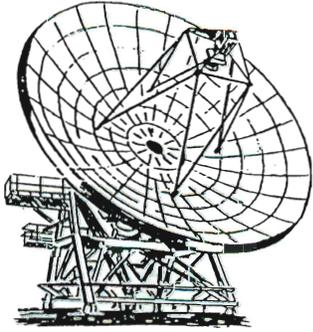
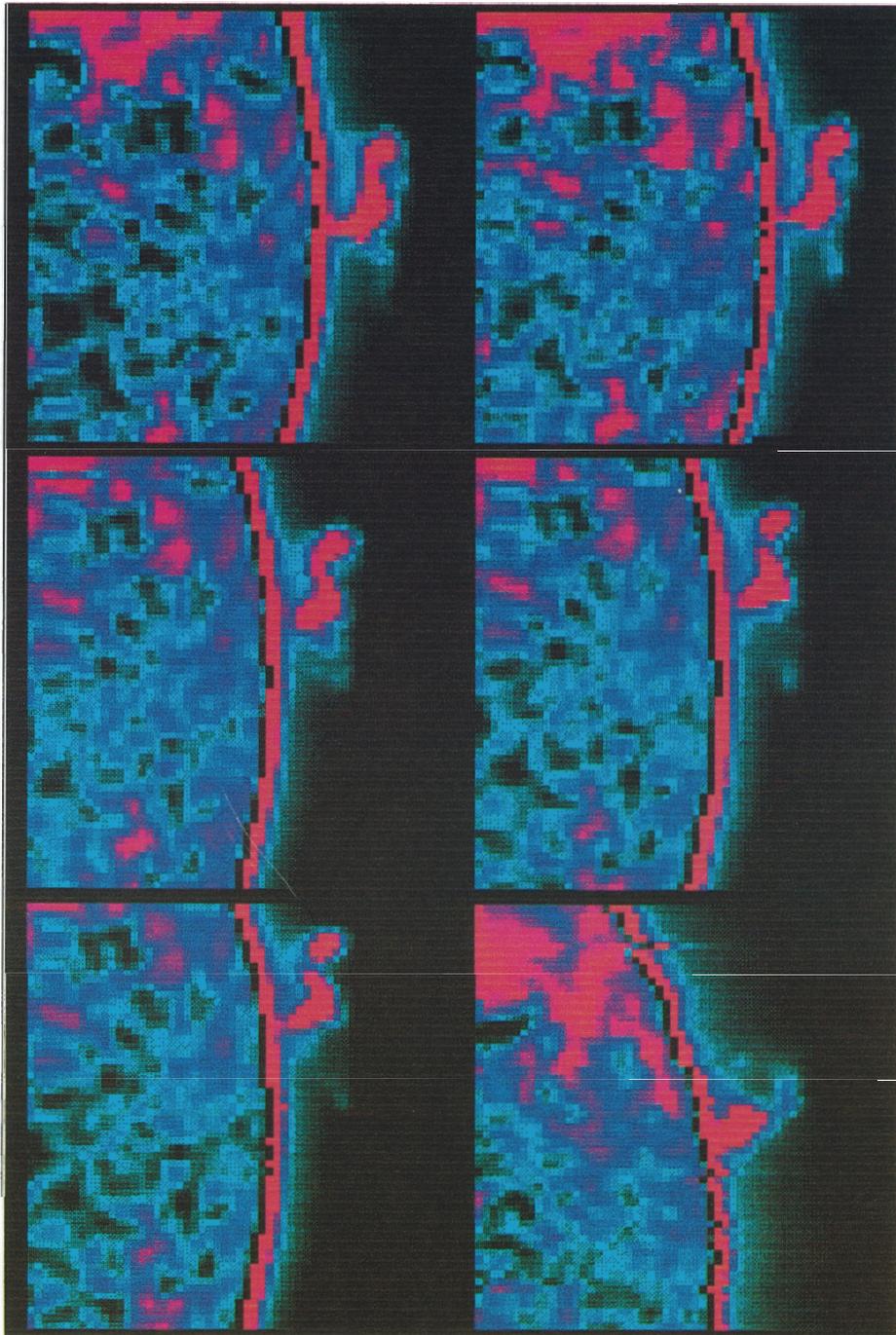
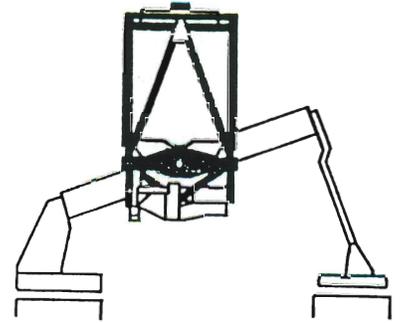


# The JCMT - UKIRT NEWSLETTER



Kūlia I Ka Nu‘U

Number 3 March 1992



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### Cover picture:

A sequence of 1.3 mm maps from JCMT observations of a solar prominence made before and after the total eclipse of 1991 July 11. This prominence, on the western limb, was identified during a rehearsal for the eclipse operation on July 10. The sequence, from left to right and top to bottom, shows maps taken at 18:43, 19:35, 19:59 and 20:18 UT on July 10, and at 19:12 UT on July 11 1991. See 'Millimetre wavelength observations of an active solar prominence' on page 30.

## News & Notes

### Recent publications

The following JCMT and UKIRT related publications were produced at ROE in 1991:

#### JCMT Annual Report 1990

#### JCMT Guide for the Prospective User (1991)

#### UKIRT Annual Report 1990

Copies of all three have been mailed to libraries; copies of the JCMT Annual Report and User Guide have been sent out on the JCMT mailing list; copies of the User guide have also been sent to some individual 'frequent users' and to part of the PATT mailing list. Bulk shipments of additional copies have been sent to the Joint Astronomy Centre in Hilo (all 3 publications), to Dr John McLeod at HIA in Canada and Dr Wim Brouw in the Netherlands (JCMT publications only). Copies may be obtained from them or from ROE (see 'Points of Contact' for addresses).

Note that the closing dates for PATT applications are now March 31 and September 30, not February & August as misquoted on the page of appendices in the JCMT User's Guide!

Please do not rip out the sample PATT form from the User's Guide; it has been amended, so please make sure you obtain copies of the current version to use for your applications.

The UKIRT Observers Manual was produced in April 1991 and circulated to most libraries. Further copies are available on request from the UKIRT Support Group at ROE.

### People

Jocelyn Bell Burnell left ROE to take up the Chair of Physics at the Open University, as from November 1 1991. The Open University (OU), at Milton Keynes, has about 70,000 students who study at home by distance-learning methods, using specially prepared textbooks, radio and TV broadcasts, home experiment kits, correspondence methods, and at summer schools. It has been in operation for ~ 20 years, and plans to expand to 100,000 students.

David Beattie is retiring from JAC in February; our best wishes go with him & Susan.

Jacques Vallée has returned to Canada from ROE.

Adrian Russell has returned to ROE as Head of the JCMT Receiver Programme.

Matt Mountain has moved from ROE to JAC.

Bob Stobie, Head of Hawaii Division at ROE, is to become Director of the South African Astronomical Observatory (SAAO) from 1 April 1992.

As a result of staff changes within ROE, Maureen McLean (UKIRT Support Group secretary) has moved to the Technology and Computing Division.

### Division Merger at ROE

The ROE Hawaii Division is merging with the Science Support Services Division (Schmidt plate library, Photolabs, COSMOS and Library sections), under a single head of Division, Ray Wolstencroft. Secretarial services for this new Astronomy Division will be provided by two part-time secretaries, Anne Bryans and Dorothy Skedd. In the first instance Dorothy will be the primary contact for UKIRT and JCMT enquiries.

### World Astronomy Days (WADs)

In connection with the world-wide activities associated with the International Space Year (ISY), the JCMT and UKIRT have been invited to join with many other observatories - ground-based and space - in simultaneous multi-spectral observations of astrophysical sources on World Astronomy Days (WADs). Possible fields of study include cataclysmic variables, hot stellar winds, X-ray binaries, active galactic nuclei, late type star flaring, comets and planets. Current planning envisages the WADs to occur in the periods 20-25 July and 15-19 December 1992 but the actual dates will depend on the projects proposed and the constraints of the participating observatories. The July slot is right at the end of Semester V which has already been fully allocated by PATT but time in the December slot can be applied for in the usual way in the forthcoming PATT round with an indication on the application if it is for a multi-frequency WAD project.

ESA has taken the lead in the organization of WADs with full support of the IAU at the 1991 General Assembly. Further information can be obtained from Willem Wamsteker (e-mail to WILSPA::SAFISY on SPAN).

## UKIRT News

### Farewell UKIRT Users Committee! Welcome UKIRT Programme Committee!

As part of a reorganization of SERC committees dealing with specific ground based telescopes the UKIRT Users' Committee (UUC) has been wound up after some 10 years and a UKIRT Programme Committee (UPC), with wider terms of reference (given below) has been formed. (In fact during the transition period the membership is the same as it was for UUC). It is now appropriate to thank all past members of the UUC for their help and advice in bringing UKIRT to its current eminent state.

The role of the UPC is an important one both in deciding the needs of UKIRT, trying to persuade other SERC Committees to provide, against strong competition, sufficient funds to meet these needs, and advising on strategies for the use of the resources that are available. The management of UKIRT of course remains the responsibility of ROE. In future UPC will also be addressing wider questions such as how best to use UKIRT when the Hawaii 8m Gemini telescope is operational.

The current chairman of the UPC is Jim Emerson from Queen Mary & Westfield College, University of London (E-mail JPE@STAR.QMW.AC.UK (Internet) or 19746::JPE (SPAN)). Other members are Peter Brand (Edinburgh), Bob Carswell (Cambridge), James Dunlop (Lancashire), George Miley (Leiden), Pat Roche (Oxford), Ray Sharples (Durham) and Martin Ward (Oxford and PATT UKIRT TAG chairman). UKIRT staff from Hawaii and ROE attend the twice yearly meetings at ROE, and provide invaluable advice and assistance.

Users of UKIRT, both from UK and overseas, are always welcome to contact any of the UPC to make suggestions as to future strategic or technical directions, suggested improvements or, if necessary, to complain or to say whatever they feel needs saying. The UPC members are hopefully aware of community feelings from talking to other users, from the reports we get from ROE staff, and from the contents of the observing report forms filled out by users after their runs which are available to the UPC members, but further inputs are always welcome. It is also intended to hold annual scientific symposia on science from UKIRT during which there will be sessions specifically set aside for discussions of future plans and directions with the users. The SERC recognizes that UKIRT is one of its most scientifically productive facilities and sets a high priority on continuing to exploit the considerable investments in money and expertise

that have been made to bring UKIRT to its current state of high scientific productivity. Contributions and ideas for how to continue and improve this are always welcome from any quarter. Let's hear from you the user soon !

*Jim Emerson,  
UPC Chairman  
30 Jan 1992*

### Terms of reference of the UKIRT Programme Committee (UPC)

1. The Programme Committee will:
  - 1.1 advise the Ground Based Programme Committee (GBPC) on the scientific programme for the United Kingdom Infrared Telescope (UKIRT) on Hawaii;
  - 1.2 advise the GBPC and the Director, ROE on the strategy for the scientific development and maintenance of instrumentation and associated enhancements for UKIRT;
  - 1.3 advise the Director, ROE and the GBPC on the overall strategy for the operation and exploitation of UKIRT including the application of remote observing;
  - 1.4 advise the Director, ROE on submissions to the GBPC for annual budgets and forward estimates for finance and manpower resources;
  - 1.5 consider such other matters as may be referred to it by the GBPC and bring to the attention of the Director, ROE or to GBPC, such other matters as may seem appropriate;
2. The Programme Committee will liaise regularly with appropriate bodies, in particular the UKIRT Time Allocation Group, and with the UKIRT user community.
3. The Programme Committee will meet at least twice a year, report regularly to the GBPC and approve, through the Director, ROE the UKIRT annual report.

## **Astronomical Infrared Spectroscopy Conference.**

A conference on the above topic will be held at the University of Calgary, Alberta, Canada from 16 - 19 June, 1992. Topics included in the programme so far are Laboratory Spectroscopy, the Solar System, Stellar Astrophysics and Calibration, Circumstellar Matter, Interstellar Medium and Extragalactic Sources. There will also be an emphasis on Future Observational Directions.

Confirmed invited speakers as of January 1992 include L.Allamandola, T.Amano, M.Barlow, P.Bernath, J.Bregman, M.Cohen, P. Cox, D.Cruickshank, L.d'Hendecourt, W.Duley, T.Geballe, T.Hasegawa, H.Kroto, C.Leung, J.-P.Maillard, G.Mitchell, A.Moorwood, A.Omont, Y.Pendleton, S.Sanford, Saykally (Berkeley), A.Sprague, G.Stacey, K.Volk and F. Witteborn.

The Scientific Organising Committee is Takayoshi Amano (Herzberg Institute of Astrophysics), Martin Cohen (U. of California, Berkeley), Marie Jourdain de Muizon (Sterrewacht Leiden), Tom Geballe (Joint Astronomy Centre), Sun Kwok (U. of Calgary), Robert Stencel (U. of Colorado). Andy Longmore (ROE) has just taken over from Matt Mountain as the UK member of the S.O.C.

The final scientific programme is still being put together and potential U.K. participants (speakers or other attendees) are invited to contact AJL at RESTAR (19889 on SPAN) for more information. A draft list of titles for the talks arranged so far will shortly be available. In particular, UKIRT users who already have CGS4 data are encouraged to use this forum to display any new exciting results! A limited amount of financial support may be available to help with travel or subsistence costs.

*Andy Longmore*  
ROE

## **New observing follow-up procedures for 1992**

From the beginning of 1992, UKIRT users who have had successful observing runs can expect to be contacted by ROE UKIRT scientists in the subsequent weeks and months, as part of an improved follow-up service. The aims of this are to identify early on the scientific highlights and to assist users with the reduction of their data. This will benefit all involved, by enabling data to be published as quickly as possible, by enabling effective exchange of information on reduction techniques, and by providing publicity for the users as well as for the UKIRT programme.

It is intended that the initial contact will be made by 'phone or e-mail a few weeks after the observing run, when users will be asked about the quality of the data obtained, whether any problems have been encountered with initial data reduction, and if they require any other assistance with data reduction or interpretation. This will provide users with a contact for any subsequent enquiries they may have. Further contacts will be made from time to time, to ensure that resulting publications can be monitored, and to identify any further scientific highlights.

*Phil James*  
ROE

## **A UKIRT Development Programme.**

Funding has been approved in the ROE Forward Look to continue running UKIRT as a developing telescope. This excellent news means that work can proceed on improvements to telescope imaging through enhancements to optics and better control of heat in the dome. It will enable us to make the best scientific use of new arrays to be installed in UKIRT's cameras and spectrometers. Matt Mountain, who has recently transferred to Hawaii, will be project scientist for the programme, taking over on 1 April from Tim Hawarden. Tim will continue to be involved in the programme but will now have some more time for other duties.

*Andy Longmore*  
ROE

## Expected availability of UKIRT instruments in Semester W (August 92 - January 93)

**UKT6** single channel 1-5 $\mu$ m photometer, 2.3-4.6 $\mu$ m CVF

**UKT8** single channel L', N, Q and narrow band 10 $\mu$ m photometer

**UKT9** single channel 1-5 $\mu$ m photometer, 1.35-2.6 $\mu$ m CVF

**UKT10** 2-banger, JHK

**UKT16** 8-banger; N, Q, 30 $\mu$ m and narrow band 10 $\mu$ m

**IRCAM** 58x62 array, JHK filters and various narrow band filters from 1.0 to 4.05 $\mu$ m; 0.6" per pixel (36" field of view), 1.2" (72"); 0.3" per pixel available using ambient-temperature 2X magnifier.

**CORONAGRAPH** A coronagraph for use with IRCAM is available, subject to the agreement of, and collaboration with, Dr. Ben Zuckerman of UCLA, who is its owner. Applicants should discuss any such proposals with Dr. Zuckerman before submission of the application.

**CGS3** 8-22 $\mu$ m grating spectrometer, 1x32 channels, resolving powers of ~60 or 200 at 10 $\mu$ m and ~75 at 20  $\mu$ m, 10 $\mu$ m spectropolarimetry. Beam sizes from 1" to 9" diameter. CGS3 must be mounted on the north or south port, and thus requires that either IRCAM or CGS4 is *off* the telescope.

**CGS4** 1-5 $\mu$ m grating and 2D array spectrometer (3" and 1.5" pixel sizes, 75 1/mm, 150 1/mm, and échelle gratings, ~90" slit). See special CGS4 notes below.

**VISPHOT** single channel visible B or V photometer, can be operated simultaneously with any of the above single channel instruments and with UKT10.

**MIRACLE** 10-20 $\mu$ m camera with 58x62 array and ~0.15" pixels. Permission to use the instrument must be granted by scientists at the Max Planck Institute, Garching, who are its owners, and may require that they be co-investigators. Proposals to PATT should verify that permission is granted. Contact Dr. Murray Cameron at the MPI for information on sensitivities and availability.

**IRPOL** 1-5 $\mu$ m polarimeter for IRCAM, UKT6, UKT9, CGS3, and CGS4. Note that the unvignetted field of view of IRCAM through IRPOL is ~35"; hence optimal usage of IRCAM+IRPOL is with 0.6" pixels. Commissioning of CGS4+IRPOL is expected to begin in Semester V and it is expected that shared risk programs will be viable in Semester W.

