THE JCMT NEWSLETTER

March 1995 Issue Number 4

Message from the Director

I am delighted to be able to report excellent news regarding the status of the JCMT and the plans for its future development. I now believe that we are on top of the major problems of the telescope and carousel, the identification and repair of which have been ongoing for the past few years. We can now make a determined effort to improve the quality of the performance of the facility for the users, especially in terms of instrumentation performance and real-time calibration. In short, a turning point has now been reached in the development of the JCMT. Highlighting this is the milestone in the instrumentation programme with the imminent delivery of three major new instruments (RxB3, RxW and SCUBA).

Against this very positive background the main business of the November meeting of the JCMT Advisory Panel was to consider a comprehensive package of costed options I had prepared, the outcome of which would determine the future programme of the development of the facility and its new instrumentation. The members of the Panel consulted their constituents prior to the meeting and, a lively discussion ensued, after which the Panel supported all the proposals and crucially, provided a scientific prioritisation for the proposed developments. The members were enthusiastic about the developments, especially the moves toward sub-arcsecond astronomy with potential future collaborations with the Smithsonian Submillimeter Array Interferometer (SMA) and the prospect of a JCMT heterodyne array programme. There was a remarkable degree of agreement within the Panel and I was very happy with the outcome. On the basis of this prioritised list, I formulated a five-year development plan, which I put to the JCMT Board for endorsement at its January meeting.

The Board carefully considered these proposals in the light of the available funding and I can inform the community that they fully supported the proposed plan of facility and instrument developments. This sets in motion the planning for the future long-term development of the JCMT, thereby ensuring that it remains at the very forefront of scientific excellence. I am grateful to the Board for their very positive support, in spite of apparent funding uncertainties all round at this time. Because of the finite nature of the existing Development Fund, the Board paid particular attention to the work to be undertaken during the next three years. The preliminary recommendations of the UK's Optical-Infrared-Millimetre review include a statement of the intention to undertake a major review of the JCMT in three years time. This will give users ample opportunity to demonstrate the fantastic and world-beating new science to be obtained with our three new instruments, especially SCUBA. We have already broken the publication record (see later) and I am absolutely confident that the JCMT will come out of this review with flying colours and with this in mind, three years hence is an opportune time to take stock of where we are and proceed with the next phase of implementation of the long-term development plan. In the meantime, we start with a broad attack on all the main headings of the plan.

The long-term development plan can be grouped under five main headings, each having a specific and mainly scientific thrust. These headings are: improvements in observational efficiency; a programme of sub-arcsecond astronomy; a heterodyne submillimetre array programme; innovative new projects; general facility refurbishment and upgrades. This list brings instrument and facility projects together, and most of the areas have very specific astronomical goals. To obtain a better grasp of the projects, the list below shows a more detailed breakdown.

Improvements in observational efficiency

1. A continuing programme of upgrades to the current and future instruments including the

conversion of RxB3i to RxA3, (a replacement receiver for RxA2) and the conversion of RxC2 to a new 850 GHz receiver to be called RxE.

2. The continued development of SIS devices.
3. The development of mixer technology.
4. Investigations of new modes of telescope scheduling and remote operation.
5. A new telescope control system.
6. Improvements to the telescope surface.
7. Computing upgrades.

A programme of sub-arcsecond astronomy

1. Improvements to the JCMT-CSO interferometer.
2. Collaborations with the Smithsonian Millimetre Array (SMA).
3. Provision of an array receiver for interferometry (RxSMA).
4. VLBI.

A heterodyne array programme

1. Provision of a new correlator (MIDAS).
2. Production of the first camera for the array at B-band (SWIFT).
3. Provision of new cameras and an enlarged backend.

Innovative new projects

General facility refurbishment and upgrades

1. Provision of new 24-bit *led* encoders.
2. Regrouting and levelling of the azimuth track.

As might be expected, the full programme of desired developments exceeds the funding available until the end of the current Development Fund and so not all parts of the overall plan were fully funded at this time. Broadly speaking, over the next three years the plan is as follows:

(i) to continue fully with the programme of efficiency upgrades as listed above. However we are currently undertaking a detailed investigation of the costs associated with the possibility of remote operation and the potential scope for improvements in the telescope surface. These costs will be brought back to the November 1995 Board meeting for further planning consideration;

(ii) the sub-arcsecond astronomy programme will commence with experiments into phase retrieval to be undertaken using the JCMT- CSO interferometer, along with the provision of trenches and optical fibres for the eventual connection to the SMA. I will be working with the Smithsonian Institute with regard to formulating collaborative proposals to be considered by the JCMT Board. VLBI will be kept on hold for the time being and I will retain a watching brief, especially on the outcome of the Haystack group's request for NSF funding to become the co-ordinating centre for mm VLBI. This is a move I very much welcome and I hope their proposal is supported;

(iii) the exciting heterodyne array programme will get under way with investment in the prototyping the new MIDAS correlator along with extensive R&D studies for the front-end B-band camera (SWIFT) and associated optical systems. It has been decided that the first array will be a 16-channel B-band camera. We expect to commence the final construction phase of the camera and production of the MIDAS correlator in three years;

(iv) the first round of innovative projects was very successful and we expect to be looking to issue an announcement of opportunity for new innovative projects in about a year's time; (v) in terms of the general facility developments, the new encoders have already been ordered and the work required for the levelling of the azimuth track will be investigated over the coming months. All told, a dynamic, challenging and exciting future for the JCMT.

Turning to JCMT operations, I reflect on mixed success over the last semester but overall I am satisfied with the general trend of improvements. The statistics show the appalling weather loss of primary programmes, dramatically demonstrating the need to move to some form of flexible scheduling. November was a disaster, but thankfully December had excellent weather during more or less the entire month, which was a great boon both to observers and ourselves as we had fortunately scheduled a significant amount of engineering time for telescope and instrument characterisation. This brings me to my major concern during the semester, the poor state of the telescope beam, which remained for a number of months. Although the telescope homology problems were cured in early July, failures in the holographic system meant that the primary was left in a rather poor state after this work. To compound this, the beam became considerably worse at the end of September, now believed to be due to a distortion of the secondary mirror. Throughout October the beam was unacceptably poor, until the primary was finally re- adjusted in early November. However, the really good news is that the telescope is now performing extremely well. The focal length change, the removal of the 'out-of-homology' variations and the recent surface settings have given us a telescope with beam shapes, homologous performance and efficiencies which are better than ever.

One of the main thrusts of the drive to improve the quality of the facility over the past six months relates to the quality of the heterodyne instrumentation performance and their calibration. We set in place a system of checks to achieve this and I am again very pleased to note that the production of the spectral standards atlas is now almost complete (at least for those sources in the currently observable RA range), and the 'facts sheets' are now displayed at the telescope, HP, JAC and on the WWW. The start of shift checks and the standard spectra have shown that the receivers are in general well behaved, but occasionally they have problems (see note by Bill Dent in the previous Newsletter) and our current feeling is that these are probably due to tuning difficulties.

On the staffing side, it is with great regret that I report the resignation of Dr Adrian Russell, the Head of the JCMT Instrumentation Programme Management Group. He moves on to become the UK Gemini Project Manager. Adrian has done a brilliant job since his appointment and the strength and great promise of the JCMT future instrument development programme owes much to his individual talents, skills and abilities. He will be sorely missed and his departure has forced me to undertake a management reorganisation which has just been approved by the JCMT Board. I am now actively seeking a replacement for Adrian. The new post of Head of JCMT Instrumentation will be based in Hawaii and as well as overseeing the future instrumentation programme, will also be responsible for the maintenance, repair and quality control of the current instruments on the JCMT. Over the course of the 1995/96 financial year, I intend to transfer all the international JCMT posts at ROE to Hawaii and with the departure of Dr Chris Purton back to Canada in the summer, I have persuaded Dr Graeme Watt to return to Hawaii for a third tour. He will take over all scheduling matters from Chris and will take responsibility for the implementation of flexible scheduling.

Ian Robson / Director JCMT

People & Events

Adrian Russell has relinquished the role as Head of the JCMT Instrumentation Programme Management Group and taken up the awe- inspiring position as UK Project Manager for Gemini. Adrian joined ROE in 1986 and was promptly shipped out to Hawaii to partake of the chaos surrounding the birth of the JCMT. He went on secondment from ROE to the MPE group in Garching and was a major force in the integration of RxG with the JCMT systems. In 1992 he returned to ROE to take on the newly formed post of Head of the IPMG.

Alex McLachlan MBE retired on November 11th after a magnificent 34 years of service to ROE. Alex joined in 1960 as a photographer, was cajoled in 1977 to journeying with his family to the other side of the world to set up the UKIRT (both the telescope and the Hilo base in Leilani Street). On his return to ROE Alex became involved with the home end section of the JCMT. In recent years he has been the 'keeper' of the JCMT Development Fund and of the JCMT Archive. Indeed it was Alex who started off JCMT newsletters with a wee production called 'Protostar' which ran to 10 issues. He has been the administration behind the UK Service observing programme on the JCMT and managed to fulfil a role as ROE Safety Officer in addition.

Douglas 'Chase' Reed has joined the JAC as Observatory Electrician. Chase had already been living on the Big Island for some 9 years and was interested in the strange domes on top of Mauna Kea. Now he has plenty opportunity to take a couple of them to bits as long as he remembers how to re- assemble them afterwards.

Nigel Atkins has joined the JAC as Head of the JCMT Instrument Support Group. Nigel was dragged away from the Harvard Smithsonian Center for Astrophysics.

Ian Pain has taken on the post of mechanical Engineer at the JAC. Ian was recruited from Vickers Engineering.

Bill McCutcheon is taking a sabbatical at the JCMT for a year. Bill has been a prolific user of JCMT observing time over the years and has just rotated off membership of the JCMT Board.

David Belton arrived before the New Year for a four month stay. He is a co-op student from the University of Victoria (Canada), a third year undergraduate, hired by NRC for his work term. David will work on data analysis, reduction, interpreting, etc.

Congratulations to **Evelyne** and **Nick Rees** on the birth of **Samuel Scott** who arrived on 7th November 1994 weighing in at 8 lb. 14.5 oz.

Congratulations also to **Nicole** and **Darrel DeCambra** on the birth of **Nicholas Wayne** who arrived on 26th January 1995 weighing 8 lb. 9 oz.

New modes of Observing with the JCMT

With the advent of the new generation of receivers, especially the high frequency receivers SCUBA and RxW, it is clear that we need to move rapidly to implement various forms of flexible scheduling. The need for excellent weather to commission both SCUBA and RxW demands that a significant fraction of semester 95B be scheduled in a flexible manner.

I put a discussion paper on new modes of observing to the JCMT Advisory Panel, ITAC and JCMT Board. All were supportive of the general need for change and to maximise the dry-weather conditions for the allocated programmes. The first major experiments of flexible scheduling will be undertaken in semester 95B owing to the need to ensure that adequate dry weather time is available to commission both RxW and SCUBA. To this end we must ensure that that there is a healthy stock of RxA2/RxB3i proposals against which the high frequency instruments can be flexibly scheduled. A separate note will be issued by e-mail but this should serve as a hint to observers that, in all likelehood, RxW and SCUBA could well take up all, or most of, the high frequency time in semester 95B (depending on the actual statistics of the weather of course).

In terms of how to make this work, my inclination is to go for a prioritised and queue- scheduled system, and I will be working closely with the Chairs of the TAGs (the ITAC members) to implement this for next semester. I expect that a number of allocated programmes will be done in a serviced mode.

However, I again wish to stress that, no matter what the downstream mode of observations, I am not attempting to stop astronomers coming to the telescope. On the contrary, I am encouraging astronomers to make fewer, but longer visits as I am convinced that a remote facility devoid of visiting astronomers will wither and die. Although there will always be the need for some programmes to be undertaken in the traditional sense, for the majority of the scheduling we must move away from the this 'weather lottery' mode of visit that is all too familiar.

The ITAC's preferred route is to seek applications, through the normal PATT procedure, for low-frequency spectroscopic observations which can be executed in 'serviced' mode (*i.e.* without requiring the applicant's presence at the telescope). They envisage that procedures developed for this immediate purpose will be applicable in the future for more general flexible scheduling involving both low- and high-frequency applications. The ITAC will consider the criteria (priority, *etc.*) to be used in assessing the running-order of approved backup proposals, so that staff at the telescope do not have to make unilateral decisions as to scientific merit.

In terms of the programmes for semester 95B, my planning is for those applicants whose observations have been selected to be flexibly scheduled to be issued with a detailed questionnaire. When completed, this will provide a template to enable the observations to be carried out by staff service astronomers if necessary. I hope that through this process we will be able to iterate to a preferred option for scheduling and staffing for the future. Downstream, I am also looking at the possibility of remote operation of the JCMT, perhaps from the JAC. This would open up a number of opportunities for extending the hours of usage of the JCMT and could also be a method of achieving some savings in the operations.

Finally on this topic, I would like to notify the community that we expect to host a JAC-Gemini workshop on *New modes of Observing* in early July in Hilo. As soon as the details of the workshop are known, they will be advertised through e-mail and the WWW. In the meantime, anyone who wishes to register an interest and to be added to a mailing list, please contact:

nmo95@jach.hawaii.edu.

Ian Robson / Director JCMT

Change in Daycrew arrangements

There has been a change in the daycrew arrangements for the JCMT. There is no longer a special daycrew as such and the telescope operator will take over some of the tasks previously undertaken by daycrew members. The primary example is cycling UKT14, but the telescope operator is also now responsible for checking cryogenic supplies, accepting delivery of water, and a number of other tasks.

Furthermore, to improve the overall efficiency of scheduling and staffing summit-based tasks, specific days have nominally been allocated to certain groups for their work. Monday through Thursday are now normally scheduled for summit tasks for the following groups respectively: software, electronics, telescope, receivers. Other work can take precedent by prior arrangement and of course fault fixing takes precedent over everything else.

As mentioned, the cycling of UKT14 is now done by the telescope operator. If no-one else is scheduled for summit work, another JCMT staff member will be assigned as 'buddy' to fulfil the two-man rule. Occasionally, an astronomer on second shift may be asked to remain behind at the telescope for a half an hour to buddy the TO while the receiver cold loads are filled. This should normally only be the case for Friday through Sunday, a time when extended hours observing should be at a premium (weather permitting). Astronomers should be aware of this if for any reason this might cause them a problem.

Ian Robson / Director JCMT

Transport to and from HP from the JAC

In order to make financial savings, we have reduced the vehicle fleet of Explorers by one. Experience suggests that we now have the minimum number of vehicles (11 FWD) for adequate operational needs of the two telescopes.

However, the situation is very tight and regrettably we can no longer be as flexible as we have been in the past in providing a vehicle for transport to HP at any time of the day. It may be the case that when you arrive, transport to HP will only be available at certain specified times.

