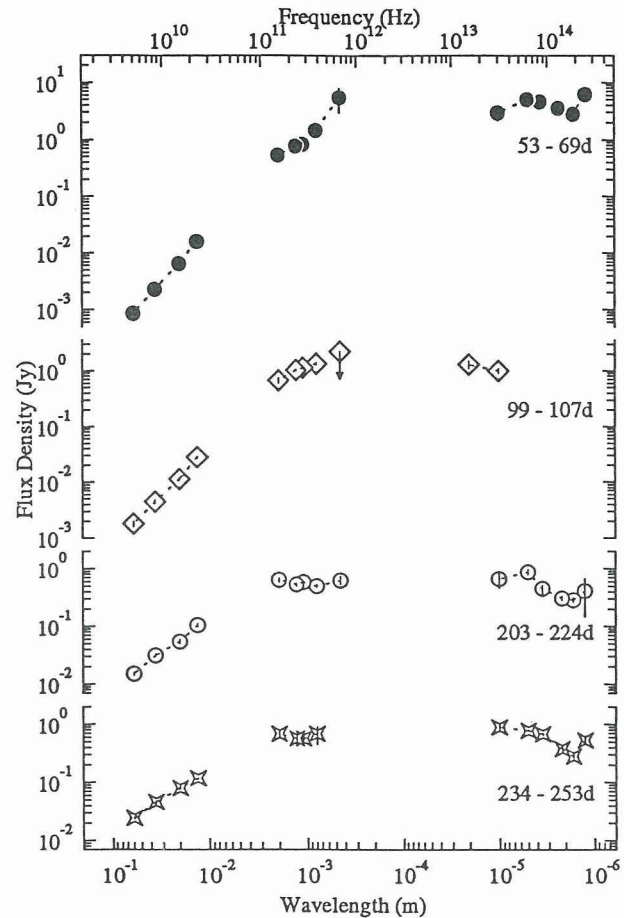


Figure 1. The radio-through-infrared continuum of Nova Cygni 1992. Dr R.M. Hjellming is gratefully acknowledged for providing data prior to publication.

continued nuclear burning on the surface of the white dwarf progenitor, and other factors which can dominate from infrared to X-ray wavelengths.

The high level of emission observed by Tuffs and Hjellming prompted our first 0.45–2.0 mm measurements during 1992 Apr 25 with the JCMT. The first measurements showed a ten-fold increase in flux density at 1.3 mm over a period of 41 days and helped trigger the first MERLIN synthesis observations which were performed on May 9. A further three MERLIN imaging runs (Pavelin et al. 1993) followed the nebula as it expanded, showing a complex structure suggestive of highly non-spherical ejection.



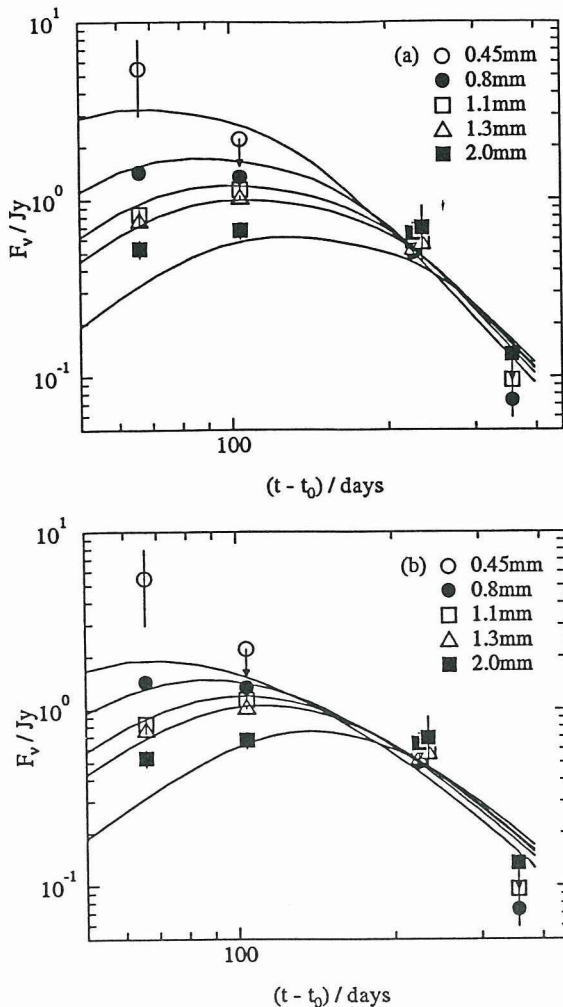


Figure 2. Data points and best-fits for (a) Hubble flow and (b) variable wind models. The curves correspond to, in ascending order,  $\lambda(\text{mm}) = 2.0, 1.3, 1.1, 0.8, 0.45$ .

## Results

Our UKT14 continuum measurements of Nova Cygni 1992 were obtained 66, 104, 224, 234, 357 and 358 days after outburst. At the earliest epoch the data were consistent with free-free emission from an optically thick nebula. Measurements obtained one month later show the nebula becoming progressively more transparent with a turnover to optically thin emission in the millimetre regime. The evolution of the cm  $\rightarrow$  IR spectrum is shown in Figure 1.