**FABRY PEROTS** - 2 $\mu$ m: 12, 25, 90 and 300 km/s resolutions; can be used with IRCAM, and UKT9; unvignetted field of view through IRCAM is ~60" diameter.

### Special Notes on CGS4:

Commissioning of CGS4's 150 1/mm grating is scheduled for February-March 1992 and observing with it is scheduled for March-May 1992. Commissioning of the long focal length camera (which doubles the resolving power of a given grating, halves the wavelength coverage, and halves the pixel size, from 3" to 1.5") is planned for June 1992, with observing scheduled for July.

Owing to the many combinations of gratings and camera focal lengths in CGS4, and the need to minimize the number of changeovers, which require considerable effort and at least two weeks of down time, some configurations may be avoided during certain semesters, while others may be scheduled during limited periods (at some inconvenience to some observers). It is expected that the CGS4 configurations to be used during Semester W will be advertised to the community one month before the proposal deadline.

Potential applicants for CGS4 programs should note any future updates on CGS4 performance and availability. If more than one CGS4 configuration is acceptable to the applicant, he/she should indicate this on the proposal.

*Tom Geballe*  
*Associate Director UKIRT*  
*January 15, 1991*

## MICHELLE, a future 10-20 $\mu$ m cooled grating spectrometer for UKIRT

Right from the start, UKIRT's design was optimised for making observations in the thermal infrared, that region of the spectrum beyond 3  $\mu$ m or so, where the heat given off by the structure of the telescope itself dominates the signal seen by a camera or spectrometer. The two windows of good atmospheric transmission in the heart of the thermal infrared, at around 10 and 20  $\mu$ m, allow the study of a wide range of phenomena inaccessible by other means, from the narrow emission lines of hot ionised gas swirling about the centre of our own and nearby galaxies to the warm dust cocooning newly formed stars.

MICHELLE is a long slit échelle spectrometer which will explore the 10 and 20  $\mu$ m windows. Building on the experience gained at ROE with CGS4, and extending its basic design into the technically even more challenging field of the mid-infrared, MICHELLE will make a range of spectral resolving powers available to the astronomer, using an automated grating exchange mechanism. This will allow broad band line surveys to be followed up within minutes by velocity mapping at a resolution of fifteen km/sec. The most commonly used slit will be 1 arcsecond wide by 100 arcseconds long on the sky, with a cryogenic slit rotation and exchange mechanism to allow alternative slits to be selected by the observer.

Other technical problems posed by the construction of MICHELLE include the need to read out the images recorded by its array detector several hundred times each second, to avoid saturation by background radiation. The development of capable array readout electronics forms part of the ALICE project currently under way at ROE, and discussed elsewhere in this Newsletter.

*Alistair Glasse  
UKIRT  
ROE*

## ALICE

ALICE is an acronym for Array-Limited Infrared Control Environment. The immediate aim of the ALICE project is to upgrade IRCAM and CGS4 for operation with 256 x 256 pixel arrays, although in the longer term ALICE will also be capable of driving mid-IR arrays.

The first of our new InSb arrays will be installed in IRCAM3 at ROE and shipment to UKIRT is planned for the end of 1992. It will replace the current infrared cameras (IRCAMs 1 and 2) for PATT use after Semester W. IRCAM3 will operate across the whole near-IR (1-5  $\mu$ m) regime with a pixel scale of 0.3 arcsec/pixel giving an unvignetted field of view of 1.3 x 1.3 arcmin. To operate efficiently at 4-5 $\mu$ m, and to make substantial gains in sensitivity via non-destructive read-out at shorter wavelengths, extensive use is made of transputers both for array control and for data acquisition. This scheme will permit read-out of the array at rates in excess of 75 frames/s, and faster for sub-areas. The initial (Mk I) version of ALICE, for use with IRCAM3, will operate in both STARE and CHOP modes (including direct control of the chopping secondary). Subsequent modifications will be made to enable real-time shift-and-add of images at rates fast enough not only to correct for guiding errors and windbounce but also to 'freeze' the seeing, as well as a snapshot mode for rapid storage of individual frames. Warm magnifiers will also be available to provide image scales of about 0.15 and 0.03 arcsec/pixel.

Upgrade of CGS4 to operation with a 256 x 256 array and ALICE (an exact copy of that for IRCAM3 control) will take place shortly thereafter. This modification will increase both the spatial and spectral resolution by roughly a factor of two (pixel sizes of 0.75 or 1.5 arcsec along the slit; R=40,000 with the échelle + long focal length camera, and R=800 with 75 l/mm grating + 150 mm camera, for example) as well as doubling the wavelength coverage at a single grating position.

Further information can be obtained from Phil Puxley (ALICE project scientist; REVAD::PJP) or Alan Pickup (ALICE project manager; REVAD::DAP).

*Phil Puxley  
UKIRT  
ROE*

## UKIRT Service Observing

Just a reminder that the UKIRT service observing programme provides the opportunity to have short (about 2 hour) observations made on your behalf by UKIRT staff astronomers. If you are not familiar with the programme then please read the appropriate section in the UKIRTINFORM electronic help system, read the files DISK\$USER3:[UKIRTSERV]UKIRTSERV.OBS and [UKIRTSERV]UKIRTSERV.HOW on the ROE STARLINK VAX, or e-mail your questions to UKIRTSERV at ROE. If you would like to be put on our mailing list and receive details of schedules, deadlines and instrument availability send your e-mail address to UKIRTSERV on the ROE STARLINK VAX (UK.AC.ROE. STAR).

Please remember to tell us if you complete your observation during a normal PATT run, or wish to withdraw it for other reasons, so we can delete it from our target list. Also we would be pleased to know when and where you publish your data, so we can keep our files up to date.

### Schedule for Semester V

The preliminary schedule for Service observing in Semester V is as follows. Don't forget that late changes of dates and instruments are possible. Applications may be submitted at any time, reminders will be issued from time to time.

Date (Hawaii)	Instrument
Feb 17-18	CGS3, UKT8, UKT9
Mar 17-19	IRCAM 1.2, UKT8, UKT9
Apr 27	IRCAM 0.6, CGS4
May 4	CGS4, UKT8, UKT9
Jun 15	CGS3, IRCAM 0.6
Jul 21	CGS4, UKT9, IRCAM 0.6

A number of old programmes have been deleted from the target lists. If you have a project more than two years old, and have not replied to my requests for a report on its status, you should contact UKIRTSERV if you wish the project to remain in the programme.

### Report on Semesters T and U

Seven nights were scheduled for service in Semester U and at this writing five have taken place. The remainder will occur while the Newsletter is 'in press'. Since the last Newsletter, 42 service applications have been received, taking the total over the years to more than 600. The

recent applications were graded as follows: 15 A, 15 AB, 7 B and 5 reject.

Conditions during the remainder of Semester T and the first part of Semester U were quite good and a total of 42 programmes were attempted. Of these 6 were ongoing monitoring, 27 were completed and 9 were partly completed.

This period saw the first use of CGS4 for service observing and although, at least for the moment, CGS4 observations are being restricted to fairly bright point sources, several useful results have been obtained. These have included a spectrum of Cyg X-3 (reported elsewhere) and observations of Neptune's satellite Triton which revealed a large number of features.

CGS 3 has also been put to good use during service, recording spectra of asteroids for comparison with data taken by another instrument and observing standard stars as part of a programme to help tie down the absolute flux calibration of these stars. CGS 3 data were also used by a group at Keele interested in modelling the carbon rich RV Tauri star AC Her and a paper has been submitted to Astronomy and Astrophysics.

IRCAM data, taken during last year's service programme, has been used by C O'Dea and others to produce K images of three GHz-peaked-spectrum radio sources and these were presented at the conference "Testing the AGN paradigm" in Maryland last October. IRCAM was also used for two programmes connected with the variable X-ray source Cygnus X-3. One of these was a simple monitoring programme to check for variability in a recently discovered nearby star whose presence was unsuspected during photometric observations of Cyg X-3 in earlier years; the other was to monitor the source during an outburst in autumn 1991.

Please keep news of your publications coming to UKIRTSERV so we can monitor the productivity of the programme.

In what may be the first of a number of ISO related proposals UKT9 and IRCAM were used to refine the positions and near infrared fluxes for a number of IRAS LRS sources which appear on the target list for the ISO core programme.

Observers and TOs who obtained data for service users included Joel Aycock, Colin Aspin, Mark Casali, John Davies, Tom Geballe, Dolores

Walther and Thor Wold. Kevin Krisciunas assisted with data reduction. Thanks to all of them and to our assessors.

*John Davies*  
ROE

## Service observations of $\alpha$ Tau for asteroids

On November 9th, 1991 the UKIRT Service Observing team obtained a series of important spectra for determining the surface composition of airless bodies like the Moon, Mercury and asteroids. These observations, made for A. Sprague, R. Kozlowski and J. Davies with CGS3 at  $\Delta\lambda/\lambda=0.05$  resolution setting, unambiguously showed the smooth character of Alpha Tau from 9.0 to 13.0 micrometers. In addition low resolution spectra of the highest quality show the deep Si-O absorption feature centered at 8.0 micrometers present in the spectrum of Alpha Tau. Because Alpha Tau is often used as a calibration star for observations in the mid-infrared (7.5 - 13.5 micrometers) these measurements contributed significantly to improvement in the understanding and interpreting of mid-infrared spectra from the Moon, Mercury and asteroids. Obtained on the same night were spectra from 29 Amphitrite and 10 Hygeia. These are to be compared with spectra of the same objects obtained by Sprague, Kozlowski, Witteborn and Cruikshank with the high resolution faint object grating spectrometer (HIFOGS) built by Fred Witteborn at NASA Ames. We are extremely pleased with the spectra and the help and consideration that the UKIRT observers provided with this service program.

*Ann L. Sprague*  
Goddard Space Flight Center

## Remote Observing with UKIRT

Remote observing is available with UKIRT from any suitable site (see below) in the UK. All UKIRT instruments except CGS4 may be used. The manual "Remote Observing with JCMT and UKIRT" is available on request.

The remote observing system is very easy to use. A remote observer (RO) logs on to one of the remote-observing usernames at UKIRT and selects from a menu which of the observing screens he/she wants to see. Usually the RO has a separate login for each screen, although it is also possible to swap between screens from a single login. There are mechanisms for file transfers and for communications with people at the telescope.

Remote observing may be passive, when the RO watches progress at the telescope but does not control any of the observations, or active, when the RO can also control the observations. Both passive and active observing require authorisation; active observing will certainly be more restricted.

The 56 kbit/sec dedicated line from ROE to JACH and the telescopes is available for remote observing and general network connections from ROE and from Starlink and Janet nodes throughout the UK. First-time ROs are advised to travel to ROE, where there is a well-equipped remote observing room and support staff are available; subsequently they may be content to use their local computer facilities.

Two compressed voice channels, each of 2.4 kbit/sec, now operate across the dedicated line, connecting the PABXs at ROE and JACH. (A conventional phone call requires 64 kbit/sec). The quality of the channels is satisfactory, but with such a large compression some losses are inevitable. Calls can be routed from JACH to the telescopes, but this final stage is at present resulting in a more serious loss of quality; work is continuing to improve this. These two voice channels should soon be accessible to ROs at sites other than ROE for the cost of a normal phone call to ROE.

Images from the UKIRT acquisition TV are now available.

Observers are encouraged to participate in remote observing with UKIRT. Remote observing allows collaborators to participate even with the current restrictions on SERC travel funds. PATT is identifying UKIRT projects suitable for a remote observer with a support scientist at the telescope.

Potential remote observers should contact me for further details of the facility. To use the facilities for a specific observing run, users should initially contact John Davies (JKD) in the UKIRT support group, who will arrange authorization and support.

*Roger Clowes*

Starlink: REVAD::RGC  
Janet: RGC @ UK.AC.ROE.STARLINK  
SPAN: REVAD::RGC or 19889::RGC  
Internet: RGC @ STARLINK.ROE.AC.UK

## Remote Observing - a user's view

Given the choice of Edinburgh or Hawaii it's not difficult to guess which my collaborator chose, which is why I found myself remote observing from ROE in January. I was a distinctly reluctant remote observer but, having sampled what is on offer, I am becoming converted, and it might be of interest to know what changed my mind.

Firstly, what is remote observing like? I was given a quiet room to myself in ROE, with a couple of workstations and terminals for my exclusive use. One workstation was used to display the continually updated telescope status, instrument status and control screens - basically all the information available to an observer at the telescope. The second workstation enabled fast reduction and display of our data using any of the standard software packages available on STARLINK (you can also import your favourite from your home node). There was another terminal for e-mail to the observer in Hawaii, logging on at UKIRT or copying across data files, and there are two outside phone lines. Data are accessible as soon as they are written to disk at UKIRT; I could pull fresh IRCAM mosaics across to ROE in a few minutes.

I encountered a few minor hitches during data reduction and analysis - maybe partly due to my unfamiliarity with the system - but I suspect these are just teething troubles which will be solved as more users attempt unpremeditated methods of data reduction. I was observing over the holiday weekend [Hogmanay...ed.] so quick fixes weren't always available, but they may be for remote observers under more normal circumstances. In all, any problems I encountered were comparatively trivial and I was pleasantly impressed with the system provided. The link to the telescope instruments seemed robust during four nights of

hectic observing, so my main fears of only intermittent contact with UKIRT weren't realised.

One frustration was that when things were going wrong at the telescope the T.O. and observer were usually busy and I often didn't have a clue what was going on. This is the last moment when anyone at the telescope will consider reading their e-mail or talking on the telephone, but it is an occasion when an experienced remote observer might be of most use. These communications problems could be solved with some kind of intercom, which I would like to see even when things are going well. [We're working on this ..Ed]. There is an implicit problem here: it's very easy to ignore the remote observer if you're at the telescope. No-one really likes a back-seat driver, and I'm sure I wouldn't be so enthusiastic about the idea had I been the direct observer!

There are a lot of positive points about remote observing, and I'll list what I felt were most relevant. First of all, you feel MUCH more involved in the observing - this is particularly important given the recent decision of SERC to only fund one observer to travel to the telescope. Remote observing also allows interaction between collaborators about the project from two different but complementary perspectives (the remote observer is at sea level and only 2 hours out of their usual day, yet is not directly tuned in to what's happening at the mountain top). The remote observer is sufficiently detached to give strategic reminders of things that might get missed in end-of-night exhaustion and can assess the need for calibrations or exposure times directly from the data. I was able to give direct feedback about signal-to-noise ratios, possible saturation of images, estimates of further observing time needed to get best results, and to comment directly on the linearity of the darks, any dark current drift, ghosting of the standard stars etc. This enabled us to perform sensible calibrations - often these problems only become evident when you get home to begin the analysis of the data, and by then it's too late. Each night I was able to spot something that would otherwise have cost us some time. Most importantly, I felt an equal partner in the observations taken, and feel that their quality has been substantially improved by my involvement.

Indeed, remote observing is an excellent way for more than one person to learn about using the instrument and telescope, experience that only my colleague would have otherwise had. It is also a lot more convenient to travel to ROE - let alone observe from your home node - and this weighs

heavily in its favour. It might be particularly relevant for observers with term-time commitments who would not otherwise be able to observe.

I arrived with a very sceptical view of the worth of the exercise, regarding myself as having drawn the short straw compared to the REAL thing, but I have been delighted both with the contribution I could make to the observations, and the sense of involvement achieved with so little effort. I would certainly like to repeat the exercise and would probably be keen on returning to ROE to do so, despite having so familiarised myself with the system this time that I could attempt to run it from my home node. Factors in this decision include the dedicated vaxstations in a peaceful room, the advice readily available from both the support astronomer and other staff at ROE, and the interest everyone seems to have in seeing this system work at its best. It can help to be away from home distractions if one is to be serious about remote observing, but if it's cloudy, REVAD is still convenient to continue work on your home node.

So, next time you have observing time on UKIRT, suggest your colleague goes to Hawaii. She/he may enjoy the fantastic panorama from Mauna Kea, but the view from Blackford Hill isn't so bad.

*Carolyn Crawford  
Institute of Astronomy, Cambridge*

## Remote Observing - another user's view

Although most observers might concede that remote observing can save time and money, I share the commonly held view that its application may be suitable for other observers' programmes but not necessarily for my own. I'm sure that this is at least partly due to the fact that the novelty of travelling to exotic locations has not yet worn off, so the delight of having a UKIRT long-term proposal for observation of Earth-crossing asteroids accepted was tempered by some misgivings at being awarded 'only' remote observation time.

The planned observations were of simultaneous visual and infrared photometry to determine albedo, diameter, rotation period and the nature of the surfaces of individual Earth-crossing asteroids among a known population of around 150. Since they have only rare close encounters with the Earth, the requirement was for short runs (~ 2 nights, or often part nights) at infrequent intervals with the possibility of newly discovered objects

being scheduled at short notice, this may be regarded as a suitable programme for remote observations. However, the special requirements of locating faint fast-moving objects, often at low elevation, without the observer seeing the finder field, caused some concern.

The first attempt at remote observing on this programme was made in August by myself and John Davies from ROE, where the full remote facilities, including the most important aspect, the men who knew how it worked, were available. Unfortunately, instrument problems unconnected with remote observing developed and these were solved just at the moment that a hurricane came in, washing out the run.

Shortly afterwards 1991EE, a newly discovered Apollo asteroid, made a close approach, and two half nights were scheduled for September. This time the observations were made directly from Kent and went fairly well because the support astronomer and telescope operator (Tom Geballe and Thor Wold) kept me informed of what was going on using VMS phone. However the local network links were not as reliable as they should have been, and I was cut off twice during the run. The observers kept going but I had no idea what was happening until I was offered an alternative route by my friendly site manager.

