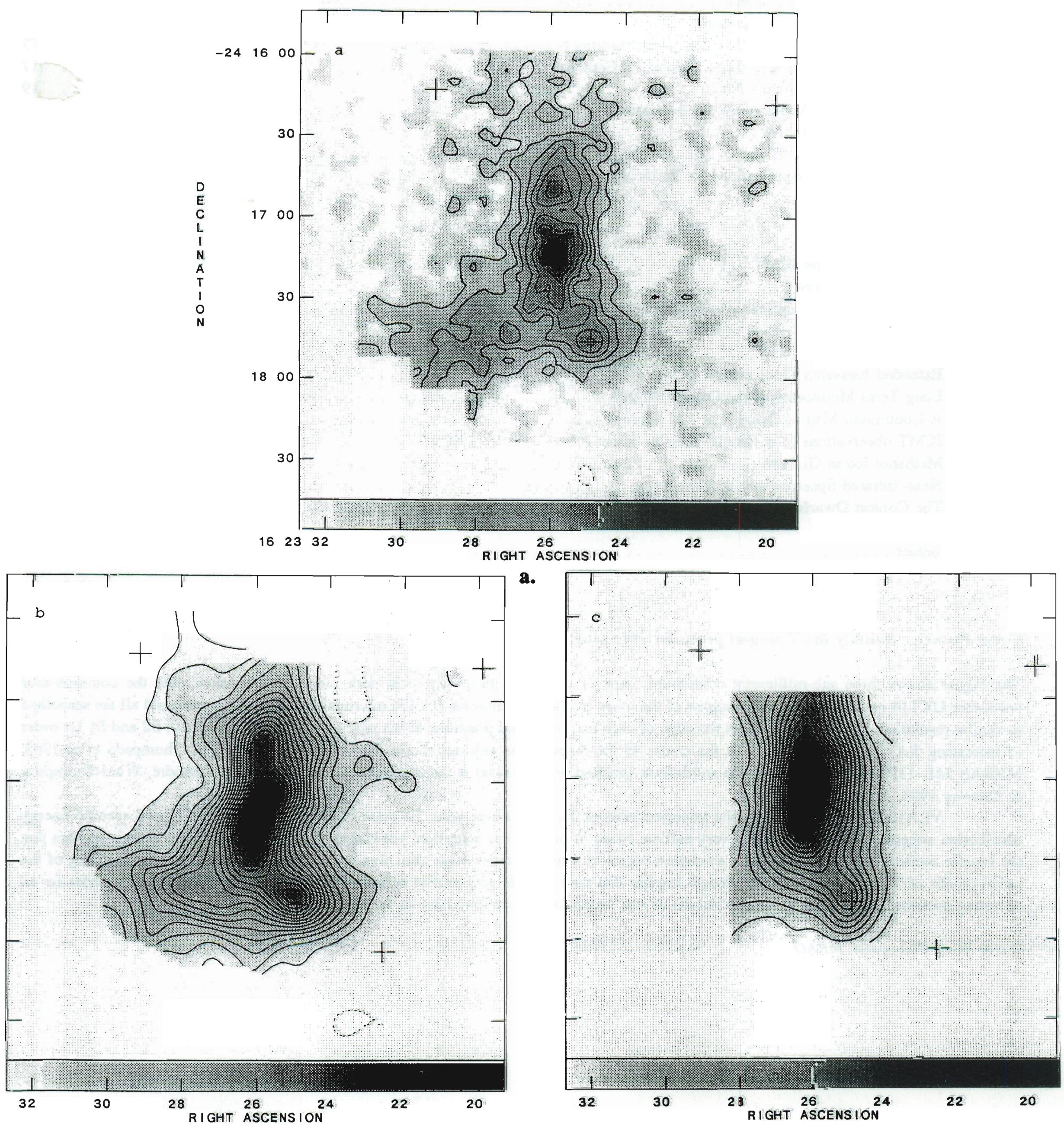
The JCMT - UKIRT NEWSLETTER

Kūlia I Ka Nu'U

Number 5 March 1993

Possibly the Youngest Protostar ever seen!



a. b. c.

Contents

Cover Picture: Possibly the Youngest protostar ever seen!

The Figure shows three sub-millimetre continuum maps of a part of the ρ Ophiuchi dark cloud region, taken with the common-user bolometer UKT14 on JCMT. The wavelengths of the maps are (a) 800 microns, (b) 450 microns and (c) 350 microns, and all are smoothed to similar resolution. The three crosses at the edge of each map mark the positions of the near-infrared sources GSS30, S2 and S1 (in order of increasing RA). The bright source at the centre of the maps is the sub-millimetre source ρ Oph-SM1 (Ward-Thompson et al 1989, MNRAS **241**, 119). The extension to the south-west (marked with a cross) is the candidate protostar VLA1623 (André, Ward-Thompson & Barsony 1993, Ap.J. 20th March).

VLA1623 is believed to be the youngest protostellar object ever seen. Its mass ($0.6M_\odot$), luminosity ($1L_\odot$) and spectral energy distribution suggest that it is still in the very earliest phase of protostellar accretion, yet it also has a bipolar outflow. Thus it appears that the bipolar outflow phase of protostellar evolution occurs at a much earlier stage than was previously believed. Detailed modelling of the radial profile of VLA1623 at each wavelength implies that the radial density profile is flatter than that predicted by current theories for an accreting protostar, suggesting that some details of star formation theory may have to be revised.

Derek Ward-Thompson, MRAO

People

Matt Mountain took up the position of GEMINI Project Scientist based in Tucson in mid-November 1992. During his short period at the JAC, Matt began work on plans for adaptive and active optics modifications to the UKIRT.

Ian Robson has now taken up his appointment as the Director, JCMT. Ian has been a frequent customer on the JCMT since it began operations and of the UKIRT prior to that. He is seconded from the University of Central Lancashire where he will retain strong research links.

Jo Fletcher has joined the JAC to work in the Engineering Division. Jo adds another Canadian to the staff and has been involved with the construction of RxB3i.

Phil Moore has joined the JAC in the post of Chief Engineer. Phil arrives from the SERC Daresbury Laboratory where he has worked for many years on mechanical engineering and operational aspects of experimental beamlines.

Maile Trask-Rierson has joined the JAC as Administration Clerk. Maile is a native of Oahu and has been resident on the Big Island for about 20 years.

Phil Williams has returned to ROE after many years in Hawaii. He left the JAC in the position as Acting Chief Engineer. As part of his new tasks Phil has taken control of the contracts and finances involved with the JCMT Development fund and is involved with the instrument management programme.

Chas Cavedoni has taken up the position of programme manager for UKIRT upgrades. Chas was previously at the University of Hawaii.

Bill Duncan has also returned to ROE after a lengthy spell involving continuum instrument work on both the UKIRT and the JCMT. More notoriously Bill is remembered as Project Scientist for the most overworked instrument on the JCMT, namely UKT14. As well as contributing to the final stages of SCUBA work at ROE, Bill will be devoting considerable time to the JCMT instrument management programme.

Colin Hall has been relocated (!) to ROE after a tour of duty at the JAC. Colin succeeded Hugh Gibson as MRAO engineer for RxA and his tasks escalated to guru for most of the instrumentation including a significant role in the short-baseline interferometry project with CSO. At ROE, Colin will also be working on the JCMT instrument management programme.

Roger Clowes has left ROE to take up a lecturing post at the University of Central Lancashire. Roger was heavily involved with the setup, administration and operation of the remote observing procedures for both telescopes.

Karl Kawauchi has joined the JAC as an electrical technician. Karl is a native of Hilo but has lived for many years on Oahu.

Happy Events

We feel sure all our readers would wish to offer sincere congratulations to **Göran and Ginger Sandell** on their recent marriage; **Saeko and Masa Hayashi** on the birth of their daughter; and **Janice and Russell Redman** on the birth of their son.

Apologies

Richard Wade has been appointed as Head of the Engineering Division at RAL which is an amalgamation of the old Applied Science and Engineering Divisions.

Gillian Wright is the JAC Project Scientist for CGS4. Matt Mountain was the CGS4 Project Scientist during the construction and initial commissioning phase.

The Editors wish to apologise to both Richard and Gillian for any upset and confusion we may have caused.

STOP PRESS

Director Observatories

Professor Alex Boksenberg has been appointed to the post of SERC Director Observatories. He will be taking up this position with effect from March 15th.

UK-Hawaii computer communications and remote observing

On March 4th, we will have to cease leasing the kilostream data circuit between Edinburgh and Hawaii with the result that the computers at the JAC, JCMT and UKIRT will no longer be accessible using DECNET from Starlink nodes in the UK. Users in the UK who are not already doing so should use Internet for e-mail, remote login ("telnet") and file transfer ("ftp").

As network-watchers are aware, the academic networks in the UK and USA are being developed rapidly and the bandwidth of the "fat pipe" which carries (inter alia) traffic between JANET and NSFnet has recently been quadrupled. However, bandwidth and real time response are not guaranteed as they were with the dedicated line and this will affect remote observing from the UK. Experience will help us quantify this and, in the long term, we expect the academic networks to provide enough bandwidth to allow remote observing.

Meanwhile, remote observing is still offered, especially on the JCMT from where the data rates are less demanding. Potential users are invited to contact me at the e-address below and also the JAC support scientist assigned to their observing run. The Remote Observing manual will be revised once necessary changes to accommodate internet have been made and more information will be given in the next Newsletter.

Peredur Williams
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Starlink: REVAD::UKREMOTE
Janet: UKREMOTE@UK.AC.ROE.STAR
Internet: UKREMOTE@STAR.ROE.AC.UK

Contributions for the next issue

The deadline for submissions for the next issue of this Newsletter is **Monday 9th August 1993.**

Please ensure one of the Editors has a copy of your article or is aware that you intend to submit one.

CIRCUMSTELLAR MATTER 1994

29 August - 2 September, 1994

EDINBURGH, SCOTLAND

The Conference is to be held at the Heriot-Watt University Conference Centre just south of the city of Edinburgh. The talk sessions will run from Monday morning through Friday mid-afternoon.

It is hoped to present a concurrent or recent overview of all features of circumstellar matter. The presentations and posters should lead participants to a better understanding of the processes of star formation, early stellar evolution and the later stages of evolution. The proceedings of this Conference will be published. It is hoped that this work will form the basis for a major review of circumstellar processes.

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

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

UKIRT News

Expected Availability of UKIRT Instruments during Semester Y (August 1 1993 - January 31 1994)

UKT6 (single channel 1-5 µm photometer, cold wire grid polarizer, 2.3-4.6 µm CVF)

UKT9 (single channel 1-5 µm photometer, 1.35-2.6 µm CVF) CVF spectroscopy with UKT6/9 is vastly inferior to CGS4 spectroscopy in almost all circumstances. Because of the almost complete lack of use of CVFs during the past several years and the continual finite amount of software support of them required, it is likely that CVF spectroscopy will be decommissioned in the near future.

UKT8 (single channel L', N, Q and narrow band 10 µm photometer).

UKT16 (8-banger; N, Q, 30 µm and narrow band 10 µm)

IRCAMs (JHK filters and various narrow band filters from 1 to 5 µm). It is expected that IRCAM3 (256 x 256 InSb array) (0.3" pixels, 72" field of view) will be commissioned during the second half of the semester and that it will be available for visiting scientists in the following semester (Z). If so, IRCAM1 with the 58 x 62 array and (0.3" – using the external magnifier, 0.6", or 1.2" pixels) would be available until about mid-November, after which it would be removed from the telescope. If the period of availability of IRCAM1 is significantly changed from this, prior to the proposal deadline for Semester Y, the user community will be notified.

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.

CGS3 (8-22 µm grating spectrometer, 1 x 32 channels, resolving powers of ~60 or 200 at 10 µm and ~75 at 20 µm, 10 µm spectropolarimetry, Beam sizes from 1" to 9" diameter). If IRCAM3 is delivered to Hawaii as currently scheduled, then CGS3 likely will be unavailable during much or all of the months of December 1993 and January 1994, while IRCAM3 is being tested at the telescope. Prior to those months, CGS3 is available. Note that CGS3 must be mounted on the north or south port, and thus requires that either IRCAM or CGS4 be off the telescope.

CGS4 (1-5 µm grating and 2D array spectrometer (3" and 1.5" pixel sizes; 75 l/mm, 150 l/mm, and echelle gratings; ~90" slit; polarizer available, but data-reduction software is expected to be minimal for this mode).

During the period August-October the configuration will be the long focal length camera (i.e. ~1.5" pixels), the 75 l/mm grating, and the echelle. Later in the semester the configuration will be the short focal length camera (3" pixels) and the 75 and 150 1/mm gratings (i.e. no echelle). The scheduling of the CGS4 down-time (~3-4 weeks) to change the configuration will depend on the IRCAM3/ALICE delivery date and commissioning schedule; at present users should expect the down-time to occur in November. If there is a large shift prior to the proposal deadline, the community will be notified.

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

10 MICRON CAMERA Berkcam (10 µm camera, 10 or 20 x 64 0.39" pixels, 10% and 1.3% CVFs). The UC Berkeley group led by J T Arens invite UKIRT users to contact them if they wish to make collaborative proposals to use their 10 micron camera on UKIRT in semester Y. Those interested should discuss any potential proposals with the Berkeley group and obtain their agreement to the collaboration prior to submission of the application to PATT. Enquiries should be directed to Dr Chris Skinner, SPAN address: 6913::"skinner@tristan.llnl.gov" INTERNET address: CBS%NSFNET-RELAY::GOV.LLNL.TRISTAN::skinner

IRPOL (1-5 µm polarimeter for IRCAM, UKT6, CGS3, and CGS4). Note that the unvignetted field of view of IRCAM1 and CGS4 through IRPOL is ~35."

FABRY PEROT's - 2 µm: 12, 25, 90 and 300 km/s resolutions; used with IRCAM1) unvignetted field of view is ~ 60" diameter.

Special note:
With the exception of Berkcam, no visitor instruments will be granted time on UKIRT during December and January, if the current schedule for delivery and commissioning of IRCAM3/ALICE is followed.

Tom Geballe
Associate Director UKIRT

CGS4 Update

CGS4 continues to be the instrument in heaviest demand on UKIRT with about 75% of Semester W allocated to CGS4 use. Less than 2% of clear time was lost to CGS4 faults this semester. I hope that successful CGS4 users will write articles describing their results, so I plan to use this regular CGS4 feature just to summarise recent progress, support issues and future plans.

The CGS4 data reduction software, CGS4DR V1.6-0, was released by Starlink on 23 November 1992 in SSC660. There is a comprehensive user guide for the software which also provides a description of how to reduce CGS4 data.

Spectro-polarimetry was commissioned during November and December 1992. The first shared risks run was very successful and some exciting results on NGC1068 were obtained. The polarisation efficiency of CGS4+IRPOL was measured to be about 85% at K, although it is somewhat less at J. The instrumental polarisation is very approximately 1%, however this is an area where much more work is needed in understanding systematic effects. Position angle calibration is a function of wavelength and should be measured for each grating setting. Excellent weather conditions are needed even for near infrared spectro-polarimetry, as results are very susceptible to sky fluctuations. There are now some 'standard EXECs' for stepping IRPOL and nodding along the slit which are suitable for observing point sources. Point source data can be read into TSP and there are ICL procedures which help you assess how the signal-to-noise is building up. Unfortunately poor weather compromised the commissioning with the L and M waveplates and prevented any attempt at extended sources.

Questions are frequently asked about the definition of slit angles on the sky. The slit angle entered in a CONFIG is defined as an angle WEST of NORTH. When a slit angle of 0 degrees is set the slit is North-South on the sky and South is at the top of the array. When a slit angle of 90 degrees is set the slit is East-West on the sky and West is at the top of the array. The final calibration of slit angle on the sky is done by centering a star at each end of the slit with the slit N-S and E-W on the sky and is accurate to about 0.3 degrees.

It is a good idea to bring a tape for your CGS4 data with you. We can provide Vax backup tapes on either Exabyte, 6250 and (coming soon) DAT tape. Both raw and reduced data are written to the tape. Figaro Fits format is also available, but users should be aware that they will lose the error and quality arrays and that Fits is only available on 6250 tape. Given the demand on our tape drives and the several hours it takes to write the data from a productive three night run to tape, it is not always possible to write the tape on the afternoon you come down the mountain. Please make arrangements with your support scientist for provision of a data tape.

In February 1993 the 150 l/mm grating will be installed. During the down time we plan to carry out preventative maintenance on the translation drive and install a K filter to provide better blocking at 2.1 - 2.2 µm in second order with the 150 l/mm grating. In May-June 1993 the long camera will be installed. During semester X we plan to significantly improve the efficiency of peaking up.

Gillian Wright
Joint Astronomy Centre
Hilo

The MICHELLE Spectrometer Project

Progress on UKIRT's mid-infrared echelle spectrometer (see JCMT/UKIRT Newsletter No. 3) has been gathering speed over the past few months, with design and testing proceeding apace for those novel cryogenic mechanisms which will make it the most versatile instrument of its kind. These include a means for selecting between four diffraction gratings and choosing from a range of entrance slit geometries, whose widths will vary from 0.75 arcseconds upwards.

ROE has been encouraged to ensure that after several years of service on UKIRT, Michelle will be capable of being used on the proposed Gemini 8 metre telescope. With what should be outstanding performance in the mid-infrared, Gemini will provide the ideal platform for Michelle in the post-ISO era. The project's delivery date to UKIRT remains at October 1996.

Alistair Glasse
ROE

Status Report on ALICE

The upgrade of an IRCAM to accommodate a 256x256 InSb array and the associated ALICE array control system have made good progress since the initial progress report in the 3rd JCMT-UKIRT Newsletter. Modifications to the IRCAM3 cryostat, involving re-wiring to cope with faster speed of operation and the procurement of a new lens assembly has been completed. The majority of the electronics sub-systems have been produced and, together with a subset of the final transputer and VAX software, enabled the first 256x256 image to be acquired in the lab on 27 January 1993. Even with the ALICE system in its present state, it will still be possible to determine several important characteristics of the system, including the maximum speed at which the arrays can be operated (important for imaging at thermal wavelengths, shift-and-add image sharpening, and non-destructive readout), an estimate of the device readout noise, and further measurements of the image quality using a telescope simulator. Measurements of the array performance are underway and we have already taken data at a continuous rate of 30 frames/s (totalling 20000 frames, or 5.6 Gbyte of data, coadded by the transputers in a little over 10 minutes !). Preliminary results from other groups operating these arrays in the lab suggest that they exceed the manufacturers quoted performance for read noise (being about 50 e-/read) and dark current (1-2 e-/s). We aim to measure these properties at high speeds of operation in the near future.

Work over the next few months will concentrate on completing the analogue electronics and the innovative "waveform generator" which allows waveforms for driving the array clocks to be quickly and simply designed in software, completion of the transputer software for the various modes of operation (stare, non-destructive stare and chop have been written; nd-chop and "movie" mode and aspects of the waveform generator control software are still outstanding) and extensions and modifications to the VAX software to facilitate efficient observing. Lastly, we must test each of the science arrays and determine their optimum operating conditions. Commissioning of IRCAM3 at UKIRT is expected to occur towards the end of 1993, with the CGS4 upgrade being completed about 6 months later.

Phil Puxley, ALICE Project Scientist, ROE.

The UKIRT Upgrades Programme

1. Introduction

During the past year a programme to upgrade the imaging performance of UKIRT has been ramping up. The stated goal of the programme is to upgrade the telescope and its environment so that it is capable of delivering diffraction limited images at 2.2 µm. While many regular users of UKIRT have probably already heard about it, I have found out that we have been very remiss in reporting it in the newsletter. Thus, I thought it might be interesting to cover a certain amount of the history behind the programme, before giving a brief rundown on how it stands at the moment.

2. History

The possibility of improving the image quality of UKIRT has been on the minds of many for a number of years and, indeed, the UUC (now the UPC) has probably discussed it at every meeting it has held. Along the way, there have been a number of gradual improvements, but none were so dramatic as that proposed by the current programme.

The origins of the current programme can be directly traced to an action to produce a costed proposal placed on Tim Hawarden during the UUC meeting of March 1991. In response, Tim wrote a report entitled 'The UKIRT Upgrades Programme: A long term plan with approximate costings' for the following meeting (September 1991). This was the first time a detailed, costed, submission had been made on the subject and the UUC agreed that the proposals should be strongly supported.

During the six months before the March 1992 meeting a number of things happened. Firstly the Max Planck Institutes in Heidelberg and Garching expressed an interest in contributing to the Upgrades programme — in return for a proportionate amount of observing time — and secondly, the ROE decided to allocate about $250,000 to the JAC during the 1992/93 financial year to be used specifically for upgrading the telescope.

Matt Mountain was the programme scientist prior to his departure to Gemini. Tim Hawarden has now taken up these duties and Chas Cavedoni has been recruited from the University of Hawaii to be the programme manager and mechanical engineer. The other people on the team at JAC are Tim Chuter — control systems and electrical engineering, and Nick Rees who will be working on the software. Over the past few months this nucleus of four have been working with the T&C group at the ROE to define the project budget and schedule so that they can be presented to the UPC in March.