Currently these times are:

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JAC-HP  departing 0745 with the summit workers
                departing 1500 in time for evening dinner
                occasionally departing late evening with a telescope operator
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The situation for transport from HP back to Hilo is more complicated due to the three different sjift arrangements for the two telescopes. In general, UKIRT observers depart from HP after lunch and this might well fit in with JCMT second shift observers. However, for JCMT first shift observers, we will try whenever possible to accommodate a departure leaving HP around mid-morning.

It is vitally important that observers are aware of these schedules and the overall limitations in our degree of flexibility. They should plan their Hilo arrival and departure with them in mind. Please be sure to work closely with your support astronomer prior to arrival to ensure the transport schedules are not compromised and that you are not subject to an unexpected delay in getting to or from HP. The vehicle scheduler (Dayna) is willing to make suitable arrangements for observers whenever possible, but some degree of forward planning and foresight is required on the part of the observers.

May I take this opportunity to remind observers that the vehicles are intensively used for transport from Hilo to HP and the summit, both for observers and local staff. Prior approval must be sought from the vehicle scheduler to use a vehicle for any other 'work-related' matters (*eg.* to meet a colleague from the airport or to obtain a meal prior to travelling to the summit). However, such use must be restricted to the boundaries of Hilo town only.

Ian Midson / JAC

INSTRUMENTATION

Summary of JCMT Instrumentation for Semester 95A

Introduction

Semester 95B (1 August 1995 - 31 January 1996) JCMT 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 over the e-mail fileserver or 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. The current version is dated January 25, 1995. The e-mail fileserver system exists to provide instrumental data, both archival and current, and other information. To get acquainted with the latter send the one-line message "help" to the Internet address:

JCMT_INFO@JACH.HAWAII.EDU

The User Guide also may be browsed on the Internet hypertext-based World-Wide Web, at URL / JCMT/home.html which carries a variety of other information too.

Spectral Line Observations

Three SIS mixer receivers form the core of the heterodyne program, A2, B3i and C2. One other SIS receiver (G) has been available on occasion via collaboration with the MPE, Garching group. A summary of the properties of this instrumentation is given below, followed by a few additional details.

Table 1. Summary of spectral line observational data.

	Freq. (GHz)	IF (GHz)	B/W (MHz)	T_{rx} (K)	Efficiency Ap.	Beam	fss	Tel. losses	HPBW (")
A2	205-285	1.50	600	95	0.57	0.69	0.80	0.91	19.7
B3i	300-380	1.50	700	180	0.49	0.58	0.70	0.91	14.3

C2	450-505	3.94	1000	250	0.31	0.52	0.70	0.83	10.8
G	660-692	1.50	800	800	(0.20)	0.25	(0.60)	0.65	7.0

The IF and IF instantaneous bandwidth (B/W) are given. DSB receiver temperature values (Trx) are typical (average) numbers for each receiver; there are significant changes as a function of frequency. The efficiencies (where measured) are accurate to at least 10%. Quoted beam efficiencies are derived from measurements towards Jupiter. The beam can be slightly elliptical and may depend somewhat on frequency. Beam maps are available via anonymous FTP (ask for fileserver item 'receivers.beam_maps' for details) and the WWW.

A new SIS version of Receiver G first saw service in March 1994 and the data given above are based on information from that time.

Users should note that because receiver C2 uses an EIP counter to phaselock the Gunn local oscillator, the resolution achievable is limited by the Gunn's intrinsic phase stability, with the consequence that lines observed with C2 are likely to be broadened instrumentally by an additional 0.5 km/sec, and thus C2 may NOT be suitable for the observation of sources requiring velocity resolution better than a few tenths of a km/sec. Note that the line frequency itself is not affected by the phase 'jitter'. Until late 1994 A2 had a similar EIP system; this has since been replaced with a true phaselock system adapted from the old receiver B2. In the case of B3i a much more agile phaselock system is used that can suppress the Gunn oscillator's inherent phase noise. Thus for B3i the resolution is limited only by the spectrometer.

(a) Receiver A2

A2 is a single-channel receiver which was commissioned in March 1992. Its excellent low-noise performance results in a total SSB system temperature (Tsys) of better than 400 K at the zenith across most of the band under normal conditions.

(b) 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.

(c) Receiver C2

C2 is a single-channel receiver which covers frequencies from about 450 to 505 GHz. In May 1993 it successfully completed commissioning at the JCMT, 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 encouraged. DSB receiver temperatures of 190 and 220 K are typical for C2 near 460 and 490 GHz respectively. Under excellent conditions total SSB system temperatures can be less than 1000 and 2000 K respectively at these frequencies. Typical system temperatures are usually 2000 and 3000 K respectively, or better, under good observing conditions.

(d) Receiver 'G'

The new SIS version of receiver G was first used at the JCMT in March 1994. Excellent results were obtained. A Gunn oscillator gives continuous coverage across the 650-692 GHz band, which includes both the CO (6-5) and 13CO (6-5) transitions. Observations with G are possible if the zenith opacity at 225 GHz is less than about 0.08.

Receiver 'G' has been available via a collaborative agreement between the MPE group in Garching and the JAC, and observers interested in using it should first contact Dr. L. Tacconi (e-mail LINDA at MPE- GARCHING.MPG.EDU for further information). Because of the collaborative nature of the use of the receiver, it is usually offered for a limited time period only. If the usual pattern of availability is followed it seems unlikely that receiver G will be offered in semester 95B however, and it is likely to be replaced subsequently by the upper band of receiver W (see below).

(e) Forthcoming spectral line receivers.

B3i will ultimately be replaced by a dual-channel receiver (B3) to be delivered in summer 1995 for commissioning in July. It should be available for use in semester 95B. The performance of B3's mixers should be better than that of B3i, with a DSB receiver temperature of typically 100 K from 325 - 360 GHz. The instantaneous bandwidth should be greater, also, but the tuning range is likely to be somewhat less than that of B3i.

Early in semester 95B, a dual-mixer dual-waveband SIS system (Receiver W; 'W' is for 'wide-band optics') for the C- and D-band windows should be commissioned (current estimates place its delivery to Hilo at late summer 1995). Receiver W will likely replace both C2 and G. The goals are for W to cover the ranges 430 - 510 GHz and 625 - 710 GHz. The sensitivity of W should easily exceed that of C2; no estimates can be given yet for the D- band window.

(f) 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. 750- and 760-MHz configurations are available to make use of the full IF bandwidths of receivers A2 and B3i. In some cases it is possible to observe several lines simultaneously with good resolution.

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. Receiver G has its own dedicated AOS.

Further details regarding both spectrometers are given in the User's Guide.

(g) Approximate rms sensitivities after 30 minutes' integration

Below is a table of 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) at selected line frequencies, for three different atmospheric transmissions. In the first case, a 'typical good' value is used for the system temperature, based on the observed distribution of values over the last six months. In parentheses, the expected values of the rms noise are given for 'exceptional' (corresponding to a water vapour pressure of 0.5 mm in all cases), and 'marginal' weather conditions. In the latter case the highest value of water vapour pressure (given in terms of zenith optical depth at 225 GHz; 'tmax' below) at which we recommend observations for the given frequency is used. The behaviour of atmospheric transmission with water vapour pressure impacts strongly on the system temperatures of receivers B3, C2 and G, and conditions worse than 'marginal' render observations unrewarding.

Table 2. Summary of spectral line sensitivities.

Freq. (GHz)	Rec.	Trx (K)	Tsys (K)	dv (MHz)	tmax	Rms noise (K) Typical (good, poor)
230	A2	95	400	0.38	0.20	0.035 (0.026, 0.059)
266		140	600	0.38	0.20	0.052 (0.036, 0.093)
331	B3i	265	1500	0.38	0.10	0.130 (0.087, 0.250)
345		180	800	0.38	0.15	0.070 (0.057, 0.220)
461	C2	190	3000	0.38	0.08	0.260 (0.150, 0.860)
492		220	3800	0.38	0.06	0.330 (0.240, 1.020)
661	G	1100	17000	1.00	0.08	0.820 (0.430, 3.400)
692		800	18000	1.00	0.08	0.840 (0.400, 4.500)

In this table, the calculations have been made assuming an observing elevation of 60 degrees, and (except for receiver G) use of the DAS in its 500-MHz standard configuration. The transmission in the 'exceptional' and 'marginal' cases has been derived from IRAM's ATM routine (authored by Stephane Guilloteau). Estimates for G are based on March 1994 performance.

Most spectral- line observations are carried out either in position-switched or beam-switched mode. In the first case, the reference position is given relative to the source position. In the second instance, the secondary mirror position is 'chopped' at a rate of 1 Hz, with a throw of typically 1 to 3 arcmin.

For relatively narrow line sources frequency switching is an attractive option. The chief advantage of this technique over either position- or beam-switching is that the telescope never leaves the source position. Thus its use reduces the rms noise by a factor of 1.4 over those values given in the above table for the same total integration time. Frequency switching is implemented in hardware for B3i (and presumably also B3), and via software ('slow frequency switching') for A2 and C2.

Spectral line mapping is usually done in a position- or frequency-switched mode, on a grid of positions. When the lines are strong (say, more than 2 K), it will be possible to use the on-the-fly mode of observing, in which the telescope is scanned at a rate corresponding to an integration time of not less than 5 seconds per point. This method is being developed, and is not offered for regular use at present.

Continuum Observations

(a) UKT14

Until displaced by SCUBA (see below) the UKT14 bolometer system will be available for observations with filters 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) under good photometric conditions.

The properties of UKT14 using the various available filters and apertures are given in the following table. The wavelength corresponds to the effective value for a precipitable water vapour of 1 mm, and a thermal blackbody (*e.g.* a planet). The value of the NEFD given is that which should be obtained under 'good' conditions for a 65 mm aperture; users should use this value to estimate time requirements. In parentheses, values for the 'best' and 'poor' atmospheric conditions are given to indicate typical ranges obtained. The aperture which gives a diffraction-limited beam is given in the table; photometry will normally be carried out with full aperture (65 mm). Beam maps are available via anonymous FTP, as noted above.

Photometry is carried out by chopping the secondary mirror at several Hz, with a throw of 1-2 arcmin in azimuth usually. Most mapping with UKT14 is done in a continuous scanning ('on-the-fly') mode.

(b) UKT14 polarimeter

So long as UKT14 is available, the Aberdeen/QMW polarimeter also will be offered as an optional accessory for it. The effective NEFD of the polarimeter/UKT14 combination is slightly worse than NEFD(p) = 2xNEFD/P, where P is the degree of polarisation 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 User's Guide.

(c) SCUBA

The submillimetre bolometer camera SCUBA is not expected to arrive in Hilo before late summer 1995. After undergoing tests in Hilo it will displace UKT14 on the left-hand Nasmyth platform, in order to undergo mechanical, electrical and cryogenic fitting. It will not be available for astronomical observations until some time later following a lengthy commissioning period.

Henry Matthews / JAC

Table 3. Properties of the UKT14 bolometer system.

Filter	Wavelength	Centre Freq.	Band-width	Aperture	Beam-width	NEFD (65 mm aperture)	Notes
(mm)	(mm)	(GHz)	(GHz)	(mm)	(")	Jy.sqrt(sec)	
2.0	1920	150	40	65	27	0.8 (0.7, 1.2)	1
1.3	1260	233	64	65	19	0.5 (0.4, 1.0)	
1.1	1090	264	74	65	19	0.4 (0.3, 1.0)	
0.85	850	354	30	47	13	0.8 (0.7, 5.0)	
0.8	790	384	103	47	13	0.5 (0.4, 5.0)	
0.75	750	411	28	42	13	0.9 (0.7, 5.0)	
0.6	625	480	119	36	11	5.0 (3.0, *)	2
0.45	444	682	84	27	8	5.0 (3.0, *)	3
0.35	351	864	113	21	6	10.0 (6.0, *)	3

Notes:

(1) At 2 mm UKT14 is poorly matched to the telescope.

(2) This filter is best avoided. It is difficult to obtain consistent calibrations, due to deep atmospheric absorption lines in the window.

(3) Observations are not possible under 'poor' conditions at these wavelengths.

Instructions for proposals for RxB3, RxW and SCUBA for Semester 95B

The builders have assured us that barring unforeseen problems, RxB3 will be commissioned in semester 95A. However, until the receiver has passed its commissioning tests, acceptance and subsequent commissioning it will not be available for astronomy. Users should propose B-band observations with RxB3i. The delivery date of RxW to the telescope is still not known due to uncertainty in the delivery of the D-band oscillator. **No proposals will therefore be accepted for RxW for semester 95B.** When it is commissioned, C-band proposals which have already been allocated time will be undertaken using RxW. Notification of D-band observations to be undertaken in SERVICE mode will be made at a later date. SCUBA is very much in the same category; although we certainly expect to begin commissioning during the semester, the precise dates are still vague and to some extent will depend on the delivery schedule of RxW. **No proposals for SCUBA will be accepted for 95B and so proposals to use UKT14 should continue.** As I indicated in the previous Newsletter, the first observations with SCUBA will be undertaken in a serviced mode by members of the commissioning team and users will be notified by e-mail exploder and the WWW of what type of proposals to submit for these 'shared risk' observations.

Ian Robson / Director JCMT

SCUBA Update

Users are no doubt still drumming their fingernails waiting to get their hands on SCUBA at the earliest possible opportunity. In order to keep you informed the current situation is as follows: Delivery has been delayed because of two major problems which the team spent most of 1994 solving. The first was noise instability caused by rf interference. This has now been solved by a more or less brute force technique of careful shielding and filtering of every line going into and out of the cryostat. The noise performance and characteristics of the detectors are now extremely stable and within specification. The second problem was microphonic noise caused by the closed-cycle cooler mounted on the cryostat. This has been a very difficult and subtle problem (SCUBA is the first bolometer system to use a hybrid cryostat) and although the effect has been greatly reduced to a more or less acceptable level within the signal band there are still some residual effects which are being worked on. However, the best news of all is that the instrument performance now allows optical commissioning, which has begun in the lab at ROE. SCUBA is now mounted in its frame and the JCMT telescope simulator optics have been set up and are currently being used to check the SCUBA optics and beam patterns. After this all the observing modes will be commissioned in turn. Work to eliminate the residual microphonic effects continues in parallel.

Walter K. Gear / ROE / SCUBA Project Scientist

PATT INFORMATION

PATT Application Deadline

Deadlines for receipt of JCMT applications for semester 95B are:

for Netherlands applications:

15th March 1995

for UK, Canadian and International applications:

31st March 1995

Note the change of the UK deadline from the previous few semesters. 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 PATT Secretariat at PPARC, Swindon. Members of the JAC staff in Hawaii (apart from those funded directly by the partners) count as International unless they are the PI on an application, when it should be forwarded to the appropriate national TAG.