The problem of keeping good communication is the biggest drawback for remote observing at the moment. Using e-mail takes time and causes difficulties for those at the telescope since the times when they are most busy are just the times when the remote observer wants to know what is happening. There is nothing more frustrating than to see everything go dead on the monitor displays and not know what is going on.

My run, essentially performing simple photometry, was fairly well suited to remote observing since I could see the quality of the data and make judgements, but I can't comment on how successful it would have been for an imaging programme. In summary, my first experiences of the full remote observing programme were, with reservations, positive (but I still would prefer to go there!).

*Simon Green  
University of Kent at Canterbury*

## Successful Commissioning of Receiver B3i

The story of last November's commissioning run of Receiver B3i at the JCMT is one of those which has an inauspicious beginning but a happy ending. The moral of this story, I suppose, is that Truth, Justice and the Pursuit of Knowledge will always triumph over Customs Regulations, Over-Loaded Airplanes and Missed Connections.

Receiver B3i was built as a collaboration between NRC's Herzberg Institute of Astrophysics, the Rutherford Appleton Laboratory and the University of Kent. Although there was some overlap of effort in its construction, the rough division of responsibilities was such that the SIS detector was produced at Kent, the design and construction of the mixer block and optical components were carried out at RAL, while the design and construction of the local oscillator and the microprocessor-driven control system were done at HIA where the overall assembly of the receiver also took place.

B3i is a heterodyne receiver with a lead-alloy SIS detector. It is intended to cover the important observing window centred on the 345 GHz  $J=3-2$  line of CO. The receiver is single-channel and does not have a sideband rejection filter, so that spectra taken with it have superimposed upper and lower sideband features. The IF is 1.5 GHz which means that the sidebands are separated by 3 GHz. Calibration is achieved by means of a chopper which permits the receiver to look at sky, ambient and cold loads.

The commissioning story begins on Monday October 28, 1991 when B3i and its retinue of electronic and test equipment, resplendent in seven large, yellow, wooden crates plastered with FRAGILE stickers and TILT-DETECTOR labels, left the shipping dock of HIA's laboratory in Ottawa. The plan was simple. A "worldwide courier for time-sensitive parcels large and small" had been chosen to ensure rapid, direct delivery from Ottawa to Honolulu, where our experienced broker had been alerted to whisk it through customs and, thence, to expedite the short hop to the JAC in Hilo. In allowing 12 days for shipment, our goal was to ensure that the receiver would arrive in Hilo, for delivery to the mountain well before the long holiday week-end which started on November 9. As events transpired, it was a close call.

The first hint of trouble was a report from our courier that the shipment had missed the Honolulu flight out of Vancouver because there was no room on the airplane. But, not to worry - in an impressive display of initiative, the courier's agent had arranged to have the shipment trucked to Seattle where a United Airlines flight had been identified that would speed it on its way. The picture that leapt to mind was of an airplane, parked on the tarmac, engines revving, door open, awaiting the flashing red lights of the delivery van bearing the seven yellow crates.

But, what actually happened was that U.S. Customs agents at the border took one look at those seven crates, and allowed as how regulations required that all shipments entering the U.S. of A. should clear customs at the Port of Entry - namely Seattle. After prolonged inspection of the relevant Operations and Procedures Manuals, which contained no recommendations for processing an Rx B3i with a UKIRT destination code, the solution finally decided upon was to place the shipment "In Bond" (thereby delaying customs clearance until Honolulu), and send it on its way to that waiting airplane. But, then, more trouble. The United flight scheduled to leave Seattle for Honolulu had developed some mechanical difficulty (perhaps engine overheating due to prolonged revving?) and was cancelled.

The next news we received was that United had flown the crates to San Francisco. This caused some scratching of heads in Ottawa, because the address labels we had plastered liberally over all the crates clearly specified "Hilo via Honolulu". But there was some method in this apparent madness; the plan was to put the receiver on the next flight to Kona.

This remained the plan for the next several days as we read of heavy rain storms in California, and pictured our seven precious crates sitting on a rain-soaked tarmac in San Francisco, under a wind-blown, flapping tarpaulin. Finally, word came that our package was in the air, winging its way to the Big Island, thereby bypassing Honolulu and our by now, no doubt, thoroughly exasperated broker who would wait in vain to whisk it through customs. Oh, there would be one "slight" complication upon arrival in Kona; there is no Customs Office there, and incoming shipments cannot be cleared. This final hurdle was overcome by our resourceful

colleagues at the JAC who assured the appropriate officials that, "No, we really don't want the shipment sent back to San Francisco", and rented a bonded truck to deliver the much-travelled crates from Kona to Hilo, where they were cleared on November 6, just in time to be driven up to the JCMT on the 8th, as planned.

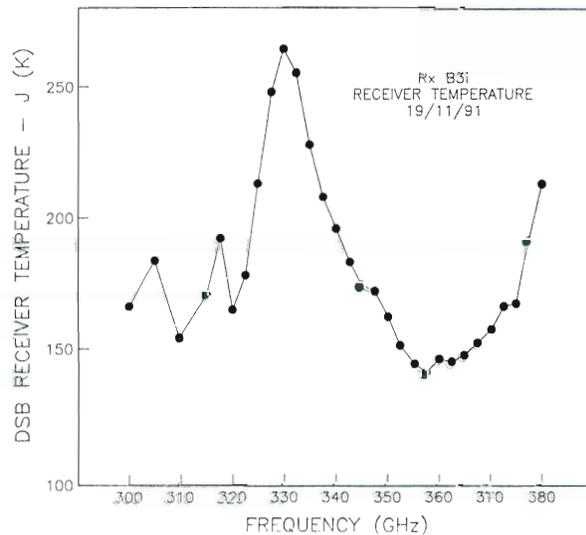
When the commissioning team arrived shortly thereafter and unpacked the crates, they found that the equipment had travelled surprisingly well in spite of the numerous unscheduled loadings and unloadings - a tribute to the yards of bubble-wrap and foam cushions used in packing. There was a single broken support strut inside the dewar which was replaced. Thereafter, things definitely started to go more smoothly as the receiver was assembled, tested in the prep room, and mounted in the receiver cabin, ready to go a couple of days before the scheduled start of commissioning on November 20.

First light was at 16:45 HST on November 20. The spectrum of the CO J = 3-2 line in G34.3 was carefully compared to one taken previously in the same source with Rx B2. The lines were the same strength! The calibration was correct! The receiver temperature was 161 K! Jubilation! Broad grins all around! The first-light spectrum was duly signed by all those present and FAXed down to HP where it was presented with a flourish to Paul Murdin, Malcom Smith and Richard Wade who were in the midst of dinner. Shortly thereafter these three arrived at the telescope to share in the excitement. Paul Murdin's salutation as he entered the control room will be forever remembered by the B3i commissioning crew.

A total of 5 shifts plus some AIC time were allocated for the commissioning. Fortunately, things proceeded smoothly. The weather, which started out fair, became good as the testing proceeded. With the progressive decrease in atmospheric opacity, system temperatures improved steadily throughout the run. Each new, lower value of  $T(\text{sys})$  was announced loudly by the observer at the time, and the preceding record marked off and replaced by the new one on a sheet pasted to the control room window. By the end of the commissioning, the best  $T(\text{sys})$  obtained was 592K (SSB) at 357 GHz, with about 1 mm of precipitable  $\text{H}_2\text{O}$  overhead. We have subsequently had reports from the JAC staff of  $T(\text{sys}) = 535$  K at 355 GHz under excellent observing conditions.

Although the receiver design specified a tuning range of 330 - 370 GHz, this goal has been

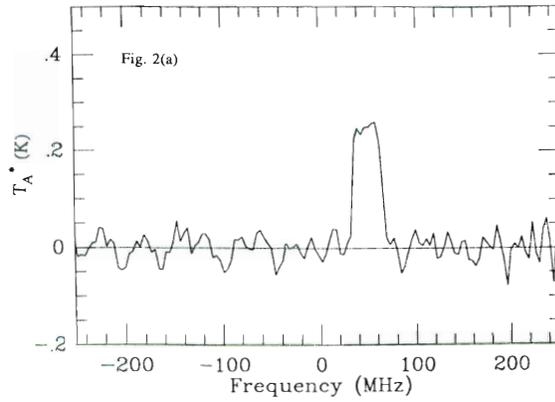
surpassed. The mixer is sufficiently broad-band, and the local oscillator produces enough power outside the design interval that the receiver appears to be operable from below 300 GHz to 380 GHz. There is some uncertainty, at present, as to the high and low-frequency limits. Most of the commissioning tests were carried out in the mid-range from 330 to 360 GHz. The extreme frequencies at which spectral lines were observed during November were 304 and 373 GHz. Above 370 GHz, sky opacity is a serious problem, and the character of receiver operation is largely of academic interest. Below the atmospheric absorption centred at 325 GHz, transmission becomes good, and the lowest usable frequency is likely to be set by decreasing local oscillator power or by generation of a 5th harmonic in the quadrupler. The entire tuning range can be accessed with the same Gunn oscillator, and tuning generally requires less than 5 minutes for frequencies between 330 and 365 GHz.



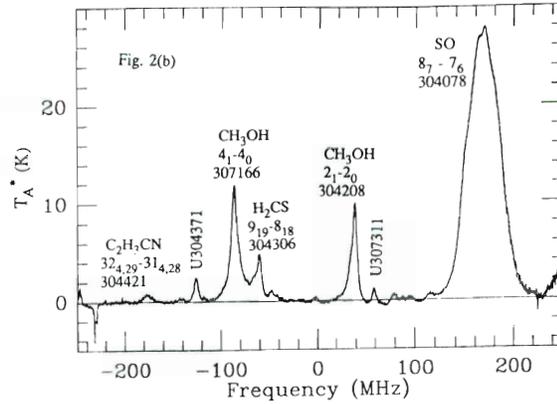
**Figure 1** Receiver temperature (expressed as radiation temperature) vs. frequency for Receiver B3i, as determined in the Prep Room at JCMT prior to installation on the telescope for commissioning.

Figure 1 shows the DSB receiver temperature expressed as radiation temperature (i.e. the quantity output by the JCMT Vax) over the tuning range. Optimum performance is between 345 and 370 GHz, with the best  $T(\text{Rx})$  around 142 K near 355 GHz. The variation of  $T(\text{Rx})$  with frequency occurs because of the frequency-dependent impedance of the mixer which cannot be perfectly

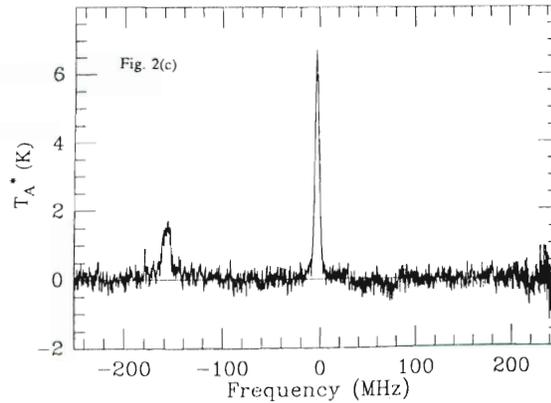
2(a) IRC 10216 spectrum with the receiver tuned to 355492.8 MHz in the USB and  $V_{\text{lsr}} = .26$  km/s. Total integration time was 3600 seconds and  $T(\text{sys}) = 597$  K. The data have been smoothed to an incremental frequency of 3.73 MHz using a 15-channel boxcar. The sideband of the unidentified feature is unknown; its frequency is either 355546 or 352444 MHz.



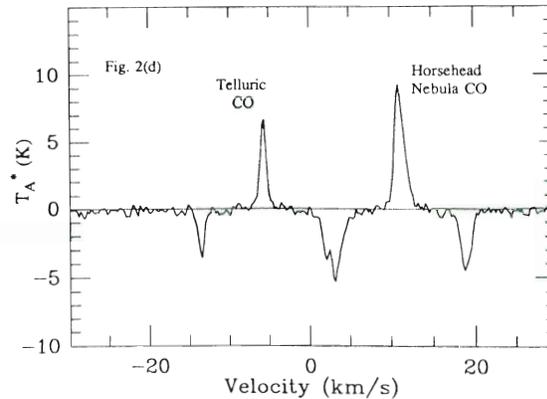
2(b) OMC-1 spectrum at 307252.9 MHz in the USB and  $V_{\text{lsr}} = 8.0$  km/s. Inregration time was 600 seconds and  $T(\text{sys}) = 648$  K.



2(c) Two-minute spectrum of N7538 IRS1 with the receiver tuned to 342886.1 MHz (USB),  $V_{\text{lsr}} = -57.4$  km/s and  $T(\text{sys}) = 679$  K. The strong feature is the CS 7-6 line at 342883 MHz and the weaker line is either CH<sub>3</sub>OH 13<sub>1</sub>-13<sub>0</sub> in the LSB at 342730 MHz or CN 3-2 in the USB at 340335 MHz (or a blend of both).



2(d) A 60-second frequency-switched spectrum of CO J=3-2 in the direction of the Horsehead nebula. The raw scan has been shifted and averaged, resulting in the 'absorption' ghosts characteristic of frequency-switched spectra. Both celestial and terrestrial CO lines are seen. The receiver was tuned to 345798.9 MHz (USB) and  $T(\text{sys})$  was 903 K.



**Figure 2** Spectra obtained 20-27 November 1991 during commissioning of Receiver B3i. Scan 2(a) is the only one which has been smoothed

compensated at all frequencies by the single backshort. Comparisons with spectra obtained using receivers B1 and B2 at frequencies between 328 and 357 GHz showed good agreement of the line strengths. Careful calibrations using an LN<sub>2</sub> bucket and ambient loads revealed the presence of a standing wave in the internal calibration path of the receiver, but this has been characterized across the observing band, and will be effectively compensated by the B3i control computer. Measurements of the same lines in upper and lower sidebands confirmed a tendency (initially revealed in laboratory tests) for lines observed in the LSB to appear about 5% stronger than when they are placed in the USB. Tests indicated that the internal receiver calibration error due to the standing wave and sideband ratio is less than about 7% over most of the band, although it may be somewhat worse around 330 GHz where the standing wave is of larger amplitude.

A few of the spectra obtained with B3i during the commissioning are shown in Figure 2. Figure 2(a) illustrates the sensitivity which is achievable with B3i under good observing conditions. It represents 1 hour of position-switched integration at 355.493 GHz, binned to a resolution of 3.7 MHz. The rms noise level is 0.026 K. Figure 2(b) is a spectrum from OMC-1 with the receiver tuned to 307.253 GHz in the USB, and 2(c) is 2-minute position-switched scan of the CS 7-6 line in NGC 7538.

Figure 2(d) illustrates the frequency-switching capability of Rx B3i. This is an important new feature which is available with this receiver. In this procedure the local oscillator is switched relatively rapidly in frequency by an amount which is small compared with the total spectral window. The telescope tracks the source throughout the scan.

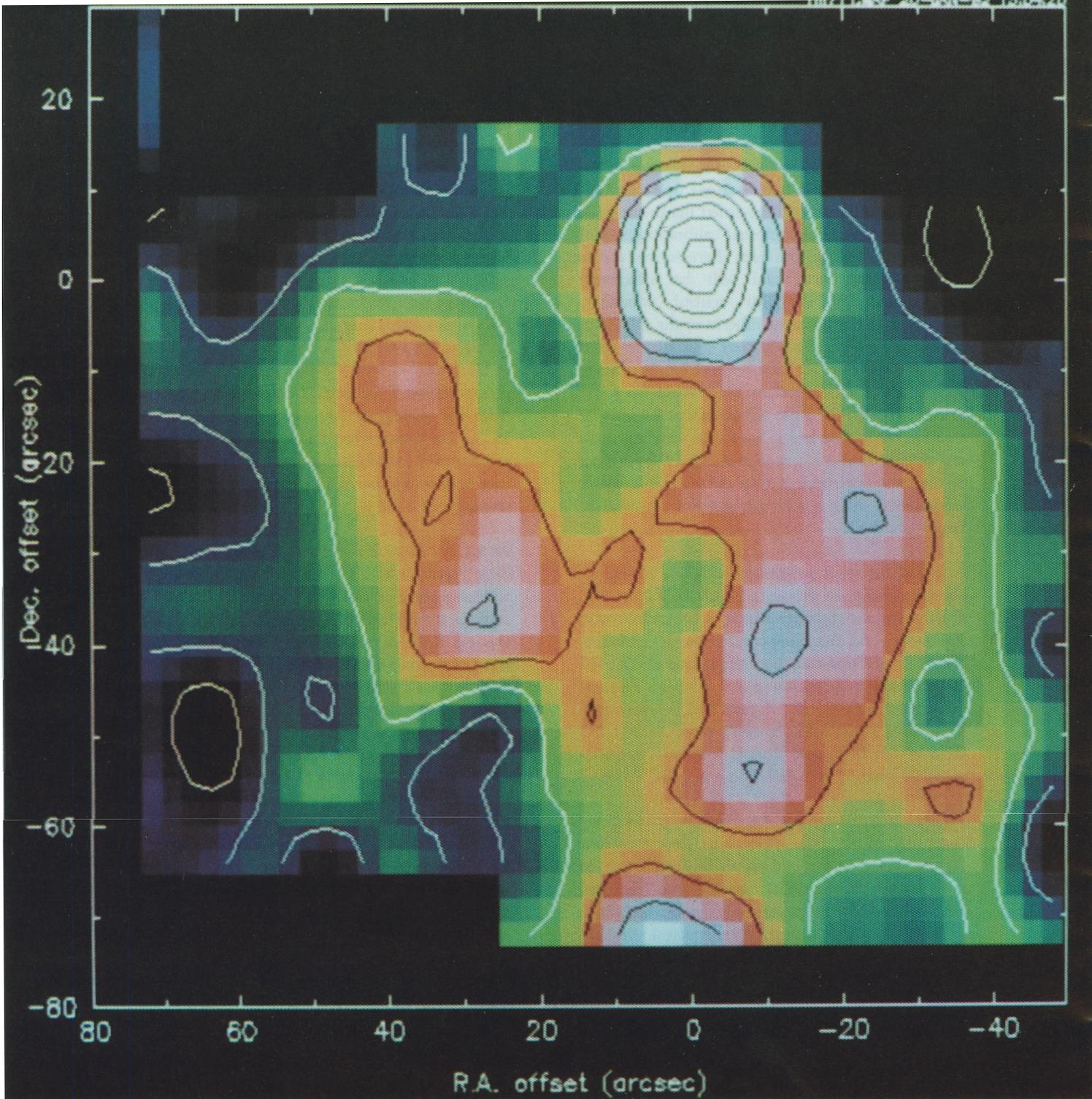
This procedure has several advantages for certain types of line observation. First, the telescope observes the source continuously, so that the amount of time on source is twice that of position or beam switching. In addition, the overhead associated with slewing the telescope in position switching is eliminated. Also, finding a reference location that is off-source and free of line emission can prove difficult in position- and beam-switching modes but is not a problem with frequency switching. Finally, since lines in opposite sidebands move in opposite directions as the LO changes, this procedure automatically identifies the sideband in which a line has been detected because the USB and LSB lines have mirror-image profiles in the unprocessed scans.