3. The Current Status

Currently the project breaks down into five main areas. These are:

3.1 The top end and fast guiding system

This is the part of the system that MPIA in Heidelberg will be committed to providing once the MOU is signed. The new f/36 top end will include a top end ring, vanes, 5 axis slow secondary drive (for collimation, focus and coarse tilt adjustment) and three axis fast tip tilt secondary drive (for fast guide corrections). The mechanical engineering challenges are considerable, since it is essential that no resonances below 450 Hz be excited by the tip tilt mirror.

The fast guide sensor that they will provide will be capable of updating the tip tilt demand positions at about 250 Hz. Preliminary calculations indicate that it may be possible to guide at this rate with 0.02 arcsecond accuracy down to about 15th magnitude, and guiding on fainter stars will be possible at proportionally lower bandwidths or guide accuracies.

3.2 The primary mirror support system

It has been known for some time that the UKIRT optical system has varying amounts of astigmatism. Currently, we believe that this may be corrected with relatively minor changes to the primary support system. If these improvements are inadequate we will investigate an active support system, driven either by lookup tables, or by periodically measuring the aberrations with a wavefront sensor.

Currently work is progressing at the ROE (we are indebted to Donald Pettie, Colin Humphries, Richard Bennett, and Eli Atad, to name a few) and the JAC to evaluate the existing system. We have also been consulting with Brian Mack at the RGO since his group has a wealth of experience accrued over the past 10 years with the La Palma telescope support systems.

3.3 Bottom end system

The current optical detector system (which includes all the instrumentation below, and including, the dichroic) has many limitations such as flexure, poor throughput and lack of versatility. To achieve the performance we are contemplating, it will be necessary to upgrade it substantially before, for example, we are able to derive the full benefit from a fast tip tilt guider.

The system is unique in that it is linked to many other areas of the programme. Not only is it where the new guider will be mounted, but it also may have to accommodate a wavefront sensor that is used to evaluate the primary mirror support system. It will also involve an upgrade to the current, aging, acquisition system, and a new dichroic which should have higher optical throughput without compromising the IR performance.

3.4 Thermal and environmental control

The fourth part of the programme is to control the environment around the telescope so that the dome and instrumentation do not significantly degrade image quality. This subject is yet to be investigated in great detail, but it is clear that it may involve projects such as cooling the primary, ducting heat away from the instrumentation cabinets and controlling the bulk dome temperature during the day, as well as the night.

3.5 Other on site improvements

The final area of the programme consists of projects that are part of the normal telescope development that would probably been undertaken even if major funding had not been available. Currently this consists of upgrades in instrument computing power to cope with demands of the 256 x 256 arrays, similar upgrades to the telescope computing power to cope with the other demands of the upgrades programme, changes in the dome control and rationalization and improvement of the main telescope servos. Work is actively proceeding in all these areas at the moment.

4 Conclusions

The Upgrades Programme should significantly improve the resolution, and hence performance, of UKIRT. It is difficult to quantify the exact benefits since there is much that is not understood about the characteristics of the atmosphere in the infrared. Although the performance will also depend on the availability of a suitable guide star, and the weather on the night, there is good reason to believe that during good seeing the telescope will deliver what the upgrades programme has set as its goal — diffraction limited imaging at 2.2 μm.

Nick Rees
Joint Astronomy Centre
Hilo

The New IRCAM Software System

A new user interface and software system is currently under development for IRCAM. The new system is needed to both make future software support easier and allow the successful upgrade to the 256 square array due in 1993. Operation of IRCAM will become much like that of CGS4 and will be a considerable improvement in terms of flexibility, observation planning and observation queuing. In the first instance, an SMS menu interface will be provided but at some later date, a command line interface will also be available. Users will then have a choice and can select their preferred method of operation.

The new IRCAM software is based on the idea of configuration files (CONFIGS) and execution files (EXECS) as in the current CGS4 software system. Instrument setup parameters (e.g. filter, on-chip exposure time, number of coadds etc) are defined in one menu called 'Define_Configuration'. On exiting from this menu, the user-defined values are saved in a named CONFIG file. EXECS, created with the editor, allow the user to plan a series of observations before the observation is started, and can include observations of the target object, sky, and dark exposures and bias frames, all with, for example, different instrument parameters (defined in separate pre-defined CONFIGS). Once the required CONFIGS and an EXEC have been defined, the users tells the system to run and all the specified observational data is sequentially acquired automatically i.e. without further user intervention. In this way, a simple 'object and sky' image pair can be taken or a considerably more complex series of observations (involving maybe automatic mosaicing, polarimetry or the Fabry-Perot) can be made without continued user intervention.

The commands available in an EXEC are very similar to those available for CGS4. Some CGS4 commands are obviously not needed with IRCAM, other commands have been added specifically for IRCAM operation. If the user wants to take an observation of his favorite object, lets say M31, at K with an exposure time of 20s and the number of coadds per exposure equal to 10, and take a sky observation at a telescope offset of 500" west, 100" north after the object observation with the same setup, followed by a dark and bias exposure, then he/she would define a CONFIG using the 'Define_Configuration' menu:

Define Configuration for IRCAM

Filter	Blanks J H *K* KP Ice Dust nbL 3.42 2.104 v=1-0S1 BrG
Magnifier	*OUT* IN
Acquisition_mode	*Stare* MND_Stare Chop MND_Chop
Object_exposure__secs	20.0
Object_coadds/exposure	10
Object_images/coadd	1
Dark_coadds/exposure	10
Dark_images/coadd	1
Bias_exposure__secs	0.145
Bias_coadds/exposure	100
Bias_images/coadd	1
CONFIG_name	M31K

(the *'ed items would be in reverse video in the real menu) and, with the editor, define an EXEC called DO_M31K :

```
TEL MAIN NOGUIDE
CONFIG GGD27K
SET OBJECT
NAME M31 K
BREAK
OBJECT
TOFF 100 -500
SKY
TOFF 0 0
DARK
BIAS
```

The user would then just tell the system to run EXEC DO_GGD27K and all the above actions will be taken. In the above example of an EXEC, the command TEL tells the telescope to setup in either the main or offset (nod) beam with or without autoguiding, the CONFIG command tells the system to load the pre-defined CONFIG file named GGD27K, SET OBJECT tells the system to load the object parameters into the system (e.g. filter, exposure time etc), NAME lets the user define the object name in the EXEC, BREAK stops execution of the EXEC and lets the user check the setup before he/she manually resumes EXEC execution, OBJECT tells the system to take the specified object images, TOFF moves the telescope from its current position to the sky position (in this case 100"N,500"S), SKY takes a SKY exposure, TOFF 0 0 returns the telescope to the zero position (i.e. on the source), DARK takes a dark image with the pre-defined dark setup and BIAS takes a bias exposure also with the pre-defined bias setup.

This mode of operation obviously allows a standard set of CONFIGS/EXECS to be defined for observations that will be repeated over and over again. For example, an observation at J, H, K and nbL of a bright (K = 6-7) UKIRT photometric standard could have pre-defined CONFIGS and an EXEC called BSTD. Once set up on the standard, the user would just tell the system to load and run EXEC BSTD. Data would be taken in all 4 filters both on source and on sky automatically.

In the CGS4 operational software system, data that has been taken is usually reduced on-line (in a user-defined way) with the automatic data reduction system running on the UKIRT Vaxstation IRTDR. We envisage that some similar processing could take place with IRCAM although the level to which reduction would take place is not yet defined. At the very least, we expect that the IRCAM automatic reduction system would allow the user to automatically display the raw data, the difference between the object and sky images and some line graphics (cuts through the image, histograms etc). In this way, the user will get some on-line automatic help in assessing his/her data. We do however hope to make the automatic reduction system more complex that the above in the future.

Under the new software system, IRCAM data will be stored on disk as separate Starlink data files (rather than the 1 large IRCAM container file created with the existing system). These files will be directly accessible by the many Starlink packages including the current IRCAM data reduction package, FIGARO and KAPPA, and users could still perform manual assessment of their data. We will certainly be able to provide users with either VAX backup or FITS tapes depending on their preference.

Colin Aspin & Alan Bridger
Joint Astronomy Centre
Hilo

UKIRT Service Observing

The UKIRT service observing programme provides the opportunity to have short (about 2 hour) projects carried out on your behalf by UKIRT staff astronomers. These observations may be for one-off projects, targets of opportunity or feasibility studies for full proposals to the PATT. Applications are solicited, received and refereed via electronic mail which enables us to provide a rapid and economical service. Projects which are accepted are maintained in our target list until they are either completed or withdrawn. Remote eavesdropping on your observations may be possible from the UK; contact UKIRTSERV for more details.

If you are not familiar with the programme then please read the files DISK$USER3:[UKIRTSERV] UKIRTSERV.HOW on the ROE STARLINK VAX or e-mail your questions to 19889::UKIRTSERV (UKIRTSERV@UK.AC.ROE.STAR). An e-mail version of the application form can be copied from DISK$USER3:[UKIRTSERV] UKIRTSERV.OBS. Announcements of forthcoming runs, and reports on recent observing, are distributed by e-mail to all on our mailing list, let me know if you wish to be added to this distribution.

Please remember to tell me if you complete your observation during a normal PATT run, or wish to withdraw it for other reasons, so I can delete it from the target list. Please also keep ROE informed of where the data is published so we can continue to demonstrate the productivity of the programme.

In order that the assessors for the service programme have significant overlap with the members of PATT who assess UKIRT applications, Chris Collins has agreed to step down from our panel and will be replaced by Phil James. Many thanks to Chris for his help over the years and welcome Phil, I'm sure you will be kept busy.

Schedule for Semester Y

The service runs for early 1993 are provisionally scheduled as follows (note that several are combined with AIC nights, hence the unusually long list). The precise balance between AIC time and service will be adjusted as we go along to ensure the correct allocation by the end of the semester. Because of this, the later dates may change and further reminders will be sent nearer each run. IRPOL (polarimetry) may be requested in conjunction with any IRCAM nights scheduled during this semester and will be attempted when possible.

Date	Instruments	Deadline (Noon UT)
4 Feb	IRCAM 0.6	
5 Feb	CGS4 (L,75,Ech)	
8 Feb	IRCAM 0.6	
9 Feb	CGS3	
6 Mar	CGS4 (S,75,150)	12 Feb
5 Apr	IRCAM 0.6	19 March
26/27 Apr	CGS4 (S,75,150), UKT8,UKT9	9 April
4 May	IRCAM 0.6	"
8/9 May	CGS4 (S,75,150), IRCAM 0.6, UKT9	"
25-27 May	CGS3,UKT9	3 May
22 Jun	Berkcam, IRCAM 0.6	31 May
7/8 Jul	IRCAM 1.2, UKT9	14 Jun
14 July	CGS4	"

Report on Semester U and V

This report covers the final night of Semester V and those of Semester W. Since the last report 41 applications have been received (plus a further 6 for the upcoming Semester Y), showing the continuing demand for service observing.

After a fairly normal start early in the semester the weather became exceptionally bad and all the planned runs between October and January (6/6) were lost because of this. A small fraction of this lost time was recovered using AIC time and we were able to complete 16 programmes, partly complete 6 and take data for a further 5 monitoring programmes.

The relatively small amount of observing means that there are few scientific highlights to present this time but I have noted the following publications using service data, please let me know if you have published recently.

Shenton et al., 1992. "Multiwavelength observations of RV Tauri Stars", *A. & A.*, **262**, p. 138-152.
Cohen et al., 1992. "Spectral Irradiance Calibration in the Infrared", *Astron. J.* , **104 (5)**, 2045.

A further three papers (1 solar system, 2 stellar) are known to be in press.

An historical sidelight, during this semester we received our 700th service application. Regrettably, there was not a prize for the applicant.

Observers and TOs who obtained data for service users included; Joel Aycock, Tom Geballe, Malcolm Smith, Dolores Walther and Thor Wold. Kevin Krisciunas and Gillian Wright assisted with data reduction. Thanks to them and to our assessors.

John Davies
ROE

UKIRT Data Reduction Software

Introduction

This document discusses the presently available software for reducing astronomical data obtained with the common-user instruments now on UKIRT. Data from the main suite of instruments (CGS3, CGS4 and IRCAM) can be reduced using standard STARLINK software. Users who are unfamiliar with data reduction for the instrument they are using should discuss this with their support scientist at the telescope, who should be able to suggest the reduction package or packages most suited to their needs. If there are any queries after the observing run is over, these should be addressed to the suggested contact at ROE.

1. CGS4 (Near-IR 1-5 micron array spectrometer)

CGS4 has its own, Figaro based, data reduction software package (SUN/27), CGS4DR, which is used at the telescope for on-line reduction. It is possible to leave the summit with all of the basic reduction of CGS4 data completed, and only analysis such as extraction and line fitting to do. The CGS4 data reduction can be set up as appropriate to automatically perform dark and bias subtraction, bad pixel removal, mask off unilluminated areas, flat-fielding, wavelength calibration from an arc spectrum, interleaving fully sampled spectra, coadding scans, coadding object-sky frames and division by a standard spectrum. You can also use it to extract point source spectra with residual sky lines from neighbouring rows removed, remove the ripples produced by baseline shifts in interleaved spectra and to flux calibrate. You can of course use CGS4DR to re-reduce data using a different flat or leaving out some bad spectra.

If you need to do more sophisticated reduction or analysis such as optimal extraction to maximise the signal-to-noise in spectra of faint sources, or combining spectra of the same source from different nights then FIGARO (SUN/86; SSN/40) can be used. UON/9.1 describes the use of Figaro with CGS4 data.

Figaro can also be used for some of the more basic reduction. Although CGS4 data is written in Figaro .DST format, the CGS4 data reduction has to be used for at least the initial stages of the reduction - the production of reduced observation files from the original raw integrations, because Figaro does not have the features required to interleave the spectra for different detector positions or manipulate and apply bad pixel masks. Combining reduced observations as object-sky pairs to form reduced groups can be done with either CGS4DR or Figaro. Normally CGS4DR is used. However if your data were taken in poor conditions the signal-to-noise ratio can be improved by removing background or baseline differences by using Figaro to individually correct each reduced observation to the same level before combining them. For subsequent reduction steps CGS4DR or Figaro may be used.

One area in which FIGARO is lacking is in sophisticated fitting of emission lines. This gap is filled by SPECDRE (SUN/140), a specialised line-fitting package which will fit Gaussians, Chebyshev polynomials and triangular functions to line profiles, and has bad pixel removal, plotting and black-body calculation options.

The contacts for any problems with CGS4 data reduction are Phil Puxley at ROE (REVAD::PJP), and Gillian Wright (GSW) at JAC.

2. IRCAM (1-5 micron array camera)

2.1 Initial data reduction

There is a comprehensive software package written specifically for the reduction of IRCAM data, IRCAM_CLRED (SUN/41). UKIRT_INFORM contains a description of how this package can be used, and lists all the commands available. It is quite possible to do all of the basic reduction using IRCAM_CLRED, and there are some options that are not available elsewhere. IRCAM data is written at the telescope as large container files in .SDF format. These can contain most or all of a night's observing, and individual frames have to be extracted using IRCAM_CLRED before any data reduction can be done in either KAPPA or FIGARO. As another example, IRCAM_CLRED includes sophisticated routines which automatically paste mosaics together taking account of changing background levels. This can be done using KAPPA and FIGARO, but is a long and tedious process. The main problem with IRCAM_CLRED is that it is not possible to use many of the functions in command files and run them in batch mode, since they require variables to be typed in interactively.

For this reason, FIGARO is often preferred for flat-fielding and bad pixel removal. KAPPA is also widely used, having some useful capabilities over FIGARO, including the ability to set bad pixels to "magic" or "don't know" values, which are then ignored when combining frames to form mosaics, or when getting pixel statistics from frames.

2.2 More specialised applications

All of the above packages are of limited use for doing photometry on reduced frames. If anything more than simple photometry in circular or rectangular simulated apertures is required, it will be necessary to use more specialised software.

DAOPHOT (SUN/42) is a widely used package for crowded-field photometry of point sources. Given a template point-spread function, it will search a field for stars or other unresolved objects, which are then listed and subtracted from the frame. The frame is then searched again for fainter objects that might have been hidden by the brighter stars. An important feature is the ability to put "fake stars" into the field at random positions, to see whether they are recovered by DAOPHOT and thus give a measure of the completeness as a function of magnitude.

Galaxy surface photometry is another area not covered by the general data reduction packages. This gap is filled by RGASP (SUN/52), the Reduced GAlaxy Surface Photometry package, which is a modified subset of the GASP package, (Cawson 1983). RGASP works on standard .SDF images. It will fit ellipses to the galaxy light profile and will do photometry within these apertures. When doing the ellipse fitting, the ellipse centres and ellipticities can be fixed or allowed to vary.

Fabry-Perot data obtained with IRCAM can best be reduced using the software written for the optical TAURUS instrument (SUN/147), which will handle the problems of correcting for wavelength shifts as a function of position at each FP position. There is no provision for this type of FP data reduction in any of the basic packages (FIGARO, KAPPA, IRCAM_CLRED), although they will be needed for the usual flat-fielding and cleaning up of images. The TAURUS routines can be listed, and their use described, by typing HELP @TAURUS within FIGARO.

IRCAM_CLRED has procedures for reducing imaging polarimetry data. These are listed in UKIRT_INFORM.

The contacts for problems with IRCAM data reduction are Phil James at ROE (REVAD::PAJ), and Colin Aspin (CAA) at JAC.

3 CGS3 (Mid-IR 8-22 micron spectrometer)

CGS3 data is reduced using FIGARO, but there are some CGS3-specific routines that are necessary for converting the raw, 4-D data files into 1-D spectra which can be processed by FIGARO, by coadding individual scans. These are generically titled RED3, and are explained in the CGS3 users guide which users receive when they use CGS3, and which is also available through UKIRT_INFORM. The development CGS3 data reduction software which can fully reduce and merge oversampled data and which is used at the summit will eventually be made available on Starlink.

Observers who wish to use RED3 should contact Tom Geballe at JACH, who should be able to make a copy of the software available. It is intended to release the CGS3 data reduction to Starlink.

The contacts for any problems with CGS3 data reduction are Tom Geballe (TOM) at JAC and Alistair Glasse at ROE (REVAD::ACHG).

4 UKT6/9 (Single element 1-5 micron photometers & CVF spectroscopy)

Single element photometry does not generally require sophisticated reduction software. There is, however, a programme to deal with UKIRT single element data, called PHRED, which is documented under UKIRT_INFORM. At the expense of some flexibility, this can save a great deal of time, since it works directly from the observation file, and can automatically identify observations of standards. PHRED is not generally available or supported in the UK, but the software can be made available to observers.

UKT6/9 can also be used for CVF spectroscopy, in which case the data are produced as .SDF format container files, similar to IRCAM data, although observers can also ask for individual ASCII files of their spectra. (This is true for all UKTn data.) CVF spectroscopy can also be reduced using the FIGARO routine RCGS2 to read the spectra into FIGARO.

Any problems with the UKT6/9 data reduction software should be referred to Kevin Krisciunas (KEVIN) at JAC or Andy Longmore at ROE (REVAD::AJL).

Appendix: Data formats and format conversions

The notes given above under individual instrument headings should enable users to convert data from the format produced at the telescope into FIGARO format .DST images or spectra, or ASCII spectra in the case of 1-D spectroscopy. However, there may be cases where format conversions are required, other possible formats including Starlink Data Format (.SDF), if KAPPA routines are to be used, or FITS format.

Converting between ASCII, .SDF and .DST formats can be done within CONVERT (type ICL cr CONVERT cr), using the following routines:

ASCII2NDF	(converts ASCII to .SDF format)
NDF2ASCII	(converts .SDF to ASCII format)
DST2NDF	(converts .DST to .SDF format)
NDF2DST	(converts .SDF to .DST format)

FIGARO-format .DST files can be written to tape in FITS format using the FIGARO programme WIFITS, though this will result in the loss of some header information and any error and quality arrays. WDFITS will write "disk FITS" with the same limitations.

Note that FIGARO can also use .SDF files, after issuing the following command:

DEFINE FIGARO_FORMATS "DST,NDF"

which can be inserted in a login.com.