At first inspection, the mm/submm light curves (Figure 2) appear to be consistent with the canonical radio behaviour of novae. The first part of the light curves (Phase I) shows an increase of flux with time and a spectral index  $\alpha > 1$ , consistent with an expanding optically thick nebula. Phase II (or the receding photosphere phase) commences when the emission peaks, and the edge

of the radio photosphere is no longer coincident with the outer edge of the nebula. The spectral index decreases during this phase, as does the overall level of the emission. The bulk of our mm/submm points were taken during this phase of development. Eventually, Phase III commences when the nebula becomes completely optically thin and the light curves decay as the nebular material becomes more tenuous due to its expansion.

We have attempted to fit the mm/submm data with models which have previously been used to fit the radio light curves of novae. We have investigated two classes of model --- Hubble-flow models (e.g. Seaquist & Palimaka, 1977) in which the envelope is ejected instantaneously (or on a timescale much shorter than that over which the radio light curves develop) with a radial velocity gradient, and variable-wind models (e.g. Kwok, 1983) in which the nova mass loss takes the form of a wind with constant velocity and secularly decreasing mass-loss rate. For the Hubble-flow model, we have used the formulation given by Seaquist (1989) for a shell with a linear velocity gradient and a density which depends on radius as the inverse square.

For both models, we have fixed the distance to the object at 2 kpc based on the best current estimates, however varying the distance affects only the best-fitting parameters and does not affect the goodness-of-fit of a given model. We have also assigned a constant temperature of  $10^4$  K to the ejecta. The fitted parameters are the shell mass, the outer velocity and inner velocity for the Hubble-flow model, and  $M_0$ ,  $t_0$  and the wind velocity for Kwok's model (where the mass-loss rate,  $\dot{M} = M_0 (t_0/t)^\beta$ ). Fits using Kwok's model were performed using  $\beta = 1$  and  $\beta = 2$ . In both cases, the inner wind radius was taken to be  $10^{11}$  cm.

We have investigated a large range of parameter space for both models and can find no good fit to the observed lightcurves. In all cases the values of chi-squared associated with the best fits represent a confidence of very much less than 1%. We therefore conclude that the data are inconsistent with both the Hubble-flow and variable-wind models. It is possible that the best kinematical model for the data is some combination of the two models we have used. However, two additional important effects are known to be present from radio imaging of the nova (Pavelin et al. 1993). Firstly, it is evident from the radio images that the ejecta are highly non-spherical which would give rise to different timescales for the development of light curves along different lines-of-sight through the nebula. Secondly, it appears that there is a temperature gradient through the ejecta or that the ejecta consist of a hot central component and a cool outer component. Since the dominant effect in the shaping of the mm/submm light curves presented



here is the recession of the photosphere through the ejecta, the presence of a temperature gradient could significantly alter the results.

We can gain some insight into the effect of a hot inner region on the wind models by varying the inner radius. Once the photosphere has shrunk to the radius of the hotter region, it will cease to exist if the temperature is high enough. Thus setting a large inner radius is equivalent to including a high temperature inner region to the wind. Using inner radii of up to  $3 \times 10^{14}$  cm results in improved fits, however the chi-squared of the best-fit model is still too large for an acceptable fit to the data. Since the inner radius is effectively a fitted parameter in the Hubble-flow models (determined by the inner velocity), this approach will not improve the fits to the data obtained using these instantaneous ejection models.

It is clear, therefore, that our mm data on Nova Cygni are inconsistent with the models which have been used to fit the radio data on previous novae. As we have already stated above, the radio images of this nova taken at early times show that the ejecta have a complex structure so it is perhaps not surprising that the simple, spherically symmetric models we have considered here are inadequate.

### Concluding Remarks

To date millimetre observations of novae have been rare yet they have the potential to throw light on the very earliest stages of nova outbursts. A nova monitoring programme similar to those operating on the VLA, the International Ultraviolet Explorer and MERLIN has now been instigated on the JCMT. The early detections of Nova Cyg 1992 have demonstrated that JCMT observations with the UKT14 bolometer (1.1 mm rms noise level of 10 mJy in 15 min) can serve as useful triggers for large synthesis arrays, for example in 15 min a 'snapshot' with the 27 VLA antennae reaches an rms noise level of 55  $\mu$ Jy at 3.6 cm, equivalent to that reached at 1.1 mm by the JCMT/UKT14 combination for a source with spectral index +1.5. This is also close to the 50  $\mu$ Jy/beam noise level quoted for a 24 hour imaging run with MERLIN at 6 cm.

In addition, it appears that the mm/submm light curves of novae can provide a powerful constraint on models of nova mass-loss. In particular, we have found that the mm/submm light curves are sensitive to the details of the mass-loss in the earliest stages of outburst. It is hoped that observations of this type will provide a new means of studying the early mass-loss in novae and provide a constraint on theoretical models of the outburst mechanism.

### Acknowledgements

This article has now appeared in MNRAS. We are grateful to Dr R.M. Hjellming for providing data in advance of publication.

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### JCMT sees QSOs at redshift 4.7

Millimetre-wave astronomy undoubtedly received a tremendous boost from the identification of the IRAS object 10214+4724 as an ultraluminous galaxy at a redshift of 2.286 [1] and the subsequent observations of CO lines [2,3] and submillimetre continuum emission [4]. It suddenly became clear that 'our' waveband is capable of major contributions on cosmological issues and that millimetre-wave spectroscopy and imaging may well prove to be as valuable for the study of protogalaxies as they have been for protostars. (Some far-sighted individuals had of course been pointing these things out for several years [5] - but to some of us at least these detections came as a big surprise.)