An interesting feature of frequency switching is that telluric lines are not cancelled out as they are in position or beam switching. Figure 2(d) shows a frequency-switched spectrum of the CO J = 3 - 2 line in the Horsehead nebula. The switching period was 1/2 Hz, and the amplitude was 5 MHz. This spectrum clearly shows CO emission from both the Horsehead and the earth's atmosphere.

Commissioning tests of frequency switching with B3i demonstrated that this is an efficient observing technique for narrow-line sources. The colour map in the HCO<sup>+</sup> J = 4 - 3 line contains data at 170 points on an 8 arc sec grid extending southeast from the young stellar object SVS 13 in NGC 1333. These data were obtained in about 3.5 hours of frequency-switched observation. The integration time was 60 sec per point, quite adequate for line strengths of 1 - 2 K.

As always in such a project, a great many people have contributed to the ultimate successful commissioning of this new receiver. The visiting commissioning team of Charles Cunningham, Steve Davies, Bob Hayward, Eric Taada, Doug Wade and Lorne Avery were admirably supported by the local JCMT staff who gave us their fullest cooperation. Special thanks to Bill Dent (B3i's support scientist), Jeff Cox, Mary Fuka, Colin Hall, Rusty Luthé, Neal Masuda, Henry Matthews, Chris Mayer, Kimberly Pisciotta and Richard Prestage, all of whom spent long hours at the telescope. Many others deserve mention; our collaborators, Dave Matheson and his group at RAL, Les Little at Kent, and, within HIA, Morley Bell, Carol Bergeron, Joseph Fletcher, John MacLeod, Ajaz Mirza and Russell Redman. The end result of the collective efforts and skill of these and others is a B3i receiver that performs well and is now available for use at the JCMT. Further details about the receiver's performance, and more sample spectra have been compiled in a brief manual which is available from HIA upon request.

*Lorne Avery  
HIA, Ottawa  
27 December 1991*



*Map of the region around HH7-11 made with the JCMT in the J=4-3 transition of HCO<sup>+</sup>. The central exciting star is the bright spot at position (0,0). Unlike previous interferometer maps of this molecule, clumps of emission are seen over much of the region around the central star, both in and out of the outflow.*

*The map was made using the new SIS receiver B3i at 355GHz using frequency switching. It is composed of about 170 spectra and took 3.5 hours to complete.*

*It is displayed using PGSPICX, an upgrade of SPICX which allows colour greyscale output.*

## JCMT Instrumentation and Observational Sensitivities for Semester W.

The instrumentation which should be available to users of JCMT during Semester W (1 August 1992 - 31 January 1993) is summarized. Additional details can be found in 'The James Clerk Maxwell Telescope: A Guide for the Prospective User', which is available through the JCMT Section of the Royal Observatory Edinburgh, by contacting the JCMT Group at the Herzberg Institute of Astrophysics in Canada, or from me directly.

### Spectral Line Observations

#### Receivers A1, A2

**Receiver A1** is a dual-channel Schottky mixer device covering the frequency range from 216 to 280 GHz. The complete range is accessed by a single local oscillator source. Receiver A1 is operated in a 'hybrid' mode, i.e. with one mixer installed nominally for each of the upper and lower frequency ranges. However the mixer responses are such that observations at frequencies up to about 245 GHz can usefully be combined using the IF dual-polarization capability of the AOSC, at least for objects requiring no more than about 200 MHz of frequency space. Above 245 GHz only one mixer may be used. The DAS (see below) will allow routine dual-polarization observations. In principle a  $\sqrt{2}$  gain in signal-to-noise ratio can be obtained in such cases. A single-sideband filter should be available for those users requiring rejection of the image sideband; it should be specifically requested in the proposal.

The SIS receiver **A2** is expected to be commissioned in March 1992 and if possible will be made available to users on a best efforts basis for the remainder of Semester V. Although no firm values for its performance can be quoted at this stage it should be available for use in Semester W. It should cover the same frequency range as A1, and may have a SSB system temperature on the sky of 400K or better.

#### Receivers B2 and B3(i).

**Receiver B2** is a dual-channel Schottky mixer system for spectral line observations covering the range 330 to 360 GHz. The system temperatures obtainable on the sky under good conditions are between 1500 and 2000K throughout this band.

**Receiver B3(i)** is a single-channel SIS receiver which has recently been successfully commissioned on the JCMT. It may be tuned over the range from

below 300 GHz up to 380 GHz, although the extremities of the band have yet to be fully explored. The DSB receiver temperature response is not constant with frequency, and ranges from a best value of near 140 K at 355 GHz to ~265 K at 330 GHz. On the sky, SSB system temperatures below 600 K have been obtained under good conditions. Full performance specifications are given elsewhere in this Newsletter.

The local oscillator system of B3(i) permits frequency-switched observations for the first time with JCMT. For narrow-line (less than a few MHz in width), spatially extended objects this is a real advantage, since in this mode telescope motion is no longer part of the observing process, and the line is observed almost continuously. This type of observing may also be used to search for a reference position free of line contamination for other, wider-line objects.

#### Receivers C1 and C2(i)

**Receiver C1** is a dual-channel 'hot electron' bolometer system designed for observations of the CO J=4-3 (461.04 GHz) and neutral carbon  $^3P_1-^3P_0$  (492.16 GHz) lines. For the form of mixing used the practical single-sideband IF bandwidth is a little less than 2 MHz and it is necessary to 'sweep' the local oscillator frequency across the line to obtain a spectrum. Typical receiver temperatures are better than 800K at 461 GHz, and about 1300 K at 492 GHz for each mixer, or about 550 and 900K if both mixers are used at the same frequency. Under reasonable sky conditions, this leads to total system temperatures of ~3000 and 7000 K per channel, or 30000 and 70000K respectively for a 50-channel spectrum.

**Receiver C2(i)** is a single-channel SIS receiver which will cover frequencies from 450 to 500 GHz, possibly with a DSB receiver temperature of 500 K. It is scheduled to be commissioned in May 1992. Proposals may be submitted to use this receiver in Semester W, but the outcome depends on the results of the commissioning just prior to the PATT meeting.

#### Receiver 'G'

This receiver is a single-channel Schottky device employing a laser local oscillator arrangement. Because of this fact, only certain discrete frequencies can be accessed, in particular in the regions around the CO J=6-5 and 7-6 lines at

about 690 and 800 GHz respectively. Typical double sideband receiver temperatures range from 3000 through 4500 K; specifically, at CO(6-5) and <sup>13</sup>CO(6-5) receiver temperatures of 3000 and 3500 K are obtained. The resulting single-sideband system temperatures are extremely sensitive to atmospheric conditions, but are likely to be of the order of 55000K or more under practical conditions.

Receiver 'G' is on loan from the MPE group in Garching and observers interested in using it should contact either Prof. R. Genzel or Dr. A. Harris to arrange collaborative efforts.

### Spectrometer Backends

Two spectrometer systems should be in use during Semester W.

The new **Digital Autocorrelation Spectrometer (DAS)** will be commissioned in January 1992, and should be offered to users already during Semester V. The DAS has 2048 delay channels having a total maximum bandwidth of 1 GHz in each of two inputs. It will be capable of a wide range of configurations, with spectral resolutions of between 0.1 and 1.0 MHz.

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. Dual-channel receivers (i.e. A1 and B2)

can make use of the fact that both channels may be observed simultaneously, each over somewhat less than half the total bandwidth.

### 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), for three different values of the atmospheric transmission. In parentheses, the expected values of the rms noise are given for 'exceptional' and 'poor' weather conditions (about 0.5 and 5 mm of water vapour respectively). Atmospheric conditions affect receiver B, C and G observations strongly, and poor conditions render work at the higher frequencies impossible.

### Continuum Observations

#### UKT14

The UKT14 bolometer system will be available during Semester W with filters for observations at 2, 1.3, 1.1, 0.85, 0.8, 0.75, 0.6, 0.45 and 0.35 mm. The aperture of the bolometer can be adjusted between 21 and 65 mm. Sensitivities range from typically 0.3 Jy/√(Hz) to 10 Jy/√(Hz) or more under good photometric conditions.

The properties of UKT14 using the various available filters and apertures are given in Table 2.

Table 1. Summary of spectral line observational data

Frequency (GHz)	Receiver	T(rx) (K)	T(sys) (K)	dv (MHz)	Rms noise (K)	$\eta_{fss}$	$\eta_l$	Notes
230	A1	350	960	0.33	0.08 (0.07,0.11)	0.77	0.91	1
270	A1	650	1600	0.33	0.13 (0.11,0.18)	0.77	0.91	
330	B2	680	2140	0.33	0.18 (0.16,0.67)			1,5
	B3(i)	265	1000	0.33	0.08 (0.07,0.38)			2,5
345	B2	560	1720	0.33	0.14 (0.12,0.32)	0.70	0.89	1
	B3(i)	165	650	0.33	0.05 (0.05,0.16)	0.70	0.87	2
461	C1	560	30800	4.00	0.72 (0.41, * )	0.73?	0.80	3,4,5
492	C1	900	76000	4.00	1.79 (1.25, * )			3,4,5
690	G	3000	48300	1.00	2.28 (0.97, * )			3,4
810	G	4000	78800	1.00	3.71 (1.43, * )			3,4

#### Notes:

- (1) Dual channel observations are possible. This reduces the rms noise by a factor of about 1.3 in practice.
- (2) Frequency switching is possible. Its use reduces the rms noise by a factor of 1.4 for the same total integration time.
- (3) This assumes a total of 50 channels in the spectrum and dual-channel operation.
- (4) A '\*' means that observations are not possible when conditions are 'poor'; the rms noise is effectively infinite.
- (5) Awaiting reports or further commissioning for  $\eta_{fss}$ ,  $\eta_l$

**Table 2. Properties of the UKT14 bolometer system**

Filter (mm)	Wavelength (micron)	Centre frequency (GHz)	Bandwidth (GHz)	Aperture (mm)	Beamwidth (arcsec)	NEFD (65mm ap) Jy√(sec)	Notes
2.0	2000	150	40	65	28	2.0 (2.0,3.0)	1
1.3	1300	233	64	65	21	0.3 (0.3,0.5)	
1.1	1100	264	75	65	19	0.3 (0.3,0.7)	
0.85	850	354	30	47	16	0.8 (0.7,5.0)	
0.8	761	394	103	47	14	0.7 (0.5,5.0)	
0.75	730	411	28	47	14	not available	2
0.6	625	480	119	36	9	not available	3
0.45	438	685	84	27	7	6.0 (4.0, *)	4
0.35	345	870	249	21	6	12. (8.0, *)	4

**Notes:**

- (1) At this wavelength the UKT14 optics is poorly coupled to the JCMT.
- (2) Not yet commissioned. Values will be somewhat greater than for the 0.85mm filter.
- (3) This filter is best avoided. It is difficult to obtain consistent calibrations, due to deep atmospheric absorption lines in the window.
- (4) Observations are not possible under 'poor' conditions at these wavelengths.

The value of the NEFD given is that which should be obtained under 'good' conditions for a 65mm 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 (65mm).

**UKT14 polarimeter**

The Aberdeen/QMW polarimeter will be available during Semester W as an optional accessory for the UKT14 bolometer system in step and integrate mode, and (possibly) also continuous rotation mode. The effective NEFD of the polarimeter-plus-UKT14 combination is slightly worse than  $NEFD(p) = 2xNEFD/P$ , where P is the degree of polarization of the source and NEFD is that given above (Table 2) for the filter/waveplate in question. Observations are possible at 1100, 800, and 450µm. Additional information appears in the article by Sye Murray in the JCMT-UKIRT Newsletter of August 1991 (p. 19).

*Henry Matthews*  
*JAC, Hilo, Hawaii*

HEM@JAC.HAWAII.EDU (InterNet)  
 18 December 1991

**JCMTINFORM**

The instructions given in the previous JCMT-UKIRT Newsletter (August 1991) how to log on to the VAX at ROE only apply to SPAN or UK STARLINK users (i.e. SET HOST REVAD <CR> username JCMTINFORM <CR>). What follows is a recipe for how to log on from an Internet site:

- 1) TELNET to sun.nsf.ac.uk , you get a "login:" prompt
- 2) Enter: janet (LOWER CASE!!). You will be prompted for the JANET host.
- 3) Enter: uk.ac.roe.star (LOWER CASE!!) and you are connected to the ROE Starlink VAX.
- 4) Log in as JCMTINFORM (no password required) and you are entering a menu driven program.

If you are trying to log in via SPAN and REVAD is not known to your host, use SET HOST 19889.

Please send any comments to me (KXH@UK.AC.ROE.STARLINK)

*Ko Hummel*  
*ROE*

## VLBI with the JCMT

In February 1992, nine compact extragalactic sources will be observed at 230 GHz when the JCMT participates for the first time in VLBI observations. The JCMT will be the important central telescope in a four element array, the other telescopes being at Nobeyama, OVRO and SEST. The longest baseline of the array, that between SEST and Nobeyama, is almost an earth diameter and will give a resolution of about 27 micro arcseconds. This is a record for angular resolution in any field of science. Equipping the JCMT for VLBI has involved substantial effort at several institutions but, at least so far, little outlay of money.

The major items of equipment, a hydrogen maser and a recording system, are being supplied by HIA, Ottawa and by the Nobeyama Observatory. The hydrogen maser is one of two that are being refurbished at HIA, Ottawa by Joseph Fletcher. The second maser has just (December, 1991) had its hydrogen bulb re-coated with Teflon. The aim is to have both masers running so that their outputs can be heterodyned and their stability confirmed before one of them is shipped to Hawaii in early January. The maser will be installed in the basement of the JCMT building, just outside of the office. The motion of the telescope may change the local magnetic field enough to have a noticeable effect on fringe frequency over a period of hours. The field changes could, in the worst circumstances, actually quench the maser in which case more shielding would have to be added. However, field changes are expected to be small enough and slow enough to have no appreciable effect on the coherence time which will likely be limited by the atmosphere to a few tens of seconds.

The recording system will be the Japanese "K-4" system which makes use of a new wide-band Sony video recorder. The K-4 recorder, which will also be used at Nobeyama and SEST, is compatible with the MkIII recorder that will be used at OVRO. Arrangements for supplying, shipping and installing the recorder have been made by Makoto Inoue of the Nobeyama Observatory. A GPS receiver may also be supplied by Nobeyama.

The local oscillator of receiver A1 has recently been successfully phase-locked by Per Friberg and Colin Hall of the JAC using a new package of electronics. The electronics were assembled by John Galt of DRAO, Penticton from a very stable source of 4.8 GHz and spare receiver B3 phase-lock electronics (lent by Bob Hayward, HIA

Ottawa). The 4.8 GHz source will be locked directly to the 100 MHz supplied by the Hydrogen maser and will be fixed in frequency. For this reason it will determine the common observing frequency for all of the telescopes.

In earlier VLBI observations at mm wavelengths it has been found extremely helpful to observe concurrently at a centimetre wavelength. This greatly reduces the uncertainties in fringe frequency and delay by providing strong interference fringes. Goeran Sandell of the JAC has arranged for a simple 8 GHz receiver to be assembled by the group at Berkeley. This will be installed in the receiver room of the JCMT and coupled to the sub-reflector with a small offset paraboloid.

Accurate Universal Time will be available for the experiment from a Rubidium clock supplied by HIA, Ottawa, and supplemented with a GPS receiver from Nobeyama or a Loran C receiver from HIA, Ottawa. The construction of a circular polarizer, custom made for the JCMT optical system, has been arranged in Sweden by Lars Baath of Onsala, who is also the Principal Investigator for the overall experiment.