Phil James
ROE

Successful UKIRT Applications for Semester X

PATT No	P/A	Title of programme	Instr	Nights
1	Browne	The inner regions of quasars	C4	3
2	Browne	Orientation and evolution in powerful radio sources	C4	3
5	Everall	The determination of the structure and kinematics of Be star X-ray binary disks	C4	2
6	Coe	A study of EXO2030+375 in Outburst	C4	3
9	Strauss	Si VI and PaA in a complete sample of ultraluminous IRAS galaxies	C4	3
10	Gear	Broad band polarimetry of Blazars: magnetic field geometries	HP	2
12	Dent	Are H2 and molecular jets manifestations of the same phenomenon?	I1.2	3
19	Longmore	Effective temperatures for cool dwarfs	C4	3
20	Puxley	Stellar populations in starburst galaxy nuclei: giants and supergiants	C4	3
23	Casali	The youngest PMS Objects on the HR diagram	C4	3
25	Mason	The IR pulsation of the peculiar intermediate polar RE0751+14	HP	2
29	Barlow	10 and 20 µm spectroscopy of vega excess stars	C3	4
30	Walton	The formation of planetary nebulae: 2 µm spec of protoplanetary neb	C4	3
31	Mason	The distances of high latitude CV	I*	2
33	Waters	High res IR spectroscopy of low density disks around normal Bstars	C4	2
34	van Kerkwijk	The nature of Cyg X-3: K band spectroscopy	C4	1
42	Garden	The dynamics of the shocked gas in the GL2591 young stellar outflow	I0.6,FP	4
43	Mathieu	Silicate emission from disks around young, short period binaries	C3	1.5
44	Noll	Comparative spectr. of Titan and the Galilean satellites from 3-5 µm	C4	2
45	Tinney	The empirical HR diagram for the lowest mass stars	C4	2
48	Sandford	A search for new ice components in interstellar dense molecular clouds	C4	3
49 & 56	Lumsden	Cometary compact HII regions - bow shocks or blisters	C4	3
51	Lacy	On and Off nuclear spectroscopy of radiogalaxies at z=1	C4	2
53	Hoare	The evolution of the stellar winds of young high mass stars	C4	3
54	Rawlings	Near IR spectroscopy of radiogalaxies at 2<Z<4	C4,I*	4
55	Lumsden	Wolf rayet stars as a probe of the initial mass function	C4	2
63	Trafton	Auroral vs NonAur. H3+ & H2 emissions in the atm. of Jupiter vs Uranus	C4	3
65	Graham	Spatial distribution of thermal IR in evolved stars and Plan. nebulae	Berkcam	4
66	Emerson	High res mid-IR imaging of low mass young stellar objects	Berkcam	2
69	Hough	Optical and IR polarization of ultraluminous IRAS galaxies	Hatpol	3
70	Oka	Studies of H3+ in Jupiter and Neptune	C4	3
71	Geballe	Study of the HeI line stars and unusual line emission in the G.C.	C4	1.5
74	Johnstone	Measuring the pressure in extended line emission around z>2 quasars	C4	3
75	Watson	Three colour IR photometry of the polar AN UMa	9,vis	2
76	Habing	OH/IR stars at the galactic centre	I0.6,8	2
78	Hewett	The quasar luminosity function	I0.6	3
80	Barthel	The polar outflow model for BAL QSOs	C4	1
81	Dhillon	Infrared cyclotron humps in intermediate polars	C4	2
82	Meikle	IR study of Supernova explosions	C4	3
84	Ellis	The ident of galaxies with 1<Z<3 along the sightlines to distant QSOs	I0.6	4
85	Adamson	3 µm spectroscopy of H2O ice mantles in the Rho Oph dark Cloud	C4	1
88	Drew	Towards an IR spectral classif. scheme for dust obscured hot stars	C4	3
89	Lawrence	IR spectroscopy of the hyper-luminous galaxy IRAS F10214+4724	C4	1

key: C4=CGS4; I1.2 or I0.6=IRCAM; HP=Hatpol; C3=CGS3; vis=Visphot; 6,8,9=photometers; Berkcam=Berkeley Camera

JCMT News

Note from the Director JCMT

(This is a modified version of the address Professor Robson gave to staff at the JAC on his arrival in mid November 1992)

The position of Director of the JCMT was not something that I had in mind for my career development when I chaired the JCMT Board committee which produced recommendations about the management structure of the JCMT. The acceptance of these led directly to the creation of the posts of Director and Head of Instrumentation Management. Adrian Russell was appointed to this latter post a year ago and as from Jan 1st 1993, all his group are in post at Edinburgh. These are Phil Williams, Colin Hall and Bill Duncan, with Colin and Bill devoting 50% of their time to the JCMT instrument management programme.

However, after spending many years intimately associated with the JCMT, and prior to that UKIRT, I knew the staff at the JAC very well and appreciated the difficulties and pressures of operations. At the same time, from my involvement in the UK HEI sector and extensive experience with SERC committees I felt that the JCMT presented a great challenge and an area in which I could make a contribution to the well being of the partner countries, the visiting astronomers and the staff supporting these functions. So there we have it, I could never resist a challenge and after five years as Head of a very successful Department I accepted the challenge and made the move from Preston to Hilo. In fact Preston and Hilo have at least one thing in common, both are known for their high rainfalls. But seriously I have absolutely no doubt that the JCMT is poised on the verge of a new era. The initial problems, common to all new telescopes, have on the whole been solved. We now, or will have within the next year, state of the art heterodyne receivers at all wavebands and SCUBA will revolutionise submm continuum astronomy.

There are a number of aspects that I see as a primary challenge. We need to maximise the scientific productivity of the JCMT and because of the critical dependence on the atmospheric transparency at the higher frequencies, flexible scheduling is a must. How that is accomplished, whether by SERVICE observing, remote eavesdropping, over-ride programmes with visiting astronomers doing whatever programme is allocated the highest priority, some combination of these, or entirely new schemes, is something which I will be pursuing during this year with the aim of presenting a scheme to the JCMT Advisory Committee and Board in the autumn. Therefore, users should be anticipating discussions with their representatives on the Advisory Committee.

I also wish to improve the JCMT's quality of service in the fullest sense of the word. This means the performance of the telescope and instruments and the support of the staff. I believe that we can make significant improvements to the information delivery mechanism at the JCMT, currently it lacks user-friendliness on such topics as calibration values, beamsizes, sensitivities, and such things astronomers want to know at the telescope in the 'how do I ?', 'how can I ?', 'do we have anything like....?' categories. This area of information presentation to visiting astronomers (and staff astronomers and TO's) will be given a prominent role and if visiting astronomers do not see a significant improvement over the next year, then I will have failed.

But to achieve the above means that the resource base in Hawaii must be carefully managed and not over-stretched. Inevitably, all the tasks we hope to achieve will not happen, mainly due to weather problems which affect the work needed to understand better the facility just as much as they do for allocated astronomical programmes. We will be trying to do as much of the work needed during daytime, but there are still areas (such as pointing and system calibration) which require night-time work. After a very helpful meeting of the Advisory Committee, I have been given backing to make inroads into PATT awarded programmes if absolutely essential information has not been obtained during Engineering and Commissioning (E&C) time. Naturally I hope that this is not necessary, and if it is I will do my utmost to repay the time from Director's Discretionary (DD) nights.

In terms of improving the quality there are two further areas I would like to mention, both requested by the Advisory Committee and agreed by myself and the Board. The next six months should see the introduction of an easily accessible archive of instrumental sensitivities and beamsizes. This will be stored at the JAC and will contain data from 1991 onwards. In its widest sense, the support provided to observers will now be monitored in more detail and observers will note a change to the

Observer's Reporting form. This is in two parts, one concerning the telescope, instruments and weather, the other in terms of support. The latter is confidential and is to be returned directly to the Director JCMT. The Advisory Committee stressed the importance of astronomers completing these reports before leaving Hawaii. I will be monitoring all these reports and responding to individual comments.

At the JAC, we are anxious that visiting astronomers are as up-to-date as possible with current system parameters and are most strongly advised and encouraged to arrive at least one day before going up to Hale Pohaku in order to discuss their programme thoroughly with the support astronomer. The support astronomer will expect to be present on at least the first shift of their run. Things do change, and experienced JCMT astronomers would do well to note this aspect. The user information system we are developing should be a big help. Additionally we intend to introduce a better system of enabling visiting astronomers to have access to the JAC when arriving at a weekend, the current system is far from efficient in staff effort.

I also wish to inject a higher profile of research at the JAC in terms of visiting students, postdocs or longer-term visiting astronomers. Over the next year I will be making moves in this direction and astronomers who wish their students or whoever to spend a significant fraction of their time (many months) at the JCMT should contact me.

Finally, I am a strong supporter of open management and teamwork with shared goals. I point out that it is not my job to run the JCMT on a day to day basis, that is for all the staff involved in the facility, from the support scientists and TO's to engineers, programmers and the administration support. My role is to ensure that all members of the team know their roles and responsibilities, the goals and targets set for them and to provide them with the support required to carry out those functions. A facility can succeed without a director, but a director cannot succeed without the staff. The staff are the most precious asset of any organisation. I also remind everyone that the usual organogram is a pyramid standing on its base, but seen in terms of user support this is the wrong way up, it should be an inverted pyramid. The TO's and support scientists provide the direct interaction and service to the visiting astronomer, the engineers and software staff ensure the telescope performs to spec. Therefore, quality of service and support must be foremost in our aims.

Together we must ensure that the JCMT is recognised as the best submillimetre telescope in the known Universe. That is the goal for which we strive and which we shall achieve within the coming years.

Ian Robson
JAC

UK Service Observing Programme

Report for Semester W

Poor weather during the second half of Semester W caused the loss of five of the eight shifts allocated to the UKSERV programme. One of the few projects completed during this period involved molecular line observations of Comet P/Swift–Tuttle and the cooperation of Rachael Padman in making these observations is gratefully acknowledged. Weather conditions improved towards the end of the semester and the final two shifts on January 25th and 26th were very productive; observations obtained for one project led to follow up studies a few days later with the MKII telescope at Jodrell Bank.

Arrangements for Semester X

Because of the slow clearance rate of projects during Semester W, it was deemed advisable not to solicit new proposals (except for Receiver A which can be usefully employed during poor weather conditions) until the situation had improved. The excellent observing conditions at the end of January have resulted in the backlog of projects in the RA range 9 - 18 hours being virtually cleared and new proposals can again be considered. The allocation for the semester will be eleven shifts with the possibility of three additional shifts as backup to PATT-approved projects. The disposition of the shifts will be such that the same RA range (9 - 18 hrs) will be favoured although the mix of first and second shifts will allow a wider sky coverage. Applications for Service Observations using receivers A, B and UKT14 during Semester X are hereby invited. Proposals should be submitted to REVAD::JCMTSERV. Reminders, in the form of NEWS items, will be issued at appropriate times on STARLINK.

A McLachlan
ROE

Expected Availability of JCMT Instruments during Semester Y.

Introduction

Semester Y (1 August 1993 - 31 January 1994) JCMT instrument availability and sensitivities are summarized below. Additional details can be found in 'The James Clerk Maxwell Telescope: A Guide for the Prospective User', which is available through the JCMT Section of the Royal Observatory Edinburgh, by contacting the JCMT Group at the Herzberg Institute of Astrophysics in Canada or the NFRA at Dwingeloo, Netherlands, or from the JAC in Hawaii.

Spectral Line Observations

Three SIS mixer receivers form the core of the heterodyne program, A2, B3i and C2. The last is expected to be fully commissioned in time for semester Y. One other receiver (G) is available via collaboration with the MPE, Garching group. A summary of the properties of this instrumentation is given in Table 1 below.

Receiver temperature values (T(rx)) are typical numbers for each receiver. The efficiencies are accurate to at least 10%. The beam is usually slightly elliptical and depends somewhat on frequency. Two bands for G are included, since they are significantly different; for G the amount of power arising in near sidelobes is significant (about 30% within a 30-40" error beam).

(1) Receiver A2

A2 is a single-channel receiver. Its excellent low-noise performance results in a total system temperature (T(sys)) of better than 350K across most of the band under normal conditions.

(2) Receiver B3i

B3i (also a single-channel device) is one of the best receivers available in this band in the world. The DSB receiver temperature response is not constant with frequency, and ranges from a best value of near 160 K at 355 GHz, up to about 265 K at 330 GHz. On the sky, SSB system temperatures below 600 K have been obtained under good conditions. The local oscillator system of B3i permits frequency-switched observations with a recommended maximum switch of ±50 MHz. The dual channel version of B3i, B3, may be commissioned at the end of 1993, and is unlikely to be available to users during semester Y.

(3) Receiver C2

C2 is a single-channel receiver which is projected to cover frequencies from about 450 to 500 GHz. It is due to be commissioned at the JCMT in March/April 1993, and is scheduled for PATT observations beginning in May. Since it has yet to arrive in Hawaii, all numbers given should be regarded as best estimates. The bolometer receiver for this frequency band, C1, is to be retired on the successful commissioning of C2.

(4) Receiver 'G'

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

(5) Spectrometer Backends

The Digital Autocorrelation Spectrometer (DAS) has 2048 delay channels having a total maximum bandwidth of 920 MHz in each of two inputs. It is capable of a wide range of configurations, with spectral resolutions of between 0.1 and 1.5 MHz. The widest bandwidth modes are useful only for receivers (such as C2) with sufficient IF bandwidth. In narrow-band modes it is possible to observe several lines from either sideband with high resolution. Currently there is a problem with baseline matching between 'sub-bands'; this should be resolved by the fall of 1993. The AOSC is an acousto-optical spectrometer which offers a resolution of about 330 kHz and a total bandwidth of 500 MHz for a single IF channel. The AOSC will serve as a backup for the DAS for a short period following the final work on the latter.

Further details regarding both spectrometers are given elsewhere in this Newsletter.

(6) Approximate rms sensitivities after 30 minutes' integration

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

Continuum Observations

UKT14

The UKT14 bolometer system will be available during Semester Y with filters for observations at 2, 1.3, 1.1, 0.85, 0.8, 0.75, 0.6, 0.45 and 0.35 mm. The aperture of the bolometer can be adjusted between 21 and 65 mm. Sensitivities range from typically 0.3 Jy/sqrt(Hz) through to 10 Jy/sqrt(Hz) or more under good photometric conditions. See the User's Guide or March 1992 Newsletter for further information.

UKT14 polarimeter

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

SCUBA

The Submillimetre Common-User Bolometer Array receiver is presently due to arrive at the JAC for commissioning in November 1993. Because the commissioning phase will be complex, SCUBA will not be offered to users until Semester Z.

Henry Matthews
JAC, Hilo, Hawaii
HEM@JACH.HAWAII.EDU (InterNet)

Table 1. Summary of spectral line observational data

	Freq. (GHz)	T (rx) (K)	Ap.	Efficiency Beam	fss	Tel. losses	HPBW (")
A2	218 - 280	110	0.54	0.72	0.80	0.92	20.8
B3i	310 - 380	180	0.41	0.53	0.89	0.89	14.3
C2	450 - 500	(400)	(0.30)	(0.40)	(0.70)	(0.80)	11.0
G	690	3000	0.23	0.30	0.60	0.65	7.0
G	690	4000	0.13	0.17	0.60	0.65	6.5

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

Freq. (GHz)	Receiver	T(rx) (K)	T(sys) (K)	dv (MHz)	Rms noise (K)	Notes
230	A2	95	350	0.33	0.02 (0.02, 0.04)	
270		105	380	0.33	0.03, (0.03, 0.07)	
330	B3i	265	1000	0.33	0.08 (0.07, 0.38)	1
345		165	650	0.33	0.05 (0.05, 0.16)	1
461	C2	400	3800	0.33	0.31 (0.19, *)	2,3
492		400	6500	0.33	0.53 (0.31, *)	2,3
690	G	3000	48300	1.00	2.28 (0.97, *)	3
810	G	4000	78800	1.00	3.71 (1.43, *)	3

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

JCMT Allocations - PATT ITAC Report for Semester X

The individual partner TAGs held meetings in their respective countries prior to the PATT session. At these meetings informal awards of shifts were listed for each application in a priority order. The Chairmen of each TAG brought their respective lists to the PATT where the ITAC combined the awards including discussion of the engineering and commissioning requirements. The final allocations were made by the ITAC.

The PATT meeting for Semester X was held at the De Montford Hotel in Kenilworth, UK on 1st & 2nd December 1992.

Applications to be considered:

U.H. applications	:	8
Appls with International status	:	15
Applications with UK status	:	43
Applications with CDN status	:	34
Applications with NL status	:	12
TOTAL	:	112

UK/(UK+CDN+NL) = 48%
CDN/(UK+CDN+NL) = 38%
NL/(UK+CDN+NL) = 14%

7 of the 8 UH applications were awarded time by the UH TAG.

International status is given to any application with neither PI nor collaborators being members of the partner countries or where the only named individual from any partner country is a member of JCMT staff based in Hilo. If that individual is the PI then the application is assessed by the appropriate national TAG. International applications are assessed by all 3 TAGs.

16-hr nights requested to PATT:	299
Nights available for PATT science:	126.5
Oversubscription = 2.36	

The oversubscriptions for the previous two semesters were 1.72 and 2.15 so a gentle upward trend is becoming evident.

PATT awards (in 16-hr nights):

No of nights in semester X	:	181.0
For engineering/commissioning	:	36.0
Given to Univ.Hawaii (10%)	:	14.5
For Director's discretionary use	:	4.0
Nights available for PATT science	:	126.5

Awards by country paying salary of PI:

No of nights awarded to INT	:	13.0
No of nights awarded to UK	:	62.5
No of nights awarded to CDN	:	28.5
No of nights awarded to NL	:	22.5

UK/(UK+CDN+NL)	=	55%
CDN/(UK+CDN+NL)	=	25%
NL/(UK+CDN+NL)	=	20%

No of applications requiring line obs	:	46
No of applications requiring cont obs	:	27

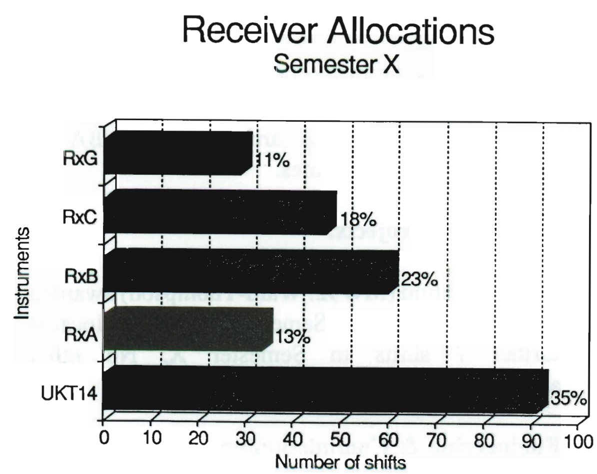
Several applications require both line and continuum obs.

The average length of time awarded per application was 3.8 shifts.

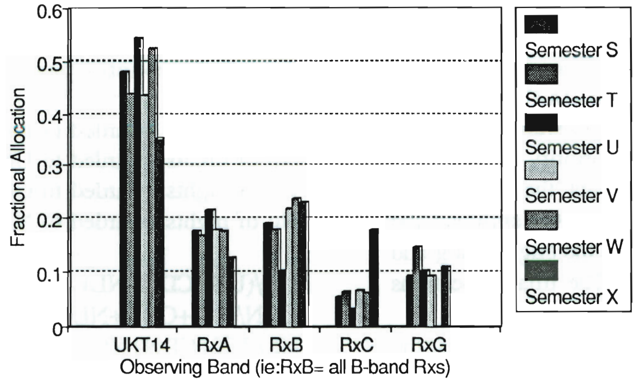
Awards by JCMT formula:

No of nights awarded to INT	:	25.3
No of nights awarded to UK	:	55.2
No of nights awarded to CDN	:	25.5
No of nights awarded to NL	:	20.5

UK/(UK+CDN+NL)	=	54.5%
CDN/(UK+CDN+NL)	=	25.2%
NL/(UK+CDN+NL)	=	20.3%



Receiver Allocations
over last 6 semesters



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

Instrument distribution:

Observing time requesting UKT14	35%
Observing time requesting RxA	13%
Observing time requesting RxB	23%
Observing time requesting RxC	18%
Observing time requesting RxG	11%

Confidence has continued in the use of the RxB band instrumentation and one quarter of the observing time is allocated.

There is a strong interest in use of RxC2 as predicted.

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

Long Term Projects:

One application (MW92: Ward-Thompson) awarded long term status in Semester W was allocated further 7 shifts in Semester X. No other applications were approved for long term.

Engineering & Commissioning:

The engineering & commissioning time has increased as a result of delays in the planned engineering schedule due to un-planned emergency repair work. Significant preliminary work is required before SCUBA is commissioned during semester Y.

Service time:

This is developing in a reasonably progressive fashion for all partners. Wider distribution of the announcements of opportunity were called for. More use should be made of service mode observations wherever small quantities of data (up to 1 shifts worth) are required.

Allocations for semester X are:

CDN	:	8 shifts allocated
NL	:	2 shifts allocated
UK	:	11 shifts allocated

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

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

Changes in Assessments Procedures:

The changes in the assessment and allocation procedures will continue for at least the next semester. Potential applicants for observing time in Semester Y should check to ensure their applications are mailed to the correct establishment.

Graeme D Watt
ROE
JCMT PATT Technical Secretary

News from JCMT Board - No.2

The JCMT Board held its twelfth meeting at the Alberta Microelectronic Centre, Edmonton, Alberta, Canada on 2nd & 3rd November 1992. In addition to the formal meeting, the Board toured the Microelectronics Centre and attended a symposium entitled 'Sub-mm Astronomy and Techniques' at which talks were given by Canadian scientists working in this field.

The Board received and discussed reports on Operations; the Instrumentation Programme; the first meeting of the JCMT Advisory Panel; Finance and Telescope Time Allocation.

Report from the JCMT Advisory Panel (JCMTAP)

Following recommendations from the JCMT Advisory Panel, and discussion at the Board meeting on 2nd & 3rd November 1992, the Board adopted a number of actions, and is assessing the need for further action in other areas. In particular, users will wish to note the following :

The Director JCMT is to provide and maintain, in readily accessible form, quantitative information on technical parameters, particularly antenna efficiency and beam maps. A further announcement will be made when the database has been established and is available for general use.