Following this discovery it was natural to ask whether millimetre-wave emission could be found from objects at still higher redshifts. A detection of continuum emission from dust would give an estimate of the amount of gas in the underlying galaxy, but still more interesting would be the detection of a spectral line. In addition to giving us kinematic information and hence an idea of the total mass, a spectral line detection would provide an indication of the metallicity at an early epoch. An obvious choice of line is the fine structure transition



of singly ionized carbon at 158 microns (that's 1.9 THz!). This is generally the strongest line in the whole far-IR waveband from star-forming regions and galaxies (including our own - as shown by COBE). A quick calculation shows that if this line had the same strength in proportion to the IR continuum as in nearby starburst galaxies it would be easy to detect it in 10214. Or rather, it would have been easy if it weren't for the fact that the redshift brings it into a part of the spectrum which is completely wiped out by water vapour absorption! At redshifts of 4.2 to 4.7, however, the C<sup>+</sup> line will come nicely into the 345 GHz atmospheric window. We don't yet know of any 'ordinary' galaxies at such redshifts, but quasars have of course been found out to these redshifts, and most people are willing to accept that these lie at the centres of substantial galaxies. Some of the most luminous and most highly redshifted QSO's known are those found in the APM colour survey [6].

Our plan therefore was to search for the C<sup>+</sup> line in a selection of objects from this survey. The main difficulty is that the emission lines of these objects are extremely wide and may not be symmetrical with respect to the velocity of the underlying galaxy. This makes the precise determination of the QSO redshift quite difficult. As a result it was necessary of us to search for the C<sup>+</sup> line over a significant frequency range, in excess of that necessary to cover the formal redshift error. We decided to look first for submillimetre continuum emission on the grounds that this would give an indication of whether or not there was thermal continuum emission from these sources. By comparison with nearby galaxies one would then expect to see a strong C<sup>+</sup> line.

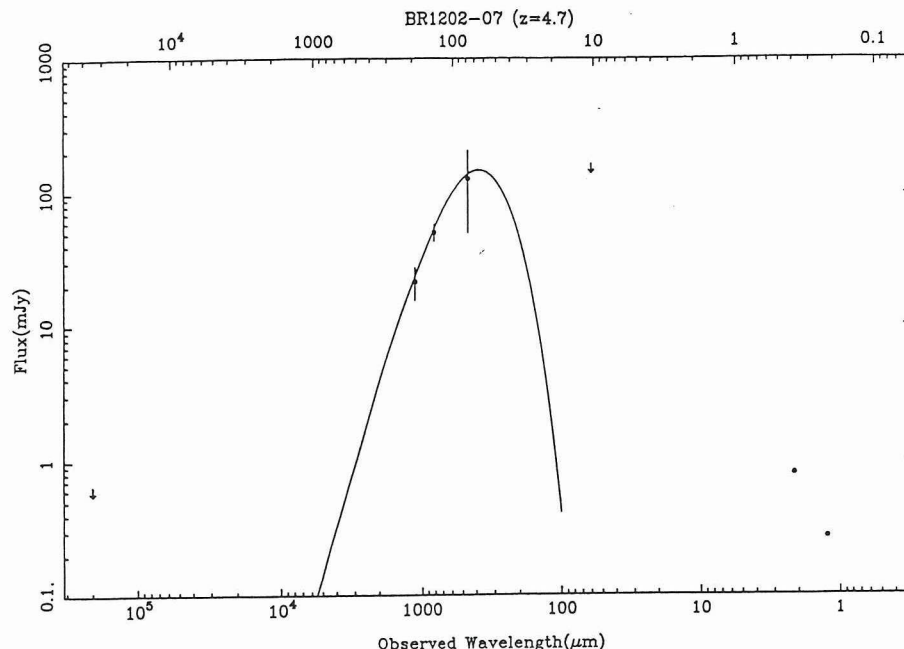
In the past the detection of submillimetre continuum from radio-quiet QSO's has generally been difficult. We were therefore somewhat skeptical when our first object, 1033-03, seemed to be showing signs of a positive signal right from the beginning. Our skepticism turned to delight when we moved on to the next candidate, 1202-07, to find that we had a definite 800 micron detection straight away (nearly 4-sigma in 20 minutes!). We were able to follow that up with an 1100 micron point which showed that the flux is rising steeply as a function of wavelength (see figure), as would be expected if the emission were due to warm dust in the underlying galaxy. Synchrotron emission cannot be ruled out completely but the evidence in favour of a thermal origin for the submm/far-IR emission from QSO's in general is now very strong [7]. A 450 micron flux proved more difficult to obtain: we tried, but the weather during our run was never really good enough. However, we did get some more data during service time when conditions were somewhat better. Combining all the 450 micron integrations gives the somewhat shaky point shown in the

figure. The figure suggests that the flux is still rising fast although perhaps not as rapidly as between 1100 and 800 microns. This 450 micron flux certainly needs to be checked before anything can be quantitatively said about the source. The other points on the curve are the near-IR fluxes (obtained using UKIRT) and limits from IRAS and the VLA obtained by one of us (RGM) with other colleagues. In addition we observed 1508+57, which is radio-loud, and detected 1100 micron emission consistent with a synchrotron spectrum and obtained an 800 micron upper limit on 1050-00.