Please help us to manipulate a consistent set of applications by only using the new revised PATT3. Older versions will still be accepted but the Technical Secretaries will frown at you and send you reminders to use the new one in future.

Country paying salary of Principal Investigator

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

PATT ITAC Report for Semester 95A

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 Chairpersons of each TAG bring their respective lists to the PATT where the ITAC combine 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

UK status	57
Canadian status	30
Netherlands status	19
International status	10
University of Hawaii	9
TOTAL:	125

The PATT meeting for semester 95A was held at The Falcon Hotel in Stratford upon Avon, UK on 7th & 8th December 1994.

It should be noted that if the PI on an application is a JCMT staff member based in Hilo, then the application is assessed by the appropriate national TAG. However, by Board rule, International status is given to any application where the only named collaborator from any partner country is such a JCMT staff member. International applications are assessed by the Chairpersons of the national TAGs at the ITAC meeting.

Time Available (in 16-hour nights)

No. of nights in semester 95A	181
Engineering and Commissioning	29
University of Hawaii (10%)	15
Director's discretionary use	4
Available for PATT science:	**133**

The above table indicates the order in which nights are removed from the total available for the semester. Semester 95A covers a summer period from 1st February 1995 through 31st July 1995 inclusive.

Awards (in 16-hour nights)

UK status	69.5
Canadian status	31.5
Netherlands status	25.0
International status	7.0
University of Hawaii	15.0

TOTAL allocation: 148.0

The number of successful applications was 82. For interest, the spread of these applications was 4 solar system, 17 stellar, 27 galactic and 34 extra-galactic. The average length of time awarded per application was 3.3 shifts.

For those not familiar with the JCMT Board 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).

Attribute by JCMT Board formula (in nights)

UK	48.0
Canada	27.0
Netherlands	22.0
International	36.0

The International attribution of nights comes out at 27% of the total allocation. Further discussion of this percentage is given in a later section. Much time is being awarded to collaborations between non-partner investigators and members of the partner consortium but applications wholly from outside the partner countries continue to obtain time.

A graph indicating the instrument distribution by semester since the beginning of JCMT operations is shown in Figure 1. The reduction in allocation of time for UKT14 is again due to reduced request as applicants await the arrival of SCUBA to continue their programmes.

Instrument distribution

UKT14	24%
RxA	27%
RxB	26%
RxC	14%
RxG	8%

A graph indicating the instrument distribution by semester since the beginning of JCMT operations is shown in Figure 1. The reduction in allocation of time for UKT14 is again due to reduced request as applicants await the arrival of SCUBA to continue their programmes.

Long-Term Status

Application L/M/94A/U19, approved for long-term status for three semesters, was given 3 shifts. This is the final award of time for this project.

Application L/M/95A/U22 was awarded long-term status for 2 semesters with 6 shifts in 95A and a further 6 shifts to be given in 95B.

Engineering & Commissioning

The engineering & commissioning time for 95A includes considerable work to improve the surface, measure receiver characterisations and efficiencies both of which were allocate time in 94B but were subsequently weathered out.

No time has been allocated for commissioning of SCUBA but 10 shifts have been set aside for RxB3. There are non-standard instrument configurations schedule for 95A (SBI, FTS & RxG2) which require set-up and calibration time.

Observatory Backup Programme

The Observatory Backup (M/94B/I09) continues to have long-term status for semester 95A for CO (2-1) and 13CO (2-1) mapping of the nominated sources and any others suggested to the ITAC as long as there is no conflict with future allocations.

All partners agreed to use this programme as a 'last resort' backup when the weather deteriorates sufficiently to prevent observers using their own allocated backup but not sufficiently to justify closing the observatory.

This programme terminates in semester 95A and must be resubmitted for future semesters.

Service time

Allocations for this semester are:

CDN = 8 shifts allocated;

NL = 3 shifts allocated;

UK = 8.25 shifts allocated

Changes to Semester Numbering

By the new convention, semesters that run from February through July are designated as '**A**' and those running from August through January as '**B**'. These are to be preceded by the last two digits from the year. Applications for the forth-coming semester should refer to semester **95B**.

Redesign of the JCMT Application form

A new design of application for observing time form, more appropriate for the JCMT and which can be common to the partner countries, has been devised and approved by the PATT. The form consists of a single double-sided page of questions to which extra pages for scientific case, technical breakdown, etc. can be attached. Questions specific to a particular country have been allocated their own layout on a separate page. A copy of the new form is included within this Newsletter and intending applicants may photocopy the pages and complete them for submission through the usual route. E- mail versions of the form are available on the World Wide Web JCMT home page and via the JCMT_INFO fileserver system.

I would like to thank Jacques Vallée and Gerald Moriarty- Schieven for their able assistance with this new layout.

International Applications on the JCMT

There has been some concern that those applications that do not contain a member of the partner consortium and are thus deemed as 'International' have not been receiving equal treatment through the PATT allocation committees.

Prior to the split into national TAGs the division of applications was made on the basis of the nationality of only the PI. Since the split only those applications with no collaborators from the partner countries are treated as 'International'. Thus the number has decreased. Although the allocation procedures have been modified the statistics show that there has been **NO** significant decrease in the time awarded to International proposals (see Figure 2), which has remained between 15% and 20% by JCMT Board formula and only slightly lower if the original method of accounting by PI is used.

National TAGs are not allocating their full quota of shifts and ITAC members are coming to the PATT meeting with 'reserve' allocations to fill the gaps if any are left after the International allocations have been made.

The success rate of International applications for semester 95A was about the same as for the various national applications at 40%.

Figures

Graeme Watt (ITAC Technical Secretary) / ROE

Successful JCMT Applications for Semester 95A

```
PATT    P.I.    Shifts          Title of Investigation

C01     Welch G A       2       Distribution of molecular gas in the dwarf
elliptical galaxy NGC 205

C02     Mitchell G F    5       Triggered star formation in NGC 7129

C03     Naylor D A      4       Search for tropospheric CO in Neptune

C04     Matthews H E    4       The recent mass-loss history of AGB stars

C05     Thornley M D    2       Physical properties of molecular gas in nearby
flocculent galaxies
```

C06	Vallée J P	2	Sub-millimetre polarimetry of magnetic clouds in central galactic environments
C07	Papadopoulos P	4	12CO, 13CO J=2-1 in Seyfert galaxies
C09	Vallée J P	4	Sub-millimetre polarimetry of nearby 'normal' molecular clouds
C10	Lee S -W	2	CO observations of NGC 5775
C13	Bastien P	1	Sub-millimetre polarimetry of nearby circumstellar disks
C14	Matthews H E	3.5	Physical properties of the circumnuclear torus and dust disk of Centaurus A
C15	McCutcheon W	3	Physical properties of selected IRAS pre-main sequence objects
C16	Matthews H E	1	A search for vibrationally excited NH3 in galactic sources
C17	Avery L W	5	The chemical properties of bipolar outflows
C21	Scott D	2.5	Variable CO absorption towards PKS 1413+135
C23	Moriarty-Sch G	3	Mapping dense gas in pre-protostellar molecular cores
C25	Clark T A	1	Mapping of the HI n=20-19 sub-millimetre recombination line across the chromospheric network and at the solar limb
C26	Wilson C D	2	The temperature of molecular clouds in M33
C27	Pudritz R E	1	Is there a disk in the class 0 source VLA 1623?
C28	Wilson C D	1	Molecular gas and dust in Arp 220
I03	Zuckerman B	4	Gas in dusty protoplanetary systems
I06	Simon R	3	CN N=3-2 emission as tracer of warm, very dense PDR surface layers
I07	Storzet H	1	CO+ in photon dominated regions
I09	Harris A I	3	Isolated hot cores: winds and spatial distributions in ultracompact H II regions
I10	Zhao J -H	2	Observations of CO emission from ultraluminous IRAS galaxies at intermediate redshifts
I11	Myers P C	1	Correlating submillimetre fluxes with outflow properties
H01	Greene T	3	Mapping outflow sources in the submillimeter continuum
H02	Senay M C	8	CO emission from comets
H03	Carpenter J	4	Testing the clumpy cloud model with multi-J

observations of 12CO and 13CO

H04	Carpenter J	5	C18O and C17O J=2-1 observations of the Serpens and B335 dense cores
H05	Owen T	4	Neptune and Titan
H07	Sanders D B	3	CO(3-2) and CO(2-1) survey of the Galactic Plane
H08	Sanders D B	3	CO(2-1) mapping of nearby starburst/active galaxies
N03	van Dishoeck E	8	Chemical and physical evolution of star-forming regions
N04	Israel F P	7	[CI] and CO J=4-3 observations of centres of galaxies
N05	Hogerheijde M R	4	HCO+ mapping of YSOs in Serpens:probing the physical structure of the surrounding envelope
N06	de Jong T	4	Mapping the CI envelope of IRC+10216
N07	Spaans M	4	CO, CI and other molecules in PDRs around cool stars
N08	Tilanus R P	2	CO in Dwingeloo Galaxy 1
N10	Waters L B F M	4	Millimetre variability of Be stars
N11	JaffeW J	1	CI emission from cold gas in high redshift galaxies
N14	Carilli C L	3	The molecular ISM in galaxies at cosmologically significant redshifts
N15	Stark R	3	The gas-dust connection in protoplanetary discs
N16	van der Werf P	3	Molecular gas in Cygnus A
N18	Tilanus R P	2	CO J=3-2 emission in the inner disc of M31
N19	Jaffe W J	2	CI emission from cool gas in cooling flow clusters
94A/U19	Zylka R	3	The variability of Sgr A* (Long Term Application)
U01	Marscher A P	4.75	Multi-frequency monitoring of g-ray bright blazars
U03	Ward-Thomp D	3	Molecular infall in protostars
U04	Ivison R J	4	Masers in symbiotic Miras
U05	Ward-Thomp D	3	Gaseous counterparts of submm continuum
U06	Holland W S	4	A search for polarised line emission in the Galactic Centre 5pc ring
U08	Holland W S	5	A multi-wavelength polarimetry study of YSO disks
U11	Yates J A	2	Detection of millimetre-wave extra-galactic H2O megamasers

U13	Minchin N R	4	C I observations of edge-illuminated molecular clouds
U14	Minchin N R	4	C I and molecular multi-line observations of S140
U15	Minchin N R	2	800 micron polarimetric observations of S140 and GL2591
U22	Rawlings S	6	CO survey of the only complete sample of high-redshift galaxies
U24	Little L T	3	CN as atomic carbon indicator?
U25	Holland W S	4	Investigating the magnetic field structure around 'class 0' protostars
U27	Mathieu R D	2	The evolution of disks around young binary stars
U28	Scott P F	5	A search for hot gas in a new sample of FIR cores
U29	Padman R	2	Interferometric studies of multiple T-Tauri star systems
U31	Zylka R	3	A study of the GMCs Sgr B1, C and D
U32	Hughes D H	3	Nearby blue compact galaxies as templates for high-redshift galaxies - II: Molecular mass in a low metallicity environment
U33	Mannings V G	5	Sub-millimetre scans of Herbig Ae/Be systems
U34	Mannings V G	3	Search for gas in proto-planetary disks around Vega-excess stars
U35	Mannings V G	1	Search for compact sub-millimetre emission in a Herbig Ae/Be system
U37	Genzel R	4	The circumnuclear disk in the Galactic Centre: a local 'torus'?
U39	Tacconi L J	6	Mid-J CO lines: probing the dense gas surrounding AGN
U40	Ceccarelli C	4	Warm dense gas around protostars
U41	Macdonald G H	4	Abundance of HCN in hot molecular cores
U42	Thum C	2	Probing the disk in MWC349: fine-scale structure of the recombination line maser
U44	Withington S	5	Submillimetre-wave continuum observations of high-redshift quasars
U46	Padman R	4	The complex outflow in L43
U47	Ward-Thomp D	1	Is there a disk around VLA1623?
U50	Emerson J P	5	Millimetre polarisation and dust grain alignment in disks of young stellar objects
U52	Rawlings J M C	3	Molecular abundances in the dense core 335

U55	Evans A	4	Dust in globular clusters?
U56	Greaves J S	3	[12C:13C] ratios in high mass-loss carbon stars
U58	Hills R E	2	JCMT-CSO Interferometry

Notes: The rules of the JCMT-CSO Short Baseline Interferometry scheme indicate that for every award in shifts from a partner quota for partner applications, an equal number of shifts from that partner's quota be 'given' to the CSO as payback. Thus in semester 95A there are 8 shifts payback from the UK and 2 shifts from Canada.

Revised PATT3 Form for James Clerk Maxwell Telescope Applications

A revision to the old PATT3 form is included in the following pages. This version of the form should be used wherever possible. The older versions are being phased out with the advent of flexible scheduling. Versions of this new form are also available on the James Clerk Maxwell Telescope home page of the World Wide Web the URL of which may be obtained elsewhere in this Newsletter.

The first 2 pages of this form (a double-sided sheet) is of relevance to all observers. The third page need only be completed and submitted with UK applications.

MEDICAL FORMS

Medical Disclaimers for James Clerk Maxwell Telescope and for UKIRT

PPARC have initiated a procedure whereby visitors to the JAC facilities on Hawaii will no longer be required to provide a medical certificate, but will be warned of the potential dangers of working at altitude and be required to sign a disclaimer. Disclaimers will be issued to groups by the PATT Secretariat following PATT allocations. Signed disclaimers need to be returned to the PATT Secretariat for every person visiting the telescopes, not just applicants.

Only one disclaimer per person will be required and it will remain valid for all approved programmes. It is intended to renew disclaimers every four years.

Failure to provide a signed disclaimer will mean that individuals will be denied access to the telescope(s).

TO: VISITORS TO U.K. TELESCOPES ON MAUNA KEA

IMPORTANT MEDICAL ALERT

PLEASE READ CAREFULLY, FOLLOW UP AS NECESSARY, AND SIGN AND RETURN THE FORM WITH YOUR APPLICATION FOR TELESCOPE TIME.

The PPARC's telescopes in Hawaii are located on Mauna Kea at an altitude of approximately 14,000 feet. Ascent to this altitude exposes you to a reduction in atmospheric pressure, which can result in a variety of medical conditions. In certain cases, severe illness or even death can result.

Visitors to the telescopes may suffer headache, tiredness, irritability, anorexia, insomnia, reduced intellectual capacity, impaired exercise tolerance and possible vomiting. It is also possible to develop one of the more serious mountain sickness of pulmonary or cerebral oedema, both of which can be fatal.

The altitude may also aggravate pre-existing disease, particularly cardiovascular and respiratory diseases.

PPARC strongly recommends that you bring the above information to the attention of your medical practitioner and seek appropriate medical advice and clearance.