Observers are now required to complete Observer Reports, which should be submitted in confidence directly to the Director JCMT. Forms will be supplied to Observers by the Telescope Operators, and the Director JCMT has undertaken to respond directly as appropriate to specific points that may be raised.

Users are urged to raise any specific requests or problems relating to telescope operation and associated matters with the Director JCMT in the first instance, and the Board would expect that the majority of issues would be resolved between Director JCMT and the individuals concerned. However, it is open to users to seek recourse to the Panel, though the Board and Panel expect such cases to be the exception.

The Board endorsed the Panel's recommendation that the Director JCMT be authorised to flexibly schedule crucial commissioning and calibration observations, especially following surface adjustment, over-riding (but then subsequently compensating if possible) previously allocated PATT time if necessary.

Policy for Allocation of Time on New Instruments

The Board agreed the following rules for the allocation of time on new instruments :

1. Director JCMT will provide to the national TAGs and the International TAC details of instruments expected to be available (and which therefore may be scheduled normally) and instruments which may be scheduled on a 'shared-risk' basis;

2. The national TAGs and ITAC will produce a priority list of proposals to be awarded time, with a reserve list of proposals for scheduling in the event that the new instrument is not available;

3. The Director JCMT will propose guidelines for implementation of this policy (including such matters as arrangements for notification of PIs on backup proposals etc);

4. The final decision on whether commissioning is satisfactorily completed will rest with Director JCMT (on the advice of the responsible JCMT project scientist);

5. Proposals for use of user-supplied equipment will be assessed by the appropriate TAG in competition with other proposals, with the technical agreement of Director JCMT a pre-requisite for any award of time.

Interferometry

The Board agreed that all interferometry experiments are at present still for proof of concept and they will therefore be considered as part of engineering time. Once the concept is proven, the issue of how to make interferometry available for common use will be addressed.

Rowena L Sirey
Secretary, JCMT Board

Successful JCMT Applications for Semester X

PATT No	Principal Investigator	Shifts Awarded	Title of Investigation
U01	Gear W K	8	Polarimetry of blazars: Understanding magnetic field orientation
U02	Ward-Thompson D	4	A protostellar cluster in NGC2264-South
U03	Richardson K J	5	Protostellar clumps in DR21(OH) probed by transitions of H_2CO and CH_3OH
U04	Williams P G	4	Submillimetre polarisation mapping of the Sgr B2 cloud
U07	Yates J A	4	Probing physical conditions of red giant circumstellar envelopes with mm-wave H_2O masers
U08	Ivison R J	1	Continuum monitoring of novae
U09	Ivison R J	1	Continuum emission from the symbiotic nova AG Pegasi
U12	Genzel R	4	Heating & ionizing mechanisms in the Galactic Centre
U13	Tacconi L J	4	The distribution of warm, dense gas in galaxy nuclei
U14	Little L T	3	Interstellar abundance variations on scales around 0.1pc
U16	Padman R	4	CO mapping of outflows from low-mass protostars
U17	Clarke C J	5	Dust around wide binary stars
U19	Hills R E	6	A further search for C^+ emission from high redshift quasars
U21	Lasenby A N	0.5	High negative velocity emission in the Galactic Centre
U22	Lasenby A N	3	^{12}CO J=6-5 obs of the circumnuclear disk in the Galactic Centre
U26	Russell A P	4	An isotopic CO J=6-5 study of low-mass star formation
U27	Watt G D	3	The HCS^+ to CS abundance ratio in molecular cloud regions
U30	Watt G D	4	Search for interstellar NH_2
U32	White G J	8	Observations of the centre of the Galaxy in C I and CO J=4-3
U33	Minchin N R	4	C I & CO obs of the photodissociation regions in S140 & M17
U34	Lawrence A	3	Millimetre CO(2-1) line observations of a complete sample of ultraluminous IRAS galaxies
U35	Mannings V G	4	Determination of the masses of disks around pre-main-sequence Ae/Be stars
U36	Minchin N R	5	Submm continuum observations of the S140 photo-dissociation region
U39	Dunlop J S	5	Are radio galaxies at z>2 primeval?
U40	Hughes D H	2	A difference in the sub-mm spectral indices of BL Lacs and OVV quasars
U41	Stutzki J	5	[C I] line wing emission in S140: Outflow or interclump gas?
U43	Evans A	3	Cool dust in RVT and RCB stars
U44	Hough J H	0.5	Is Cen A really the nearest blazar?
W92	Ward-Thompson D	7	The collapse of pre-stellar cores
N03	Helmich F P	8	The chemical evolution of the W3 molecular cloud
N04	Burton W B	4	High-velocity, possibly collimated, molecular gas near Sgr A*
N05	Wesselius P	2	C I in L134N
N07	De Jong T	4	Observations of neutral carbon and CO(4-3) in IR carbon stars
N08	Israel F P	4	Molecular clouds in NGC 2403
N10	Israel F P	9	C I and warm molecular gas in W58
N11	Coleman P H	4	Low frequency cutoffs in highly luminous, redshifted radio quiet qsos
N12	van der Hulst J M	5	CO observations of low surface brightness galaxies
N13	Lees J F	3	Submillimetre emission from cold dust in elliptical galaxies
C01	Clark T A	1	Study of solar submillimetre H & Mg recombination lines in the chromospheric network & at the solar limb
C02	Wilson C D	3	The physical properties of the molecular ISM in M33
C05	Kwok S	2	CO emission in young planetary nebulae
C07	Mitchell G F	3	Dense shocked gas in molecular outflows

Successful JCMT Applications for Semester X

PATT No	Principal Investigator	Shifts Awarded	Title of Investigation
C08	Welch G A	2	Distribution & kinematics of the molecular gas in the dwarf elliptical galaxies NGC 185 & NGC 205
C10	Naylor D A	4	Broadband intermediate resolution spectroscopy of Saturn
C11	Redman R O	4	Surface properties of bright asteroids from their rotational lightcurves and continuum spectra
C12	Matthews H E	3	Detection of β-transitions in the recombination line maser MWC 349
C14	Matthews H E	2	A search for new recombination line maser sources
C16	Purton C R	3	Luminous YSOs with no apparent outflow
C17	Matthews H E	3	Ions in oxygen-rich circumstellar envelopes
C24	Moriarty-Schieven G	4	The far-infrared/sub-millimetre continuum spectra of protostars
C25	Rucinski S M	3	Rho Oph B1 at high transitions of formaldehyde
C26	Mitchell G F	2	Optical jets and molecular outflows
C28	Vallee J P	3	Extreme-infrared polarisation survey of molecular clouds
C29	Avery L W	2	A search for vibrationally excited SiCC in IRC+10216
C30	MacLeod J M	3	A study of newly-identified young stellar objects in Taurus
C35	Taylor A R	2	Circumstellar C I in AGB and post-AGB objects
I01	Stutzki J	3	High angular resolution study of warm molecular gas: a clue to the heating mechanism
I02	Anderson N E	4	Water masers & very dense warm gas in W49 & W51
I04	Mundy L G	2	Anatomy of a Pig II: Studying the dust properties
I08	Olmi L O	2	CS and $C^{34}S$ multitransitional study towards ultracompact HII regions
I11	Mathieu R D	4	The evolution of circumstellar disks in young binary stars
I12	Skinner C J	4	CO observations of red giants
I13	Thum C	2	High-Frequency hydrogen recombination line masers
I15	Kuiper T B H	5	Observations of ground-state HDO
UH01	Jewitt D	3	Submillimeter continuum studies of comets
UH02	Tholen D	3	Thermal studies of different terrain types in the outer solar system
UH03	Sanders D	4	The molecular gas properties of normal galaxy nuclei
UH04	Owen T	6	Submillimeter observations of Neptune, Saturn and Titan
UH06	Sanders D	2	Warm dust near the galactic centre annihilator 1E1740.7-2942
UH07	Sanders D	6	C^+ and N^+ emission at high redshift
UH08	Ladd E F	5	Submillimeter mapping of luminous embedded sources

The JCMT Data Archive

1. Introduction

An archive of the data acquired with the JCMT is maintained at the Royal Observatory Edinburgh (ROE). A catalogue of all the observations in the archive is publicly available, and anyone can search it to identify observations of interest and subsequently request copies of them.

The archive contains essentially all the observations made with the JCMT since January 1992. The data are stored in exactly the same form in which they were obtained by the original observers; that is, as GSD (Global Section Data) files. However, the file names have been changed because the original file names are ambiguous, and unambiguous names are required for the archive. The archive is kept up to date. However, for a period of one year after an observation is acquired the original investigators who acquired it retain a right of sole access. Thus, an observation will not be released from the archive to anyone except its original investigator until this proprietary period has elapsed.

The observations are stored off-line on magneto-optical disks. However, summary details extracted from each observation, such as the object observed, its celestial coordinates, the instrument used etc, are used to maintain a catalogue of all the observations in the archive. This catalogue also contains the information necessary to retrieve individual observations, but these details are usually hidden from the user. The user simply interrogates the catalogue to identify observations of interest and then requests copies of them. The catalogue is updated regularly and is kept on-line at the ROE Starlink node REVAD. For the year 1992 it contains about 30,000 entries, including calibrations. Note that each entry is essentially one integration at the telescope and is in general only part of an observation of an object.

The JCMT data archive uses the archive software developed by the NFRA, Dwingeloo for the WSRT and La Palma data archives. Users of these archives will find the JCMT archive very familiar. Currently, only one catalogue containing the JCMT observations (called HATCAT) is available. It is planned to set up an archive and a catalogue for observations made with some of the UKIRT instruments at a later date.

The remainder of this note gives a short introduction to using the software to query the observation catalogue. Some documentation is available (see Section 4, below). In particular, the user guide gives a more complete description of the material presented here and should be consulted before making serious use of the catalogue and archive.

2. Getting started

The archive is maintained on the Starlink cluster at the ROE and it can be queried using the captive account ARCQUERY.

(1) To log on from your local computer:

Starlink users	:	SET HOST REVAD
SPAN users	:	SET HOST 19889
Internet users	:	TELNET STAR.ROE.AC.UK or TELNET 192.108.120.10

In response to the username prompt, reply: ARCQUERY; no password is required

(2) You will be prompted to enter your initials (which need not be the same as any username that you may have). These initials identify you to the archive system.

After a list of available functions you will be prompted

Function (or <CR> for the summary):

To query the JCMT observations catalogue type ARCQUERY or ARC for short. Alternatively you can type ARCQHAT.

If you typed ARCQUERY or ARC you will be prompted for a catalogue name. Reply HATCAT, currently the only catalogue available.

(3) After more informational text, the prompt ARCQUERY: appears.

If this is the first time that you have used the archive, you will need to supply some details. This information will be used to send you copies of observations that you request. Type

ADDRESS_INFO

and answer the ensuing prompts. Most of the information asked for is straightforward. Difficulties can arise in specifying the information defining your electronic mail address. The system prompts: MAIL_ADDRESS. You should answer literally <host::><user> when you are on DECNET (Starlink users) or SPAN, "<user><@host>" when you are using INTERNET.

Having specified the form of your electronic mail address you will be prompted for USERNAME and HOST and here you should specify your actual user name and host name.

(4) You can now proceed to query the catalogue to identify observations of interest. However, before proceeding, there are some preliminaries which it is useful to be familiar with.

* To abort an ARCQUERY function and return to the ARCQUERY: prompt type <CTRL-C>.

* To obtain general help type HELPQUERY or ? To obtain help on individual commands type HELPQUERY command. In either case, HELPQUERY may be abbreviated down to and including just H.

* To log out type EXIT. You will be asked whether you want to save your query context (reply YES if you want to continue after lunch) and it brings you back to the Function (or <CR> for the summary): prompt. Type EXIT again and you will be logged out.

3 Some examples

The archive software allows you to query the observation catalogue to identify observations of interest. The observation catalogue is a table, where the different details recorded for each observation (the object observed, its celestial coordinates, the instrument used etc.) are the columns of the table and the different observations the rows. The various commands of the archive system operate on a table (either the entire observation catalogue or a subset of it) and either generate a new table or display some aspect of it. Every table known to the system has a unique name or number. The entire observation catalogue is table number 0. In the simplest case tables will be given numbers in an ascending sequence, in the order in which they were created. By default commands operate on the most recently created table (or, if no tables have been created, on the entire observation catalogue).

The most commonly used commands are SELECT and LIST. SELECT selects observations which satisfy some criteria and remembers them as a new table. LIST displays the contents of a table on the screen. In both these commands the qualifiers \INP= and \OUT= can be used to explicitly specify the input and output tables, rather than relying on the defaults.

Three usages of the select command are particularly common: to select objects by name, to select objects within a range of Right Ascension and Declination and to select objects within a given distance of a specified Right Ascension and Declination. You could use any of these three forms to select observations of the Lynds Dark Nebula L1498:

```
SELECT  OBJECT_NAME=L1498
```

```
SELECT  /INP=0 /OUT=2  <hit return>
  RA= 4:10:51 TO 4:10:52  .AND.  DEC=
          25:09:58 TO 25:09:59
```

```
SELECT  /INP=0 /OUT=3  POSITION=(4:10:51,
           25:09:58, 0:0:30)
```

There are several points to note about these examples:

* in the first case the input and output tables are omitted and the defaults used (since no tables have been created, the input table will be the entire observation catalogue and the output table will be table 1),

* the first example will only find observations where the object was called 'L1498'; it will not find synonyms such as 'LYNDS1498',

* Right Ascension and Declination are both specified as J2000 sexagesimal values, Right Ascension in hours and Declination in degrees,

* in the second example, the dots in the '.AND.' are mandatory; alternatively '&' may be used instead,

* The three arguments of POSITION in the third example are: Right Ascension, Declination, radius. The radius is in degrees.

The LIST command is used to display the contents of a table. For example, to list the first table

```
LIST /INP=1
```

Table 1. Example of archive catalog of observations

Line_N	Object_ Name	Eqposition J2000	Instrument	Date	Observer Day
1	L1498	4:10:51.5 25:09:58.2	UKT14:UKT14	28-DEC-91	WRFD
2	L1498	4:10:51.5 25:09:58.2	UKT14:UKT14	28-DEC-91	WRFD
3	L1498	4:10:51.5 25:09:58.2	UKT14:IFD	28-DEC-91	WRFD
4	L1498	4:10:51.5 25:09:58.2	UKT14:UKT14	28-DEC-91	WRFD
5	L1498	4:10:51.5 25:09:58.2	UKT14:IFD	28-DEC-91	WRFD
6	L1498	4:10:51.5 25:09:58.2	UKT14:IFD	28-DEC-91	WRFD
7	L1498	4:10:51.5 25:09:58.2	RXA:AOSC	29-DEC-91	WRFD

Again the /INP= qualifier can be omitted if the most recent table is to be listed. Something like the listing in Table 1 will appear.

Once you have created a table containing the observations that you are interested in, you can request a copy of them. For example, to request a copy of the observations in table 2 type

REQUEST /INP=2 /OUTPUT_TYPE=H

Once again, if the /INP= qualifier is omitted, the most recent table will be used. REQUEST will prompt you to give comments to explain your request; there is no reason why you need to do so, so simply reply <CTRL-Z>. Subsequently, the Archive Administrator will retrieve copies of the observations, and contact you (probably via electronic mail) to tell you where you can copy them from.

This short example has touched on only a few of the functions available in the archive software. Other possibilities include: various options for more complex selections, including using wild-cards in object names, selections based on coordinate systems other than equatorial, joining tables and changing the information displayed by LIST. All these possibilities are described in the user guide (see below).

4 Further information

There are a number of documents describing how to use the archive:

1) User's Guide to the Hawaii Telescopes Data Archive
2) Quick Reference Sheet for the Hawaii Telescopes Data Archive
3) La Palma Data Archive User's Guide. Isaac Newton Group, La Palma, User manual No. XIX

You are particularly encouraged to obtain a copy of the first document before making serious use of the archive. The La Palma Data Archive User's Guide is primarily intended for users of the La Palma data archive, but much of the information is also relevant to the Hawaii archive.

Both electronic (LATEX) and paper versions of the documents 1) and 2), as well as advice and assistance on using the archive, can be obtained from Ko Hummel at ROE.

Ko Hummel ROE
Starlink DECNET: REVAD::KXH
SPAN: 19889::KXH
INTERNET: KXH@UK.AC.ROE.STAR

Clive Davenhall
Department of Physics and Astronomy, University of Leicester

AOS Problems

Introduction

During the commissioning of RxA2 a blue wing was detected on the IRC+10216 ^{12}CO J = 2→1 line profile. The wing was 20 km/s wide with a peak intensity of 0.4 K close to the main profile. Consultations with Gillian Knapp convinced us that this could not be true, a proper ^{12}CO J = 2→1 spectrum of IRC+10216 does not have such a wing. Something was wrong. Spectra obtained with the DAS correlator failed to show the blue wing. In addition a weaker feature close to the CO lines was absent in the DAS spectrum. These data were obtained in the lower sideband of the 230 GHz SIS receiver. In November 1992 I finally obtained some data in the upper sideband. The wing was now found to occur on the red side, confirming the suspicion that the wing was an AOS feature, see figure 1.

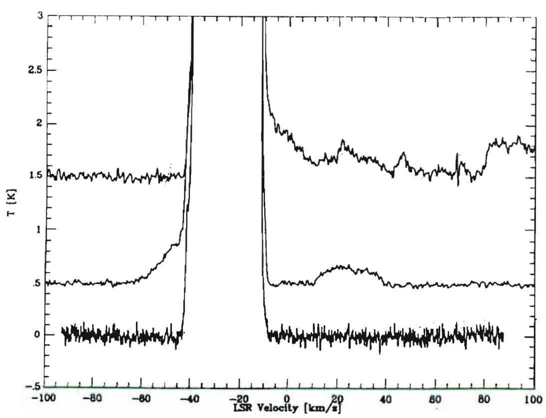


Figure 1. ^{12}CO J = 2→1 spectra of IRC+10216 clipped so the artificial wing on the AOS spectra is easy to see. From bottom up i) DAS spectrum in the lower sideband. ii) AOS spectrum in the lower sideband. iii) AOS spectrum in the upper sideband. Note also the extra line in the AOS spectra.

Results

Tests during the heavy engineering in January confirmed the problems and gave a better idea of the causes. Spectra obtained with the AOS over the last few years may contain two kinds of defect which could affect their interpretation.

1. For each signal of strength S in the spectrum at channel C, there will be a ghost feature of intensity 0.007*S at channel 2026-C. This is caused by mixing with one of the LOs in the AOS IF converter. The above formula assumes that the AOS frequency scale has been linearized.

2. Every real signal in the IF will have an apparent 'wing' extending to lower channel numbers. Lower channel numbers corresponds to a blue and red wing using lower and upper sideband respectively. The wing is caused by the convolution of the line with the AOS response. The AOS response to a single frequency can be seen in figure 2. The response is adequately, but not perfectly, approximated by four Gaussian components.

Comp.	Rel.Int.	Width	Rel.Pos.	Rel.Int.
Int.				
	%	ch.	ch.	%
1	89.4	1.58	0	73.9
2	10.1	3.97	-0.5	21.0
3	0.417	13.9	-5.5	3.03
4	0.0805	50.7	-45.1	2.13

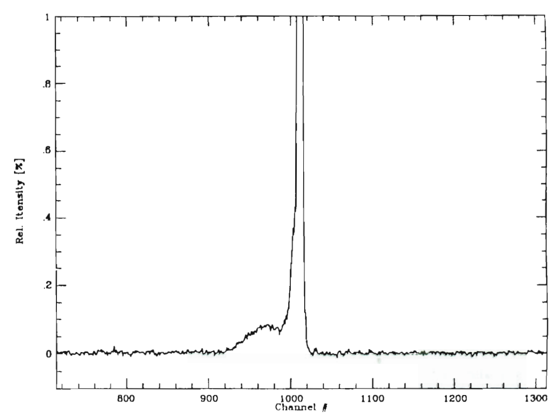


Figure 2. The intrinsic AOS response to a narrow band signal clipped so the weak structure can be seen. The response can be modelled by four Gaussians.

Even if the fourth Gaussian component only has a relative intensity of 0.08% the integrated intensity rises to about 2%. Thus for lines broad enough to fill the width of this component a wing will appear that is about 2% of the intensity of the main line. It is not known what causes this wing, but it scales linearly with the intensity of the feature and seems to have the same shape for all IF frequencies. The designer and builder of the AOS hardware, Lauri Malkamäki, suggests that "the problem is caused by a slight optical misalignment, most probably a combination of wrong cell illumination and slight defocussing".

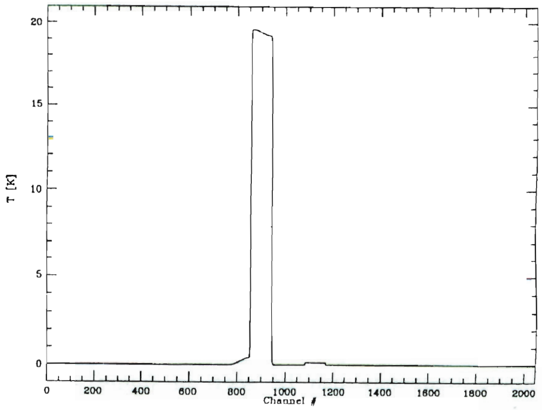


Figure 3. The modelled response of the AOS assuming a rectangular line of intensity 20 K and a width of 87 channels. Note the wing and distortion of the main line and the extra feature caused by the unwanted mixing in the AOS IF section.