So, why were the detections so easy in spite of the huge distances implied by the large redshifts? IRAS has shown us that at relatively modest redshifts both quasars and starburst galaxies have large luminosities. The emission peaks in the far-IR and falls off very rapidly at longer wavelengths, both because one is in the Rayleigh-Jeans part of the spectrum and because the emissivity of the dust is falling fast. The point is that as one goes to higher redshifts the peak emission moves down towards the JCMT bands. In fact calculations show [8] that the 800 micron flux expected from a typical starburst galaxy actually rises as  $z$  increases from 1 to 4. Physically this is due to that fact that the increase in the emissivity of the grains at the wavelength at which the signal is emitted outweighs the losses due to distance. In this sense the detections were not unexpected, although the flux from 1202-07 is remarkably high. We need better 450 and 350 micron points to make a good estimate of the luminosity, but it is certainly in the same class as 10214. Even if the dust is being heated by the active nucleus rather than by a huge burst of star formation, the mass of dust involved must be very large and the dusty region very extended. The lesson is that things happen quickly once massive galaxies form!

The rest of our time was taken up with the search for the C<sup>+</sup> line, naturally concentrating on 1202-07. This proved more frustrating. In view of the known problems of observing broad weak lines with the AOS, we decided to do a first scan using the heterodyne detector in a continuum mode. This meant that we could chop fast to get good sky subtraction and use the standard continuum data-taking and analysis techniques. Unfortunately it turned out that the 345 GHz SIS receiver has instabilities that produce a large excess noise when used in this mode. A great deal of effort was spent trying to overcome these, but without success. We therefore used RxB2, the Schottky receiver which has a higher system temperature but is much more stable. A further misfortune was that the better of the two mixers in that receiver had failed shortly before our run. We were nevertheless able to integrate down to good limits over the range of frequencies where the line should be. In fact we





**Figure.** JCMT fluxes for the redshift 4.7 QSO are shown with 1-sigma error bars. Circles denote other measured fluxes, and arrows upper limits. Observed wavelengths are shown at the bottom of the figure, with the corresponding scale in the emitted frame at the top. The curve is a typical dust emission spectrum that fits the submillimetre points. There is, however, insufficient data to constrain the model tightly.

were clearly detecting the continuum in our heterodyne observations at an antenna temperature of less than 2 mK, which we find pretty impressive. It seems that either the C<sup>+</sup> line is not as strong in comparison to the continuum as we might have expected or, perhaps more likely, that we did not search far enough in frequency.

The project is very much an on-going one; we plan to go back in the autumn when, with a refurbished mixer in RxB2 and the DAS available as a wideband backend, we hope to repeat the search for C<sup>+</sup> in 1202-07 and to look at similar sources on the other side of the sky.

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## JCMT Annual Report 1992

Copies of the 1992 JCMT Annual Report have recently been distributed. If you do not receive your copy in the next few weeks, please let me know. If you wish to be added to the mailing list for Annual Reports, please let me know.

You may be aware that distribution of both Annual Reports and Newsletters has now been separated from SERC, Swindon and is achieved from ROE with bulk mailing to distribution centres at HIA and Leiden. Whilst trying to consolidate various mailing lists it is possible that some names may get omitted. Please assist me by letting me know if you have not received your copies.

Graeme



## Pre-Protostellar Cores

Current theories of star formation predict that stars form within molecular clouds, where density inhomogeneities lead to the formation of dense cores. Hydrostatic equilibrium is possible for a given core provided a certain critical mass is not exceeded. Once this condition is no longer satisfied, inside-out collapse sets in, with the innermost part of the core collapsing first, and a collapse expansion wave propagates outwards at the local sound speed (Shu 1977). Collapsing material accretes onto a central object, known as a protostar.

Recent observations with the JCMT have identified a number of candidate protostellar objects - eg: B335 (Chandler et al. 1990), NGC1333-IRAS4 (Sandell et al. 1991) and VLA1623 (Andre, Ward-Thompson & Barsony 1993 - see also JCMT-UKIRT Newsletter No.5). These sources are so deeply embedded in their respective molecular clouds that they emit no visible or near-infrared radiation, very little or no mid-infrared radiation, and emit all of their luminosity in the far-infrared and submillimetre wavelength regimes.

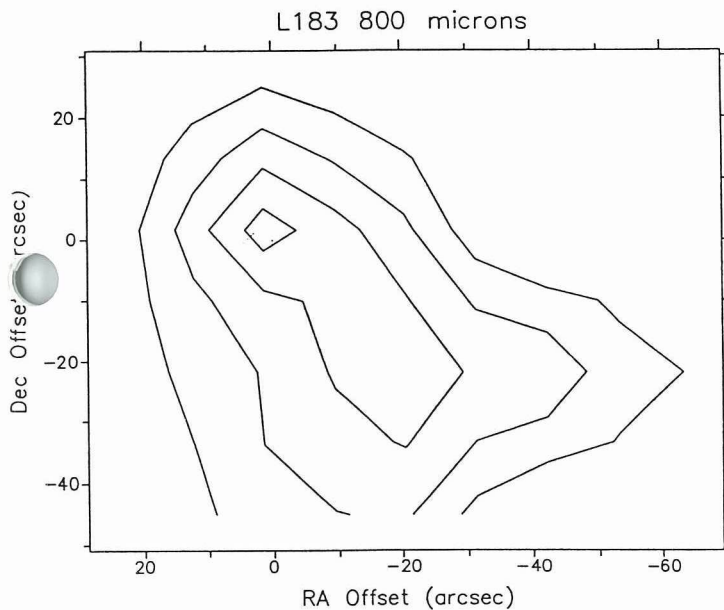


Figure 1.

However, a more recent project has been aimed at trying to observe a still earlier phase of cores in which collapse has not yet set in. This project has had long-term status on JCMT over the last three semesters, and the goals of the project include trying to examine in detail molecular cores which do not contain young stellar objects, to determine their physical characteristics, to compare them with model predictions, and to try to identify which cores are the most likely sites of future star formation (Ward-Thompson et al. 1993).