The sensitivity on the JCMT-Nobeyama baseline is expected to allow the 3 sigma detection of a 1.2 Jansky unresolved source, assuming 1000 K system temperatures at both telescopes, 90  $\mu$ m and 30  $\mu$ m surface accuracies, 128 Mbit/sec recording bandwidth (about equivalent to 35 MHz of analogue bandwidth) and a 30 second coherence time. Judging from past results at 100 GHz over baselines about twice as long, there should be an excellent chance of detecting interference fringes...provided everything works. The sensitivity will be greatly improved when lower noise SIS receivers are installed and when a "burst-mode" scheme recording is incorporated. The burst mode will allow the recording of a very wide bandwidth for a short time, thereby giving the equivalent of a much longer coherence time. It may be that all of the equipment will NOT work in the first trial in February, but the long term prospects for VLBI observations with the JCMT now look very bright.

*T. H. Legg  
HIA  
Ottawa*

## Digital demodulation and fast sampling with UKT14

The UKT14 data-taking system at present relies on an analog lock-in amplifier. Two modes of operation are available: the lock-in or PSD output can be sampled and read back using an Ithaco data buffer controlled by the UKT14 D-task, or alternatively the lock-in output can be read by the IFD microprocessor, which includes facilities for on-the-fly mapping. In both modes, however, the shortest sampling time is one second, which limits the size of an Az-El map that can be made without excessive source rotation, and neither mode has provision for a gating signal to suppress the detector output while the chopper is moving from one beam to the other. Prompted by the wish to make large maps of M17 at 450 and 800 microns, we recently conducted some very successful experiments with true digital demodulation, which improves performance in both of these areas.

Before we discuss these experiments we present a brief examination of the present on-the-fly mapping system. Because the standard UKT14 hardware and software does not permit this mode, alternative methods must be used, and this makes it quite different from the standard "step and integrate" or GRID mapping method (Duncan *et. al.* 1990).

### On-the-fly mapping

On-the-fly (OTF) mapping has been available since the telescope was first handed over to ROE in 1987, or rather, some time before that. Paul Scott's original design for the telescope control system anticipated that we might need to make maps with integration times of a second or less, and it was quite clear that this could only be done with the telescope in continuous or raster scanning mode -- the large inertia and low resonant frequencies of the telescope mean that the minimum slewing and settling time for discrete steps is around a second or so, which leads to very inefficient use of the telescope for integrations shorter than a few seconds. Accordingly Sidney Kenderdine's TEL task included the code necessary to set up a raster relative to a moving map centre, and made the appropriate handshaking signals ("event flags") available to the receiver tasks. Jon Fairclough wrote a ROW command for the holography D-task, while one of us (Rachael) wrote the corresponding ROW command for receiver A and the necessary micro code for RxA and RxH.

If the receiver is to be integrating continuously, then the results of one integration have to be read out while the next integration is in progress. This

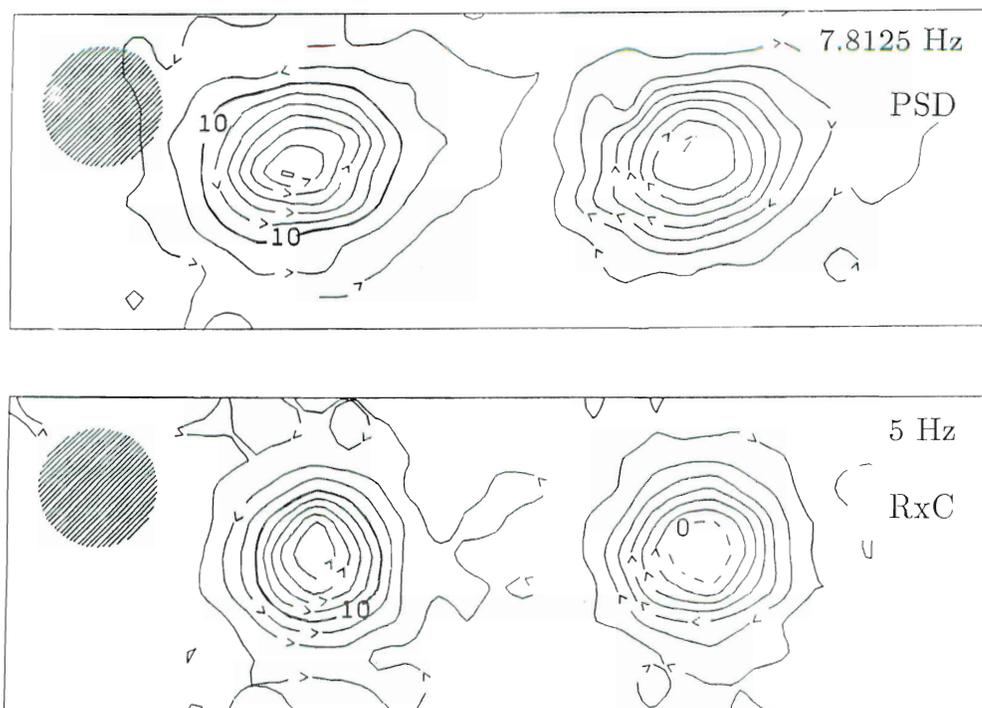
process is known as "double buffering", and requires some complication in the receiver micro code. This turned out to be relatively easy for the holography micro, which was taking one sample per point, but somewhat harder for receiver A which averages 100 samples each second to get the final value. Nonetheless this all worked fine, and in fact the first data taken by the JCMT -- holography data at 31 GHz, and RxA beam maps of the sun (with the secondary mirror removed) -- were taken in OTF mode. Somewhat later Richard Hills conducted an experiment to see if the output of the UKT14 PSD could be logged by the RxA D-task rather than using the Ithaco sampler and UKT14 D-task. This seemed to be very useful, and Adrian Russell then wrote a set of ADAMCL procedures to simplify OTF continuum observing. The system then remained essentially unchanged until mid-1991 when a dedicated on-the-fly backend (using the same principles) replaced the RxA backend and a RASTER procedure was written which fully integrated this mode into the normal choice of observing schemes.

### Problems and improvements

Although OTF mapping is for many purposes superior to the default "step and integrate" mode for UKT14, it does have some drawbacks. Chief amongst these is that the integrations are still not synchronized with the secondary mirror chop. Since one chop cycle may actually take a significant fraction of the integration period, this can lead to weird ripples and other effects in maps. For example, in one integration we may be averaging 2 ONs and 3 OFFs, while in the next we average 3 ONs and only 2 OFFs. In principle these effects can be reduced by increasing the PSD output smoothing, but this then tends to smear out the map... As well, there is always the problem mentioned earlier that there is no gating in the standard UKT14/PSD system, so that data are being taken even when the chopper position is not well defined, as when it is moving from one beam to another. The main effect of this, as demonstrated below, is that the effective beam of the telescope can be corrupted because of the finite risetime and ringing of the chopper waveform, giving in some cases a markedly degraded beamshape. The apparent chopper throw and sensitivity are also somewhat chop-frequency dependent, which is obviously undesirable.

For very short integrations of less than one second these problems become significant, and so when the

3C 273



**Figure 1** A comparison of digital demodulation with the standard IFD backend. 1100  $\mu\text{m}$  maps of 3C273 in a 19 arcsecond beam. Both maps are 33x11 on a 5-arcsecond cell, 60 arcsecond chop and 1 arcsecond per point. Note that the chop speeds are *not* identical for the two maps.

necessity for short integrations arose we investigated possible improvements to the standard OTF mapping mode. The first possibility was to modify the RxA micro to take more than one point per second, but the problem of synchronizing with the secondary mirror remained. Then we realized that the RxC micro already contained nearly all the code necessary for this job. In beam-switching mode RxC provides the reference signal for the secondary mirror, and observes a complete spectrum, in each of the Left and Right beams. The spectra are double-buffered to permit OTF spectral mapping, and the micro knows to leave a blanking time before it starts integrating after the chopper is told to move. This is true *digital demodulation*, and is exactly what we need if we consider observations with UKT14 as single-point "spectra". One modification was required to the RxC micro code, to permit the accumulation separately of more than one data point per second, but this was (relatively) trivial. Modifications of the RxC D-task were needed to accommodate this

extra degree of flexibility, and to CONTROL and DISPLAY to allow us to do FIVEPOINTS, FOCUS etc using a heterodyne backend -- these were somewhat more difficult, but were accomplished (by Richard) without too many grey hairs.

Thus in this revised system the (amplified) output from the UKT14 detector is fed directly into the RxC samplers. The overall length of a row should still be an integral number of seconds, but the D-task can handle any integration time which is a rational number -- thus 2 sec, 1 sec, 0.5 sec (i.e. 2 points per second), 0.4 sec (5 points per 2 seconds) and 2.5 sec (2 points per 5 seconds) are all allowable.

## Results

The first results from this system were obtained in August of 1991, during the M17 continuum mapping run mentioned above. In fact the main

Mars

Fast sampling at JCMT

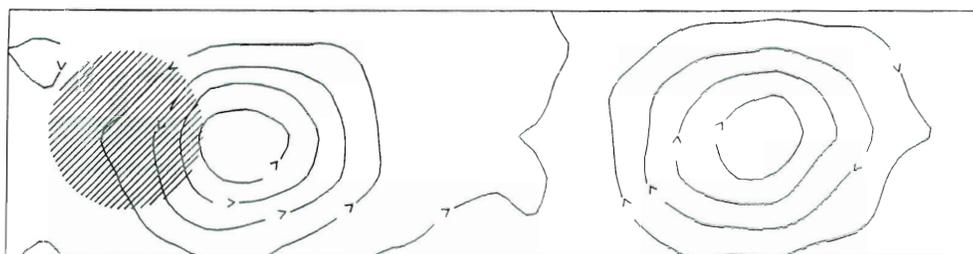


Figure 2 A fast sampled map of Mars using RxC as a backend. The map is 25x7 on a 5 arcsecond cell, sampled at 2-sec per 5 points (0.4sec/pt). The chop is 60 arcsec at ~ 5Hz

reason for wanting to use fast sampling was not so much that the source is very bright (although it is), but the wish to reduce source rotation during the

time taken to make a big oversampled map. In the event it all went very well, although the system certainly cannot yet be described as "common-user".

M17, 800 $\mu$ m

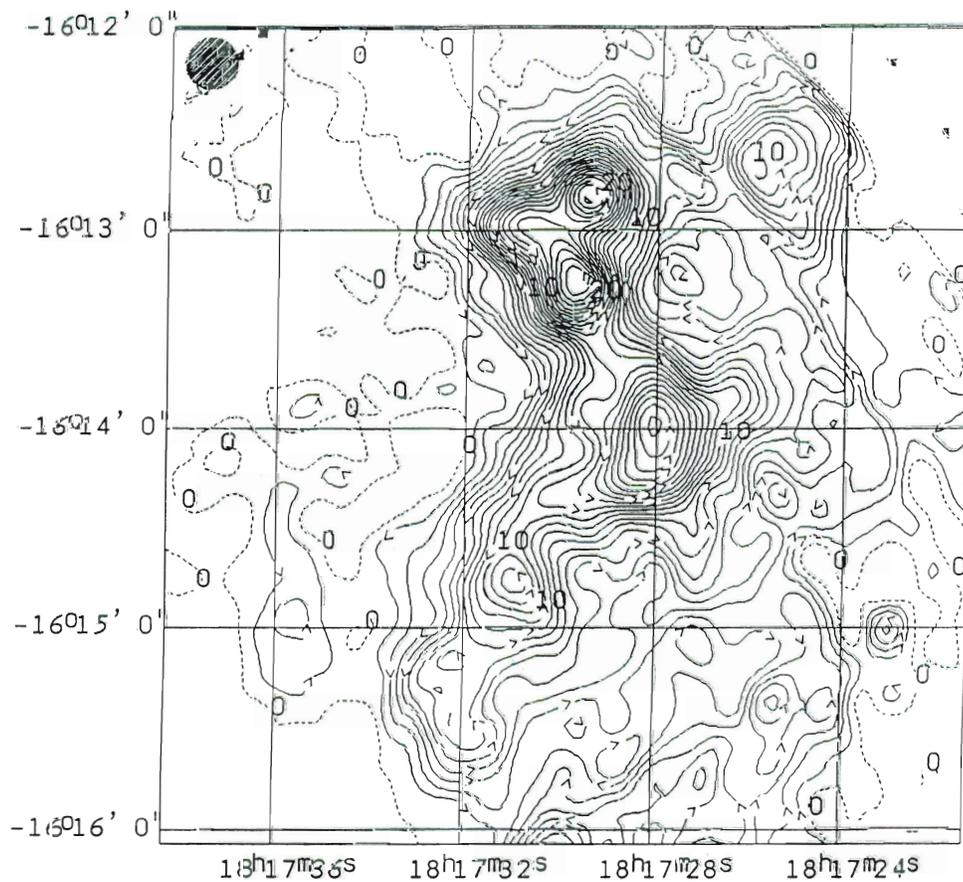


Figure 3 A fast sampled map of M17, at 800  $\mu$ m in a 47 mm aperture. There are 6480 datapoints on a 3.5 arcsecond grid, using a 40 arcsecond AZ chop, and the map took just on an hour to make, at 0.4 seconds per point.

## Digital demodulation

Figure 1 shows a comparison of two beam maps of 3C273 at 1100 microns, using an integration time of 1 second per point. The first map was made in the traditional way and the second using digital demodulation. The elongation of the beam along the chop direction due to not gating the chopper is quite apparent: the magnitude of this effect is probably because the standard chop frequency of 7.8125 Hz (that is, a period of 128 msec) is so close to one of the chopper resonances - the beam distortion is much less marked at lower chop frequencies. In contrast, the digitally demodulated map, using a  $\sim 5$ Hz chop, shows no deviations from circular symmetry at all.

## Fast sampling

Figure 2 shows a 25 x 7 beam map of Mars, taken with 0.4 second per point (5 points in 2 seconds), at 1100 microns on a 5-arcsec cell, again using digital demodulation. The chop was 60-arcsec at  $\sim 5$ Hz. Figure 3 is a 800 micron map of M17, measuring 80 x 81 points, with 3.5 arcsec sampling and a 40-arcsec chop. The total time to make this map was just on one hour, also using 0.4 seconds integration time per point.

## Status

As noted above, the system is not yet available on a "common-user" basis, largely because of some infelicities which have still to be expunged from the RxC micro code, because of some uncertainty about the relative S/N of the two techniques, and because of difficulties in accomodating the wide range of gains needed - when going from planets as pointing sources to faint objects for example. The experiment has however been highly successful, and we hope to report in the next newsletter that this observing mode has been fully commissioned.

We thank Colin Hall and Bill Duncan for their invaluable assistance with parts of this project.

*Rachael Padman*  
*MRAO*  
*Richard Prestage*  
*JACH*

Reference: Duncan, W.D., Robson, E.I., Ade, P.A.R., Griffin, M.J. and Sandell, G. 1990. *MNRAS* **243** pp126-132

## SPECX notes

### SPECX and Unix

Starlink has announced its intention to move toward Unix machines, and although this will not make any difference to operations at the telescope in the short term, it appears that VMS systems will disappear there too on a time scale of order 10 years. The change to a Unix-compatible graphics package (PGPLOT, with GKS device drivers), as described below, is the first step to making SPECX run on Unix machines, but quite a lot of work will be necessary to port the whole thing. In the first instance I propose to port SPECX to Sun workstations, using the (fairly tolerant) F77 compiler, since I believe this will satisfy the majority of Unix users. How big a job it will be to port SPECX to true FORTRAN-77 is not yet clear, and it may not be worth the effort. With any luck however the Sun version should be available by about the middle of next year. Any feedback on this proposal would be most welcome.

I have received two offers of help for the Unix port, for which I am very grateful. The main reason for not accepting them at this stage is that SPECX requires some major internal modifications, which I would like to have out of the way first -- The data stack has to be redesigned to cope with spectra of arbitrary length, and then the the SPECX file system has to be redesigned to cope with arbitrary numbers of sectors. It goes without saying that the revised subsystems will be written in standard FORTRAN-77! Once this has been completed (in a way that does not make all existing files obsolete, or at least unusable), I may accept those offers.

### PGPLOT Graphics support

SPECX 6.2, which is now running at the telescope, should be completed and released through Starlink early in 1992. As well as fixing a number of bugs (mostly minor), I have provided a "graphics-package independent" graphics interface. The so-called SXG routines are implemented using MONGO83, MONGO87 and PGPLOT, so that any of these graphics libraries can be used to get SPECX graphics output just by changing a logical name used by the LINK command. I have eliminated the dependence on non-standard routines in the old MONGO83 version, which should ease installation. It would be a relatively minor matter to write new versions of the SXG routines to support other graphics packages not mentioned here.

The advantage of the PGPLOT interface is that GKS drivers are available for all devices in use at the telescope and at Starlink sites (although the GKS drivers have a number of annoying bugs!) Some minor editing of the SPECX source code is still necessary to add new devices to the ones SPECX knows about, but it is far simpler than it used to be. I expect the PGPLOT version to be the default at the telescope and at Starlink sites, but the MONGO versions will continue to be supported (though they do not yet have greyscale capabilities).

### Colour and grey-scale output

Two new commands, SET-GREY and GREYSCALE, let you produce greyscale images on the terminal or postscript printer. These work exactly like SET-CONTOUR and CONTOUR. SET-GREY includes an option to select a colour table for compatible devices: choose from linear grey scale (option 1), "colour contours" (option 2), a power law grey scale (option 3, useful for enhancing or reducing contrast), a blue-to-yellow colour scale (option 4) or the MRAO colour spiral (option 5). Contours can be overlaid if required.