Discussion

Russell Redman tells us that these defects were not present when the AOS was delivered. They have been visible on spectra taken since Spring 1992 and appear to have been stable since then. Since the peak intensities of both the ghost and the wing are less than 2% of the intensity of the real signal, they will be troublesome only for spectra with signal-to-noise ratios greater than 50, and so may not have been noticed in older spectra. There is an hint of the wing in data obtained with the 230 GHz Schottky mixer in May 1991. If the problem is caused by a slight optical misalignment it was most likely introduced when the laser tube was replaced in June 1990.

Because they are so weak, these ghosts will not affect many observing programs. The most seriously affected programs will likely be line searches for weak species near strong lines and spectral surveys of bright objects. Observers with high signal-to-noise spectra taken in the past 2 or 3 years should check their data to see if they suffer from these defects. We anticipate that the latest set of receivers with low system temperatures will enable many more programs to achieve signal-to-noise levels high enough to be affected. Efforts to diagnose and cure the problems are continuing.

Conclusions

The weakness and linearity of the ghost and wing suggest that it should be possible to remove them effectively during data reduction. Since they have distinct origins they should probably be removed in separate operations. The spectra should first be calibrated and have their baselines corrected. The wing should be removed first, using a deconvolution routine. The ghost can be removed by reversing the spectrum, scaling it by 0.007 and subtracting it from the raw data. Iterating this procedure 2 or 3 times should be sufficient to reduce the ghost and all its artifacts below the noise level.

If you have questions or need assistance with addressing this problem please contact Per Friberg at JACH. I wish to thank the following people for help during these investigations — Russell Redman, Göran Sandell, Henry Matthews and Lauri Malkamäki.

Per Friberg,
JAC

JCMTDR - Figaro Applications for Reducing JCMT Data.

The JCMTDR package was released through Starlink a few months ago, though it made little impact in the national papers due to their continuing fascination with the Royal Family. It comprises a set of Figaro applications intended to replace NOD2 for the reduction of continuum mapping data obtained with UKT14 on the JCMT. JCMTDR does not duplicate all the functions of NOD2 since many of these were already present in KAPPA or Figaro.

SUN 132 gives a full description of the applications currently available. Briefly, they are:-

MAKEMAP
This takes a JCMT data file in GSD format and converts it to a Figaro file. If the logical name FIGARO_FORMATS is set to NDF before running MAKEMAP then the output file will be a Starlink NDF, readable by both Figaro and KAPPA. All other applications in the package work with Figaro input files.

JCMTEXTC
This corrects JCMT data for the effect of atmospheric extinction.

MAP2TS
This sorts map data into a time sequence, with the measured pixels stored in order of increasing LST

of observation. With the data in this form you can more easily spot and correct variations that are a function of time.

TS2MAP

This converts a datafile that has been sorted into a time sequence by MAP2TS back into map format, as required by the other applications.

RESTORE

This deconvolves the chopped-beam from a JCMT dual-beam map of a source in a manner similar to that described by Emerson, Klein & Haslam (Astron.Astrophys., 76, 92). The algorithm is exactly the same as that used in NOD2.

AE2RD1 & AE2RD2

These both resample the map data into a tangent plane image centred on a specified RA, Dec. In AE2RD1 the necessary rebinning is performed by convolving the input data with a truncated Bessel function, very similar to the method used by CONVERT in NOD2. AE2RD2 rebins using NAG interpolation routines. Both applications can correct for telescope pointing errors.

MAP2MEM

Readers of the Newsletter will know that John Richer has written a package called DBMEM which uses the maximum entropy method to simultaneously deconvolve the beam response and resample the data onto a tangent plane grid (replacing RESTORE and AE2RD1 in the reduction sequence). MAP2MEM converts a JCMT map file into a format that can be read by DBMEM.

J.Lightfoot,
ROE.

DAS status report

As most of you are probably aware the DAS was delivered to Hawaii in late 1991 and underwent first tests in early 1992. As a result of those tests it was decided not to release it for PATT programmes.

The main problem has been with merging of the sub-bands of the DAS. The DAS has a total coverage of 2 x 1 GHz bandwidth. To achieve this the band is split into sixteen sub-bands of 160 MHz each. The sub-bands are spaced at 128 MHz intervals so that they overlap and can be "merged" to form continuous spectra.

It is the merging which has caused the problems. Two inter-related problem areas have been identified. One is that of non-linearities in the hardware (sampler chip) while the other is related to the calibration procedure. Non-linearities in the analogue to digital converter lead to input level dependent errors in the sub-bands. This means that when the input level changes between an 'on' and an 'off' spectrum, two overlapping sub-bands produce different baselines for the same piece of spectrum. These errors cause a platforming effect when the sub-bands are merged and make broad-band observations impossible. This hardware problem causes the baselines to have random slopes. Without this problem, the baselines would still have different offsets but would be flat and hence correctable with software by matching the overlaps.

Despite these problems it has been possible to use the DAS for trial interferometry with the CSO and for a few programmes which require high resolution spectra.

An extensive investigation into the problems with the DAS has been carried out at NFRA by Albert Bos and his team. Their proposed solution is to implement an automatic gain control circuit before the ADC. Initial tests in the laboratory have shown that this has reduced the magnitude of the errors by at least a factor of twenty, and should allow broad-band operation of the DAS.

Work to implement the AGC is now under way at NFRA and it is hoped to re-commission the DAS late this summer. In the meantime the DAS will be used again for more interferometry tests and some high resolution observations before the sampler boards are returned to NFRA for modification.

Once the DAS is available on the JCMT, users can look forward to both broad-band observations and on-the-fly spectral line mapping.

Adrian Russell,
Head, JCMT Instrumentation Programme
ROE

SPECX Notes

More on SPECX velocity scales...

Firstly, an apology. In the last article (August 92, p20), equations 1 and 2 contain minor errors. Of course (c-v)/c = 1-v/c (not -v/c), and c/(c+v) = 1 - v/(c+v). Rest assured that the errors were only in the article, and not in the program.

Following publication of the last issue of the Newsletter, Pat Wallace (author of the SLALIB package) wrote to point out that my use of the phrase 'the LSR' may have been confusing. The 'local standard of rest' is strictly a defined frame, but is meant approximately to represent the basic solar motion with respect to the neighbouring stars. This motion is established by measuring the radial velocities of the stars in the solar neighbourhood. The number you get depends on the depth of the sample (how far out you go), and the spectral classes of the stars you use. Thus there are several determinations of the **kinematic** solar motion, which differ by a few kilometres per second, and by a few degrees in direction. Spectral line radio astronomers however traditionally use the defined 'LSR', which has a velocity of 20 km/s in the direction of 18h, +30° (B1900), and differs slightly from the most modern determinations of the solar motion.

Pat has recently altered the SLALIB routine SLA_RVLSR to provide a better estimate of the **dynamical** solar motion — i.e., the motion of the sun with respect to the appropriate circular orbit around the galactic centre. This also makes SLA_RVLSR consistent with the routine SLA_RVGALC, but unfortunately there is now a velocity difference of up to ± 3 km/s between the velocities calculated by SLA_RVLSR and those used by radio astronomers (and SPECX). I propose **not** to implement this new definition in SPECX, as I suspect it will only cause confusion if Orion starts to come out with 'an lsr velocity' of 6 km/s. Pat Wallace's program RV, which is included in the JCMT utilities, is based on the SLALIB routines, but the older version is being retained (as RVRADIO) to prevent undue confusion arising as a result of the change in the SLALIB routines.

One further note: SPECX and the JCMT control system have both in fact been using a velocity of 20 km/s towards an apex of 18h, +30° (B1950), as used in the original Bonn software. For consistency I will change the epoch used in SPECX to B1900 in the next release, but the difference in velocities will be very small (<< 0.1km/s), so shouldn't be observable for AOSC data. The apex used in the telescope control software will also be changed to B1900 as soon as practicable.

My thanks to Pat Wallace, Chris Mayer and Per Friberg for helping me to sort out what was actually going on here.

References:

[1] J.D.Kraus, 1966. "Radio Astronomy" p47 McGraw-Hill, NY (first edition).

[2] D.A.MacRae and G.Westerhout: "Table for the reduction of velocites to the Local Standard of Rest", The Observatory, Lund, Sweden 1956. ('The Lund Tables'). Uses 20 km/s toward 18h, +30° (B1900)

[3] M.A.Gordon, 1976, in "Methods of Experimental Physics", vol 12-C, Chap 6.1 (Astrophysics – Radio Observations), Academic Press, NY.

Bugs

One serious bug has surfaced in SPECX V6.2, which means that some maps are 'unopenable'. The program starts to open them, and then falls over. A kluge which fixes this in some cases is to open another map first, then open the offending map afterwards. However the only real fix is to replace the incorrect routine. Any site which has problems can obtain a copy of the routine direct from me, or from John Lightfoot at ROE (REVAD::JFL).

JCMT Updates

A slightly revised version of SPECX (V6.2-A) is running at JCMT. This fixes the bug described above, and one or two other very minor problems. Changes include now being able to open up to 8 SPECX data files (was 3), and being able to change the parameters controlling the 'MRAO colour spiral' (colour 5 for colour-greyscale mapping). There is also a tentative implementation of logarithmic greyscales — just hit the '0' key to toggle from log to linear and back.

I have added a command definition UTILS, which prints a file that describes the 'system macros' — .spx files written to accomplish certain oft-needed functions, including those such as 'map-average' and 'fetch' that have been described in previous versions of the newsletter.

Rachael Padman
MRAO

SCUBA

Many readers will no doubt be waiting avidly for news of SCUBA being available. SCUBA is currently scheduled for delivery to JCMT at the end of 1993, after which there will be a commissioning period lasting approximately 3 months. It is therefore clear that SCUBA will NOT be available for proposals in Semester Y. Information on its availability in Semester Z will be given in the next Newsletter. Eager users should not despair at this delay to their experiments however, as no compromise in the scientific performance of the instrument is being made, and the detectors so far constructed achieve the sensitivity goals originally specified. Further details will again be given when it is known what the availability in Semester Z will be.

Walter Gear
SCUBA Project Scientist

1993 UK National Astronomy Meeting

The 1993 UK National Astronomy Meeting (NAM) will be held at the University of Leicester from Tuesday 30th March to Thursday 1st April. Review presentations will be given each morning on a variety of topics with parallel specialist sessions in the afternoons consisting of short oral presentations. Public lectures will be held on Tuesday and Wednesday evenings. On Friday morning there will be a special review session on 'Astronomy on Mauna Kea'.

For further details contact:
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Ice build-up on the JCMT

On a small number of occasions, observers have reported the frustration of being in the JCMT with what appears to be a great night but unable to open as a result of freezing fog earlier in the night. It might be useful to provide some background as to why this situation occasionally can occur.

The most obvious point is that the limit switches might freeze, and thus the dome cannot be opened due to safety. One simple answer would seem to be to install heaters on the limit switches. However, the problem is more complex in that the roof/rail tracks must be inspected for ice build-up which could damage the weather seals and cladding. The roof cable tracks must be cleared of any ice/snow which could damage the power and signal cables and cable track supports. The leading edge of the roof must be inspected to ensure that no large pieces of ice/snow can fall on the membrane as the roof is opened. Ice and snow build-up behind each roof section must be checked and cleared to ensure that the roof will be able to close.

Therefore, the build-up of ice is a potential for damage to the carousel and so visual inspection is mandatory prior to opening. If the TO feels that the conditions do not allow an adequate visual inspection during the night, then the telescope will remain closed until a time when an inspection can be undertaken.

The JCMT management will be looking at the prospects of installing heaters on the limit switches, but the rare occasions that pertain may not warrant the resulting effort and expenditure especially when there would be no guarantee that this would ensure that the telescope could be opened on all occasions of earlier freezing fog.

I have explained the above in some detail so that observers understand more about the reasons behind the inspection rule and will be tolerant if they are unlucky enough to be unfortunate victims of this particular aspect of the weather on Mauna Kea.

Ian Robson
Director, JCMT

What's it doing now ?

The above is a common question of observers at the JCMT as they watch their precious observing time tick away. The 'it' in question is the JCMT control system and users are quite rightly concerned about any time when they are not integrating on their favourite object.

You can't of course spend all of your time observing your source, some 'overheads' are unavoidable. The nature of sub-millimetre astronomy means you have to spend a considerable time on calibration, integrating on an adjacent patch of blank sky etc.

Some overheads are however avoidable and this article addresses those that arise from the software that controls the telescope and its instruments. What is the control system spending its time doing and is it doing it as efficiently as possible ?

The first step in answering this question is to accurately time all the steps involved from the moment an observation is started to the moment you can start another. Since the JCMT has a large number of different observing modes and an equally large number of different combinations of receiver and detector detailed timings are only given in the table below for one particular type of observation. The observation shown is a position switched sample of two cycles of 60 seconds each. The receiver used was RxB3i and the detector AOSC. In this example the telescope was position switched in azimuth by 300 arcsec while observing at an elevation of 50 degrees.

The various columns in Table 1 have the following meaning. The action column is the command that is sent by the control system to the task that controls a particular piece of hardware or software. The task name is given afterwards in parentheses. The next column gives the time the action is started followed by the time to complete the actual command and the elapsed time. The final column is the overhead from the control system itself which is just the elapsed time minus the start time minus the action time.

A couple of points should be noted before going on to consider the detailed timings. Firstly, given that the required total integration time is 120 seconds, the total 'overhead' is 33.7 seconds or 28%. Secondly, the overhead due to the control system itself is quite small (0.88 seconds). This overhead is a combination of the time taken for one piece of software to send a message to another plus the time taken for the control system to send a message to a micro.

Let us look now at what is going on during each of the actions in the table. The first command, setup,

Table 1. Detailed timing of standard test for position switched observations (60 sec cycle time, 2 cycles, 300 arcsec switch)

Action		Start Time	Action Time	Elapsed Time	Control Overhead
SETUP SAMPLE	(RXB3)	0.00	3.00	3.03	0.03
INIT_SCAN	(AOSC)	3.03	0.15	3.19	0.01
OPEN	(STORAGE)	3.19	0.67	3.89	0.03
BEGIN_INTEGRATE	(AOSC)	3.89	0.06	3.97	0.02
STORE BEGIN_SCAN	(STORAGE)	3.97	0.06	4.16	0.13
INTEGRATE 30 1	(AOSC)	4.16	31.93	36.16	0.07
STEP 300 0 0 0 0	(TEL)	36.16	4.41	40.66	0.09
INTEGRATE 30 -1	(AOSC)	40.66	34.35	75.06	0.05
INTEGRATE 30 -1	(AOSC)	75.06	34.78	109.97	0.13
STEP 0 0 0 0 0	(TEL)	109.97	4.44	114.45	0.04
INTEGRATE 30 1	(AOSC)	114.45	32.39	146.91	0.07
END_INTEGRATE	(AOSC)	146.91	0.08	147.00	0.01
STORE END_SCAN	(STORAGE)	147.00	0.09	147.17	0.08
SCAN_SPECTRUM	(DISPLAY)	147.17	6.25	153.54	0.12
CLOSE	(STORAGE)	153.34	0.16	153.70	0.00

is sent to the receiver. This tells the receiver which frequency to observe at and checks that the Gunn is locked. A couple of commands are then sent to the storage task and the AOSC. The AOSC initialises some arrays and fetches the various observing quantities relevant to this particular observation e.g. system temperature, observing frequency. The storage task then opens a file and writes in all the data that stays fixed for a particular observation.

The commands to actually take data are now sent. The AOSC is sent the command 'integrate 30 1'. The 30 is the number of seconds to integrate for and the 1 indicates this will be an on-source integration. The telescope is then stepped 300 arcsec and a second integration of 30 seconds performed on the off-source position. This sequence completes the first cycle. The second cycle is then begun which because we were observing with cycle reversal is performed in the opposite sense to the first i.e. integrate off-source, step the telescope, integrate on-source. Finally, the AOSC processes the data in the end_integrate action, it is written to disk by the storage task and displayed with the scan_spectrum command.

In order to understand the reasons for some of the action times we must consider the way in which various operations are co-ordinated. Timings are controlled by the '1 Hz tick'. This is a hardware signal that is sent around the observatory to all the JCMT's instruments to synchronise operations. A detector, once it has been told to integrate will actually only start doing so when it sees the rising edge of the next tick. Equally important, the telescope itself is intimately locked to the 1 Hz tick. If the telescope is told to move it must do so with an acceleration, coast and deceleration phase. (unless the step is very small in which case a special one second step is performed). These phases must each be integer number of ticks so in general a move takes at least 3 seconds. The actual control of the telescope involves two tasks in the Vax plus the servo program in the PDP. A typical sequence of actions is shown in Fig. 1.

The on source counter is what is displayed by the screen task in the control room. It shows the number of seconds to go before the telescope arrives on source and is set to zero when the telescope is physically on source. Between ticks -3 and -2 the telescope will be accelerating, between ticks -2 and -1 it will be coasting at constant velocity and between ticks -1 and 0 it will be decelerating.

We are now in a position to understand the timings given in Table 1. The on-source integrations take 32 seconds rather than 30 seconds. The extra overhead is a combination of two factors, the fact that the integration has to start on a tick plus the time needed to read out the detector over the IEEE bus to the Vax. The off-source integrations take some 2 1/2 seconds longer as a measurement of the dark counts is made with every off position and this too has to be read back to the Vax. The step time to move 300 arcsec is about 4 1/2 seconds as is illustrated in Figure 1. Three seconds of this is actual movement of the telescope and the other 1 1/2 seconds are overhead caused by the need to synchronise to the 1 Hz tick.

Looking at the timings in Table 1 it is obvious that there are some areas the JCMT control system could be more efficient. I would of course not be writing this article if we had not done something about them! A glaring overhead is the time taken to complete the display of the data. This amounts to some 6 seconds of the total overhead of 34 seconds. A new version of the display task has recently been installed that eliminates this overhead completely. The control system now no longer has to wait until the display finishes, it simply initiates the display and then continues. The overhead for this is about

```
on source counter        -3          -2          -1           0           1

    |__________|__________|___________|___________|___________|___________|
               ^     ^     ^                                  ^^          ^
               |     |     |                                  ||          |
      command to     |    PDP starts to              Telescope |    integration
       TEL task      |    act on command             physically|        begins
                     |                                on source|
                     |                                         |
          TEL_CYCLE sends                                AOSC told to
          command to PDP                                   integrate
```

Figure 1. Sequence of actions involved in moving the JCMT.

0.03 seconds.

Another modification under test but not yet released is to only make one dark measurement per observation rather than one per off-source position. This saves approximately 2 1/2 seconds in the test observation as expected. This will be released when it is confirmed that taking fewer darks has no affect on the operation of the AOSC.

Other tests under way involve sending commands to instruments in the second before the telescope gets on source. The AOSC would then start integrating when the on source counter goes to zero in the figure above, saving a second on every telescope step command. These tests have shown the relevant time is saved but we need to look carefully at whether the telescope is really on source at this time. At the moment we are quantifying how much the telescope overshoots and how long it takes to settle before we release these changes. If these modifications were implemented along with the new display task we would cut the overhead on the example shown by a total of nearly 11 seconds (6.25 for the display, 2 seconds for the telescope steps and 2.5 for the dark).

What else could we do to increase efficiency? At the moment we integrate and then read out the detector before moving to the next position. We are looking at splitting the integrate action into two parts an integration and a separate read to allow us to read out the detector whilst the telescope is moving. This would save about another 2 seconds in total in the example shown.

It would be extremely hard to reduce the overheads on this type of observation much further given the way the current control system has to be synchronised to the 1 Hz tick. However, there are other inefficiencies in the system that we can improve on. This article has concentrated on the details of a particular observation. Once we have these single observations as efficient as possible we must look at how we string such observations together. This can be achieved with software that allows an observer to specify a queue of observations to be made one after the other such as will be delivered with SCUBA. It will be important to extend such software to all types of JCMT observations so that observers have the tools to make the best use of their hard won telescope time.

Chris Mayer,
JAC

COADD : UKT14 continuum reduction software for long integrations.

The format of UKT14 continuum data, in particular the relative ease with which the final mean signal level can be absolutely calibrated (at least a first guess), makes it possible to reduce data soon after the observation has been completed. This is often an advantage when, for example, one wishes to compare the fluxes of secondary calibrators during a run and check for consistency with their accepted values or, in the case of variable sources, to know immediately if a source has flared or faded and whether the result is important enough that it should be confirmed by a separate observation. For bright sources, together with a quiet and stable atmosphere, the reduction is usually simple to achieve. However for faint sources the care with which the low signal-to-noise data must be treated, to obtain reliable detections or upper limits, often prohibits attempts to fully calibrate such data at the telescope.