An extensive survey of cold cores in molecular clouds has been carried out by Myers and co-workers of so-called Myers cores (Benson & Myers 1983), and roughly half of the 90 or so cores were found to have associated IRAS sources (Beichman et al. 1986). Of these IRAS sources, about a third are associated with visible T Tauri stars, but the remaining two-thirds have no optical counterpart and are thus believed to be either T Tauri stars still deeply embedded in their parent cloud, or else younger objects. Some display similar characteristics to the above-mentioned candidate protostars - eg: L1527 (Ladd et al. 1991). Therefore it was hypothesised that the Myers cores without IRAS sources were at a still earlier evolutionary stage, and these were selected as the target sample for this project.

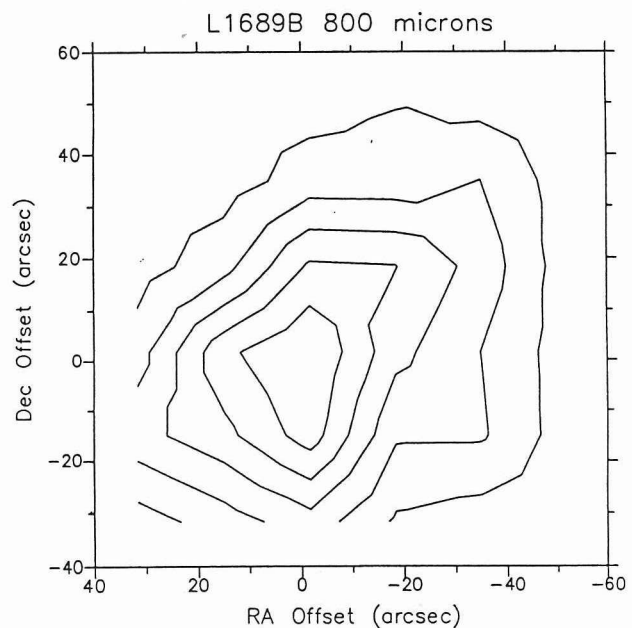


Figure 2.

Around 20 Myers cores which do not contain IRAS sources were studied, and the figures show 800-micron isophotal contour maps of two of the cores. Figure 1 shows L183, and has a base contour level of 50 mJy/beam, with subsequent levels of 100, 150 and 250 mJy/beam. Figure 2 shows L1689B, and has a base contour level of 60 mJy/beam, with subsequent levels of 120, 180, 240 and 300 mJy/beam. The estimated 1-sigma noise level is 20-30 mJy/beam. The maps were made point-by-point with integration times of 5 minutes per point. These are among the faintest objects ever mapped in the continuum by JCMT, using UKT14.

The cores do not have distinct edges, but merge into the more diffuse material of the molecular clouds in which they are embedded. However the



FWHM's of the cores are  $<0.05$  pc, and the mass contained within this volume is of order  $1-3 M_{\odot}$ . The peak densities of the cores are calculated to be around  $10^6 \text{ cm}^{-3}$ , but with temperatures in the region of only 10-20 K. Since the cores were not detected by IRAS we can place upper limits on their luminosities of  $<1 L_{\odot}$  for L1689B and  $<0.25 L_{\odot}$  for L183. These luminosities and temperatures are too low to be consistent with cores containing accreting protostars. They are therefore hypothesised to be the precursors of star formation, and pre-protostellar in nature. Work is continuing to study their detailed physical properties and to test theoretical model predictions.

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*D.Ward-Thompson, ROE*

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The copy deadline for articles and contribution for the next issue of this Newsletter is:

**31 January 1994**

This is the date by which ALL contributions MUST be on my desk and/or pc. It is set hard so that layout, printing and distribution can be achieved in advance of the following PATT deadline. Canadian and Netherlands authors should check with their Associate Editors who may set earlier copy deadlines.

*Graeme*

## European & National Astronomy Meeting 1994

5 - 8 April 1994

NAM'94 incorporating the 3rd Royal Astronomical Society National Astronomy Meeting & 3rd Annual European Astronomical Society Meeting will be held at the Edinburgh Conference Centre at Heriot-Watt University from Tuesday 5th April to Friday 8th April co-hosted by the Royal Observatory Edinburgh and the University of Edinburgh.

### PROGRAMME

Solar Physics - Solar System - Stars & Stellar Systems - Degenerate Stars - Star Formation - Galactic Structure - Normal Galaxies - High-z Galaxies - Galaxy Evolution - Jets from Stars to Quasars - Active Galaxies and Unified Models - Clusters of Galaxies - Gravitational lensing - Cosmology & Large-Scale Structure - Astroparticle Physics & Inflation - High-Resolution Imaging - Infrared/Submillimetre Astronomy

The Royal Astronomical Society recently established annual National Astronomy Meetings, covering any topics at the forefront of astronomical research, in both observational and theoretical fields. The European Astronomical Society organises similar meetings, but concentrating more on a specific theme. Every third year, the EAS meeting coincides with a national meeting of one of the member countries. There will be morning plenary sessions with invited review. Afternoons will comprise three parallel sessions, with symposia organised by session chairmen, at which contributed papers may be presented.