You can also select greyscale output for PLOT-LINE-PARAMETERS and for CHANNEL-MAPS. If you plotted the last map using GREYSCALE then this will be the default; if you used CONTOUR then contouring is the default. You can switch to greyscales just by typing 'plot\_grey = t' in response to the >> prompt, or conversely enforce contours by typing 'plot\_cont = t'.

### FITS output

I have now written a set of routines to produce standard FITS output of single spectra, on either tape or disk, with or without byte-reversal. These functions use Keith Shortridge's FIT\_routines, and I am very grateful to Keith for his permission to use these and distribute them with SPECX. Relevant commands are OPEN-FITS-OUTPUT-FILE, WRITE-FITS and CLOSE-FITS-OUTPUT-FILE. More details can be found in the manual. The form of the header was chosen to mimic the IRAM-CLASS header as closely as possible, to make it easier to exchange data between SPECX and CLASS. Either in this version (6.2), or the one after, I will also supply a FITS writer for 2D data, which will be made compatible with AIPS.

### Interactive Graphics

Finally, just a note about the interactive graphics capabilities in SPECX. You know when you get

that annoying crosshair up on screen, and you have to hit 'E' or 'Q' to get back to the command line? Many people know that you can interactively rescale the spectrum or map using the L, R, T, B and N keys, but there are in fact lots more functions available. To start with, you can find out exactly what functions *are* available by using the 'H' key (for Help!). Tables of options are also printed in the back of the manual.

For 2D-plots in particular, you can use these options to do things very much more quickly. Use the 'I' key to change the contouring (without having to generate the map from the cube again), find the maximum and minimum on the selected area using 'X', and measure the integrated intensity in the current LRTB box by using 'S'. You can also mark the map value at the crosshair position on the screen, using 'M', or get the spectrum corresponding to the current crosshair position and read it into the current buffer for further processing, using 'G'. And finally, for greyscale plots, you can change colour tables using keys '1' to '5'. Try it -- it's fun!

*Rachael Padman*  
MRAO

### DBMEM: an update

In the last newsletter I described the DBMEM program I have written to replace the NOD2 system currently used by most continuum observers to reduce on-the-fly maps. I have now installed a pre-release version of the program at the Joint Astronomy Centre, Hilo for evaluation by visiting observers. A proper STARLINK release will follow in early 1992: those of you eager to have a go at using the program before the official STARLINK release are encouraged to mail me (electronically or otherwise) and I may be able to let you have copies of the program sooner than that. The program is at the moment primitive in its handling of astronomical coordinates and output formats, but it is hoped to improve this before the official STARLINK release - support and development by myself will be on a best-effort basis. Hopefully, the routines will eventually be incorporated into the FIGARO package.

*John Richer*  
MRAO Cambridge

## JCMT Data Archive

At ROE an archive has been set up that will store observation files (raw data) acquired with the JCMT. The purpose of the archive is to store these data and to allow astronomers access to these observations. The observations can be re-used by investigators other than the original observers (after a certain proprietary period) and allows the original observers to replace lost or corrupted observations. At its meeting in November/December 1988, the JCMT Board agreed that the proprietary period for observations with the JCMT should be one year, extendable in exceptional circumstances to two years.

The archive consists of two basic components:

- i) the collection of observation files. In the case of the JCMT these are compressed GSD files. This data is stored on off-line magneto-optical disks. For safety reasons every observation is stored on two disks which are kept separately.
- ii) the observation catalogue containing summary details of each observation file and its location (i.e. on what disk it is stored). The observation catalogue is kept permanently on-line on magnetic disk so it can be queried by users.

The procedure to obtain data from the archive or to find out whether your favourite object has been observed before is to query the observations catalogue. This is done with the astronomical archive software developed by NFRA. In particular the program ARCQUERY is used to query the catalogue and to construct your request for data. The program ARCQUERY can be run using JCMTINFORM. Alternatively, users on Starlink or SPAN can gain access by SET HOST 19891 and logging in as ARCQUERY.

This query software is functionally identical to that used to query the La Palma telescope data at RGO and the WSRT data catalogue at Dwingeloo. A "User's Guide to the Hawaii Telescopes Data Archive, written by Clive Davenhall, is available upon request. This in particular describes the use of ARCQUERY.

For more information and a copy of the User's Guide contact Ko Hummel. (KXH@UK.AC.ROE.STARLINK)

*Ko Hummel*  
ROE

## JCMT Service Observing

Time for service observing in Semester V (February 1 to July 31) has been allocated to the partner countries as follows: Canada and the UK, 8 shifts each; Netherlands 4 shifts. Separate arrangements have been made in the three countries for administering the service observing programmes.

In Canada proposals should be submitted to Paul Feldman at HIA, Ottawa, by e-mail via Internet to JCMTSERV@HIARAS.HIA.NRC.CA (preferred), or via Bitnet to JCMTSERV@HIARAS.NRC.CA. For assistance with the preparation of proposals prospective investigators may contact the following:

Lorne Avery (for spectral-line proposals) at (Internet) LORNE@HIARAS.HIA.NRS.CA or (Bitnet) LORNE@HIARAS.NRC.CA

Russell Redman (for continuum proposals) at (Internet) REDMAN@HIARAS.HIA.NRC.CA or (Bitnet) REDMAN@HIARAS.NRC.CA

In the Netherlands information may be obtained from, and proposals submitted to, Frank Israel at Leiden University, at ISRAEL@HLERUL51

In the UK information may be obtained from ROE by logging on to REVAD::JCMTINFORM and reading the relevant INFORM document. Proposals should be submitted to REVAD::JCMTSERV.

### Elsewhere

Astronomers in countries outside the JCMT consortium may apply to any one of the above.

*Alex McLachlan*  
ROE

## Late news from Hawaii

The commissioning tests for the new Digital Correlator on the JCMT have been going well. It is likely that the DAS will be available to users from February. The DAS provides up to 1GHz of backend bandwidth in two channels, and up to ~100 kHz of resolution. More details will be available in the next edition of the Newsletter.

*Bill Dent*  
JAC  
January 23 1992

## JCMT 1991 Publications in refereed journals

This year has seen a dramatic increase in the number of papers based on JCMT observations. The provisional total of 36 papers published in refereed journals and listed below is double the corresponding figure for 1990 and compares very favourably with those for other major facilities at similar stages of their development. The full bibliography, including contributed papers, will be published in the next Annual Report. To help us make this accurate and complete, please notify the JCMT Section at the ROE of any additions to this list and of your contributed papers or abstracts published in 1991.

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Millimeter continuum emission from flare stars.  
*Astr. Astrophys.* **241**, L41, 1991.
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Continuum emission at 1 millimetre from the elliptical galaxy NGC205  
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*Astrophys. J.* **382**, L75.
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*Astrophys. J.* **374**, 177, 1991.
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Properties of the molecular cloud about S140 IRS 1 deduced from HCO<sup>+</sup> J=3-2 observations.  
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## Report from the Chairman of the JCMT TAG

Approximately 100 proposals were received for the last Semester, covering a wide range of galactic, extragalactic and planetary science. In addition to assessing the scientific urgency of individual proposals, the telescope allocation group (TAG) also had an extremely difficult task to ensure that proposals to observe the same region of the sky (such as the Orion or Galactic Centre regions) did not exceed the available time slots.

Consequently, the TAG took a more directed approach towards the use of time, in particular to bring in flexible and backup scheduling, and service observing to a greater extent than previously. For some of the highest frequency programmes (those which currently use Rx C, G and the high frequency observations with UKT14), flexible scheduling status has been awarded. This means that a high frequency observer is given a time slot somewhat longer than the number of shifts allocated, and that in consultation with local staff and using all available quantitative data (such as looking at the CSO sky monitor), chooses which nights are suitable for high frequency work. In general these flexibly scheduled nights have been interleaved with programmes using lower frequency receivers which may be less affected by weather. Much thought, and some trials have already gone into the practicalities of flexible scheduling for operating JCMT. Ground rules for use of flexible scheduled observations are available from Richard Wade.

For many high frequency programmes, the weather may not be good enough to get scientifically reliable data. Now that there is a first order understanding of the relative atmospheric window transmissions (see the JCMT Users Guide), and with the availability of quantitative measures of estimating the opacity, it is timely to move towards ways of using dynamic scheduling of the telescope more efficiently to take account of those periods which are more suited to higher frequency observations. Indeed may be argued that it is only at the highest frequencies that the JCMT is truly an unique system. Consequently, for conditions in which, due to atmospheric or instrumental reasons, an observer's 'primary' programme becomes impractical, the TAG have allocated a number of proposals to 'Backup' status to make use of the observing time which has been freed. In general these 'Backup' programmes use Rx A or UKT14, and should be able to be carried out either remotely or by local staff on the observer's behalf (for example a 9 x 9 map of an outflow source on CO 2-1, or a deep integration on a galaxy or searching

for a molecular line). These 'Backup' programmes may now take priority over the 'backup' programme which an observer has mentioned on their PATT forms. All observers are recommended to contact Graeme Watt at JAC to confirm whether other 'Backup' programmes have been scheduled concurrently with their own 'primary' programmes.

As in previous semesters, there have been few requests for Long Term Programmes. It should be clearly stated (again) that applying for a Long Term Programme puts you at no disadvantage relative to other proposals. The TAG would like to see more well argued long-term proposals coming forward. Even if you are not allocated Long Term Status, an ordinary allocation will often be made. It is clear that the JCMT has a smaller proportion of Long Term Programmes than some other telescopes. This however is a consequence of the proposals which have been submitted to date. A Long Term Programme must have a clearly demonstrated and well thought out structure, rather than just being a good way to get a larger share of telescope time, or of having to write less proposals. To date, there have been few proposals which have met in full the criteria which the TAG consider essential, viz; an attempt to solve a major scientific problem, a well-thought out and constructed proposal, a comprehensive or a statistical study which requires large amounts of time spread over several semesters, and something which is well suited to the telescope and receiver systems. It is well known that ROTA recommended substantial amounts of time be awarded to Long Term proposals. However, the TAG cannot award Long Term Programmes without there being either a demand from the community (and this does not seem to be the case at the moment for the JCMT), or a substantial influx of Long Term proposals.

It was also decided to increase the allocations of time for service observing to 8 shifts each for UK and Canadian Service observations, and 4 shifts for Dutch Service observations. A call for proposals for service observations will be made on Starlink (and in Canada and Holland via their own systems) early in 1992, using a system for electronic submission similar to that which has been used in UKIRT service observing for several years. It will be possible to propose anything from a small map or short integration, up to a whole shift's worth of observations. The proposals will be subject to refereeing by a committee which includes several of the present TAG members. The service programme will be operated by the JAC and RGE.

Based on the response to this, the TAG will decide whether to continue this programme at its present level, or expanded as appropriate. Just think how nice it will be to be able to obtain your data promptly and well-calibrated, without jet lag!

*Glenn J White, Queen Mary and Westfield College*

### JCMT Time Allocation

The JCMT Board is currently reviewing how telescope time is allocated, and is considering changes to the operation of the Time Allocation Group (TAG) and the possible introduction of Key Programmes for the JCMT. These issues are to be fully discussed at the May meeting of the Board. Meanwhile, there is no change to the present system, and applications for telescope time in Semester W should be submitted as normal.

### Remote Observing with the JCMT

Remote observing with JCMT is available from any suitable site in the UK, Canada and The Netherlands. All JCMT instruments should be usable. The manual "Remote Observing with JCMT and UKIRT" is available on request.

The system is very easy to use. A remote observer (RO) logs on to one of the remote-observing usernames at the JCMT and selects from a menu which observing screen (s)he wants. Usually there is separate login for each screen, although it is possible to swap between screens from a single login. There are mechanisms for file transfers and for communications with people at the telescope.

Most ROs will use passive remote observing - the RO watches progress at the telescope but does not control any of the observations. Routine JCMT procedure is for the telescope operator to control the observations, so passive observing is efficient and appropriate. Active observing, with the RO able to control observations, is available on request.

ROs in the UK use the facilities for UKIRT described elsewhere; ROs in Canada and The Netherlands may use Internet. Observers are encouraged to participate in remote observing, though it is still expected that one member of the observing team will travel to Hawaii.

Potential ROs should contact me for further details, and their assigned support scientist to discuss feasibility and for authorisation.

*Roger Clowes, ROE*

## New Results

### Observations of the elongated cloud L1582

IRAS observations of the northern part of the elongated cloud L1582 show a source that presents a very steep spectrum. Thus the object is probably very young. We decided to map it in the continuum at 1100  $\mu\text{m}$  with the JCMT using the UKT14 bolometer (see Bastien *et al.* 1991 for more details). To our surprise we found two sources separated by a distance of 12,000 AU assuming a distance to the cloud of 400 pc (Figure 1). It seems that we are observing the early stages of the formation of a binary system. A quick search through the literature revealed that HH objects are present a few minutes north of L1582b (Jones *et al.* 1984, Cabrit *et al.* 1988). Furthermore, these HH objects are more or less perpendicular to the radius connecting the two submillimeter sources. Zhou *et al.* (1988) mapped the cloud in  $^{12}\text{CO}$  and superposed a 2  $\mu\text{m}$  source and the star HK Ori on the map. Figure 2 shows their map to which we added the position of L1582b that we represent by two bars within a circle. The distance between the bars is to scale. It is interesting to notice that all 3 sources are aligned and equally spaced. Furthermore, if we superpose Figures 1 and 2, we see that the radius connecting the two L1582b sources is perpendicular to the axis connecting L1582b with the 2  $\mu\text{m}$  source and HK Ori. We will consider that the line connecting these 3 objects is the major axis of L1582. Zhou *et al.* (1988) also found that the  $^{13}\text{CO}$  near to the 2  $\mu\text{m}$  source is rotating around an axis more or less parallel to the

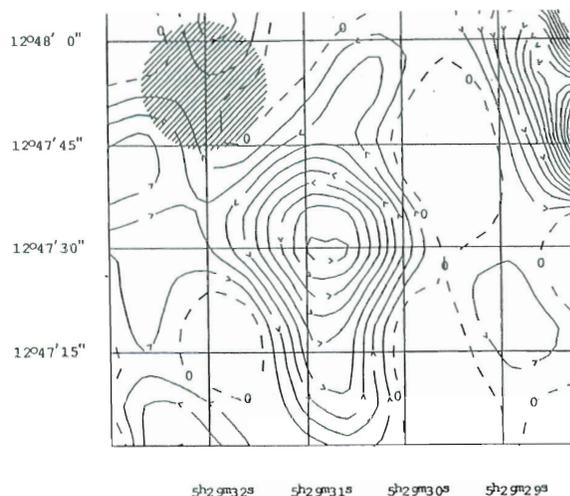
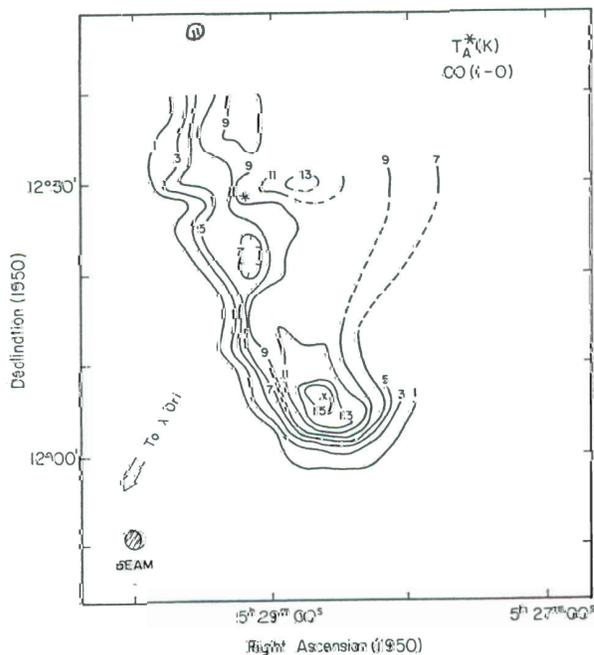


Figure 1 Map of L1582b at 1100  $\mu\text{m}$

major axis of the cloud. This seems to suggest that the whole cloud is rotating around its major axis. Finally, Finkenzeller & Mundt (1984) mention the possibility that HK Ori is a young system consisting of two spectroscopic pre-main sequence binaries. The spectral types would be A5 and F5. The L1582 system presents an evolutionary sequence since the system closer to  $\lambda$  Ori is more evolved than the  $2\mu\text{m}$  source which itself seems to be more evolved than L1582b. This sequence is easily understood if the O8 star  $\lambda$  Ori is responsible for triggering the star formation process.

Maddelena and Morris (1987) present a CO map of the region surrounding the elongated cloud L1582. Many elongated structures are present in the region near L1582. These structures form a broken molecular ring around the O8 star  $\lambda$  Orionis, one of the pieces of the ring being L1582. The HII region of this star extends to the molecular ring. They present a scenario describing the evolution of the whole region: initially there was a flattened molecular cloud in the plane of the sky which gave birth to  $\lambda$  Orionis. This star then excavates an HII region that expands and eventually breaks out forming a continuous molecular ring that becomes unstable and breaks apart.



**Figure 2** CO map of L1582 from Zhou *et al* (1988). We indicate the region observed by a circle containing two marks. The distance between the marks corresponds to the distance between the two objects shown in Figure 1.