There are now a number of research programs on the JCMT that require long integration (>> 3 hour) observations of very faint sources (< 20 mJy at 800 μm). Such integration times can only be obtained by concatenating the data from a number of observations separated by calibration, focusing and pointing scans. At the shorter submillimetre wavelengths the low atmospheric transparency means that the measured signal level can vary significantly as the source rises and sets even if the transparency remains stable over the duration of the added scans. The result is an incorrect measure of the mean signal and the dispersion in the data which together can conspire to produce a detection out of noise or vice-versa. Either outcome has important consequences in the interpretation of JCMT data.

Inhomogeneities in the atmosphere drifting through the beam, with spatial and temporal scales comparable to the chop throw and frequency, produce sky-noise which is one of the dominant causes of poor signal-to-noise measurements. Observations at shorter submillimetre wavelengths in particular can suffer significantly from a noisy atmosphere, introducing spikes into the data at a level or with a frequency too low to be thrown out by the on-line despiking routine as the data is collected at the telescope. If the spikes have sufficient power they can significantly bias the final resulting mean and signal-to-noise. Such spikes can only be removed at the end of the observation (or

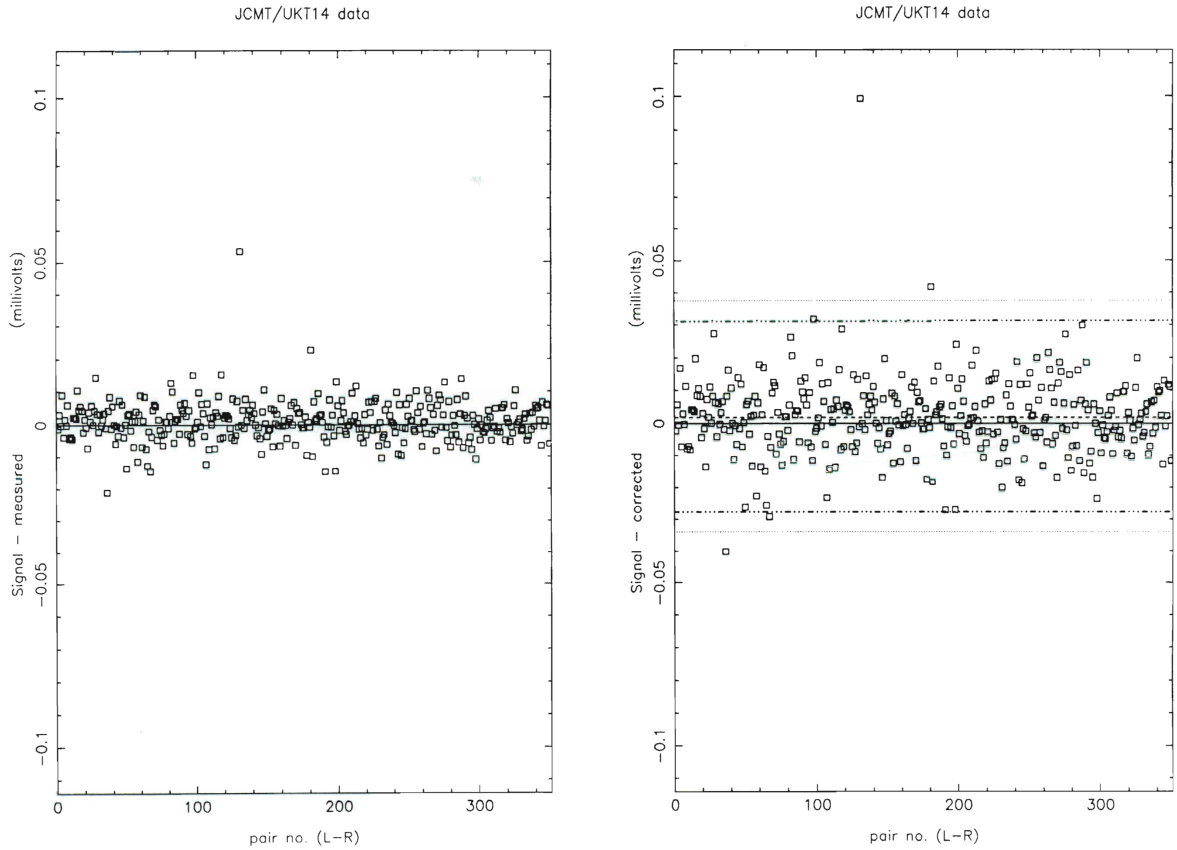

Figure 1. An example of the screen output after concatenating a number of GSD scans. The left-hand panel shows the raw data (mV) against the running pair number. The right-hand panel shows the data corrected for atmospheric extinction. The dashed line indicates the mean value, before despiking, and the dotted lines represent the 3-sigma deviations from the mean. The dot-dashed line shows the user's decision to clip the data at 2.5-sigma and reject 5 samples.

observations) after the considering the quality of the entire integration.

Due to the variable nature of the submillimetre atmospheric transparency it may not always be appropriate to add every sample from a number of successive observations taken over a period of a few hours. There are often periods where the sky-noise suddenly changes, often associated with significant short-term fluctuations in the local humidity. Some further analysis of the data is necessary to ensure that the all or part of the added scans are statistically consistent with each other before a final mean signal and error can be calculated.

A simple but effective software routine (COADD) has been written to analyse UKT14 continuum data and a brief description of the routine is given below;

(i) The programme works directly on the GSD format files (e.g. OBS_UKT14_0192.DAT) so that no conversion is necessary and reads a single scan or any number of individual observations to be concatenated. The mean, median, standard error and signal-to-noise are calculated and displayed for the individual or concatenated observation at each stage of the reduction.

(ii) A correction for variable or constant sky opacity can be made to the individual samples in any observation. If a large number of scans are to be concatenated over a period of several hours then variable sky opacity is likely and the result is sensitive to the quality of the overall calibration and the determination of the changing atmospheric transmission if a large range of airmass is covered by the source.

(iii) The data are now in a form that may be usefully displayed graphically. The raw signal levels (mV) and extinction corrected signal levels (mV) for each sample are plotted against pair or cycle number for the total concatenated (or individual) observation (see Fig.1). The mean signal level and the 3σ upper and lower limits for the extinction corrected data are shown. These aid the user in their decision about the *significance* of any noise spikes and if any despiking is necessary. The option

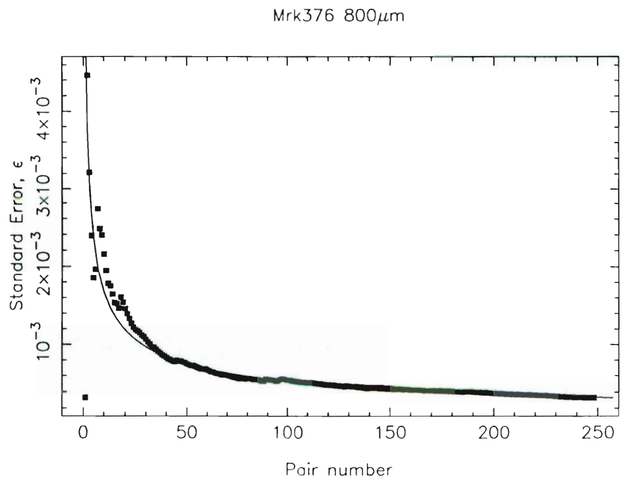

Figure 2. The decrease in standard error, ε, for a 5000 second concatenated integration on Mrk376 is plotted against pair-number (or time for equal length samples). The thin line represents $\varepsilon \propto t^{-1/2}$ and demonstrates that the noise properties of the data are close to normal.

is provided to despike the data automatically at some user-defined significance level or to despike manually with a cursor. The graphics routines are based on PGPLOT and are device independent.

(iv) At this stage the data have been concatenated, corrected for sky opacity and despiked to a satisfactory level. It is now necessary to identify the periods during which the statistical properties of the data vary significantly from the rest of the total integration. Such periods should be due to either short-term fluctuations in opacity, drifting in pointing towards the end of a long integration or changes in telescope focus often encountered if observing around sunrise or sunset. The Kolmogorov-Smirnov two sample statistic is used to test the null hypothesis that any two independent samples in the data are drawn from the same parent population and the following approach was adopted to test the entire data set. The total coadded integration is chopped up into smaller sub-samples. The user chooses both the size of the sub-samples and the significance level at which inconsistent data will be thrown out. Some common-sense has to be applied in the choice of sub-sample size. Examination of the graphical output gives a good indication of the structure size of any temporal trends in the data. The first 2 sub-samples are tested against each other and, if passed, are concatenated. The next sub-sample is then tested against the previously concatenated data and the procedure repeated, resulting in a continually increasing statistically consistent sampled observation, until the entire integration has been tested.

(v) After completing the initial pass through the data reduction one can choose to repeat all or any single part of the process with different parameters without re-reading the data. Finally, if the responsivity value (Jy/mV) is known for the filter and aperture of interest, the data are calibrated.
On exit a summary of the reduction process is written to a file in addition to a number of unformatted ASCII data files which are written out at various stages of the reduction. These include the calculation of the running standard-error, ε. This should decrease as $n^{-1/2}$, where n is the number of samples in the concatenated observations which, for equal cycle times, is a measure of the integration time. In the example shown (Fig. 2) 5 observations of 50 samples (20 secs/sample) have been concatenated and despiked, producing a total integration of 5000 seconds on the quasar Mrk376. The dependence of standard error on integration time, after despiking, is clearly very close to the expected $\varepsilon \propto t^{-1/2}$, as shown by the solid line, and demonstrates that even at submillimetre wavelengths, under reasonable sky conditions, one can continue to improve upper-limits or the sensitivity of a detection with long integrations.

The use of this routine or something similar is essential to reduce low signal-to-noise data in an attempt to reach significantly low flux densities after many hours integration. However it is equally applicable to single short integrations of bright sources (including calibrators) where, in some instances, isolated noise-spikes can have a more damaging effect on the final result or the calibration of the entire night. Occasionally observations of a source at different epochs produce very different results which may be due to intrinsic variability but may also be due to differing sky-noise characteristics. COADD allows the statistical properties of the noise to be investigated and aids the decision about which of the observations (if any) must be rejected. The longest integration I have attempted to date is 16700 secs (4.6 hours) on a radio-quiet quasar at 800 μm. The result was a 4σ detection with a flux density of 20.9 ± 5.2 mJy.

COADD is available for use at the JCMT and anyone interested in using this routine or requiring further information should contact David Hughes (DHH@UK.AC.OX.ASTRO, OXVAD::DHH). I thank Firmin Oliveira and Gõran Sandell at JAC for their continued efforts to improve COADD.

David Hughes,
Oxford.

New Results

Extended Emission Lines around 3C9 at $z \sim 2$

Extended optical emission-line regions (EELR) have been known to be common around low-redshift ($z < 0.1$ - 0.3) radio-loud quasars, since the early 1980s (e.g. Boroson, Persson & Oke 1985, and references therein). The EELR extend over radii of tens of kiloparsecs, distributed into a patchy and filamentary nebula illuminated by the quasar. The observed strength of the off-nucleus narrow lines such as [OII], Hβ, [OIII], Hα and [SII] is consistent with photoionization of the nebulosity by a power-law continuum source, leading to early estimates for the density of the emitting regions of between 0.3 cm^{-3} and 500 cm^{-3}.

We have pioneered a method of using optical long-slit spectroscopy to discover and probe new EELR around radio-loud quasars out to much higher redshifts, $z \sim 1$ (Fabian et al. 1988; Crawford & Fabian 1989; Forbes et al. 1990; Bremer et al. 1992a). Our technique not only reveals the nebulae, but also enables us to use the spatially extended emission-line ratios as a quantitative diagnostic of the immediate environment of a quasar. We compute improved photoionization models of the nebulae using CLOUDY (Ferland 1992) to match the observed line intensity ratios of [OII]λ3727 and [OIII]λ5007 in the spatially-extended gas subject to the observed ionizing spectrum of the quasar nucleus (as measured from IUE and X-ray spectra).

Our work shows that the EELR are consistently at high pressure ($nT \sim 5 \times 10^5$ - 1×10^7 cm^{-3} K at tens of kiloparsec from the nucleus), the larger pressures inferred for the higher redshift quasars. If unconfined, the emission-line clouds would disperse rapidly in their sound crossing time ($\lesssim 10^6$ yr). The observed common occurrence of the quasar nebulosities argue against such short lifetimes — either we are only seeing the illuminated tip of a $> 10^{11}$ $M_\odot$ gas cloud, or the EELR are prevented from evaporation by a confining agent such as a hot halo similar to the X-ray emitting intracluster media seen in nearby clusters of galaxies. Current X-ray satellites do not have sufficient sensitivity or spatial resolution to resolve X-rays from an intracluster medium against the X-ray bright nucleus at these redshifts. Our findings do, however, appear to be in agreement with both optical number counts of galaxies associated with such quasars (Yee & Green 1987; Hintzen, Romanishin & Valdes 1991) and the environment required to produce the observed selective depolarization of radio structure (Garrington & Conway 1991).

Pressure equilibrium between the warm line-emitting clouds and the confining X-ray halo restricts the hot gas to be cooling on timescales much less than the Hubble time — i.e. cooling flows exist around these quasars. By analogy to nearby flows we infer cooling rates of up to 1000 $M_\odot$ yr^{-1} distributed within the inner 20 kpc. If such mass deposition rates have continued for much of the lifetime of the quasar, they can certainly form the quasar host galaxies, as well as fuel the quasar itself (Fabian & Crawford 1990).

Our method of using optical spectroscopy to measure the pressure in the EELR is made more difficult above $z \sim 1$ by the increased atmospheric absorption and emission there. While extended Lyα (still in the optical) can reveal higher-redshift quasar EELR (Heckman et al. 1991; Bremer et al. 1992b), it cannot form a sensitive pressure diagnostic on its own, and other lines such as CIV are usually too weak to be observable. Thus the best way to push our exploration of quasar environments to higher redshifts is to continue observing the [OII] and [OIII] lines, now redshifted into the near infra-red. The newly-commissioned long-focus camera on CGS4 at UKIRT has given us the sensitivity and spatial resolution to do this (1.5 arcsec per row along the slit).

In September 1992, we observed the radio-loud quasar 3C9 (z = 2.018) which was shown from Lyα imaging to have an EELR (Heckman et al. 1991). Using two grating positions we were able to cover the redshifted [OII]λ3727 multiplet and the [OII]λλ4959, 5007 multiplet in two exposures at spectral resolutions of between 450 kms^{-1} and 1200 kms^{-1} with a North-South slit. Due to the better seeing conditions on the third night the [OII] regions were observed using a narrower slit to improve the sensitivity. This does however make the calculation of an accurate line ratio more uncertain since we observed less of the nebula. Exposure times for each line were about 1 hour.

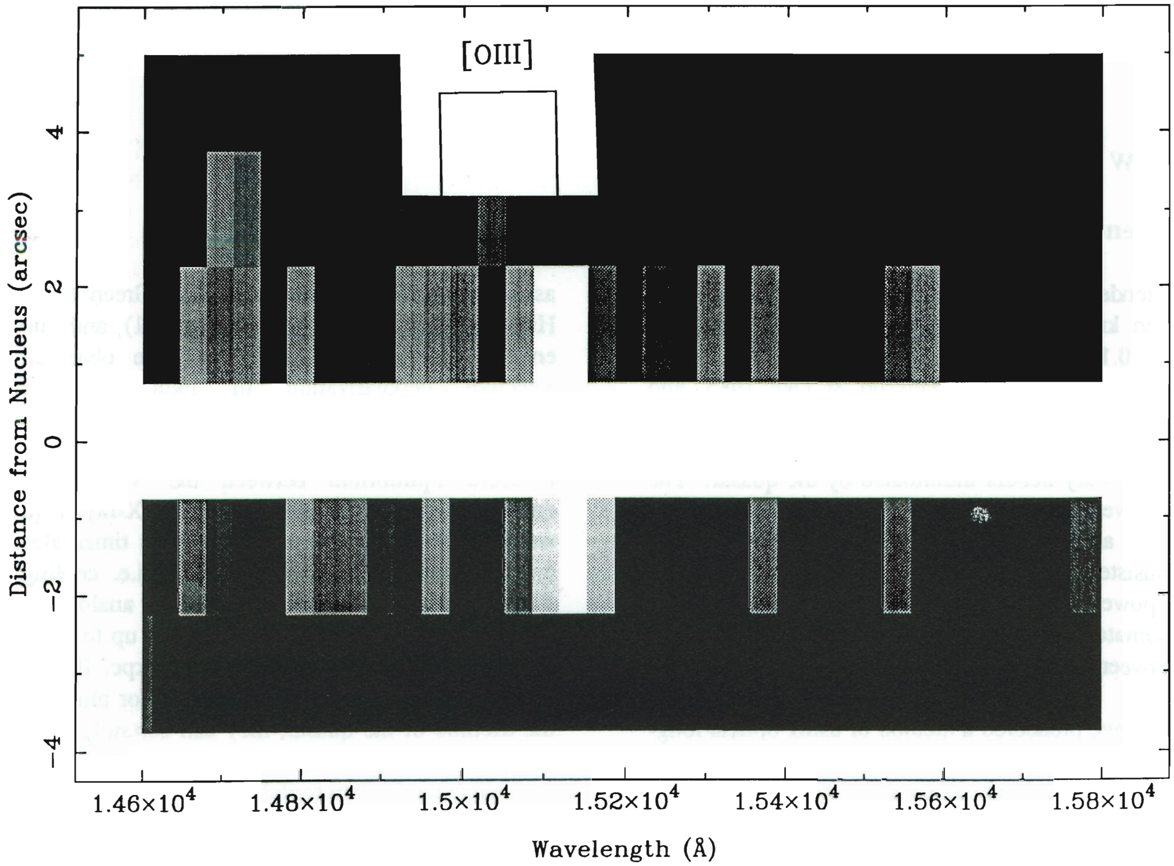

Figure 1. CGS4 spectral image of the quasar 3C9 in the region of the [OIII] lines. Each row in the spatial (y–direction) covers 1.5 arcsec on the sky. North is at the bottom and South at the top.

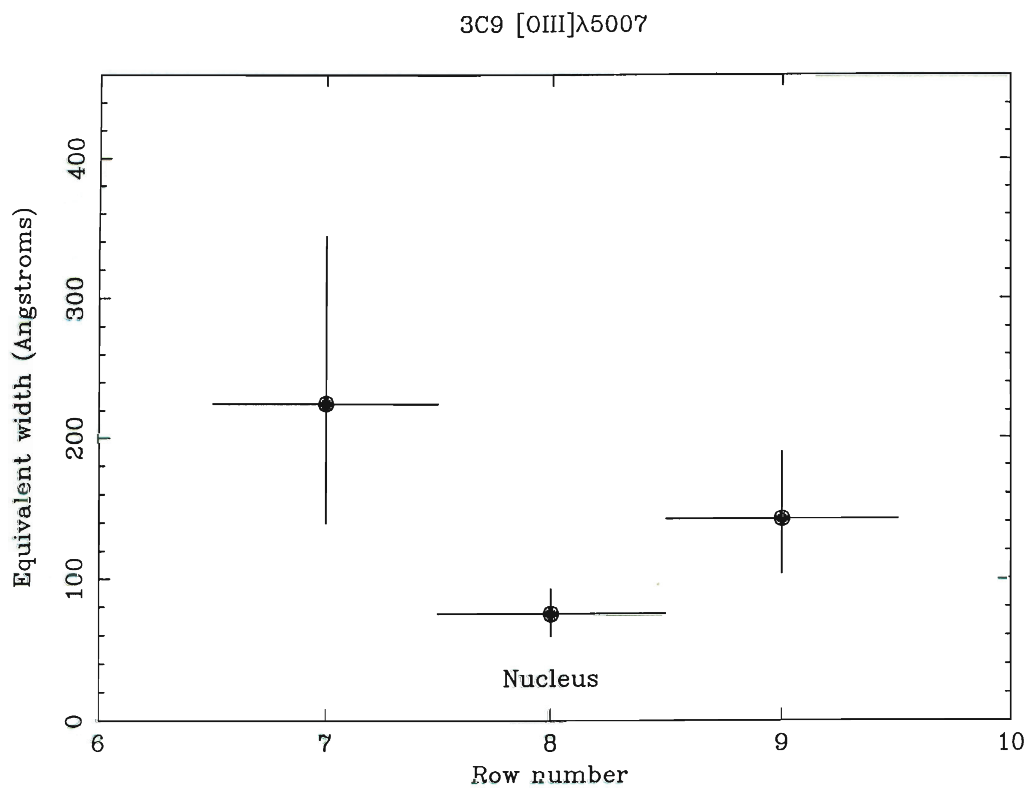

Figure 2. The equivalent width of the [OIII]λ5007 emission line in 3C9 as a function of spatial row showing a clear increase off nucleus.

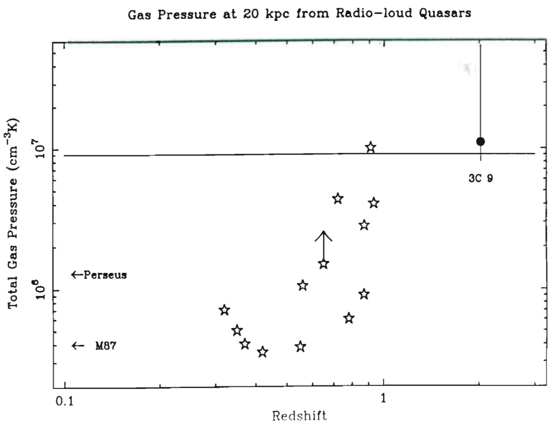

Figure 3. Pressure at 20 kpc in the EELR around quasars as a function of redshift. The straight line indicates the maximum pressure possible for confinement by a massive halo.