*To register your interest in attending, and for more information contact:*

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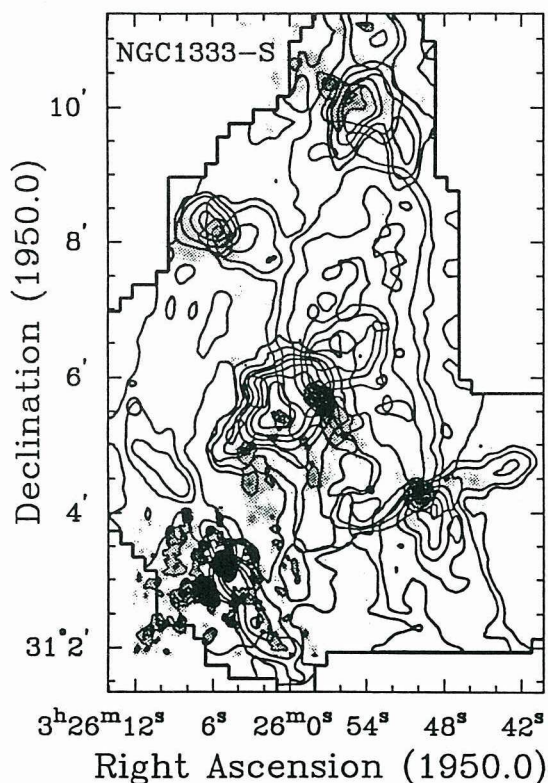
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## Highlights from the NGC1333 project

In the first joint JCMT-UKIRT Newsletter we reported some preliminary near-IR and sub-mm continuum results from our NGC1333 study (Aspin and Sandell, 1991). Now, when JCMT again goes for an independent Newsletter, it is also appropriate to provide an update of our findings in NGC1333-S, one of the most extreme star formation regions yet found.

The CO J=3-2 mapping, which we initiated during the first JCMT observing semester, proceeded very slowly for several years. The situation changed quite dramatically last year, when we got access to RxB3i, the first JCMT SIS receiver to stay on the telescope. In Figure 1 we show a contour map of the red- and blue-shifted CO emission superposed on a 1.1 mm continuum mosaic. This CO map contains data from all B-band receivers that have ever been on JCMT (B1, B2, the Sutton SIS, and B3i), but about 70% of the data come from B3i. It is immediately clear that NGC1333-S harbours



**Figure 1.** The low velocity blue- and red-shifted outflows seen in CO J=3-2 superposed on a grey scale map of the 1.1 mm continuum. Note the large number of outflows (7), which make the whole cloud look like a maze.

quite a few outflows: the "classic" SSV13 outflow, the precessing IRAS4A jet, the compact IRAS4B flow, the large (fossil?) IRAS2 flow, the east-west IRAS2 jet, the bipolar HH6 outflow, and the complex HH12 flow, which is only partially covered in this map. In an area of less than 6' x 10' we therefore find 7 outflows, covering quite a variety in morphological and physical conditions.

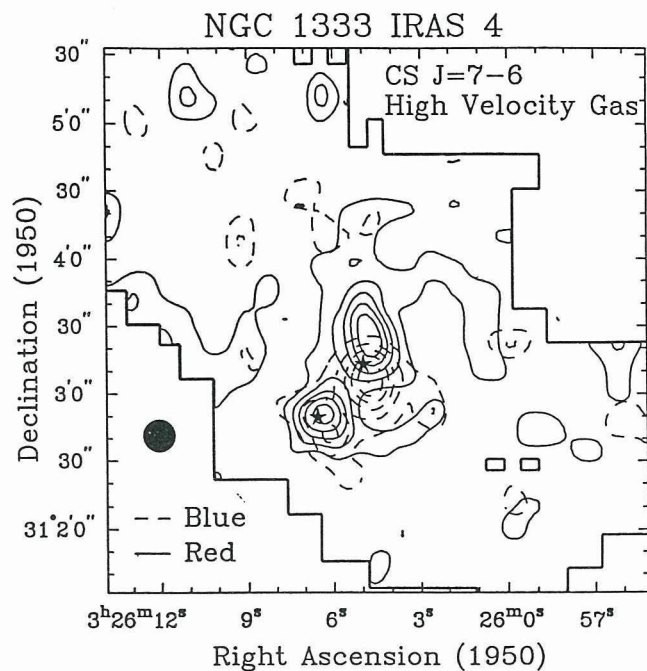
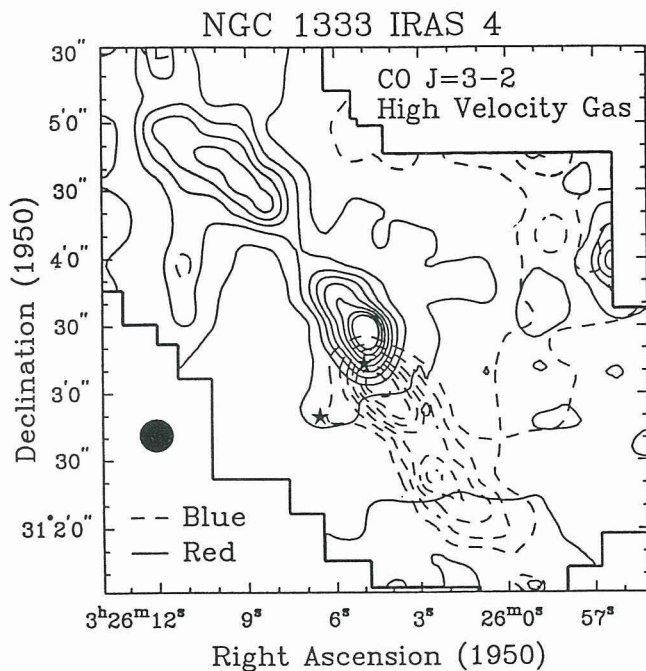
PATT has rewarded us a significant amount of time for mapping NGC1333-S in the mm/sub-mm continuum. After a very successful start, resulting in the detection of IRAS4A and 4B, two of the most extreme "protostellar" sources known to date (Sandell et al. 1991), the program has been hampered by both unusually poor sky conditions and a surprising amount of instrumental problems.