In conclusion, L1582 is a cloud that seems to rotate around its major axis. This cloud gave birth to at least 3 stellar systems that are equally spaced along the cloud's major axis. The system to the north of the cloud, L1582b, is double and probably turns around the cloud's major axis. The system in the middle possesses an angular momentum parallel to the cloud's major axis. Its multiplicity is not yet clear. The southern system, HK Ori, is probably a double system composed of two massive pre-main sequence stars. The alignment of the orbital angular momentum of this system is not yet determined. There seems to be a star formation process that proceeds from the southern tip to the northern tip of the cloud. This process could be induced by the presence of the massive O8 star  $\lambda$  Ori.

Calculations of the collapse of elongated clouds rotating around their major axis have repeatedly formed equally spaced aligned condensations which are more often than not binary systems with mass ratios varying between 0.2 and 1.0 (Bonnell *et al.* 1991). It would be highly desirable to model the L1582 region in more detail using an SPH code.

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## JCMT observes the solar eclipse

On 1991 July 11, the JCMT became the largest instrument to have observed a total solar eclipse. The centre of the path of totality passed close to the telescope and first contact of the Moon and Sun occurred shortly after sunrise at 16:30:42 UT. Second and third contacts occurred at 17:28:09 and 17:32:21, giving 4 minutes of totality. Besides the occultation observations on the points of second and third contact by Charles Lindsey and collaborators, the JCMT observed a large prominence before, during and after the eclipse. The prominence, featured on the front cover of this Newsletter, was discovered during the rehearsal runs for the eclipse observations and is further described in the following contribution by Richard Harrison. Full details of both experiments have been sent to Nature.

## Millimetre Wavelength Observations of an Active Solar Prominence

On 11 July 1991 the James Clerk Maxwell Telescope was used to detect 1.3mm radiation from the solar atmosphere, taking full advantage of the occurrence of a total solar eclipse over Mauna Kea. The observation sequence was conceived and executed by an international team of scientists from the USA, Canada and the UK, and the operations included occultation experiments and coronal scans. The former make use of the fact that the moon tracks across solar features, thus allowing the reconstruction of 1.3mm structure to a far better spatial resolution than otherwise possible. The scans were designed to investigate emission from structures in the corona. The first results from these two experiments have been submitted for publication (Lindsey *et al.* 1992, Harrison *et al.* 1992) and we summarise here the results of the scanning campaign.

The principal aim of the scanning campaign was to detect 1.3mm radiation from a prominence and the Sun provided a suitable target on the western limb. Prominences are large-scale atmospheric features which consist of high density, low temperature plasma - i.e.  $10^{11}$ - $10^{12}$ cm<sup>-3</sup>, 10<sup>4</sup>K - supported by arcade magnetic structures, with the plasma being isolated thermally from the surrounding coronal plasma (low density, high temperature,  $10^8$ cm<sup>-3</sup>, 10<sup>6</sup>K). Prominences can be quiescent, showing little sign of activity over many days, or active, displaying mass motion within the prominence structure and an uplifting of the structure itself. The Sun expels material in the form of Coronal Mass Ejections (CMEs), and in a single event up to  $10^{15}$ g of mass may be released through a major restructuring of the corona. This involves the ejection of a large, coronal magnetic structure of which the prominence is often a part. These CME events generate significant transient density and magnetic structures in the solar wind and are related to flares and other chromospheric activity; knowledge of the sequence of events leading to

such eruptions is essential in understanding, and therefore, predicting such activity.

The western limb prominence was identified in JCMT 1.3mm scans made on July 10, during a rehearsal for the eclipse operation. Subsequently, several rastered images were produced at 1.3mm on July 10 and on July 11, after the eclipse, and scans through the prominence were made during the four minutes of totality (17:28-32 UT) on July 11. A sequence of some of the 1.3mm maps is shown on the front cover, taken at 18:33, 18:43, 19:35, 19:59 and 20:18 UT on July 10, and 19:12 UT on 11 July, from top left to bottom right.

A colour table has been used which scales features on the disc and off-limb in a different manner, thus allowing a simultaneous inspection of disc features and the much fainter prominence. On the disc we see a mottled pattern which is unchanging from image to image and is similar the next day - this relates to the topology of magnetic features such as active regions, and the so-called granulation. Above the limb, we can identify the prominence with ease. It resembles an "S" shape apparently only attached to the Sun at one point some 9° north of the western equator. Two parts of the prominence dominate the emission; for clarity of discussion, let us call them the southern and northern patches. The pixel size for the display is 10 arcseconds, i.e. 7500 km, so the total extent of the brightest portions of the prominence is over  $10^5$ km in the solar north-south direction, with an altitude of up to 75,000 km.

There are also weaker features. These include the bridge connecting the northern and southern patches, completing the overall "S" shaped appearance, as well as some brightness to the south, at similar altitudes to the bulk of the structure.

There are changes between July 10 and 11. Assuming that the footpoint of the 1.3mm prominence was on the limb on the previous day, from geometrical arguments it can be shown that we may expect a displacement toward the limb of 2-3 pixels. Thus, the physically higher bright patches would move toward the limb and the leg would be occulted. This is consistent with the images of July 11, except that the northern patch has disappeared.

Clearly visible above the southern patch is a new weak enhancement, which may be part of an overlying loop structure with one footpoint common with the "S" and one to the north. It reaches some 10-11 pixels above the limb, i.e. apparently at an altitude of up to 83,000 km. Assuming that the prominence was directly over the limb on the previous day this would translate to an altitude nearer to 120,000 km.

Given a solar disc brightness temperature of 5,400K, which is consistent with past analyses, we are witnessing an effective prominence brightness of up to 2000K. It can be shown that these numbers are not at first glance consistent with the electron density ( $3.16 \times 10^{10} \text{ cm}^{-3}$ ) and temperature (6500 K) commonly accepted for prominences. Accepting an electron temperature of 6500 K demands a significantly lower density, and demanding a density of  $3.16 \times 10^{10} \text{ cm}^{-3}$  requires a much lower temperature. However, the existence of H $\alpha$  radiation in the prominence indicates that the material is not 100% ionised. The standard optical depth calculation thus refers only to a fraction of the existing density and we can account for this by using an effective filling factor of less than 1. Estimating the ionised fraction at ~33%, giving a density of  $\sim 10^{10} \text{ cm}^{-3}$  leads to a temperature of ~6000K which is not unreasonable for prominences.

Various features of the figure display behaviour which varies with time. The most obvious is the disappearance of the northern patch which was one of the brightest features of July 10 but was not evident on July 11. This could have been due to several scenarios. Part of the structure may have erupted or drained to the surface, or a temperature change may have rendered part of the structure invisible at 1.3mm.

The weak enhancement to the south of the southern patch shows signs of activity on July 10, and is also not evident on July 11. The feature shows some motion to the south, at constant altitude during the observations of July 10. Another change is associated with the light bridge between the two

brightest patches. This shows a significant decay from image to image. Finally, as mentioned above, the overlying enhancement clearly visible on July 11 is not evident on July 10.

The brightness of the two principal patches remains constant through the observations of July 10, yet significant brightening is seen just after the eclipse itself.

Between the time of the last image taken on July 11 and the start of operations on July 12 the prominence erupted. Thus the JCMT observations not only showed a large, activated prominence, they provide a sequence which apparently shows a prominence preparing to erupt. A comparison with data taken using the traditional H $\alpha$  band, indicates that the 1.3mm emission may originate from a region which surrounds the H $\alpha$  emitting material and reveals some features not found in the H $\alpha$  data. Thus, inclusion of observations of this kind has great potential in leading to a better understanding of prominence activity and eruption.

The events reported here represent a unique dataset. To assess the uniqueness of the features of this particular event and to discover the general properties of mm prominences we encourage further observations of this kind.

The observations described here are discussed in full in the references. They are the result of a lot of hard work done by a lot of people and, on behalf of the scientific team, I would, in particular, like to express my thanks for the efforts of the JCMT staff.

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Lindsey, C and 10 co-authors, 1992 Nature (submitted)

## Infrared spectrum of a radiogalaxy at $z = 3.22$

The discovery of radiogalaxies at  $z > 3$  aroused the hope that the study of these objects would lead to a better understanding of the early evolution of galaxies (for  $\Omega_0 = 1$  a redshift of 3 corresponds to the Universe being only 10% of its present age). There have, however, been two difficulties with using these objects to study galaxy evolution. Firstly, the redshifts are so high that most of the astrophysically useful lines have been shifted out of the optical passband; the only strong line still in the optical passband is Ly $\alpha$ . Secondly, there is uncertainty about how much the two standard ways of using radiogalaxies to investigate galaxy evolution - studying the spectral energy distributions of individual objects and studying the K-z diagram for radiogalaxies as a whole - are affected by line contamination. The high equivalent width of Ly $\alpha$  in the optical passband suggests that the crucial K-magnitudes of  $z > 3$  objects may be substantially contaminated by [OIII]500.7.

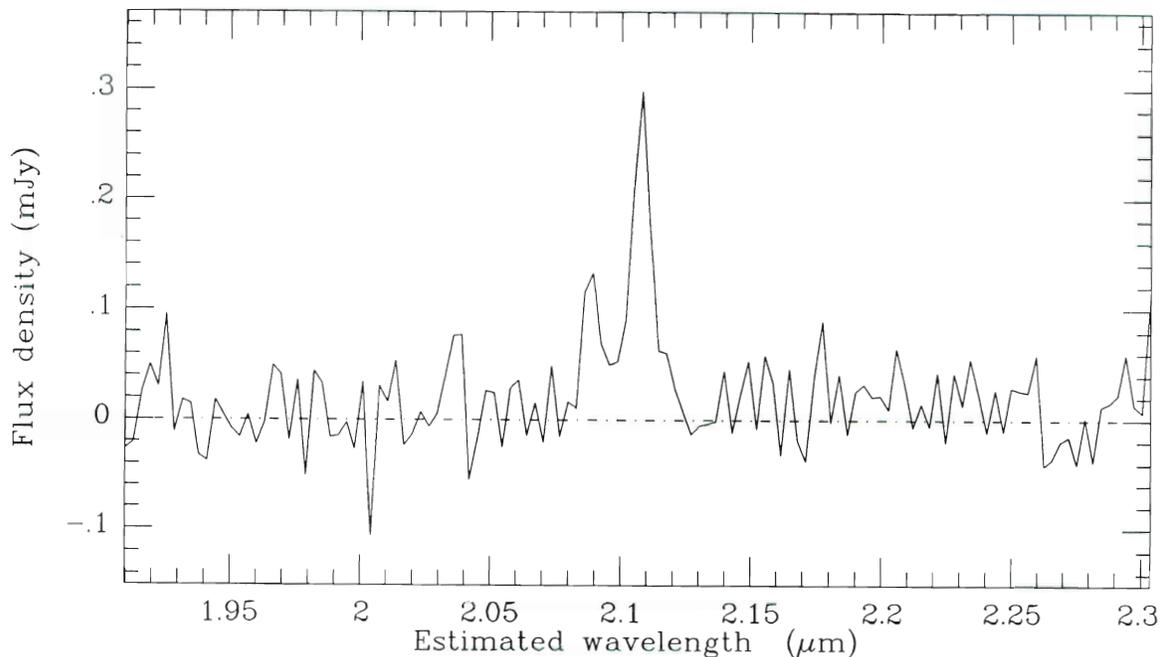
We have been using CGS4 to address this problem, and we now have high-quality infrared spectra of four  $z > 3$  radiogalaxies. In each case, we have detected [OIII] 500.7. The figure shows the spectrum of the radiogalaxy 6C1232+39, which we took in mid-January on UKIRT. We have detected [OIII] 500.7 and [OIII] 495.9 and possibly H $\beta$ .

Once we have reduced our data in detail, we will be able to determine accurately how much of the K-band flux is due to lines. We will also be able to use the infrared-optical line ratios to investigate the physical state of the circumambient gas.

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*Steve Rawlings*  
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[OIII] in 6c1232+39 ( $z=3.22$ )



## Infrared Helium Emission Lines from Cygnus X-3

Cygnus X-3 is one of the most luminous X-ray sources in the galaxy, and a radio source which undergoes huge outbursts. Because the source is obscured by intervening spiral arms, no visual information is available. The source is detectable at infrared wavelengths, however. The X-ray and infrared fluxes are modulated by a 4.79 hour orbital period, which is increasing on a time scale of 600,000 years.

Two models of Cygnus X-3 have been proposed. Both invoke a compact object (white dwarf or neutron star). In one model, the companion is a low mass star, transferring material to the compact source. In the other, the companion is a massive, and possibly highly evolved star, with a strong wind. Indeed, the companion would have to be a helium star, as a massive hydrogen-burning star would not fit within the volume of the system.

In order to reach an improved understanding of Cygnus X-3, an infrared K-band spectrum of it was obtained for J. van Paradijs (U. Amsterdam) on June 29, 1991, during service observing. A spectrum had been obtained the previous year with CGS2, but the S/N was not sufficient to reveal spectral features. The new spectrum is shown in the figure; it was obtained in 16 minutes of actual exposure time (~ 1/2 hour elapsed time). All the lines can be identified with He I or He II transitions. Even the line at 2.166 $\mu$ m, which is

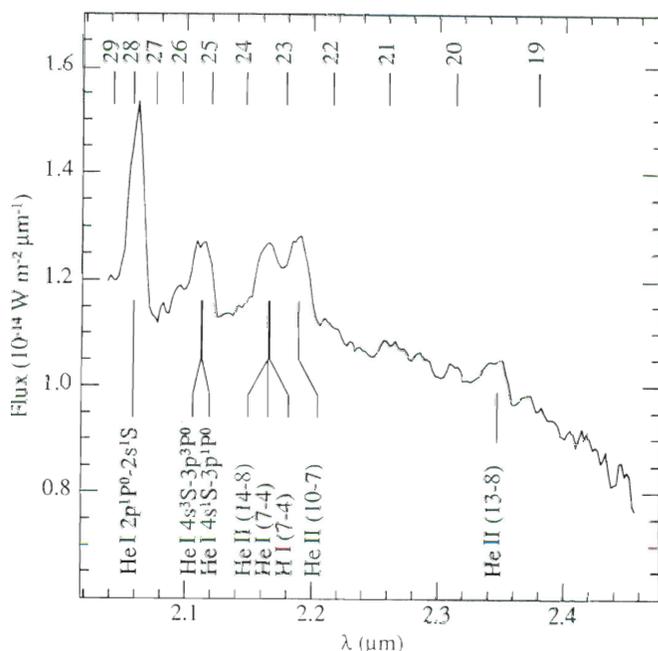
usually assigned to H I Br $\gamma$ , is probably largely He I 7-4 and He II 14-8. The lines are broad, and slightly asymmetric, indicating a high speed outflow, with the back portion obscured.

The model of a compact object and a (relatively massive) helium star appears to be confirmed. Indeed, the spectrum appears similar to those of certain Wolf-Rayet stars. On the basis of the spectrum, Cygnus-X3 is suspected to be the first known example of the hypothesized evolutionary link between massive X-ray binaries and binary radio pulsars such as the Hulse-Taylor pulsar.

In early July, 1991 Cygnus X-3 experienced a major outburst. A new K spectrum of it was obtained on July 20. The continuum has reddened; it is weaker at shorter wavelengths and brighter at longer wavelengths than the earlier spectrum. The relative line strengths are dramatically different. The He I lines have weakened considerably, and the one at 2.06  $\mu$ m, which was the strongest line in the earlier spectrum, has all but disappeared. It is not clear whether this change is a result of the outburst or because the system was observed at a different orbital phase. Further observations are required for a more complete understanding.

A paper containing these data, authored by M. van Kerkwijk (U. Amsterdam) and 7 co-investigators, is in press.

Tom Geballe  
JAC



CGS4 K-band spectrum obtained on June 29, 1991. Shown is the reduced spectrum, corrected for telluric absorption and flux-calibrated using a spectrum of HR7796 (with its Br gamma absorption line artificially removed). The resolution is 0.007 microns. Below the spectrum the identifications for the stronger lines are given. Above the spectrum, the rest wavelengths of the HeII (n-9) lines are shown, as several of these coincide with marginally significant emission features in the spectrum.

## S106FIR: a young (proto)stellar object?

We have recently completed a study of the circumstellar environment of the well-known bipolar nebula S106 using the JCMT. Continuum maps at 1100, 800 and 450  $\mu\text{m}$  have been made using UKT14, and the on-the-fly maps were reduced with the DBMEM maximum entropy dual-beam mapping package. This new program (written by JSR) replaces the RESTOR and CONVERT routines of NOD2 by a single superior algorithm which *deconvolves* a given beam pattern.

The HII region S106 lies at the centre of a molecular cloud: it is *bipolar*, and is photonized by an O9.5 star which is referred to as S106IR. The youth of this star is indicated by the large amount of circumstellar molecular gas present, and by the unusual properties of the ionized stellar wind. The bipolarity of the region has been attributed to the presence of a large (30-arcsec) protostellar disc of cool molecular gas surrounding the star which may still be accreting matter. Maps near 1mm in dust continuum and molecular lines have shown tentative evidence for such a structure.

Maximum entropy images of the 450 and 1100  $\mu\text{m}$  emission are reproduced in the figure. At 1100  $\mu\text{m}$ , most of the flux is free-free emission from the north-south extended HII region, and part of the elongation east-west around S106IR is due to weak dust emission. At 450  $\mu\text{m}$ , the free-free emission is negligible, and the 8-arcsec beam of JCMT has resolved much of the circumstellar dust emission.