Figure 1 shows a greyscale image of the spectrum of 3C9 near the [OIII] line. Figure 2 demonstrates how the equivalent width of the [OIII] emission increases with spatial distance from the nucleus (and hence that its extent is not due solely to the point spread function of the instrument). The redshift measured from fitting the [OIII] doublet (z = 2.019 ± 0.001) agrees well with the improved published redshift given by Tytler & Fan (1992). This value is somewhat higher than the value z = 2.012 assumed by Heckman et al. 1991.

The [OII] data are more difficult to interpret. There is a relatively strong emission line in one row on the south side of the nucleus, but at a redshift of z = 2.012 ± 0.0005. A weaker feature is present in 3 rows centred on the nucleus at z = 2.022 ± 0.002 which agrees more closely with the [OIII] redshift. The velocity difference of these two features is ~ 650 kms^{-1}. We select the higher velocity system for our analysis since its position is consistent with that observed from the [OIII] lines. However, in this preliminary analysis we remain cautious of this detection since we do not currently have external errors from the individual pairs of observations. Our uncertainties are estimated from the spectral line fitting procedure used to measure the line flux. We proceed assuming our detection is correct but note that our results become lower limits to the [OIII]/[OII] line ratio or upper limits to the pressure, if not confirmed.

The nucleus of the quasar is well-centred (within 0.1 pixels) in both [OII] and [OIII] images and most of the light is contained within a single row on the detector. We measure the [OIII]/[OII] intensity ratio one row either side of the nucleus (± 20 kpc assuming H_0 = 50 and q_0 = 0), after correcting for contamination of spill-over from the nuclear line emission (this is scaled from the ratio of continuum intensities in the nuclear and off-nuclear row). In the row to the North we obtain [OIII]/[OII] = 2.2 ± 1.2 at a radius of 20 kpc from 3C9. Due to the difference in slit widths between the [OIII] and [OII] data the true [OII] flux in the region of the [OIII] slit could be at most a factor of two higher, reducing the line ratio. However because of the steep surface brightness profile of the nebula we expect that the correction is rather less than this. The ratio in the row to the South is poorly constrained but consistent with this value.

Predictions of this line ratio from photoionization models assuming a power-law continuum over the ultraviolet to X-ray region as given by Worrall et al. (1987) (this can be considered a lower limit since additional spectral features such as a 'blue bump' will act to increase the ionization and hence the inferred gas pressure) were then matched to the measured ratio. We thus obtain a pressure of $1.1_{-0.3}^{+4.4} \times 10^{7}$ cm^{-3} K at 20 kpc from the nucleus of 3C9.

This result is shown as the filled circle with error bars in Fig. 3 with a comparison to our previous optical results for quasars at $z < 1$ and some nearby clusters of galaxies. The horizontal line indicates an upper limit on the pressure. Above this line, hot intracluster gas cools too quickly to maintain pressure equilibrium with its surroundings. Our data do allow pressures less than the maximum value possible for pressure equilibrium, and maintains the trend of large inferred mass deposition rates ($\dot{M}$ ~ 1000 $M_{\odot}$ yr^{-1}) at high redshifts. (If the ionizing continuum is any stronger than we have assumed then the radiation field must be anisotropic — in that the EELR sees fewer ionizing photons than we do — in order not to violate the maximum pressure condition. If the [OIII]/[OII] line ratio is higher, i.e. the [OII] is fainter then the pressure will be lower.) *Our results show that the high-pressure environment of the quasars is an important long-lived factor that may influence both the subsequent evolution of the quasar, and the creation of its host galaxy.*

A forthcoming paper to be submitted to Monthly Notices will extend this preliminary reduction, discuss similar observations of PKS 2222+051 and make a comparison with the extended Lyman-α flux seen in these objects by Heckman et al. (1991). This may tell us about the presence of dust in the nebula. Limits on the presence of extended Hβ also covered in our spectroscopy will allow us to examine the oxygen abundance. We have more UKIRT time allocated in the Summer of 1993 to enlarge our sample.

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Long Term Monitoring of the Quasar 3C 273

Blazar is a term reserved for a phenomenon associated with certain categories of active galactic nuclei, specifically BL Lac objects, optically violently variable (OVV) quasars and high polarization quasars (HPQs). All are radio loud and have cm → submillimetre emission which is typical of flat spectrum radio sources. Superluminal motion, derived synchrotron self-absorption brightness temperatures exceeding the Compton limit and rapid variability have led to a picture of relativistic beaming with a narrow opening angle oriented towards the line of sight to the observer.

The nearby, luminous quasar 3C 273 has been well studied at all wavelengths. It has a redshift of 0.158, a well defined broad line region, observed continuum emission from the radio through to gamma rays, is variable on a range of timescales as short as one day and shows superluminal motion of ~5c(100/h).

The spectrum of 3C 273 is composed of a number of superimposed components and these vary as a function of time and state of the source. In general the highest frequency synchrotron component peaks around 1 mm from where it follows a decline into the optically thin regime, extending smoothly into the mid infrared. Observations at millimetre and submillimetre wavelengths reveal the transition from optically thick radio emission to optically thin higher frequency emission, which arises from the most compact region of the relativistic jet assumed to exist in these sources.

The key features of the general behaviour seen in the light curves (Fig.1) can be described by: (i) a series of fast flares in the early part of 1988 observed at IR and near mm, (ii) a second flare in the summer of 1988 with a decline towards the end of the year; (iii) a quiescent period during all of 1989; (iii) a further large flare in early 1990 and, before the source could decline to its 'quiescent' flux levels, (iv) another flare in the early part of 1991, giving a much longer period at high emission at mm wavelengths, following which 3C 273 began to decline slowly towards the quiescent level.

This well-sampled series of data allows the quiescent spectrum to be determined by binning the flux over this period to produce an average quiescent flux (Fig.2). This can then be used to calculate the mean spectral index for the millimetre

→ submillimetre region.

We associate the steady, quiescent flux (Fig.2) with emission from this underlying jet. The flaring and polarization behaviour seen in Fig.1 has been explained by sophisticated shock models (e.g Marscher and Gear, Astrophys. J. **298**, 114, 1985) involving the propagation of a shock down the jet with associated enhancement of synchrotron emission. Monitoring in the millimetre and sub-millimetre regimes enables us to test the predictions of these models and also to provide a longer and more complete temporal database from which even more refined models are being developed.

The data from the near IR to cm radio wavelengths are presented in a paper currently in press (Robson et al, M.N.R.A.S., 1993), preprints are available from Simon Litchfield at Preston (LPVAD::SJL, SJL@UK.AC.LANCSP.STAR).

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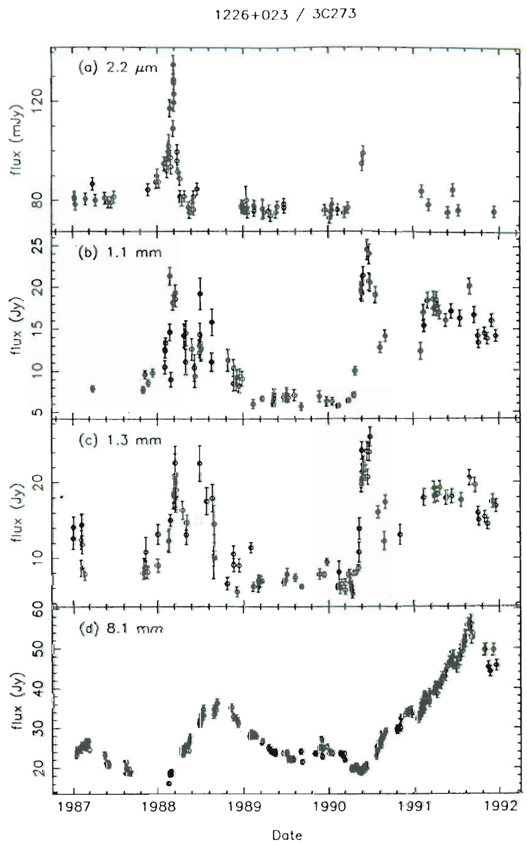


Figure 1. Light curves for 3C 273 from 1987 to end of 1991. Panel (a) shows K band emission, (b) and (c) show 1.1 mm and 1.3 mm data taken mainly at the JCMT and (d) shows 8.1 mm radio data taken by Finnish collaborators at the Metsähovi Radio Research Institute, Helsinki.

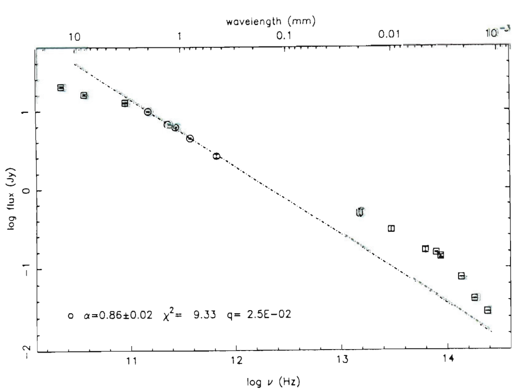
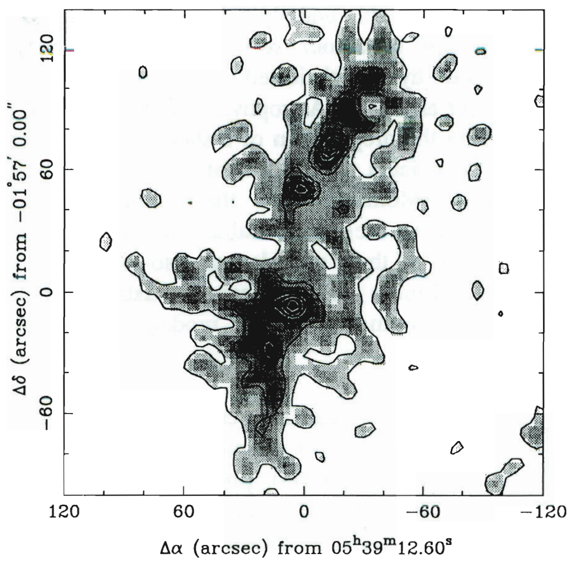


Figure 2. The quiescent spectrum of 3C 273. The power law fit to the mm-submm regime is shown; radio and IR points are plotted for illustrative purposes.

A Continuum Map of Orion B at 800 microns

In a recent PATT observing run at the JCMT, I was trying to make a spectral index map of the central region of the Orion B molecular cloud between 450 and 800 microns: the idea was to measure the optical depth at 450 microns in the compact far infrared (FIR) objects in the cloud core, and to use that information to test the conflicting models of the objects. In one model, these objects are cold (< 20 K), massive collapsing protostars without stellar cores. In another, these objects are less massive, more evolved YSOs containing hot stellar cores which heat the surrounding dust to 30-40 K or so. Both these models have explanations of why the maps of molecular line and dust emission from the cold core are so different. In the cold protostar theory, the molecules are frozen out onto the cold grains in the FIR objects, which leads to a deficit of line emission compared to continuum emission in these objects. In the warm YSO theory, no depletion takes place since the dust is warm: a combination of excitation effects (optical depth, density and temperature) is then used to explain the differences between line and continuum maps.

Well this is all well and good in theory; in practice, Orion B at 800μm



I was unable on two successive observing runs to obtain a 450 micron map — during the July to October period, the weather remained obstinately mediocre. So I'm still waiting for the high frequency map; I did, however, make an 800 micron map during one run, and I thought it was worth presenting this in the Newsletter to compare the imaging performance of the JCMT with the IRAM 30-m telescope at 800 microns. Mezger et al. (A & A, **256**, 631, 1992) have already published an 800 micron map taken with the 30-m telescope which in principle should have twice the resolution of the JCMT map. However, by judicious use of DBMEM to deconvolve the JCMT beam response, the image obtained at JCMT (shown in the accompanying figure) appears to be almost as good as the IRAM 30-m map. The much higher beam efficiency of the JCMT at this wavelength, and the different data reduction strategies used, are responsible for this similarity despite the factor of two difference in telescope size.

The seven or eight bright 'protostellar' condensations stand out clearly in a north-south ridge, and the low surface brightness extended envelope surrounding them can be seen. Completion and publication of this project awaits good weather at a suitable time for us to obtain a 450 micron image. This will hopefully be before the arrival of SCUBA...

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MRAO

JCMT observations of molecular lines in comet P/Swift-Tuttle (1992t)

Introduction

Comet P/Swift-Tuttle is the comet associated with the Perseid meteor stream seen each year in August. Observed as a bright object of magnitude 2 in August 1862, its return was originally expected in 1981 but it was not recovered that year. Marsden (1973) linked P/Swift-Tuttle with comet Kegler 1737II and tentatively predicted its return for autumn 1992 and the comet was indeed recovered on September 26th, 1992 with a magnitude of 12. Although the observational conditions would be less favourable than at its last return, with a closest approach to the Earth of 1.2 AU compared with only 0.3 AU in 1862, further observations showed that comet P/Swift-Tuttle would be one of the brightest comets of this decade, justifying an extensive observational campaign. This had to be organised at short notice since the best observing period proved to be between November and mid December 1992, a compromise between closest approach to the Earth (November 4), to the Sun (perihelion on December 12) and large solar elongation. The visual magnitude of the comet reached 5 in mid-November and observations of the OH radical in the radio and the UV (A'Hearn et al. 1992) showed that the gaseous production rate was 5×10^{29} s^{-1} near perihelion, not much less than that reached by P/Halley (1×10^{30} s^{-1}).

The unexpected appearance of P/Swift-Tuttle provided an exciting opportunity because studies of Halley and other comets had already proved that millimetre and submillimetre spectroscopy is a powerful technique for identifying key molecular constituents of cometary atmospheres and for measuring their abundances. Observations with the IRAM 30-m telescope of P/Halley led to the first unambiguous detection of HCN at 89 GHz (Bockeleé-Morvan et al., 1987). HCN was then observed in other comets through its J=3→2 and J=4→3 lines using the IRAM 30-m, SEST and the CSO (Colom et al. 1992a; Winnberg 1990; Schloerb and Ge, 1992). Observations of comet Austin (1990V) and Levy (1990XX) at the IRAM 30-m led to the identification of H_2S (169 and 217 GHz) and CH_3OH (a dozen lines at 96, 145, 165 and 218 GHz) (Bockeleé-Morvan et al. 1991, 1993; Crovisier et al. 1991). Formaldehyde was detected at 225 GHz (IRAM 30-m) and 351 GHz (CSO) in several comets (Colom et al. 1992b; Schloerb and Ge, 1992). Observations of several transitions of the

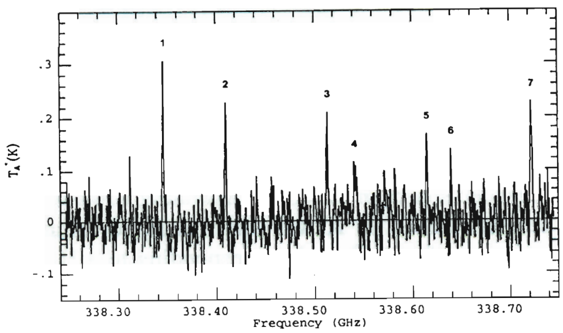

Figure 1. The spectrum of CH_3OH observed at 338 GHz in comet P/Swift-Tuttle on December 7th, 1992. The spectral resolution is 0.5 MHz. The following lines are clearly detected on the figure: (1) (7,-1)-(6,-1)E at 338.3446 GHz; (2) (7,0)-(6,0)A at 338.4087 GHz; (3) (7,2)-(6,2)A^- at 338.5128 GHz; (4) (7,3)-(6,3)A^+ and A^- at respectively 338.5408 and 338.5432 GHz; (5) (7,1)-(6,1)E at 338.6150 GHz; (6) (7,2)-(6,2)A^+ at 338.6399 GHz; (7) (7,2)-(6,2)E and (7,-2)-(6,-2)E lines at 338.7222 GHz.

same molecule allow a probe of the excitation conditions in the coma and give constraints to the kinetic temperature. Measurements of molecular abundances give important clues in the search for a better understanding of how comets were formed. Thanks to the high sensitivity spectral resolution, radio spectroscopy is in addition a powerful tool to study the kinematics of the coma, measuring outflow velocities and the anisotropy of the gas.

Results

For the first time, a search for cometary molecular lines was undertaken using the JCMT. The first shifts attributed on UK Service Observing Time at the end of November were unsuccessful due to bad weather, Comet P/Swift-Tuttle was then observed on December 6, 7 and 8th 1992 between 3h and 5h UT, as it was at 1.48 AU from the Earth and 0.96 AU from the Sun. The observations were performed using receiver B3i and the AOSC spectrometer. Originally we intended to use frequency switching, but we had some problems, and with only limited time available before the comet set we therefore changed to beam-switching rather than trying to sort out the problem. To confirm that the lines were in the correct sideband observations were made at two frequencies separated by 10 MHz. Fortunately the comet was only about 20 degrees from Uranus, so we are confident that the pointing was good. Comparison spectra were obtained on G34.3 using the same instrumental setup. Several molecular lines were detected in a few hours integration, demonstrating the high efficiency of the JCMT for cometary studies.

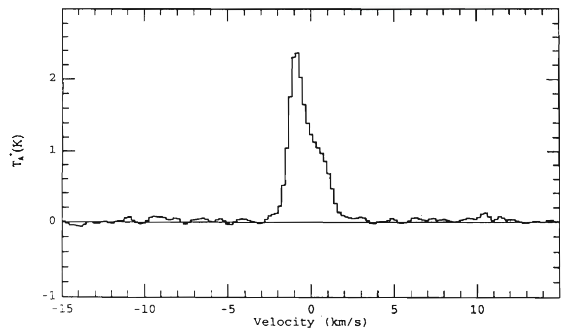

Figure 2. The J=4→3 HCN line at 354.505 GHz observed in comet P/Swift-Tuttle on December 8th, 1992. The spectral resolution is 0.5 MHz. The velocity scale is with respect to the nucleus velocity, uncorrected for the AOSC non-linearity.

1. CH_3OH at 338 GHz

CH_3OH was detected through several of its rotational lines at 338 GHz and one line at 341 GHz, placed respectively in the lower and upper sidebands of the receiver. The spectrum observed on December 7th is shown on Fig. 1: 7 lines are detected with signal-to-noise ratios larger than 6, while 3 other lines are marginally present. The observed lines correspond to J=7→6 transitions within different K ladders. A preliminary study of the relative line intensities suggests a rotational temperature of 50 K for the J=7 levels. Significant deviations from a Boltzman distribution are also present, indicating that the observations were sampling molecules outside the inner collision-dominated region. These observations will complement the observations of methanol at 145 and 165 GHz performed two weeks earlier with the IRAM 30-m telescope that sampled rotational levels of lower energies (Paubert et al., 1992). As a preliminary estimate, the intensities of the 338 GHz lines correspond to a methanol production rate of 2 x 10^{28} s^{-1} and an abundance relative to water of about 0.04. This is in close agreement with the abundances deduced from the observations of the 3.52 micron methanol band performed at UKIRT (Davies et al. 1992) and the millimetre observations at IRAM.

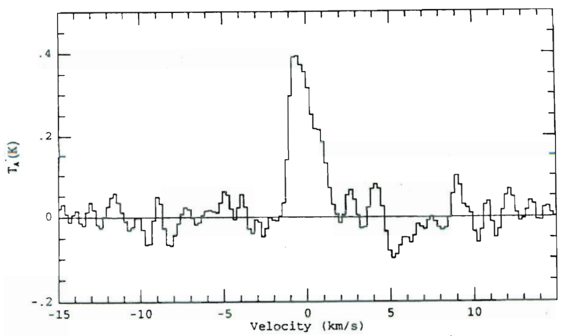

Figure 3. The $5_{1,5}$ - $4_{1,4}$ H_2CO line at 351.669 GHz observed in comet P/Swift-Tuttle on December 8th, 1992.

2. HCN at 354 GHz

The J=4→3 rotational line of HCN at 354 GHz was detected with a signal-to-noise of 85 on December 8th. As shown on Fig. 2, the peak antenna temperature reached 2.5K. To our knowledge, this is the strongest radio signal ever recorded from a comet, both in T_A^* and signal-to-noise ratio. Such a high signal-to-noise will allow a detailed study of the kinematics of the coma through the line shape. In particular, the large blueshift observed at the line position is indicative of strong anisotropic outgassing towards the Sun. This result has to be correlated with the morphology of the dust in the inner coma observed in the visible (Jorda et al., 1992), which shows a strong helicoidal jet. In contrast to methanol, the derivation of the HCN abundance from the observed line intensity is highly model dependent since it relies on the assumed rotational temperature. Indeed, there is a priori no reason to assume the same rotational temperature as that found for methanol since the population distribution is probably the result of the balance between collisional excitation, infrared excitation and radiative decay, as expected from excitation models. We can however already note that the comparison of these observations with the observations of the J=1→0 HCN line performed two weeks earlier at IRAM would suggest a rotational temperature on the order of 80 K and an HCN production rate of 1 x 10^{27} s^{-1}, which corresponds to an abundance relative to water on the order of 0.002.