After extensive work on the data, with complete data reduction in both NOD2 and DBMEM, we have managed to produce a 1.1 mm and an 800  $\mu$ m mosaic of the region. The 1.1 mm map is rather deep (presented in gray-scale on the cover), and reveals a large number of interesting features. All IRAS sources have associated mm- continuum emission, which in some cases break up into several sources. In addition we see a lot of small clumps in the cloud. These clumps, or cloudlets, may just be dense condensations in the cloud. We currently do not have enough information to determine whether they are directly associated with "protostars" or whether they are regions that will eventually form "protostars". Backup line programs in poor weather have additionally yielded important and striking information on both IRAS4 and IRAS2, which will be briefly discussed below.

### The IRAS4 region

Both IRAS4A and IRAS4B have high velocity outflows (Fig 2a, b). The IRAS4A outflow is very highly collimated with the blue and red parts of the outflow appearing to be mirror images of each other suggesting an interpretation in terms of a precessing, episodic outflow. The outflow from IRAS4B is very compact and only partially resolved. The DBMEM reduced continuum maps indicate that IRAS4B is most likely double, which would make IRAS4 a triple system. VLA observations at 1.3, 2.0, 3.6 cm show that at least 20% of the 1.3 cm emission from IRAS4A is due to dust. It is possible that none of the emission at 1.3 cm is free-free emission (Mundy et al. 1993), but we are still attempting to obtain a detection or a deep limit of IRAS4A at 6 cm to further constrain the amount of free-free emission. The new continuum maps from JCMT show a lot of structure around IRAS4. Some of the emission appears clearly to be dust in the blue-shifted outflow,





**Figure 2:** *a) Red- and blue-shifted CO emission from IRAS4A and 4B (same as picture on the cover). Note the mirror symmetry between the red and the blue outflow; b) The same outflow in CS J=7-6. In CS J=7-6 one only sees the beginning of the flow, which is almost north-south whereas the CO map shows that the outflow is largely ne-sw further out.*

whereas some of it forms unrelated features (clumps), that may yet turn into stars.

Whether IRAS4A and 4B are really "protostars" still remains to be seen, however, they are certainly some of the most extreme young low-luminosity objects ever observed. The well developed outflow from IRAS4A suggests that the associated young star may already have turned on, whereas the less massive IRAS4B system may not yet have evolved to the stage where nuclear fusion dominates the energy output. A spectral line survey of IRAS4A and 4B, done mostly on CSO and complemented with JCMT data, reveals high velocity wings in molecules and transitions which typically trace either dense or hot gas like CS J=7-6, H<sub>2</sub>CO and CH<sub>3</sub>OH. Quite a few molecules and molecular ions appear depleted (i.e. frozen onto dust grains), but to what degree depends on a more thorough modelling of the dust emission (Blake et al., 1993).

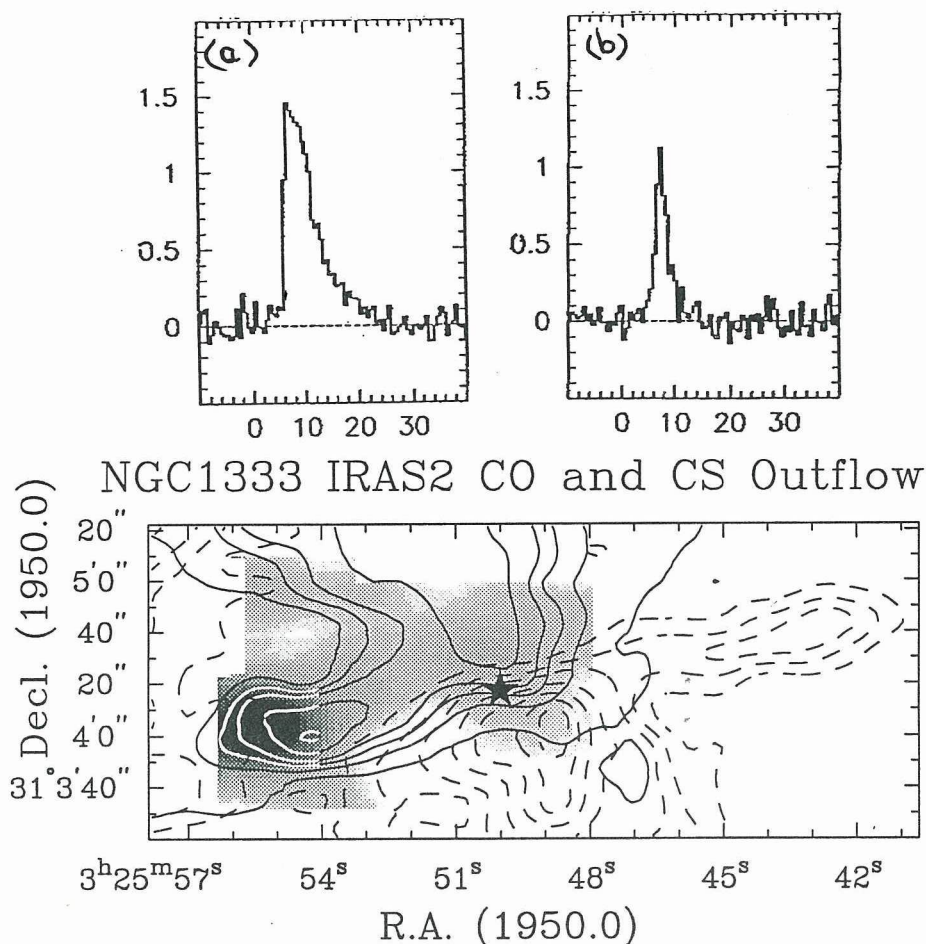
#### The IRAS2 region

IRAS2 is located in the centre of a very complex outflow. The mm- continuum emission from the source appears resolved and elongated mostly in an east-west direction, (i.e. disk-like with an associated