This warning is given freely without any legal obligation. The PPARC does not undertake a duty properly to warn or otherwise to relinquish its rights, immunities, or other protections under Hawaii Revised Statutes, Chapter 520.

No visitors under the age of 16 are permitted.

THE PPARC DOES NOT ACCEPT ANY LIABILITY FOR VISITORS TO MAUNA KEA IN RESPECT OF THE POTENTIAL ADVERSE EFFECTS OF ALTITUDE. IF YOU INTEND TO VISIT THE TELESCOPES RUN BY THE PPARC ON MAUNA KEA, YOU ARE REQUIRED TO SIGN THE DECLARATION BELOW. YOU ASSUME ALL RISKS.

I have read and understood the medical alert provided by the PPARC above, concerning the potential harmful effects of altitude. I have been recommended to seek appropriate medical advice.

I accept that the PPARC shall not be held responsible for any adverse effects arising from exposure to high altitude.

Print Name & Address:..

....

Signed:... Date:...............................

(Parent or Legal Guardian if Under Age 18)

SP349L

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STATISTICS

Weather and Fault Statistics for Semester 94B

The following tables present the weather loss and fault loss for semester 94B. Full details are stored on database at the JAC and interested readers are referred there for further information. ***The total clear time (including backup time) lost for semester 94B is 4.7%.***

Month	**Avail**	**Ext**	**Primary Loss**	**%**	**Backup Loss**	**%**
August	493.0	24.3	110.1	22.3	5.0	1.0
September	416.0	7.9	154.5	37.1	8.0	1.9
October	496.0	18.1	40.5	8.2	10.5	2.1
November	480.0	23.5	189.7	39.5	4.0	0.8
December	477.5	19.9	17.0	3.6	0.0	0.0
January	496.0	34.2	69.8	14.1	1.8	0.4
Total	2858.5	127.9	581.6	20.3	29.3	1.0

Table 1: *JCMT weather statistics for semester 94B. Values are in hours. First column is total hours available; 2nd column is exteneded hours used; 3rd & 4th column refer to primary programme; 5th & 6th column refer to backup programme.*

Month	**Avail**	**Total**	**ANT**	**INS**	**COMP**	**SOFT**	**CAR**	**OTH**
August	493.0	21.3	8.0	8.9	1.0	0.8	0.0	2.7
September	424.0	15.4	3.6	10.7	0.0	0.0	0.2	0.9
October	496.0	30.2	3.1	17.5	4.0	4.8	0.0	0.8
November	480.0	18.4	3.8	8.9	5.0	0.0	0.0	0.6
December	477.5	12.8	2.4	6.9	0.0	1.2	0.0	2.4
January	496.0	9.6	2.3	4.0	1.7	0.8	0.9	0.0
P(hrs)	2866.5	107.7	23.2	56.9	11.7	7.6	1.1	7.4
B(hrs)		0.7	0.1	0.6	0.0	0.0	0.0	0.0

Table 2: *JCMT fault statistics for semester 94B. Wherever possible the faults are categorised into ANT = antenna; INS = instrument; COMP = computer hardware; SOFT = software; CAR = carousel; with the remainder going to OTH = other. The figures in the table may not appear to add up correctly due to rounding in the original program. P defines the time lost from Primary projects. The category B(hrs) is the time lost to Backup projects.*

Publications

The two figures below indicate the publication status of the JCMT from the beginning of operations in

1987 through till the end of December 1994. Figure 1 indicates the total number of refereed publications appearing in journals each year. Figure 2 compares the JCMT totals with those of other telescopes at the same stage in their evolution. It can be seen that the number of papers based on JCMT observations continues to increase in 1994. The annual total of **64** papers published in refereed journal is significantly more than the total figure for 1993 of 42. These numbers compare very favourably with those for other major facilities at similar stages of their development.

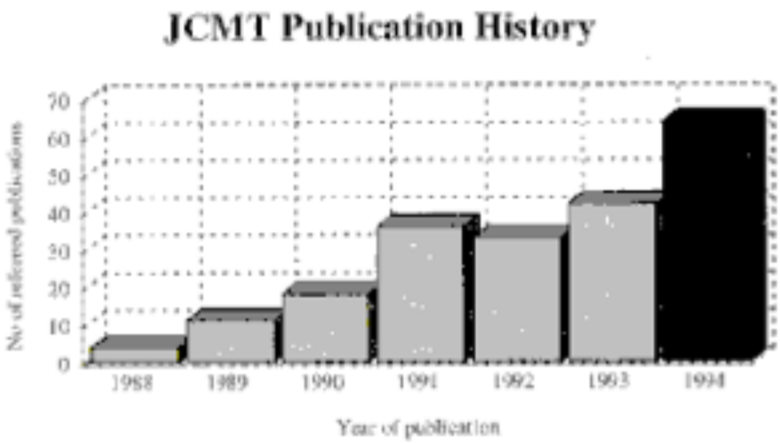

Figure 1.

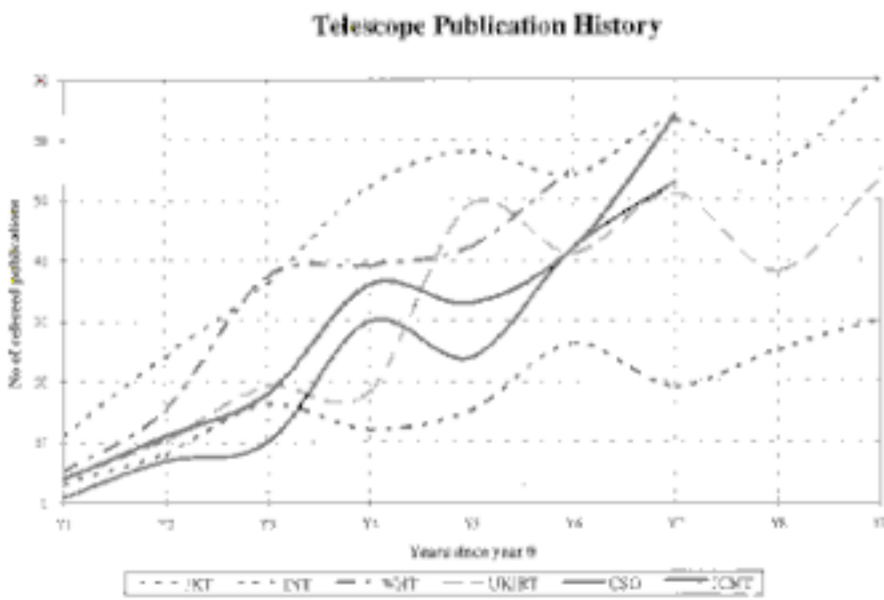

Figure 2.

TECHNICAL NEWS

Raster Mapping available with the DAS

Raster (or 'on-the-fly') mapping has now been released using the DAS. This is a high-efficiency method of mapping reasonably bright spectral line sources. The telescope is scanned continuously while the DAS is integrating and, at the end of every row, a reference (sky) position is observed. This reduces overheads due to telescope moving, off-source integration, etc. The true on-source integration time using this method is typically 60-70%, compared with 25-30% with normal grid mapping.

The minimum on-source integration time per point (Itime) is 5 seconds and the reference position is observed for sqrt(N)*Itime, where N is the number of points per row. This gives and optimum s:n over the map. The maximum number of points per row is 59. The distance between points should normally be 1/3 - 1/2 of the beamsize, to avoid smearing along the row. A data rate of ~450 spectra per hour can be obtained.

See the DAS manual or contact WRFD for more information.

Bill Dent / JAC

Is There Life after NOD2?

As those of you who are based in the UK are no doubt painfully aware, Starlink is in the process of abandoning VMS-based systems. I will not dwell here on the pro's and con's of that decision, except to say that it necessarily precludes the UK's JCMT users from access to the NOD2 software. This may not be a matter for much wailing or gnashing of teeth, but it does raise the question of how to reduce continuum on-the-fly maps.

It has never been JCMT policy to port NOD2 to UNIX. Instead, a replacement software package has been written by John Lightfoot, which will in due course form the basis of the SCUBA software. This package is called JCMTDR, which stands for JCMT Data Reduction. It runs under SunOs, Solaris or OSF/1, is compatible with all Starlink software, and also allows access to the dual-beam maximum entropy package DBMEM. Once a single-beam map has been made, you can output this in FITS format, and thence to AIPS or IRAF or whatever your favourite plotting package may be.

The last obstacle to JCMT users abandoning VMS altogether has now been overcome, in that there are now GSD file readers (MAKEMAP and GSD_PRINT) for UNIX incorporated into JCMTDR. At the time of writing (January 1995) this has just been completed by Remo Tilanus and Horst Meyerdierks and I have taken it for a test-drive on a Solaris system. I am happy to report that it appears to work fine. Users already familiar with the VMS version of JCMTDR should see little change. By the time you read this, the new version should have been released, along with the equivalent UNIX version of SPECX, with GSD file readers, so that you will be able to wave a final fond farewell to your VAX.

A JCMTDR Cookbook has been released which is designed to be an introduction to the package to help you to get started. It lists the commands with a brief description of each, guides you through a simple reduction procedure, and provides details of where to find out more.

Canadian, Dutch, UH and other non-UK users of JCMT will be pleased to learn that a stand-alone version of JCMTDR, which will not require all of the Starlink software to be installed with it, is planned for release by Starlink later this year. This has come about at the request of the JCMT Advisory Panel and the Submm/Radio Starlink Software Strategy Group.

For your copy of the JCMTDR Cookbook see the JCMT Homepage of the World-Wide-Web **(/JCMT/index.html)**, or e-mail me **(dwt@roe.ac.uk)** and I'll send you a copy.

Derek Ward-Thompson / ROE

The JCMT-CSO Interferometer

Introduction

Over the last few years work has been underway to link the JCMT and its neighbour, the 10.4 m Caltech Submillimeter Observatory together to form the first astronomical interferometer operating at submillimetre wavelengths. The telescopes are located at an altitude of 4100 m on the summit of Mauna Kea, Hawaii, separated by a baseline of length 164 m, giving a fringe-spacing of 1.1 arcseconds at 345 GHz.

The progress of this difficult project has been charted in the pages of the Newsletter. Beginning with semester 94B the interferometer was made available to the general user community of observational programmes. Since any use of the system requires the use of both telescopes and the special expertise of its builders, there are some particular conditions attached to applications for time. To bring together all the necessary requirements the interferometer is scheduled in much the same way as the MPE high-frequency receiver (RxG); that is, typically for a period of a couple of weeks per semester. Within this period, successful programmes are scheduled flexibly, depending on weather conditions and equipment availability.

There follows brief information on the technical design, the baseline geometry, the correlator, the system temperature and sensitivity, the effects of the atmosphere on observing, and the data-reduction process. Application procedures for those wishing to make use of the interferometer and complete information on the JCMT/CSO interferometer is also available on the JCMT homepage of the WWW.

Technical outline

The interferometer uses the existing heterodyne receivers at the two telescopes to down-convert signals to an Intermediate Frequency (IF) in the range 1-2 GHz. The two local oscillators must be highly coherent for interferometry to be possible, so they are phase-locked to a common reference frequency that is transmitted from the CSO to the JCMT over a wideband fibre-optic link. Optical fibres are also used to deliver the two IF signals from the receivers to the digital correlator (the DAS) at the JCMT. In general, astronomical signals arrive at one antenna before the other, and delay compensation is thus needed before correlation. Coarse delay compensation is realised by switching appropriate lengths of optical fibre into the signal paths. Finer corrections are made in the software during post-processing of the data. The rotation of the Earth causes the sources to move through the fringe pattern of the interferometer producing a fringe rate of up to ~15 Hz for observations at 345 GHz. Numerically-controlled oscillators are used to generate offset frequencies which are introduced into the LO and IF chains in such a way that this fringe rate is removed. Phase-switching at a fixed rate is also introduced which helps to remove any offsets in the correlator.

This arrangement naturally ensures that only one of the two sidebands generated by the receivers is correlated. The fringe rate can only be removed precisely for one frequency (chosen to be the centre of the IF band) and this sets a limit on the maximum integration time for individual records of around 10 seconds.

The interferometer uses heterodyne receivers in the 220 - 270 GHz and 318 - 360 GHz bands. Observations at around 460 - 500 GHz may also be possible, but the performance in this band is very uncertain and will be extremely weather dependent. Applications requiring this band will be considered but the chances of them being carried out are relatively low. Note that because the interferometer provides its own LO chain, the frequency coverage of the receivers available at JCMT/CSO will likely be somewhat different than is the case for single-antenna work.

Baseline geometry, resolution and applications

The components of the baseline (going from the CSO to the JCMT) are: +43.38 m in the polar direction, - 157.91 m in an east-west direction, and -1.93 m towards the celestial equator. The fringe-spacing is given by l divided by the length of the baseline projected perpendicular to the source. The minimum fringe spacing (1.1" at 345 GHz) therefore occurs when the source passes through the plane perpendicular to the baseline.

With a single baseline, the imaging ability of the interferometer is of course very limited. However the visibility of the fringes as a function of the length and orientation of the projected baseline can be measured and this can provide a good estimate of the size of the source and some information on the shape. By measuring the phase of the fringe, it may eventually be possible to measure positions of objects relative to known sources like quasars, to an accuracy of perhaps 0.1", but this has not yet been achieved. It is however quite easy to measure the relative phases of different spectral line components in a single source, provided they fall within the bandpass of the correlator. These phase differences give information about the angular separations between the different components.

The correlator

The Dutch Autocorrelation Spectrometer (DAS) at the JCMT is used to form the complex cross-correlation function of the two IF signals. There are 2048 lags which produce 1024 complex frequency channels (although only about 800 of these contain good data because of the bandpasses of the filters).

The lags can be distributed in many different ways amongst up to 8 sub-bands, each with a bandwidth of about 125 MHz. Some examples of the configurations available are: 800 channels covering 125 MHz with a resolution of 0.156 MHz; 100 channels in each of 8 sub-bands with 1.25 MHz resolution — total bandwidth covered 920 MHz (there is some overlap between the sub-bands); 400 channels covering 500 MHz with a resolution of 1.25 MHz, and the remaining 400 channels covering 125 MHz at 0.313 MHz resolution.

The system temperature and sensitivity

The system temperature is the geometric mean of the JCMT and the CSO system temperatures. These are determined by the standard method by measuring the power from the sky and an ambient load, so that the contribution due to the atmosphere is taken into account. Single-sideband values for operation at 345 GHz are presently in the range 500 K to 1000 K. The value is lower at 230 GHz, but increases going to low elevations and near to the main atmospheric absorption lines. The conversion factor from effective antenna temperature to units of flux is expected to be about 50 Jy/K, assuming an efficiency of 50%. The true value on a given observing run is determined by observing quasars as flux calibrator sources.