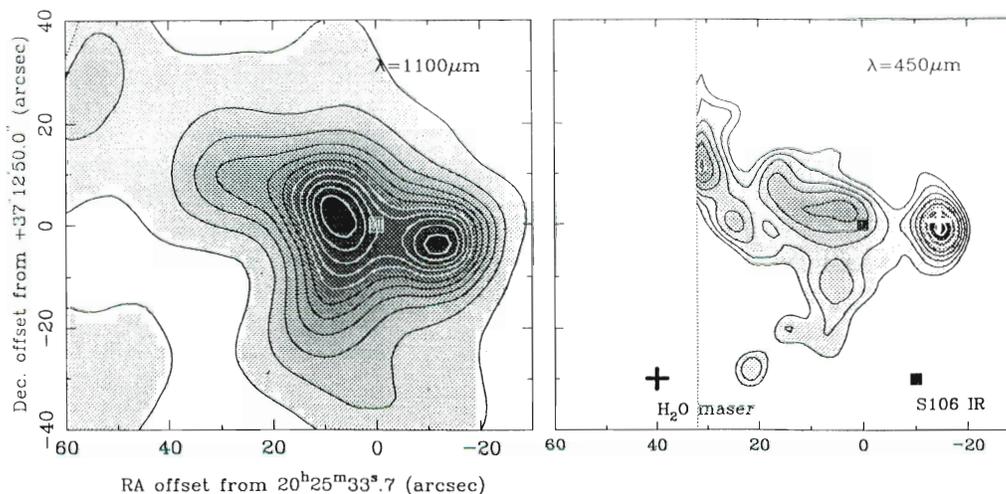
Rather than there being a smooth east-west extended dust disc around S106IR, we see that the emission is very clumpy indeed, and not symmetrically placed about S106IR. There is an extended bar to the east of S106IR, of mass  $\sim 10$

$M_{\odot}$  and dust temperature in the range 40-60K: this is presumably gas and dust left over from the star formation process, or perhaps the remains of a protostellar disk now fragmented by the stellar wind from S106IR.

The other main feature on the 450  $\mu\text{m}$  map is the bright *point source* 15 arcsec to the west of S106IR. This bright submm object has a flux of  $> 50$  Jy at 450  $\mu\text{m}$ , but is not seen in 10 and 20  $\mu\text{m}$  images of the region. Analysis of its spectral energy distribution indicates a dust mass  $\sim 5 M_{\odot}$ , a mean density  $> 10^9 \text{ cm}^{-3}$  and a visual extinction  $A_v > 500$  mag. The dust temperature is in the range 20-40 K, and the luminosity 50-1000  $L_{\odot}$ . We christened this new source S106FIR. It has properties similar to the objects IRAS4A and B discovered in NGC1333 by Sandell, Robson and Russell. These properties, and its coincidence with an  $\text{H}_2\text{O}$  maser, suggest that S106FIR is a very young self-luminous object which will eventually form a near neighbour to S106IR.

On the basis of IRAM 30-m observations, Mezger *et al.* have suggested that S106IR is surrounded by a massive disc of cold (16K) gas and dust in which molecular gas-phase abundances are severely reduced by depletion onto the cold grains. However, our JCMT and complementary IRAM line observations show that gas and dust to be warm (40-60K), and that the line and continuum emission are well correlated, indicating that molecules are *not* frozen out onto the grains. A full description of these observations is soon to be submitted to Monthly Notices.

*John Richer, Derek Ward-Thompson, Rachael Padman, Richard Hills*  
MRAO, Cambridge.



## First Results from the MIRACLE Mid-IR Camera at UKIRT

MIRACLE (Mid-IR Array Camera of Least Effort) is a collaborative project between the infrared astronomy group at the Max-Planck-Institut für extraterrestrische Physik (MPE) and the Royal Observatory Edinburgh (ROE) to build a mid-IR imaging system which could be periodically made available to the UKIRT community. The aim has been to construct and test on relatively short timescales a state-of-the-art camera which could achieve specific scientific goals whilst at the same time providing experience in operating an imaging system in the 7-22  $\mu\text{m}$  wavelength regime. MPE has been responsible for the mechanical design and construction of the camera, purchase and testing of the array, optics and filters, and the development and implementation of the data acquisition system which it was originally foreseen would only be used during the initial runs. ROE supplied the dewar housing (which used to contain UKT-9), makes available logistical support at UKIRT and is considering the provision of an interface to one of the UKIRT data acquisition systems. The project is managed from Garching and the MPE MIRACLE team consists of Murray Cameron, Siegfried Drapatz, Reinhard Genzel, Alfred Krabbe, John Storey (University of New South Wales), Valentin Rotaciuc and Laurent Verstraete.

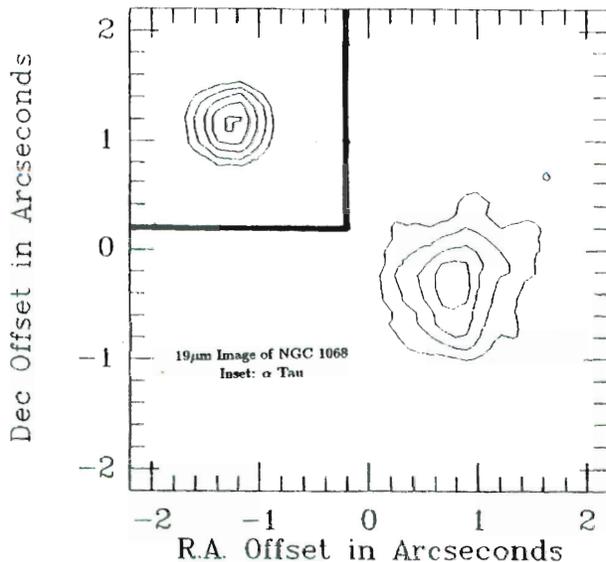
The MIRACLE detector is a 58x62 pixel Si:As array which cuts-off at 23  $\mu\text{m}$ . It was purchased from the Santa Barbara Research Center. The array is cooled with liquid helium to 10K. A filter wheel with space for 14 discrete filters and a 7-14  $\mu\text{m}$  CVF allows the selection of various low spectral resolution filters (bandwidths between 2-10%) across the N & Q windows. The MIRACLE image scale of 0.17"/pixel results in a field of view of 10" and implies that we well over-sample the telescope diffraction spot (0.65" at 10  $\mu\text{m}$ ).

The data acquisition system is based on a VME computer which handles array control, data transfer, accumulation, storage, chopping secondary movements and filter selection. The system can acquire data at a rate of 30Hz (in stare mode) whilst reading out the array at 60Hz. This speed is crucial in order to prevent saturation due to the high thermal background. The *Least Effort* nature of the project stems from the fact that because the detector has the same multiplexor as that in the MPE FAST near-IR camera, MIRACLE could borrow the already available electronics and a large part of the data acquisition system. However, a considerable amount of the array control software

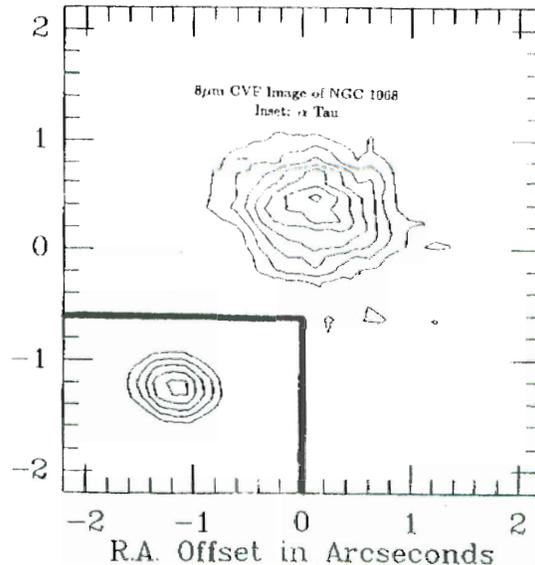
had to be re-written in assembler code in order to provide a continuous clocking mode. The MIRACLE array was delivered in July 1990 and we had our first daytime pre-commissioning run on UKIRT in December 1990. This opportunity allowed us to test the mechanical and electrical interface to the telescope and to identify the source of several problems which were degrading the system sensitivity. Resulting changes to the array control software enabled us to greatly enhance the overall performance of MIRACLE. With these improvements in place, MIRACLE was commissioned at UKIRT in November 1991 during its first night-time access to the telescope.

From the point of view of the MPE MIRACLE team, the commissioning went extremely smoothly. Following several days of tests in the UKIRT prep room, the dewar and MPE electronics were mounted on the telescope and connected to the VME computer in the control room. We then had daytime access to the telescope during which we were able to tune the system, align the detector with the secondary and begin optimising the array performance via observations of several bright standard stars - illustrating that there are a few time saving advantages to working in the mid-IR! During parts of our first two nights we experienced conditions which gave rise to almost diffraction limited stellar images at 10  $\mu\text{m}$ . We used the available time to carry out various tests to determine and improve the sensitivity through both narrow- and broad-band filters operating in the 10 & 20  $\mu\text{m}$  windows. In addition, as a means of determining the astronomical potential of MIRACLE we undertook a broad and varied scientific programme. Preliminary results are illustrated here but it should be stressed that, at the time of writing, only a small part of the dataset was available for analysis because our equipment had not yet returned from Hawaii!

The image on the back cover shows a 3x3 mosaic of the Orion-KL complex through a narrow-band filter (bandwidth 1.5%) centred at 18.7  $\mu\text{m}$ . This is the first published image longward of 14  $\mu\text{m}$  of this region made with such a large array. The image itself clearly shows some of the extremely luminous IR objects deeply embedded in this cloud. The white contours indicate the distribution of the surrounding dense gas as traced by (3,2) inversion line of  $\text{NH}_3$  at 1.2 cm. One striking spatial anti-correlation between this line and the mid-IR continuum emission indicates that these highly energetic sources have blown away a substantial



19 $\mu$ m image of NGC 1068. Inset:  $\alpha$  Tau



8  $\mu$ m CVF image of NGC1068. Inset:  $\alpha$  Tau

Preliminary images of the active galaxy NGC1068 obtained with MIRACLE at UKIRT. This is the first time that NGC 1068 has been imaged in the 20  $\mu$ m window. The 19  $\mu$ m data includes a contribution from the [SIII] line and work is under way to isolate this line from the continuum emission. Preliminary analysis of the 8  $\mu$ m data suggests that the source may be resolved, allowing an estimate of the extent of the emitting region. The lowest contour in the NGC 1068 images represents the 1 $\sigma$  level; the lowest contour level in the standard star images has been selected to show the FWHM. The MIRACLE image scale is 0.17"/pixel.

fraction of their embryonic material via the action of intense winds. This region, one of the brightest IR targets in the sky, was chosen to determine how well we could mosaic such frames together.

Other scientific targets during the run were the bright planetary nebula NGC 7027, imaged with a 10% wide filter which includes the 11.3  $\mu$ m PAH feature, the Egg Nebula (a bipolar outflow source) and the Red Rectangle (an dust-enshrouded late type star). Our main extragalactic target was NGC 1068, a relatively nearby (83 Mpc) active galaxy. We obtained data on this source at 8, 10 & 19  $\mu$ m with the aim of determining at least an upper limit to the extent of the emitting region. Such information is crucial for modelling the extent of dust heating in circumnuclear disks. The figures show preliminary reductions of 8 & 19  $\mu$ m data.

During the commissioning run MIRACLE, even at this early stage, achieved one of the original design goals: to reach a sensitivity comparable to current cameras based on similar type arrays as a stepping stone to further optimising the performance. However our sensitivity figures are still a factor of about 8 away from BLIP (Background Limited

Performance). Our objective is to further develop the system so as to bring us as close to BLIP as this technology will allow.

The MPE commissioning team consisted of Murray Cameron, Alfred Krabbe, John Storey and Laurent Verstraete. Terry Lee (ROE) took part in the observational programme. We would like to thank all the UKIRT and JAC personnel who contributed to the success of the run, in particular the night assistants who happily worked on into the morning (that's mid-IR astronomy!), the UKIRT day crew who ensured that problems were put right quickly and Colin Aspin who acted as our principal UKIRT contact. Back at MPE, Valentin Rotaciuc is credited with the implementation of the new array control system.

*Murray Cameron*  
*MIRACLE Project Leader, MPE*

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CBS%NSFNET-RELAY::EDU.HAWAII.JACH )

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JCMT Carousel: 935 0852

UKIRT dome: 961 6091

Fax in JCMT carousel: 935 5493

### User manuals

Copies may be obtained by contacting:

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Dorothy Skedd at ROE (UKIRT and JCMT)

The Newsletter is distributed in Canada by the HIA, Ottawa. Readers in Canada wishing to be placed on the mailing list should contact:

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Please send material for the next edition of this Newsletter to an Editor by **June 15** - earlier if possible, please.

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### On-line Documentation

Captive accounts available on ROE Starlink cluster:

JCMT RESTAR::JCMTINFORM

UKIRT RESTAR::UKIRTINFORM

These are not currently directly available via Internet, but can be accessed as described on page 17.

**Bulletin Boards** and Vaxnotes conferences, available for your contributions and for information, are accessible to SPAN and STARLINK only, viz.

19898::JCMT, 19898::UKIRT and  
19898::REMOBS (for remote observing).

The UKIRT Vaxnotes conference includes various subheadings including CGS4.

### Service Observing

Applications should be sent by e-mail to the following:

#### for JCMT:

Canadian: JCMTSERV@HIARAS.HIA.NRC.CA

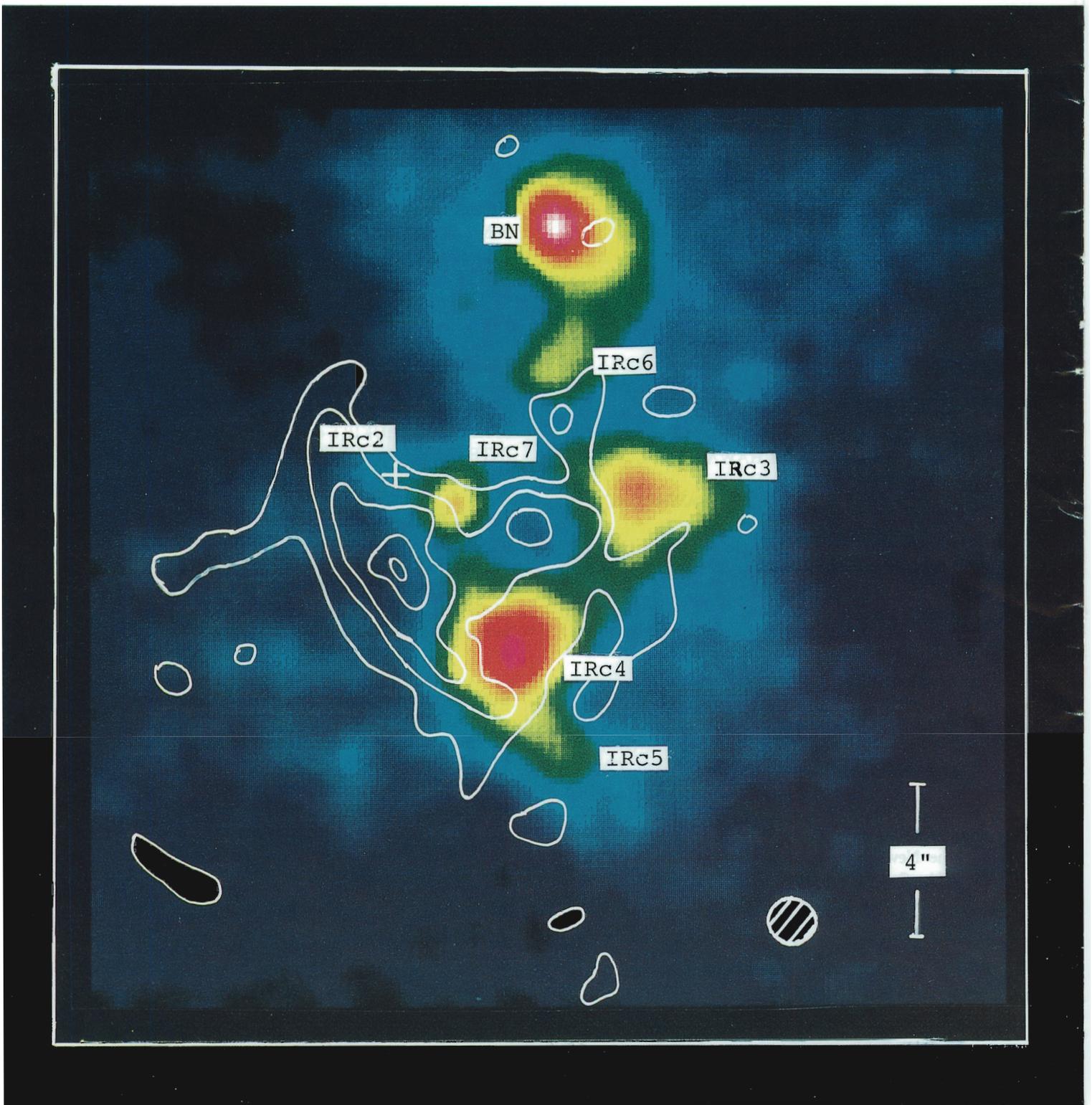
Dutch: ISRAEL@HLERUL51

UK: REVAD::JCMTSERV

#### for UKIRT:

REVAD::UKIRTSERV or

UKIRTSERV @ UK.AC.ROE.STAR



The Orion-KL complex at  $18.7\mu\text{m}$ . Taken with the mid-infrared camera MIRACLE on UKIRT, this is the first published image of this complex taken at a wavelength longward of  $14\mu\text{m}$  with a large array.