faint extended component). The large scale CO map shows a very extended north-south outflow, which at high velocities become more confined and lumpy. We call the n-s flow the "fossil flow" since it must be considerably older than the other outflow seen from IRAS2 namely the collimated jet-like east-west outflow. Both outflows have their activity centre very close to IRAS2, which in our continuum observations appear as a single source. However, it is difficult to see how a single star would be able to drive orthogonal flows, therefore, we consider that IRAS2 is most likely another binary system. In this interpretation the mm-continuum source would drive the east-west flow (the young outflow) while the source for the n-s (fossil) flow would be more evolved and hence much fainter in the dust continuum.

The IRAS2 east-west jet, which we have mapped in CS J=5-4 also possesses a striking bow-shock at the tip of the red flow. The CS J=5-4 line, which is hardly visible outside IRAS2 (where it shows faint wings), suddenly becomes very strong and has a striking half-parabola shape suggestive of a bow-shock. The methanol 5-4 ladder is even more striking; the methanol lines are hardly visible at the IRAS2 position, yet the 5<sub>1-4,1</sub>E and 5<sub>0-4,0</sub>A<sup>+</sup> lines are about twice as strong as the CS emission at the





**Figure 3:** The central part of the IRAS2 outflow, showing fully the jet-like e-w flow and only a minor part of the large n-s flow, superposed on a greyscale image of the integrated red CS emission. The spectra show the CS J=5-4 emission (a) at the tip of the red flow, where the CS is strongly enhanced and appear to trace the bow shock of the flow, and (b) on the position of IRAS2.

tip of the flow. We have not yet had a chance to look for other molecules and transitions in the bow-shock, but the IRAS2 flow may be an ideal source for studying low-velocity shock chemistry.

#### The SSV13 outflow

The SSV13 outflow is one of the most well studied outflows. Nevertheless, the mapping done by us in both line and continuum reveals several new and exciting features. The outflow is actually perfectly bipolar, although previous studies have indicated that the red outflow is much more extended. This is because the IRAS2 outflow crosses the SSV13 outflow. The high spatial resolution provided by JCMT allows us to discriminate between the two flows, especially since their velocity structure is rather different.

The improvement in pointing accuracy on JCMT also reveals that the continuum emission actually does not peak on SSV13 - it is offset to the south-west by about 10". This therefore confirms the detection of SSV13b by Grossman et al. (1987) making our analysis of the SSV13 continuum emission incorrect (Sandell et al. 1990). These

maps were obtained during the first observing season on JCMT at a time when we had neither the experience nor the reliability that JCMT now provides. The SSV13 region may actually harbour additional outflows. Note, for example, the blue 'streamer' protruding south from SSV13 almost into the blue IRAS4 outflow. There are also several cloudlets of continuum emission in the blue-shifted outflow. These are most likely clumps or compressed regions in the outflow, but it is possible that they could form new low mass stars.

#### Other highlights

We also note that the HH6 continuum emission is significantly offset from the H<sub>2</sub>O maser and VLA continuum source associated with the HH6 complex. This suggests that most of the young sources in NGC1333-S are either binary or multiple. There are at least two continuum sources in the vicinity of HH12, but since our CO map is incomplete in this region, we cannot yet say which of the components excites HH12, if any of them.



Even though the CO map (1500 spectra) is among the largest acquired on JCMT, it is clear that it needs to be extended. Only then can we obtain a more complete picture of all the activity occurring in NGC1333-S. It is also clear that one should not limit the investigation only to CO, doing so would miss features like the IRAS4 bow-shock! However, CO is a very good and fast way to get an overview of a star-forming region. We stress that spatial resolution is very important, and one should never attempt to under-sample maps. If our CO map had been under-sampled, we could easily have failed to detect the IRAS2 E-W jet which is largely unresolved in our fully-sampled map. Full sampling is actually always advisable, time allocation permitting.

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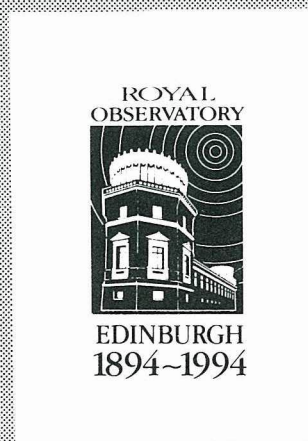
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Göran Sandell & Colin Aspin  
 JAC

## ROE Centenary Year 1994

The year 1994 is the centenary anniversary of the completion of some of the building work on the site at Blackford Hill. The stone on the end of the Library bears this date. Throughout the year it is the intention of the ROE to organise several events of a scientific nature in honour of this anniversary.

A new logo has been devised specifically for use by ROE during the celebrations. You may come across it several times so a copy is shown below.





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