(1)

(2)

The sensitivity of the interferometer to continuum emission after integrating for time t(int) over bandwidth *d*n is given by Equation 1.

For a spectral line of width *dv* the corresponding result is given by Equation 2.

The interferometer starts to resolve sources of size > 0.5". A thermal source 0.5" x 0.5" must have a brightness temperature of at least 12 K to produce a flux of 260 mJy at 345 GHz.

The integration time of 10 seconds implicit in the above is the shortest which is normally used. For most purposes the records would be added together (after correcting for the effects of the changing delays) to give longer integrations. There is however a limit to this which is set by phase drifts due to uncertainties in the baseline, thermal effects an the atmosphere. This is quite often no longer than 100 seconds. To continue integrating coherently for longer than that it is necessary to have a source in the beam giving a signal to noise ratio of greater than 1 which can be used as a phase reference.

The effects of the atmosphere

The interferometer is more sensitive to the weather than the individual antennae. The Earth's atmosphere introduces random phase fluctuations that decorrelate the signals. The rms. phase fluctuation depends on the weather conditions, the observing frequency and the elevation. There is a strong diurnal effect because the heating of the ground by the sun drives much of the turbulence. In good weather, observations may be possible between ~5pm and 7am, but often the start has to be delayed by an hour or two while the atmosphere settles. Observing beyond 7am is limited because direct sunlight must not be allowed to fall on the CSO surface. A typical night-time rms. Phase fluctuation value is 30 degrees for observations at 345 GHz. Sources can be observed down to elevations of ~25 degrees above the horizon, allowing up to 8 hours of observations on a source of moderate declination. In practice the observations of the main source must be interleaved with those of a quasar for phase, flux and passband calibration.

Data reduction

The output of the DAS is processed using software written specifically for the JCMT-CSO Interferometer. This performs the fine delay correction, the passband correction and has facilities for adding and smoothing spectra. The final output is usually either a complex spectrum or an average flux and phase for the specified part of the passband. The output can be written out in the form of a UVFITS file for further processing with other software packages.

For further information, contact

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Avoiding Mountain Sickness

Introduction

When an observing team came to Hawaii for an run of a few nights on the JCMT (or UKIRT), each member of that team **MUST** have participated in a pretty thorough medical examination designed to detect possible problems that may occur to the user when working in a hostile environment such as the summit of Mauna Kea.

The requirement to produce a valid medical certificate has now been reviewed and medical torture has been avoided for most observers. The move to a medical alert disclaimer form does not imply that the JAC believes Mauna Kea is now a safer place to visit. Rather it transfers the emphasis of awareness of the potential medical difficulties and their symptoms from the administration directly to the observers themselves. It is their responsibility to ensure they are sufficiently healthy to work on Mauna Kea.

The JAC still firmly believes that the summit of Mauna Kea is a hostile and potentially hazardous working environment. This is reflected by the fact that the JAC staff will still have to pass a strict medical examination in order to be allowed to work up at the telescopes.

The medical disclaimer form very concisely describes a variety of symptoms that a victim may experience at any time when at altitude. However in order to give a little more understanding of what observers are signing I have attempted below to describe some of the potential problems in more detail from a layman's viewpoint.

The general problem

Mountain sickness is primarily caused by a lack of oxygen (hypoxia). Lower levels of oxygen in the air lead to a variety of physiological changes. At the summit of Mauna Kea the oxygen content of the reduced atmosphere is a mere 60% of that at sea-level. This has been described as being at the point when the brain decides to go 'off-line'.

It is possible for the human body to acclimatise to these conditions if the reduction in oxygen level is met slowly. Visitors would not suffer many mountain sickness symptoms if they were issued with backpacks and maps and made to walk from Hilo to the summit.

There are 4 main categories of mountain sickness. These are not necessarily independent and one may develop into another at an alarming rate if the symptoms are left untreated.

The cure for all mountain sickness is an immediate descent to sea level.

Acute mountain sickness

Most, but not all, observers are likely to suffer some of the symptoms of acute mountain sickness. These are headaches, shortage of breath, nausea, fatigue, loss of memory, lack of concentration, lack of appetite and inability to get to sleep. It is estimated that about 20% of people are affected by the above and the usual cause is a climb to over 8,000 feet too rapidly.

The law-abiding JCMT/UKIRT observer takes about one hour to drive from Hilo to HP (at 9,300 feet) which comes into the category of 'too rapidly'. However it is a JAC policy that visitors remain at HP for at least 8 hours (and preferably the night before the observing run) before proceeding to the summit. During that time the body partially adjusts itself to the reduced atmosphere. Visitors are advised to drink plenty of liquids (avoid alcohol, carbonated drinks, tea and coffee — which does not leave a lot of option!).

Residual 'hangovers' may persist for a few days whilst observing but if any of these symptoms become debilitating, or cause constant dull pain, the TO should be informed immediately.

The JAC stated maximum stay at the summit is 14 hours in a 24 hour period for visitors and staff alike. Only in exceptional circumstances do staff remain for the full duration.

The best cure for acute mountain sickness is to descend to sea level, not just to HP but completely down to Hilo.

High-altitude pulmonary oedema

Pulmonary oedema refers to a build-up of fluid in the lungs due to inflammation. This results in symptoms similar to pneumonia. They are a more severe form of those for acute mountain sickness. Victims may suffer a severe migraine-like headache, shortage of breath when at rest, may have a raised temperature (fever) and feel lethargic. A hacking cough may develop often spitting frothy, bloody fluid.

This rarely affects people below 9,000 feet but such cases are not unheard of. It usually develops after a longer period at altitude (which in this case includes HP and above) of about 48 hours or more. Descent from the telescopes to HP will not immediately alleviate the symptoms and descent to Hilo is recommended.

High-altitude cerebral oedema

This is more common at altitudes over 10,000 feet but, like pulmonary oedema, can occur even below 9,000 feet. The 'cerebral' part implies this condition has symptoms relating to brain behaviour and in fact the central nervous system is affected. Symptoms such as confusion, hallucination, slurred speech, loss of balance, lack of hand co-ordination, difficulty in focusing and aggressiveness may occur which appear very similar to drunkenness.

In fact, one effect of drinking alcohol is a reduction in the oxygen-carrying capacity of the blood. Lack of oxygen is the air produces similar symptoms. Drinking of alcohol is forbidden on the summit of Mauna Kea and is definitely not recommended at HP.

The victim may be the last person to realise that they are suffering these symptoms. The Telescope Operators (and all JAC staff) undergo training to make them more aware of such illness. They also have sufficient authority to order visitors (and other staff) off the mountain should they feel the situation is dangerous.

If left untreated this stage can easily develop and cause death. The cure is descent to sea level and possible medical treatment.

Chronic mountain sickness

People who fail to acclimatise but ascend rapidly to altitude (usually above 11,000 feet) may well end up with a case of chronic mountain sickness. This is characterised by extreme tiredness, palpitations, swollen ankles, chest pain and in some cases heart failure and death. The symptoms can occur quite suddenly and develop rapidly. There are some people who are unable to acclimatise properly even if they stay for 24 hours at HP. Chronic mountain sickness is very rare.

JAC mountain staff receive training in First Aid and Cardio-Pulmonary Resuscitation (CPR). However it must be remembered that on Mauna Kea they too suffer from lack of oxygen and may have difficulty avoiding altitude sickness if they are trying to breathe for you or perform strenuous pumping exercises on your chest. This coupled with the long, bumpy drive from summit to Hilo makes the successful CPR on the summit unlikely.

And finally...

Now that you are no longer required to take a medical to use our telescopes please do not misuse the disclaimer form. It is much better to go to your own GP and have a check-up than it is to fall over on Mauna Kea and have JAC staff test out their emergency procedures.

1. Research has shown that every 1,000 foot increase in altitude reduces a person's work capacity by 3%. Therefore on top of Mauna Kea everybody is running at a mere 58% of their operating efficiency at sea level, which for some people may not be a large amount!
2. Above 10,000 feet the large supply of oxygen that the rods in the eye require is no longer available and as a result night vision is reduced by about 50%. Astronomers without night vision?
3. It is recommended not to ascend more than 2,000 feet per day when above 7,000 feet. A tent and a flask of hot water may be provided!
4. One suggested treatment for mountain sickness is to place the victim in a sealed bag that can be inflated to sea-level pressure. Maybe this should be imposed on all visitors as a precaution!

References:

Houston C S; 1992, *Scientific American* **267**, 58.

Gantenbein D; 1993, *Discover* **14**, 114.

Graeme Watt / ROE & soon-to-be born-again JAC

Improving the telescope - a risk we have to take

Those of you who had a chance to use the JCMT in the last year or so may not always have been completely pleased with the telescope. We have undoubtedly had periods when telescope surface has been rather poor. However, those of you who have been lucky to use the telescope recently should have come home rather pleased with the experience, because the telescope is working very well. It points accurately, all receivers work, and the beam and aperture efficiencies are extremely respectable — at 490 GHz we have a beam efficiency better than 0.5 in stable night time conditions.

Last year we undertook several major upgrades of the telescope surface and the chopping secondary in order to improve the performance of the telescope. Any work on a telescope which is in constant use, always involves a risk. We try to minimise the downtime of the telescope. We cannot build in large safety margins if things go wrong, or if the weather is poor during the few recovery nights that we believe should suffice.

The second stage of the focal length change was performed in late January, and we had to shim a relatively large number of adjusters to get the panels into the right position. Although the mechanical operation went rather smoothly, we were plagued with bad weather, shaky adjuster electronics and problems with the holography receiver. Neither did we have well-placed planets for astronomical testing. It therefore took us into mid-March before we had the surface back to decent, although not perfect shape. Tests done later during the spring indicated that the focal length change was very successful in reducing the diffraction ring to an acceptable level. Currently there are no plans to do the final step (another 8mm), because the gain that could be achieved is too small compared to the efforts it would take.

Figure1. Beam maps of Mars at 800 microns.

(a) from July 29

(b) from September 8

(c) from October 11

The contour levels in each map start at 2% of the peak intensity with a step of 2% and after we reached the peak intensity in the error beam we continue with steps of 10%. In a) this occurs at 10%, in b) at 16% in c) at 22%, *i.e.* the surface appears progressively poorer.

During the spring we finally managed to diagnose the cause for the lack of homology of the telescope (the change in gain as a function of elevation, which had plagued us for several years). Five of the twelve conebars, which support the backup structure of the telescope, showed large movements in excess of 20 microns when the telescope was tipped in elevation. They are not supposed to move. After some testing in May of how to cure the problem, we finally decided to weld all conebars and scheduled the work for early July.

During a short heavy engineering period in July (July 7-8), the conebars were wedged and welded to eliminate the flexing in the backup structure. This clearly deformed the antenna. An in-focus beam map at 1.1 mm taken immediately afterwards showed a clear three-lobe error structure, which looked very similar to beam maps taken during the autumn of 1991, when the lack of homology first became apparent. Due to problems with the holography receiver, we had quite a bit of struggle before we managed to recover the dish. The holography maps looked rather good before the last adjustment, which was made on July 12. After this adjustment we could not get the holography receiver to work, but the adjustment went smoothly and should not have caused any problem. The weather during the whole period was too poor to permit observations at wavelengths shorter than 1.1mm, but out-of-focus (oof) beam maps made with RxA2 on Venus looked very similar to the holography maps. We therefore believed that we had cured the homology problem and successfully set the telescope surface.

Figure 2. Beam maps at 450 microns.

(a) Beam map of Uranus obtained in August

(b) Beam map of Mars obtained by Ned Ladd in October

In both maps the contour levels start at 10% of the peak intensity with steps of 10%. Note how poorly defined and elliptical the main beam is in October.

During an EAC shift on July 29th with marginal sub-mm weather we obtained several in focus beam maps both with UKT14 and RxA2. The beam maps showed surprisingly large error lobes (Fig 1a). Because the holography receiver was still broken, the decision was taken to wait until we got the holography receiver fixed (projected as early October). No reports from visiting astronomers reported any problems with telescope performance until after the heavy engineering period last week of September.

The heavy engineering in September, where the SMU was taken off and new stiffer flex-pivots, new LVDTs and the digital controller put back on- line, was finished late evening Sept. 30, 1994 (Friday). Testing done on Friday and Saturday night indicated that the chopper was working fine apart from some initial problems the first night which were fixed the following day. We checked pointing and focus (the 8 mm shim was also removed from the secondary), re-measured the chop scales and they appeared reasonable. The sky conditions were marginal and as in July we could not work shortward of 1.1 mm. Tilt tests of the secondary, however, indicated that there might be a tilt in the secondary and further tests were planned for the EAC shift on Saturday, October 8.

Since the sky conditions improved on October 2 and continued to stay good, PATT observers were asked to take beam maps at 800 and 450 microns so that we could compare the shape of the beam with earlier data. Tuesday evening (Welsh on 1st shift) was poor and no beam maps could be obtained, but improved radically on second shift and Ned Ladd took two large beam maps at 450 microns (Fig 2), showing an incredibly poor beam!! The Director (DDT, Sunday eve, October 2) also reported drop in UKT14 sensitivities at 1.1 mm and 800 microns, and so did Ned Ladd later in the week.

Figure 3.

Beam map of Mars obtained with RxC2 in December 1994

The contour levels are 1%, 2%, 3% and 10% and continue in steps of 10%. Note how clean the beam appears at 495 GHz.

At this stage we dropped everything we were working on and started to investigate what could possibly have gone wrong. A fair amount of telescope time was used for testing, but most of it was either done during daytime or using service and DDT time, which could be paid back later. We did use regularly scheduled PATT time as well, and Matt Griffin, who had a long run in mid-October gave us a fair amount (~1.5 shifts) for carrying out various tests. In the beginning a lot of the work was concentrated on the secondary, because this was the logical point to start at. We spent quite some time checking the tilt of the secondary, but this was just a red herring. Even though tilting the secondary can remove some of the telescope errors, re-focusing the telescope will effectively cancel out the tilt. However, we could not really find anything obviously wrong with the secondary. The next step was to eliminate UKT14, because it appeared to show a poorer performance than our heterodyne receivers. We therefore checked the alignment of UKT14, and in the end we decided to take it off the telescope and open it up, but in the event nothing amiss was found. Neither could we find anything wrong with the conebar joints or the telescope backup structure. However, we got more and more evidence suggesting that either the surface or the secondary had deteriorated.

Our tests showed conclusively that the performance of the telescope was poorer than we have ever had it before. Beam maps showed large error-beams and at 450/350 microns, the beam was largely elliptical, often split into two peaks. Although it is clear that the telescope performance was never fully recovered after the welding of the conebars in July (because the holography receiver broke down), analysis of the available data prior to the heavy engineering period in September appear to show that the telescope performance was satisfactory, although far from good.

Figure 4. Beam maps of Mars deconvolved with DBMEM.

(a) The 800 micron map is an average of three beam maps obtained, two obtained in the December 1994 and one in January 1995

The size of the map is 95" x 95" and contour levels are 0.5%, 1%, 2%, and 10%. All contours thereafter are in steps of 10%

(b) The 450 micron beam maps is an average of two maps of Mars obtained during the same night in December, but with two different chop throws: 20" and 25"

The size of the map is 40" x 40" and contour levels are the same as for the 800 micron map.

However, after the September heavy engineering period the performance appeared much poorer, but this could partially be due to the fact that we had no decent sub-mm weather before October. The prevalent view is that the cause for this dramatic decrease of telescope performance was due to deformation of the chopping secondary, which could have somehow been damaged during the heavy engineering. As we later found out when we started to investigate this matter in detail, the secondary could have been damaged during the crash tests, that were made on the chopper. The main support for this hypothesis is in the apparent large scale errors of the telescope deduced from oof-maps and holography, which show a north-south squint of the telescope. What somewhat contradicts this view is that the in-focus beam maps show the same error beam pattern (strong elliptical error lobe mostly oriented east-west) from late July onwards, only much more amplified in October (Fig 1c & 2b). If the poor performance is due to the secondary, it must already have had some damage before the heavy engineering period. An alternative hypothesis (considered mechanically less likely) is that the telescope surface was stressed by wedging and welding the telescope in July. The stress put into the dish by the conebars was gradually released and redistributed over the dish. In this scenario it is the relaxation of the dish, which eventually made the surface almost unusable for sub-mm work, but this does not adequately explain the squinting of the dish seen in the holography maps.

After solidly verifying that the problem was in the telescope surface or deformation of the secondary, we decided to take out the errors by adjusting the primary. This was done in November (Nov. 3 - Nov.

6, 1994), and fully recovered the performance of the telescope. The telescope is now better than we ever had it before. Extensive testing done in December 1994 and January 1995 shows that the homology problem has been cured by welding the conebars.

We now have the best surface we ever had on JCMT. With relatively small and rather safe efforts we can improve it even further. Holography, oof-maps and aperture efficiency measurements predict a total surface error about 30 microns. Extensive sets of beam maps show very clean and symmetric beams. At 490 GHz we can hardly see any error lobes at all (Fig 3) and beam maps of Mars at 800 microns and 450 microns (deconvolved with DBMEM) show that the error beam adds about 10 – 15% of power at 800 microns and 20 – 35 % at 450 microns (Fig 4a,b). We now have the holography receiver back in operation and most of the problems with the adjuster electronics have been solved as well. We have set up a regular monitoring of the dish. No further changes have been seen since our last adjustment in early November.

We will continue our work on improving the telescope, with the aim of minimising any problems that it may cause our users.

Göran Sandell / Head of telescope group / JAC

New IF Unit

A new IF switching unit will be installed in early 1995. This will allow automatic setting of IF power level and switch-over between receivers. It is also designed to provide a single channel with 1800 MHz of instantaneous bandwidth.

The amount of usable bandwidth will depend on the receiver. However, we hope that RxC2 will have reasonable performance over ~1400 MHz.

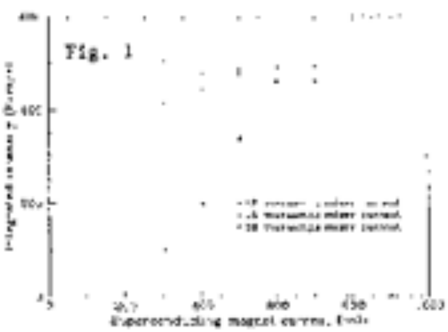
RxB3 (CU) and RxW may also have a similar bandwidth. RxA2 and RxB3i will still be limited to ~600 MHz.

In this wideband mode, only one channel of a dual-polarisation receiver can be used.

Bill Dent / JAC

LO Saturation of the 1.3 mm SIS Receiver

During the summer and fall 1994 were there several reports of low line intensities using the 1.3 mm SIS receiver RxA2. During normal test observations were we not able to reproduce these low intensities. Nevertheless the tuning was a prime suspect and a test was performed using different LO power levels and magnet currents. The magnet is used to suppress the Josephson super-current. A Josephson super-current can cause severe calibration problems if present. The normal magnet current had been 700 mA to completely suppress the Josephson super-current. However, after cryogenic problems during the Spring the current was decreased to 500 mA. This was to decrease the risk of very explosive boil-off occurring when the magnet coil became non-superconducting. Previous tests had shown that the lower current level did not cause any calibration problems in spite of a weak remaining super-current.



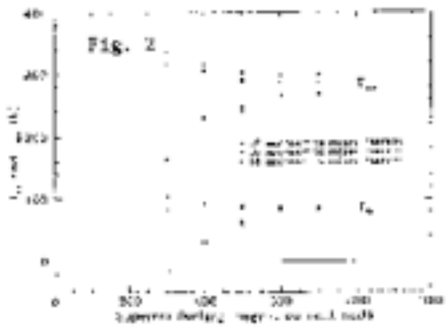


Figure 1. The integrated intensity of the 12CO J = 2-1 in IRC+10216 as function of magnet current for three different mixer currents. **Figure 2.** The system and receiver noise temperatures as function of magnet current for three different mixer currents.

The 12CO J = 2-1 line was observed in IRC+10216. The LO power was adjusted to get 12 mA, 15 mA and 18 mA mixer current while the magnet current was set to 300, 400, 500, 600 and 700 mA. The results are shown in figure 1 and 2. Figure 1 shows the line intensity as a function of the magnet current for the three mixer current settings. A mixer current of 18 mA will cause calibration problems with the magnet set to 500 mA, the curent used during the summer and fall of 1994. Figure 2 shows the system and receiver noise temperatures as functions of the magnet and mixer current. Note that for a mixer current of 18 mA and a magnet current of 300 mA the receiver temperature is negative !

The above results explain the low intensities obtained during the summer and fall of last year. The TO would optimize the tuning and occasionally get a high current level. However, this would not be the normal case. To make sure this not will be repeated the magnet current has now been returned to 700 mA. Further, to simplify the tuning and improve the intensity stability, the mixer current will be set to 15 mA and the mixer bias voltage to 2.05 mV. The reason for calibration differences of 7% between different mixer currents for the same magnet current is not clear. However, setting the mixer current to the given value will increase the stability of the intensity scale with only a small change in performance.

Per Friberg / JAC

UK Service Programme

The UK Service Programme has recently come under new management after the retirement of Alex McLachlan. Alex had been the controller and administrator for the service programme since its inception in semester Y. The 'UK' in the title is a bit of a misnomer since the service programme is open to applications from UK and International applicants alike. Canada and the Netherlands run their own service programmes on the JCMT.

Applications are accepted for observations that take no more than 4 hours to complete (half of a standard JCMT shift). Typical applications include those requiring completion of PATT projects that have been partially weathered out or nearly-but-not-quite finished; pilot projects which may lead to full-blown PATT applications; short investigations that would not justify a full PATT application; monitoring programmes; and targets of opportunity.

Currently the UK-TAG allocates about 9 shifts to UKServ per semester which the JCMT Scheduler then attempts to distribute throughout the semester so as to maximise the RA range covered. This is not always as simple a task as it may sound. An Announcement of Opportunity (AO) is then circulated to a wide list of users via e-mail well in advance with a deadline for submission for a particular UKServ session about 4 weeks prior to that session.

All applications are awarded a scientific grading by 2 independent assessors, one of whom is a member of the UK-TAG for PATT. In addition the applications are technically assessed by staff at the JAC. The assessment process should take no longer than two weeks after which the applicant is notified whether his project has been added to the service list or whether a rewrite is necessary. The UK Service Programme can be an extremely rapid method of obtaining your data.

Prospective applicants can obtain information about the UK Service Programme from the ROE home page on the World Wide Web (**http://www.jach.hawaii.edu**). If you wish to be included on the e- mail distribution list for AOs then send an e-mail request to:

jcmt@roe.ac.uk

It is appropriate here to thank all the observers, telescope operators, assessors, and Alex who have built up this useful system over the semesters. During semester 94B the UKServ scheme processed 29 new applications in addition to 18 remaining from the previous semester during which many service shifts were lost to weather. A total of 185.5 hours was requested from an allocation of 8 shifts (64 hours). An extra 10 shifts came available from the UKFlex block thus giving 144 hours to service. Of course the RA time within the service shifts never quite matches the time required so it is impossible to directly compare time required against time available.

UKServ in semester 95A

Date	Shift	Instruments	Times
Feb. 12	M	UCBA	0530-0930
Feb. 13	M	UCBA	0530-0930

Feb. 14	M	UCBA	0530-0730
Feb. 15	M	UCBA	0530-0730
Mar. 4	E	UCBA	2130-0130
Mar. 5	E	UCB	2130-0130
Mar. 6	E	UCB	2130-0130
Mar. 7	E	UCB	2130-0130
Mar. 16	M	UCBA	0130-0930
May 9	E	UCBA	1930-0130
May 10	M	CBA	0130-0330
May 22	E	UCBA	2130-0130
May 23	E	UCBA	2130-0130
May 24	E	UCBA	2130-0130
May 25	E	UCBA	2130-0130
Jun. 4	E	UCBA	1730-2130
Jul. 24	E	UCBA	1730-1930

There are 8.25 shifts of UKServ scheduled this semester. They are provisionally located on the above dates (but are subject to change).

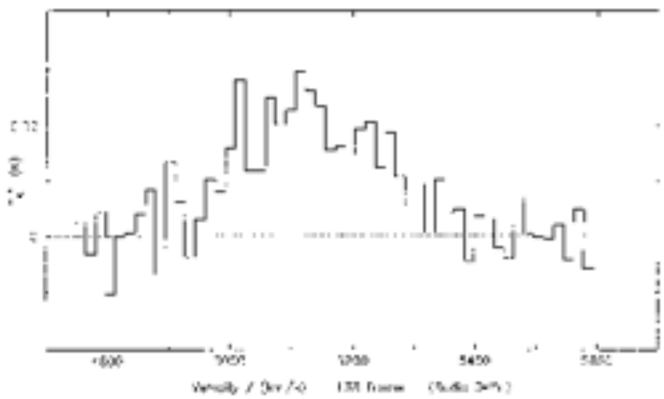
In the second column E indicates evening shift and M indicates morning shift. The third column indicates the instruments expected to be available for each period: U=UKT14; C=RxC2; B=RxB3i; A=RxA2. The times in the fourth column are local Hawaiian time on the date given.

Graeme Watt / ROE

SCIENCE HIGHLIGHTS

Cooling Flow Gas in NGC 1275 / Perseus

X-ray data have revealed evidence for the infall of typically several hundred solar masses of gas per year in many galaxy clusters, with these **COOLING FLOWS** focused onto centrally-located gE/cD galaxies (Fabian 1994). However, the fate of this infalling gas is still largely a mystery, as there is little evidence for it at other wavelengths. On average, 10(11) - 10(12) solar masses of material should be deposited in a Hubble time, and some fraction of this material should be found in cool atomic and/or molecular clouds. However, NGC 1275, the gE galaxy at the centre of the rich Perseus cluster, is the **ONLY** cluster cooling flow galaxy which has been detected in CO (Lazareff *et al.* 1989; Mirabel *et al.* 1989; Reuter *et al.* 1993). NGC 1275 thus presents us with a rare opportunity to learn about the physical conditions of cooling flow gas.



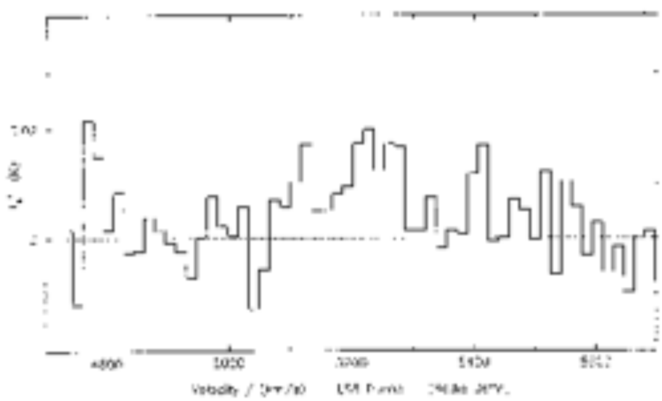


Figure 1. (top) **Figure 2.** (bottom)

To this end, the Canadian TAG awarded us 3 shifts in Nov. 1994 to observe NGC 1275 in CO emission. Our primary goal was to observe in the CO (3-2) line in order to supplement available data in 12CO (2-1) and 12CO (1-0) which Reuter *et al.* (1993) had already obtained for the inner 20 arcseconds of the galaxy. However, bad weather (Tsys ~ 2000 K !) forced us to switch to receiver A2 for observations of CO (2-1) instead. We therefore observed 13CO (2-1) at the galaxy centre and also obtained a 9-point map in 12CO (2-1) with 7 of the points lying within 20 arcseconds of the galaxy centre and 2 points 40 and 60 arcseconds from the centre.

Figure 1 shows the average of 7 x 10-minute scans (obtained in beam-switching mode) for 12CO (2-1) at the galaxy centre, while Figure 2 shows an average of 10 x 10-minute scans for 13CO (2-1) at the same position. These spectra have been binned by 20 channels, giving a velocity resolution of 16 km/s, and are baseline-subtracted. The beam size at 230 GHz is 20 arcsecs, corresponding to 6.8 kpc at the distance of NGC 1275 (Ho = 75 km/s/Mpc). The 12CO detection is quite strong, and 13CO (2-1) is also detected, though these data are noisy and require better baseline subtraction. The 13CO (2-1) data will provide an important constraint for subsequent analysis using a radiative-transfer code. There also seems to be a velocity offset of 50-100 km/s between the 12CO and 13CO emission at this position. Finally, we believe we have made a weak detection of 12CO (2-1) emission as far as 1 arcminute from the galaxy centre, corresponding to ~ 20 kpc. This is still well within the cooling radius of ~ 100-200 kpc however, and it is important to carry out further mapping to determine the CO distribution in this galaxy/cluster.

We are currently requesting more time to acquire the CO (3-2) data, at least for the central position. Together with our CO (2-1) data and the maps of Reuter *et al.* (1993), we should be able to place constraints on the density, kinetic temperature, and CO content of the molecular gas in this most unusual region. These data will thus eventually give us a much better idea of the physical conditions in cooling flow gas, and may shed some light on the nature and final state of the inferred large amounts of infalling material.

References:

Fabian 1994, ARA&A, **32**, 277.

Lazareff *et al.* 1989, ApJ, **336**, L13.

Mirabel *et al.* 1989, ApJ, **340**, L9.

Reuter *et al.* 1993, A&A, **281**, 673.

Terry Bridges / RGO / Cambridge / England
Judith Irwin / Queens University / Kingston / Ontario / Canada

Limitations on Detecting Faint Broad Lines: Low-level Instrumental Ripples

Introduction

Since the CO molecule is a good tracer of star formation in galaxies, studying this molecule at cosmological distances is important for understanding the evolution of young galaxies. In this note we will briefly report on our recent experience with the JCMT attempting to observe CO in distant radio galaxies. We will show that, at least in some modes of operations, faint baseline ripples are the limiting factor in these observations and can behave in a way indistinguishable from a real astronomical signal even when various LO settings are observed.

Scientific Rationale

To date, the two objects at high redshift that have a confirmed detection of a CO line are the ultraluminous IRAS galaxy F10214+4724 at $z = 2.3$ (Solomon *et al.* 1992) and the cloverleaf quasar (Barvainis *et al.* 1994). The good news is that these two detections demonstrate convincingly that studying CO in the early universe is possible. The bad news is that the IRAS galaxy F10214+4724 is the only IRAS galaxy known at these distances. Studying a sample of such objects is therefore not (yet) possible. Since the cloverleaf quasar is a gravitationally lensed quasar for which the amplification factor is not well known, the estimate for the intrinsic CO luminosity of this object is uncertain.

The significant samples of quasars and radio galaxies that exist are a good starting point for a further search for CO in the early universe. The expected width of the CO emission lines is a few hundred km/s (FWHM) and the bandwidth of the receivers and backend combination as used in major millimetre observatories is limited to about 1000 km/s. It is therefore important that objects to be studied have well determined redshifts, preferably to better than a few hundred km/s. Since the FWHM of the emission lines of radio galaxies is of order 1000 km/s, a factor of 5 - 10 smaller than in quasars, there is some advantage in using radio galaxies rather than quasars for a survey of CO in the distant universe.

By focusing on the steepest radio continuum spectra we have found more than 30 of the 60 known radio galaxies at z > 2 (*e.g.* Miley *et al.* 1992, Röttgering *et al.* 1994). We have started a programme to detect CO emission from distant radio galaxies from this sample using the James Clerk Maxwell Telescope. The results will be reported in the PhD thesis of Rob van Ojik.

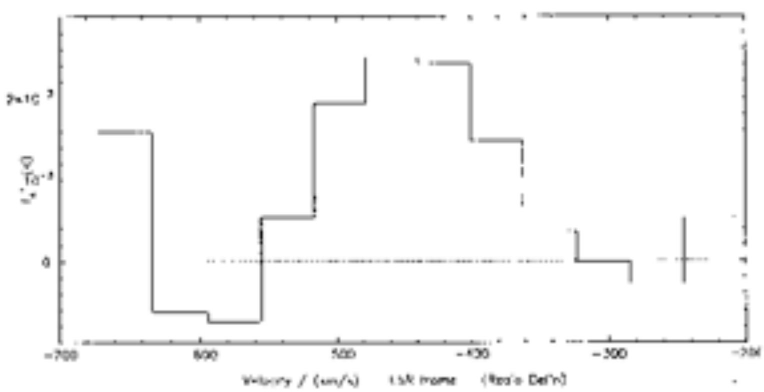


Figure 1: The average of all the CO(7-6) spectrum centred at -450 km/s from the optical redshift of 0211-122, binned at 50 channels.

One of the most intriguing objects from this sample is the radio galaxy 0211-122 at z = 2.34. It is an ultra-steep spectrum radio source and identified with an object with an R-magnitude of 22.7. For a distant radio galaxy its optical spectrum is highly anomalous; it has very faint Lya emission and strong NV *lambda* 1240 emission. The spectrum resembles that of the IRAS galaxy F10214+4724. We have suggested that 0211-122 is undergoing a vigorous starburst possibly induced by the passage of the radio jet. Such a vigorous starburst would produce enough dust to attenuate the Lya emission (Van Ojik *et al.* 1994).

Observations

Last December we had an extensive run at the JCMT to detect CO in distant radio galaxies. Since there was good evidence that 0211-122 contained enormous amount of cold gas, this object was our prime target to detect CO(7-6) emission from the early universe.

The set-up of the whole system was standard. We used the receiver A2 and the DAS digital backend with 2 overlapping bands of 500 MHz each. These two bands consist of 4 overlapping subbands. The total band width is then 750 MHz, although the noise increases somewhat towards the edges of the bands. We investigated different merging parameters, but the standard DAS-merge seemed to give better results. About 5% of the data had bad baselines and were discarded in the subsequent reduction. Only a dc offset was removed before averaging, *i.e.* no linear or higher order baselines were removed.

We employed standard beam-switching with a throw of 60 arcseconds. The secondary was chopped at a frequency of 2 Hz and the telescope was moved every 30 seconds in such a way that the off-source position was on alternate sides of the source. The theoretical noise (in Ta*) averaged over 64 channels in an 8 hour integration is 0.6 mK. The expected level of the CO emission in distant radio galaxies is not really known. However, in the case where CO at the JCMT was detected in high redshift galaxies it was at the 3- 5 mK level, regardless of the transition. This would indicate we would have a fair chance of detecting CO in these distant radio galaxies.

The main limitation in this kind of observations is that the expected width of the lines (at least a few hundred km/s) is comparable to the width of broad, low level ripples in the baseline of the spectra. It might not be too surprising that these ripples are present, since with typical system temperatures of 400 K the expected signal is at a level of about at least 5 orders of magnitude fainter.

The technique that is being used to check the reality of possible detections of faint lines is to switch the LO setting every time after the required noise levels have been obtained. If the detection is real, then each individual spectrum should show the presence of a faint line, at the same Doppler-shift/velocity.

During the first shift we observed CO(7-6) using the redshift as determined from the optical emission lines. A peak was detected at approximately -150 km/s from this redshift. The next night we centred the frequency setting at this value and found an additional and even stronger peak at -400 km/s. We then spent a total of one shift at -450 km/s. The resulting spectrum from this shift seemed to show a clear 2.5 mK CO detection with a width of 150 km/s (FWHM) (see Figure 1).

However, we were worried that this possible detection and the detection at -150 km/s might be due to a baseline ripple. We therefore decided to continue to observe at different velocity settings to investigate this. We spent a total of 6 shifts on 0211-122 during good weather conditions (CSO tau between 0.03 and 0.06). The total integration time was approximately 40,000 seconds, divided over 5 different LO settings. In Figure 2 we show 7 different spectra smoothed with a gaussian of 200 km/s (FWHM). The baseline ripple shows a sinusoidal behaviour with a period of 300 km/s and a peak to peak amplitude of 2 mK. The main point of this note is to emphasise that the baseline appears to be stationary; shifting the LO frequency does not shift the ripple. This makes it very difficult to distinguish between these ripples and a true signal at the level of a few mK. At the moment it is not clear what is causing the ripples. The frequency spacing of the ripple corresponds to a standing wave over a path of about half a metre. This led Richard Hills to suggest that they might be due to a coupling between the LO plate and the receiver, since their distance is of this order. Further investigations are necessary to determine its nature.

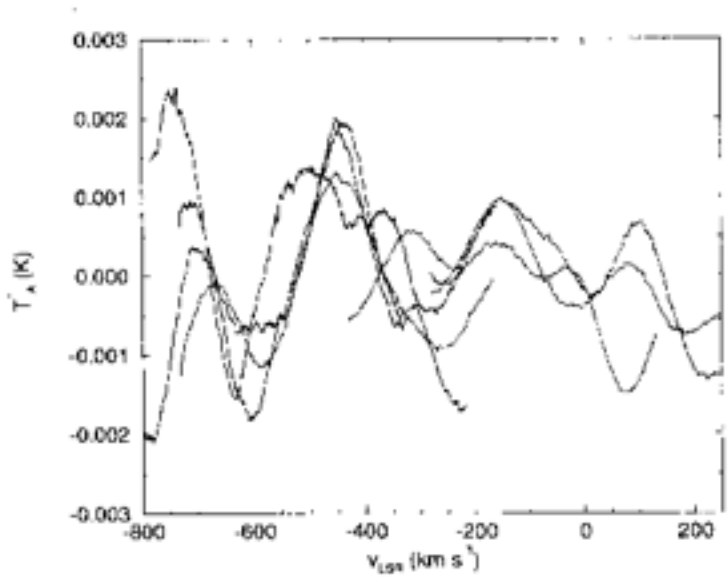


Figure 2: 7 different spectra centred at 5 different Vlsr from the CO(7-6) transition of 0211-122, smoothed with a gaussian of 200 km/s.

Conclusions

By showing these data we hope to accomplish two things. First, we quantify an important limitation of the present instrumentation on the JCMT for detecting weak broad spectral lines. Relevant programmes include observations of clusters of galaxies, absorption systems, quasars and radio galaxies. The expected spectral features from these objects will also be faint and broad and therefore the cautionary note given here will certainly apply. Only because of the large number of shifts at our disposal were we able to explore a relatively large range in frequency, thereby showing the ripple. It is clearly essential to do this in programmes of this type.

Secondly, we hope that these data, together with the astrophysical importance of such work, will provide additional drivers for developing wide-band spectrometers and specific observing techniques for carrying out programmes of this type.

Acknowledgements.

We would like to emphasise that these observations could not have been done without the very good support of the staff at the James Clerk Maxwell Telescope. Special thanks to Fred Baas, Chris Purton and Remo Tilanus. Furthermore, we would like to thank the Netherlands TAG who had the courage and the enthusiasm to allocate a very significant amount of time for such a difficult project. We further acknowledge support from an EEC twinning project.

References:

Barvainis R., Tacconi L., Antonucci T., Alloin D., Coleman P., 1994, Nature, **371**, 586.

Miley G., Röttgering H., Chambers K., Hunstead R., Macchetto F., Roland J., Schillizi R., van Ojik R., 1992, ESO Messenger, **68**, 12.

Röttgering H. J. A., Lacy M., Miley G., Chambers K., Saunders R., 1994, A &A, **108**, 79.

Solomon P. M., Downes D., Radford S. J.E., 1992, ApJ, **398**, L29.

van Ojik R., Röttgering H., Miley G., Bremer M., Macchetto F., Chambers K., 1994, A &A, **289**, 54.

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Tim Jenness & John Sleath / MRAO Cambridge / UK
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First Heterodyne Lunar Occultation with the JCMT

During EAC time on 16th December, some UKIRT observers mentioned that they were out to study a lunar occultation of T-Tauri. It happened that we were in the process of testing DAS rastering, which is well suited to the relatively fast observing required for occultations. However, it was unclear how useful the results would be when a very bright continuum source (the lunar limb) passed through the beam. To check out the method, we decided to give it a try. The whole event only lasted about 1 minute, so timing was, not surprisingly, rather critical.

Of course, despite several successful test runs, a minor operational oversight required a complete reload of the software just 10 minutes before disappearance. Apparently this is a perfectly normal occurrence during such events!

Image not available yet

Figure 1. Disappearance of the CO (J=3-2) line in T Tauri during occultation by the Moon.

After a few minutes of panic, we started a successful series of cycles at 03:04:13 HST, about 1 minute before the event. The re-emergence was also captured about 1 hour later.

The Figures show the results of (a) the disappearance and (b) re-appearance of the CO J=3-2 line. The plots show lsr velocity (km/s) along the y-axis and time along the x-axis (NB: increasing to the left). The x scale is 0.1 units per integration cycle, each cycle being 5 seconds, or equivalent to 1.3 arcsecs of lunar movement. The total x scale corresponds to 150 seconds of time. Structure along the x-axis which is smooth on a scale of about 1.0 units must be greater or equal to the JCMT beam size. Smaller scale structure (*i.e.* 1-5 arcseconds) will show up as sharp edges in the time-direction at the appropriate velocity. The spectra have just had linear baselines subtracted; we found this was adequate to remove the effects of the lunar continuum.

We have compared these results with Weintraub *et al.* (1989, ApJ). They interpreted their interferometric CO J=1-0 data as a rotating disc of size ~5 arcsec. Its E-W orientation meant that it should have been detectable in our data as a velocity shift just before the Moon covered the source. However, there is no compelling evidence for this structure in the Figures. One possible explanation is that most CO J=3-2 emission is from optically thick gas at large radii and not from the compact disc.

Image not available yet

Figure 2. Re-appearance of the CO (J=3-2) line in T Tauri after occultation by the Moon.

Thanks to Andy Longmore for providing accurate times of the events, to Mary Fuka and Hans van Someren-Greve for the DAS rastering software, and to Alan Hatakeyama for hitting the <Return> key at the right times.

Bill Dent & Iain Coulson / JAC

The L1582B outflow -- A 5 parsec long molecular superjet

The picture on the front cover of the Newsletter (RNO43 - 1.8Mbyte Postscript file) is a CO J=2-1 map of the bipolar outflow associated with RNO43 in the L1582B dark cloud. As shown by the scale bar, this outflow (which is nearly in the plane of the sky) is at least 4 pc long, and we are not entirely confident that we have yet covered the full extent of the source. In fact this outflow shows a number of other remarkable features, and here we draw attention to some of them.

Optical emission

This outflow source is one of a select few that show both collimated molecular outflow and also optical emission associated with a so-called 'optical jet' (others that spring to mind are HH46-47, HH111 and perhaps NGC 1333, but the number *is* increasing steadily.) In the picture on the front cover the Ha optical emission is overlaid on the CO map. Since the Ha emission is generally thought to be indicative of shocks at a velocity of at least several tens of km/s, this seems like excellent evidence for a molecular outflow driven *directly* by the optical jet. The picture we have in mind is of a highly collimated, mostly neutral jet, which is ejected from the unseen star at a speed of about 300 km/s. As the jet propagates through the surrounding cloud it generates the familiar 2-shock structure: since the shocks are highly radiative the shocked material cools rapidly into a dense swept-up shell, which then generates the observed optical emission. As the shell cools further and continues to expand away from the jet it sweeps up molecular material, which forms the observed CO outflow.

Highly collimated CO bowshocks

In the past it has been common to interpret similar pictures, in H2 S(1) for example, as lumps or instabilities in a rather poorly collimated outflow. Here the overall north-south symmetry, and the association of collimated optical emission with individual regions of excited CO, persuade us that in fact each of these excited regions is itself a separate bowshock.

In fact there is lots of less circumstantial evidence that this is the case. In particular, position-velocity diagrams along the axes joining the individual regions to the supposed exciting source all show patterns characteristic of those expected from prompt entrainment in the working surface of a highly supersonic jet. But if this is the case, then the collimation of the CO outflow is really *very* high, and we need to invoke a fairly rapid variation in the original jet direction to explain the spread in the position angles. The overall 'envelope' of the emission appears to be biconical, with an opening angle of 20 degrees, and we are investigating mechanisms which might produce this 'precession' -- currently torques exerted by a binary companion look very promising. It is interesting to note that the velocity widths at the bowshocks are highest towards the centre of the apparent cone, where the jet lies closest to the line-of-sight, and symmetrically less at the outer edges.

Bullets?

We have avoided this term so far. But one remarkable feature of the CO map is just how lumpy the outflow is. Channel maps show that there are very high velocity features associated with each of the bowshocks, and that the CO excitation is high there. So it looks as though, with further observations, these bowshocks will turn out to be rather similar to the 'bullets' claimed in sources such as L1448 and Orion-S. On the other hand, there doesn't appear to be any need to hypothesise that these are semi-solid lumps expelled from the central source. All that is necessary -- as shown by Alex Raga and collaborators in the UK, and numerically by Stone and Norman in the US -- is for a slight modulation of the basic jet, either in density or velocity. Internal working surfaces (shocks) then rapidly form downstream, in the jet as stuff piles up non-linearly at particular places. Add in precession, and you have a recipe for something very similar to that observed.

It is worth noting that the tails of individual CO bow shocks don't extend all the way back to the source. In our model this is a consequence of the relatively short cooling time for the hot molecular material: assuming a velocity of 300 km/s and a distance of 450 parsec the 150 arcsec tail corresponds to a cooling time of only 1000 years, which is much less than the dynamical timescale. The observed hotspots are therefore the sites of *current* interaction between jet-fragments and the ambient cloud. It looks as though the jet fragment is rather denser than the environment, and therefore should appear to move with something like the true jet speed. Which all fits in rather well with the Ha proper motions for the three regions where they have been measured.

The Inner Region

The inner region has been mapped with almost full sampling (a luxury otherwise denied to us -- until very recently -- because of the overheads on single-point observations), as shown in the blow-up on the cover. To those of us conditioned by years in the company of extragalactic radio astronomers, this is the spitting image of Cygnus-A, right down to the hot-spots and the essentially unresolved jet symmetrically joining the two lobes.

Numerical modelling shows that the nice fluffy cocoons that you see around the bowshocks in Cygnus, as in most extragalactic sources, result from the interaction of an *underdense* jet with the surrounding medium when the cooling time scale is *long* with respect to the dynamical time. We argued above for a (molecular) cooling time of around a 1000 years, and since this is about the same as the dynamical timescale of the 'inner' outflow, this also seems fairly reasonable. Richer *et al.* hypothesised that for NGC 2024, the jet in the inner regions of the source is less dense than the surrounding cloud, and perhaps the same is true here; presumably the cloud density falls off fairly rapidly away from the FIR source, but this is something that can be fairly readily checked.

And now?

Whatever the final extent of the L1582B outflow may prove to be, it is clear already that it has managed to shock a very large volume of its parent cloud, and that the cloud retains a memory of this shock, in the form of broadened lines, long after any particular shock has passed by. So indeed it looks as though outflows can do a lot to keep the ISM stirred up.

The case for the molecular outflow being driven directly by the optical jet is so strong in this source that we really have to ask if other mechanisms are *necessary*. We could, with some confidence, turn the usual argument on its head, and claim that we can *determine* the momentum flux in the optical jet from observations of the swept-up molecular gas. The number is clearly bigger than has hitherto been assumed. It seems to be time to forget about looking for the driving sources of molecular outflows, and to concentrate on seeking mechanisms for driving the optical jets.

Stephen Bence, John Richer & Rachael Padman / MRAO Cambridge

Shoemaker-Levy 9 lives on in the atmosphere of Jupiter

Just about the time the previous issue of the JCMT Newsletter was due to go to press, in mid-July 1994, comet Shoemaker-Levy 9 obligingly collided with the atmosphere of Jupiter. This event was predicted a year in advance, when the comet was discovered in orbit around the giant planet, so that the JCMT and essentially every other telescope in the world was able to plan to observe the event. This was not in fact just a single 'event', but a bombardment stretched over a week in time; the comet had been torn apart in a previous close encounter with Jupiter, and was strung out along its orbit like 'a string of pearls'. It was fortunate for the Mauna Kea telescopes that this was so, because, as was noted in the August 1994 Newsletter, the weather was atrocious during this week there being one hurricane and a tropical storm passing by. A single event might have been cancelled due to poor weather.

Image not available yet

Figure 1. A typical aspect of Jupiter's disk during the past six months. North is up, East is left. This sketch includes the comet impact sites visible on July 20 1994 at 3:00 UT. For comparison the beam of the JCMT at 354 GHz is 14", rather less than the semi-diameter.

As it was the cometary fragments came into Jupiter's atmosphere one after another like beads on a wire, impacting in much the same place relative to the Earth-Jupiter line-of-sight, just behind the south-eastern limb. Within an hour of impact each site was clearly visible as the planet rotated. Even before this, optical and infrared telescopes were able to see the fireballs peeking over the limb, as hot gases were ejected into the stratosphere of the planet from the tunnel driven deep into the lower layers of the atmosphere by each fragment. However, while most of the visually exciting effects were recorded by CCD's and on film, Jupiter soon after became a day-time object, leaving the field to the radio telescopes. And now, as Jupiter once again can be seen at night, and the impact sites are much less visible, it also turns out that the most long-lasting effects are likely also to be those which can be seen by radio telescopes.

For orientation purposes, the sketch in Figure 1 shows a typical face of Jupiter as presented to Earth during the July 1994 observations and, with only slight changes, throughout the follow-up observations described here. The apparent diameter of Jupiter is somewhat smaller than it was last July, now typically 33". The collisions of the comet fragments took place just behind the south-east limb (lower left in Figure 1), and 'rose' shortly afterward. Thus gas from the collisions was observed approaching the Earth (blue- shifted with respect to the mean velocity of Jupiter) in the south-east. Some eight hours later a given point 'sets' at the south-west limb, with a corresponding receding velocity. The relative red- and blue-shifts are about ą 8 km/sec respectively.

From the beginning of the international Jupiter/SL-9 campaign the decision was taken to use the JCMT to concentrate on observations of the HCN molecule, mostly of the J=4-3 ground-state rotational transition at 354 GHz. Under truly desperate atmospheric conditions we retreated to the J=3-2 line at 265 GHz. Observations of CO were to be carried out by IRAM, since HCN could not be covered by IRAM's receivers, and this seemed like a fair division of the labour. Nobody knew what to expect actually; no molecules had been detected in the radio-mm-submm regions in the atmosphere of Jupiter hitherto. However, many molecules, such as H_3^+, CH_4^+ and other hydrocarbons, NH_3 and PH_3, were already well known in the near and middle infrared.

So it was an occasion for rejoicing (as far as sleep-deprived astronomers will allow it) when a clear HCN(4-3) line was seen in emission on July 16. Nobody knew what it meant, but we have not looked back since that time. At IRAM both CO and CS were also detected. On the premise that such molecules were being thrown into the stratosphere, and that there should be something to learn about chemistry and the origin of the species being observed, we continued afterwards sporadically to monitor the HCN lines. In fact the emission faded quickly, and when we next looked in August, there was nothing to be seen. Also, at this time, and throughout the fall the sky was mostly poor, and the quality of the data were not very good as a result. Nevertheless, observations were continued, making use of the kind efforts of various visiting observers and local staff staying after formal shift end. The Director JCMT gave his go-ahead to pre-empt other daytime observations at weekends.

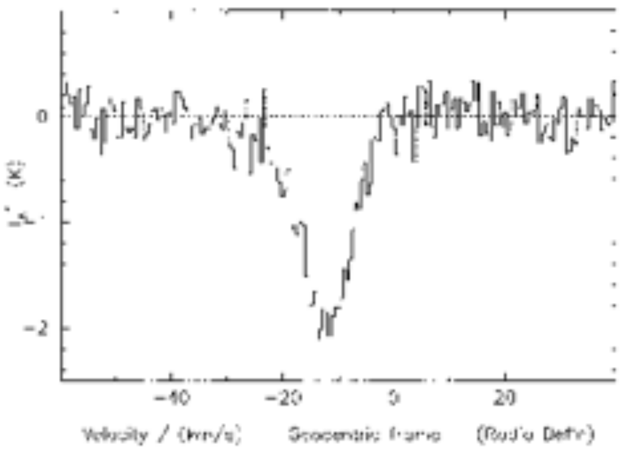

Figure 2. A typical (*i.e.* good) spectrum of the J=4-3 HCN line in absorption against the disk of Jupiter. This spectrum was taken on 21 December 1994 towards the impact site of one of the largest fragments (G), about an hour before the site's transit. A baselevel has been fitted to put the line profile at zero level; typically the true baselevel in such spectra is close to 100 K Ta* due to the background from Jupiter.

When we started looking at the data we saw that HCN was now in absorption. The implication was clear: that the hot gas which had been seen in emission had cooled enough that it was now colder than the background of Jupiter, and was now residing in a stratospheric haze layer. CO and CS could also be seen in absorption by IRAM. In fact the first tentative evidence of HCN absorption is in late August-early September, in data where the lines had been confused with baseline ripples. In between-times the lines must be very weak, and it is no surprise, given the sky conditions, that they could not be seen.

Since that time a more concerted effort to make use of late mornings to observe Jupiter has been made. We were (and still are) interested to know (a) how long HCN molecules could last before being destroyed, (b) how quickly they would migrate away the specific impact sites in longitude, (c) whether they would disperse in latitude, and (d) whether other species could be found in the haze. As far as we know the Jupiter-SL9 'event' (if it happened to Earth we might be less clinical about it, and we would need a bigger word, like 'catastrophe', or 'apocalypse') was unique. However, sightings of visual blemishes on Jupiter going back into early telescopic times has to make one wonder how often this does happen.

As this issue of the Newsletter goes to press, we can say that HCN is still there. However, it appears that CO has faded away, according to IRAM. We can also say that of the other species we have searched for, including H2S, HNC and H2CO, none have been detected. We know that there has been no appreciable north-south migration of HCN - we have done quite a few measurements of the 'anti-site' positions as controls. Although the beam of the JCMT (14" at 354 GHz) is a significant fraction of the size of Jupiter, it is possible to set limits on the width of the stratospheric band in latitude; it seems to be rather less than 7". As well, it looks as though the stratospheric haze is uniform in longitude on the scale of the beam; we are able to point at any part of the latitude zone and see HCN clearly within 5 minutes under decent sky conditions.

For a time in late 1994 the JCMT was the only telescope capable of observing Jupiter in the HCN lines, because of the planet's position in the daytime sky. In fact on December 17 the planet passed within about 20 arcmin of the limb of the Sun, and the following day very nice observations of HCN were made by Fred Baas just before local noon. As it has for solar observations, the fact that the JCMT has a membrane transparent to sub-mm waves in place during observing allows one to avoid damage, and to maintain excellent pointing and focus control.

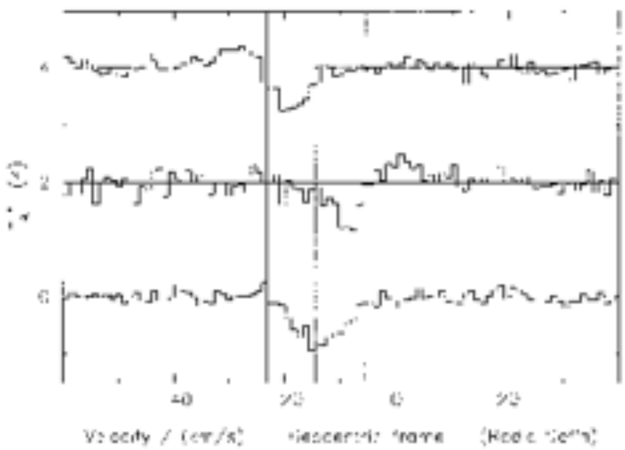

Figure 3. Observations of HCN(4-3) towards the East limb (top), West limb (middle) and middle of the southern impact zone (bottom) of Jupiter on 24 December. Towards the Eastern limb gas at and beyond the limb is approaching the observer; at the same time some absorption is picked up from less blueshifted seen against the disk of the planet. The two components partially cancel each other, and lead to apparently narrow line components. The opposite effect is seen on the (receding) western limb. On the meridian the usual absorption line is visible. Spectra intensities are normalised to a Jupiter background of 100 K.

Just when the monitoring of HCN was starting to become mundane, on the morning of December 21 Fred Baas obtained a rather strange result: a 'P-Cygni' profile towards the eastern limb. For the first time since July it seemed we were seeing emission in HCN, and first instincts said that this was an instrumental artefact. However, further thought suggested the following explanation: that while the absorption was as usual, cold gas seen against the disk of Jupiter, the emission was due to gas in the Jovian stratosphere seen projected against colder sky beyond the limb. The sense of the emission and absorption was consistent with this idea, and suggested that if one observed the other limb, the profile should be reversed.

An opportunity to test this naive explanation presented itself on Christmas eve, and Fred was again there as we obtained exactly the expected result, as shown in Figure 3.

Since this result, which continues to consistently repeat (for the HCN 3-2 line also), the same effect has been seen by IRAM in the CS(5-4) transition, and, looking more closely at our own data, it would seem to be present even as far back as September 2, when poor baselines were judged to be the cause. As for a serious model, we have some doubts about the naive explanation being the full story. The extreme velocities are not quite as we would expect. There is plenty to chew on in this material, and I expect it will take us some time to unravel it. Some insights should be gained at the DPS meeting in Baltimore in May.

For the moment however there are a few things we can say. First, the line widths of HCN (typically 8-10 km/s to half-power) are much greater than the thermal line widths expected anywhere in Jupiter's observable atmosphere. If the line width is due then to pressure broadening it fixes the altitude at which HCN is situated. Second, the observed cooling of the molecules would imply a substantial cooling of Jupiter's stratosphere due to material tossed up by the explosive impacts. Third, it seems likely that HCN was formed by shock chemistry in the impacts. Fourth, having lived for six months, HCN is probably shielded against photolysis by solar radiation by methane, and we have to look for other means for the eventual demise of HCN. We expect HCN to last for at least several months, and perhaps years. In the meantime it will be important to continue looking at HCN in Jupiter with the JCMT.

Reference:

"*The Collision of the Comet Shoemaker-Levy 9 with Jupiter: Detection and Evolution of HCN in the Stratosphere of the Planet*"; A. Marten, D. Gautier, T. Owen, M.J. Griffin, H.E. Matthews, D. Bocklee-Morvan, P. Colom, J. Crovisier, E. Lellouch, D.A. Naylor, G.R. Davis, G. Orton, I de Pater, S. Atreya, B. Han, D.B. Sanders, D. Strobel; submitted to Geophysical Research Letter (1995).

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