3. H_2CO at 351 GHz

The $5_{1,5}$-$4_{1,4}$ H_2CO line at 351 GHz was observed simultaneously with the HCN line, by placing them in opposite sidebands of the receiver. It was detected with a signal-to-noise ratio of about 15. As shown on Fig. 3, this line is remarkably similar, in shape, to the HCN line. The determination of the formaldehyde abundance from the observed line intensity poses an additional problem, linked to the density distribution. Indeed, several observational facts suggest that formaldehyde is not solely produced at the nucleus surface, but partly in an extended source in the coma. Assuming a rotational temperature of 80 K, we derive a H_2CO column density of 8 x 10^{12} cm^{-2}, corresponding to a H_2CO production rate of 5 x 10^{27} s^{-1} if direct release from the nucleus is assumed. The H_2CO production rate could be higher, if formaldehyde is effectively produced from an extended source.

Conclusion

With the present observations, the JCMT has proved its efficiency for the study of cometary molecules of minor abundance, and its complementarity to other telescopes such as IRAM or UKIRT. This should open further opportunities for the identification of new cometary species.

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Methanol Ice in GL2136

It has long been known that refractory grains (e.g. silicates) in dense molecular clouds acquire icy mantles (Tielens & Hagen, 1982, for example). The principal observed mantle constituent is water ice, which generates a very strong and well known absorption at 3.07 µm. Such icy mantles may lock up a large fraction of the condensible elements in cloud cores, and UV processing of the mantles around young stars may generate complex organic residues. Organic grains in the ISM may be entirely due to this process (Butchart et al. 1986).

After H_2O and CO, methanol should be the most abundant molecule in grain mantles in dense clouds. However, the abundance estimates from observations are controversial, and range from 5% to 50% of that of H_2O ice. Methanol ice has 4 observable features in the IR: a CH stretching mode at 3.53 µm, a CH deformation at 6.85 µm, a CH_3 rock at 8.87 µm and a CO stretch at 9.7 µm. There are difficulties with all 4 features, however. The 3.53 µm feature lies in the wing of the very strong water ice feature, and tends to be almost drowned by it. The 6.85 µm feature can only be observed with the KAO or from space, and additionally the observed 6.85 µm features might be better ascribed to other molecules (Grim et al. 1991). Finally both the 8.87 µm and the 9.7 µm features lie in the very strong silicate absorption feature seen towards star forming regions. The 8.87 µm feature is away from the peak silicate absorption, but rather weak, whilst the stronger 9.7 µm feature lies at the bottom of the silicate absorption, and also lies in the strong telluric ozone band. The 3.53 µm feature has been seen toward a number of sources, but at low S/N due to the stronger water ice feature. The 6.85 µm feature has been observed in a few sources, but abundance estimates disagree strongly with those based on the 3.53 µm feature. The remaining two features have never previously been observed.

We observed the massive protostar GL2136 at UKIRT using CGS3, on May 23 1991. Low resolution spectra covering the 8 – 13 µm and 17 – 24 µm regions were taken, as well as intermediate resolution ($\lambda/\Delta\lambda = 250$) spectra in the 8.3 – 10.9 µm region. Figure 1 shows the observed intermediate resolution spectrum, after calibration against the bright spectrophotometric standard β Peg. We also calibrated against two other stars, β And and α Lyr, obtaining the same result with all three stars — though not all of such good S/N. This confirms that we have effectively cancelled out the telluric ozone feature. The solid line in Fig. 1 represents the best fit of a silicate emissivity function to the intermediate resolution spectrum. The small triangular feature in absorption at 9.7 µm represents the first detection of the methanol ice feature in an astronomical source. Fits to the low resolution spectrum reveal the same residual absorption feature. If we subtract the best fit from the observed spectrum, we obtain the residual spectrum shown in Fig. 2. Not only do we see the 9.7 µm methanol ice feature, we also see its poor relation at 8.87 µm, albeit at rather low S/N.

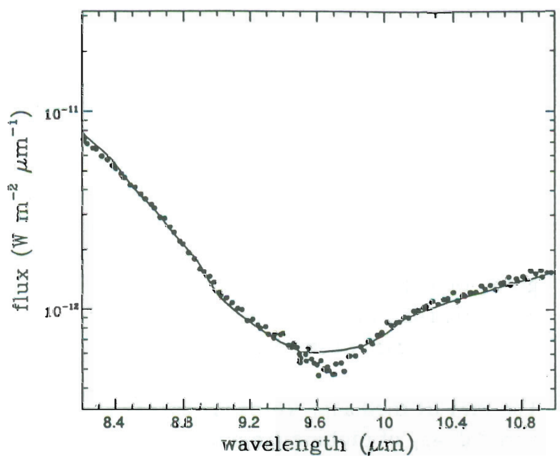

Figure 1.

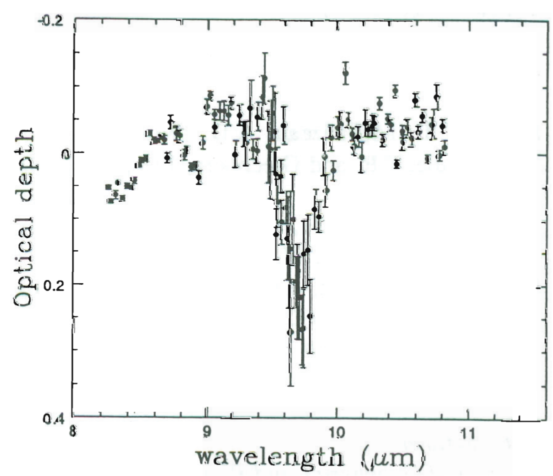

Figure 2.

The wavelength of the 9.7 µm methanol ice feature shifts depending on the relative abundances of water and methanol ice in the grain mantles. Laboratory spectra show the feature at 9.8 µm when the methanol ice has only 5% of the abundance of the water ice, whilst when this is increased to 50% the wavelength has shifted to 9.7 µm. Additionally a shoulder appears in the absorption feature around

9.9 µm. Fits of laboratory spectra to our observed spectrum are very good for a methanol abundance somewhat in excess of 50% of that of the water ice. However, when we determine the abundances of water and methanol ice from the strengths of the four methanol bands (all have now been observed in this source) and from the 3.07 µm and 5.99 µm water ice features, we find that the 3.53 µm, 8.87 µm and 9.7 µm methanol ice features all yield an abundance somewhat less than 10% of that of the water ice. The 6.85 µm methanol ice band yields an abundance more than four times higher. This discrepancy casts some doubt on the earlier identification of the 6.85 µm feature with methanol ice. Finally, the discrepancy between the 50% methanol ice abundance from the 9.7 µm feature's wavelength and the 10% from the band strengths may imply that the methanol ice is not uniformly distributed in the source, but that some grains have large amounts of methanol ice in their mantles, whilst others have very little. This could result from the mechanism by which the grain mantles grow, or could result from outgassing of volatile materials (like methanol) near the massive young star at the centre of the source.

The mid-IR methanol ice bands appear to provide a useful way of probing grain mantles in molecular clouds, and we would like to observe more such sources. More details of this work appear in Skinner et al. (1992).

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Near-Infrared Spectroscopy of Supernovae

1. Why study supernovae?

A supernova results from the catastrophic breakdown of the balance between gas pressure and gravity in a star. We want to understand the remarkable physical processes which must be involved. In addition, a supernova allows us to look deep into the progenitor material and so investigate the preceding evolution.

There appear to be two fundamentally different types of supernovae. Type Ia explosions are thought to result from mass transfer in a binary system to a carbon-oxygen white dwarf component, taking it above the Chandrasekhar limit. In attempting to collapse, thermonuclear burning is triggered. Since the material is electron degenerate, runaway occurs, eventually completely exploding the star. A Type II supernova is believed to have a highly-evolved progenitor whose main sequence mass exceeds about 8 solar masses. The trigger appears to be the collapse of the relativistically degenerate iron core, dramatically confirmed by the detection of a neutrino pulse a few hours before Supernova 1987A was optically discovered. Supernovae of Type Ib and Ic also probably have massive progenitors.

In spite of the wide acceptance of these scenarios, there are still gaps in our detailed understanding of supernovae. There is uncertainty about the evolutionary processes which lead to the Type Ia explosions. Also it is unclear how the burning starts and then spreads. Type Ias are reputed to be highly homogeneous events but for some examples spectroscopic evidence suggests otherwise. For Type IIs the long standing difficulty has been how to convert the collapse of the core into an explosion. Largely as a consequence of this problem, the explosion energy, and the masses and distribution of heavy elements generated by explosive nucleosynthesis are difficult to predict. In addition, the composition and structure of a Type II supernova is affected by the nature of the progenitor. For both types of supernova it is increasingly clear that mixing must also be considered, and indeed may play a major role in the explosion processes.

2. Early-time versus late-time spectroscopy

To model the consequences of a supernova explosion, the standard procedure is to dump a large amount of energy in the interior of a stellar model causing it to 'explode'. The subsequent velocity, density and nucleosynthesis is calculated. These results are then used to model spectra which can then be compared with observation. Early-time (up to a few months post-explosion) optical and infrared spectra can be of very high signal-to-noise and have good temporal coverage, but they suffer from the disadvantages that the line formation processes are very complex and that most of the ejecta are optically thick.

Late-time spectra (a few months post-explosion) appear more promising. The ejecta have become optically thin, most of the ions are in their ground state, the radiative transfer problem is simpler and the atomic physics involved is better understood. However, in late-time spectra covering the blue and UV, the large numbers of lines plus the strong Doppler broadening (velocities of about 10,000 km/s) produce spectra where identification is difficult and the extraction of detailed information about profile shapes is near to impossible. In contrast, the region which lies roughly between 0.65 and 2.5 microns is less crowded, but still contains prominent lines representing a wide range of elements including H, He, C, O, Na, Mg, Si, Ca, Fe, Co and Ni. The possibility of obtaining clean line profile measurements is important. The profile width and shape is determined by the velocity of the ejecta and can indicate the spatial distribution of the matter. This is because, shortly after the shock reaches the surface of the star, the expansion of the ejecta becomes homologous (velocity proportional to radial distance).

3. First attempts at late-time near-IR spectroscopy

When our near-IR spectroscopy programme began in 1984, the development of late-time spectral models had not yet reached the stage where useful comparisons with IR spectra could be made. We therefore confined our attention to the simpler aim of testing the ^{56}Ni hypothesis, which is central to the understanding of supernovae (e.g. Woosley 1990). Most explosion models predict that, under the extreme conditions of temperature and density which exist in the supernova, 0.05 to 0.5 solar

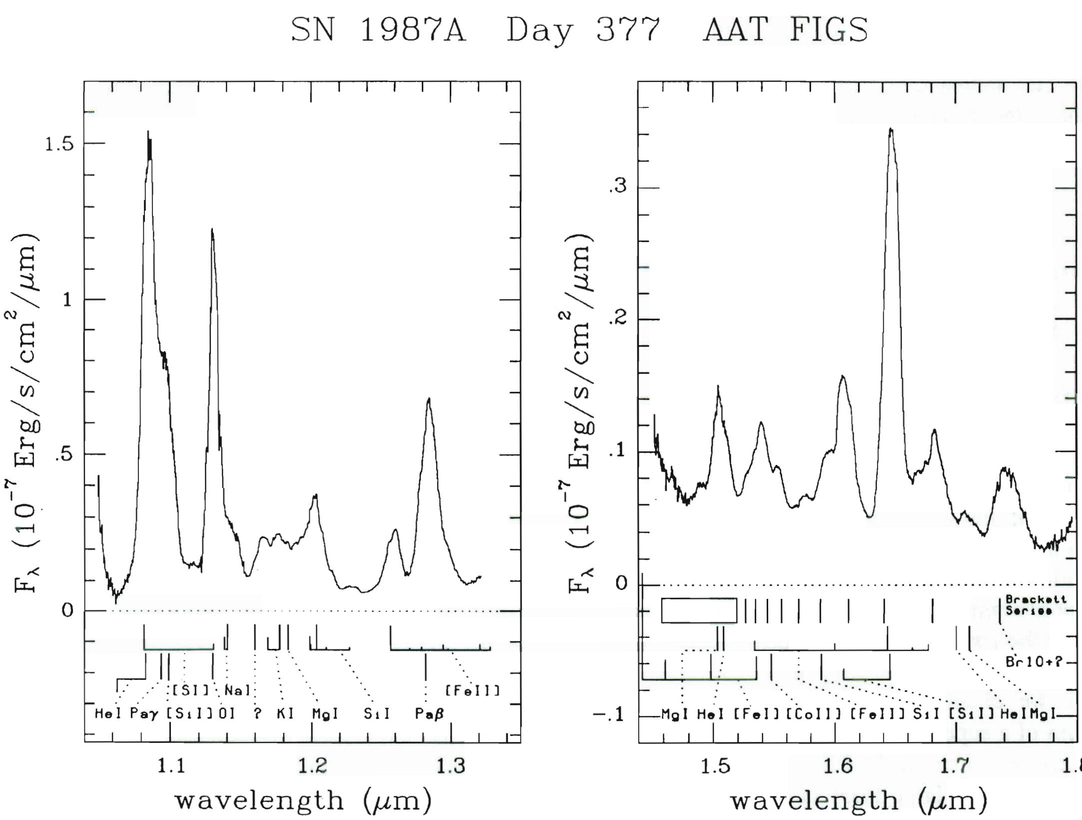

Figure 1. J- and H-window spectra of SN 1987A obtained at the AAT (FIGS) 377 days after the explosion. Line identifications are given by the vertical markers. (Figure reproduced by courtesy of Monthly Notices of the RAS).

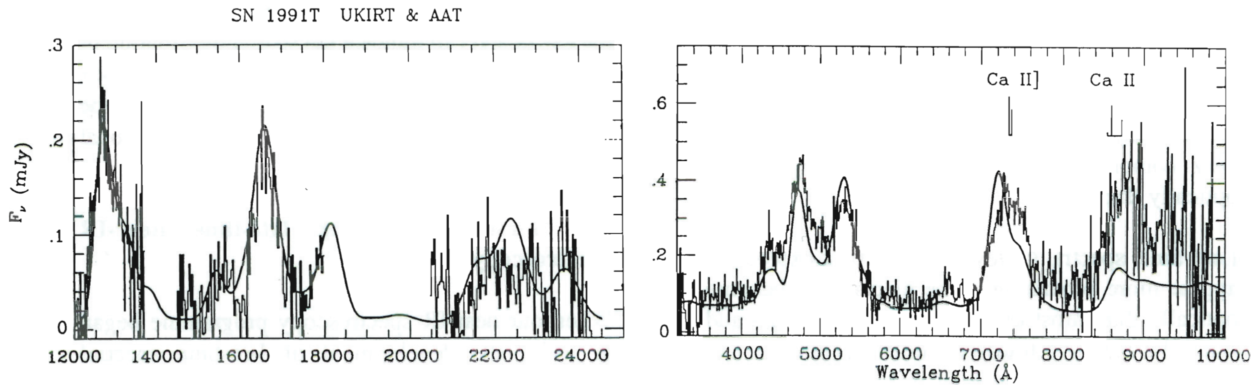

Figure 2. Spectrum of SN 1991T between 3200 and 25000 Angstroms. The near-IR spectrum was obtained with CGS4 (UKIRT) about 330 days after explosion, and the optical spectrum 65 days later using FORS (AAT). The optical spectrum has been scaled by a factor of 2.45 to compensate for the different epoch. A pure-iron emission, non-LTE model fit is shown by the smooth line. The locations of possible emission due to Ca II and CaII] transitions are also indicated. These are not included in the model. (Figure reproduced by courtesy of Monthly Notices of the RAS).

masses of material will be converted to ^{56}Ni. This isotope is radioactive, and according to the hypothesis the late-time luminosity and slow rate of decline of *all types* of supernova light curve is a consequence of the two-stage decay, $^{56}\mathrm{Ni} \rightarrow {}^{56}\mathrm{Co} \rightarrow {}^{56}\mathrm{Fe}$. The half-lives of ^{56} Ni and ^{56}Co are respectively 6.1 days and 77 days. The hypothesis also suggests that it is the release of thermonuclear energy when the ^{56}Ni forms which causes the actual explosion of a Type Ia.

Currently, the most practical direct test of the ^{56}Ni hypothesis is to measure the mass of the stable daughter product, iron. High overabundance confirms the hypothesis. In the near-IR, the existence of the prominent [Fe II] 1.257, 1.644 micron lines offers the prospect of an effective test but, until recently, available sensitivities restricted such measurements to supernovae within about 5 Mpc. In the past 10 years there have been only 3 such events. In 1984, using CVFs at the AAT and UKIRT we obtained the first ever late-time IR spectrum of a supernova (SN 1983N, and Type Ib) and discovered a strong 1.64 micron feature. From this we inferred a large mass of ^{56}Ni in the ejecta (Graham et al. 1986). However, the feature could also have been caused by [Si I] emission (Oliva 1987) and we could not check this via the [FeII] 1.257 micron line since J-window spectroscopy was not yet available. In 1987, at the AAT and CTIO we made several attempts to detect the IR [Fe II] lines in SN 1986G (a Type Ia), but only achieved inconclusive upper limits (Spyromilio 1989).

4. Supernova 1987A

The occurrence of SN 1987A (an unusual Type II) at a distance of only 50 kpc, transformed the whole subject of supernova spectroscopy. Late-time spectroscopy was carried out in the gamma-ray region right through to the far-IR. In our AAT near-IR spectra we clearly identified a large number of lines, including those of iron and cobalt (Meikle et al. 1989, 1993). An example of the near-IR spectrum of SN 1987A is shown in Fig. 1. The iron and cobalt masses derived from such spectra were consistent (to within a factor of 2 or 3) with the 0.08 solar masses of ^{56}Ni inferred indirectly from the bolometric light curve. In particular, the cobalt mass was at least a hundred times greater than the mass of stable cobalt expected in the star prior to explosion (Meikle et al. 1989). By measuring the cobalt to iron mass ratio at several epochs we were also able to directly demonstrate the gradual disappearance of the radioactive ^{56}Co as well as providing the earliest evidence for the presence of the longer-lived ^{57}Co in the ejecta (Varani et al. 1990). Thus, the near-IR lines provided direct, independent evidence in favour of the ^{56}Ni hypothesis for the origin of the late-time energy.

A notable discovery in SN 1987A was the high degree of mixing of the ejecta, and much of the evidence for this came from near-IR spectroscopy. The strong, isolated [Fe II] 1.257 micron profile revealed that iron was present at velocities as high as 3000 km/s, much higher than predicted by the standard, radially symmetric, stratified explosion models. Moreover the profile shape could be interpreted as being due to an asymmetric distribution of discrete high-velocity 'fingers' of iron penetrating the outer layers (Spyromilio et al. 1990). Models of Rayleigh-Taylor instabilities at the metal-He and He-H interfaces have been unable to produce such high velocities and asymmetries. It seems that to account for the IR observations we must consider strong instabilities which formed in a hot bubble just above the neutron star surface during the *first five minutes* after core collapse (Herant et al. 1992). To produce an explosion, an unstable hot bubble appears to be needed and the IR data indicates that this does indeed exist.

5. Supernova 1991T

SN 1987A provided us with the confidence that near-IR spectroscopy is a powerful tool for investigating supernovae. However, to address the physics of supernovae in general we need to acquire a database of spectra covering a range of types and examples. At the beginning of 1991, a new generation of significantly more sensitive near-IR systems became available, including CGS4 at UKIRT and IRIS at the AAT. This has at last made it feasible to acquire late-time spectra of adequate signal-to-noise, of the nearest few supernovae (distance about 15 Mpc) which appear each year. In March 1992, we used CGS4 to acquire the first ever late-time near-IR spectrum of a Type Ia supernova — SN 1991T. The spectrum is shown in Fig. 2, along with a red spectrum obtained using FORS at the AAT two months later. We found that a simple non-LTE model (smooth line in Fig. 2) comprising *only* [Fe II] and [Fe III] emission accounts for virtually the entire observed spectrum. From this we estimated a total observed iron mass of 0.4 to 1 solar masses (Spyromilio et al. 1992). This is the most convincing direct evidence to date in favour of the ^{56}Ni hypothesis for this kind of supernova. In Semester X we shall continue this programme with the observation of SN 1992ad, one of the closest Type IIs since SN 1987A. In the longer term, these observations will be used to test explosion models through their comparison with comprehensive spectral synthesis models currently under development by ourselves and others.

Collaborators

This work has involved David Allen (AAO), Robert Cumming (ICSTM), James Graham (Berkeley), Andy Longmore (ROE), Peter Meikle (RGO/ICSTM), Bahram Mobasher (ICSTM), Jason Spyromilio (AAO), Gian Varani (ICSTM) and Peredur Williams (ROE).

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The Coolest Dwarfs

Introduction

M dwarfs are the most common stars in our stellar neighbourhood but also probably the least understood stars largely due to their intrinsic faintness. Over the last decade numerous surveys have attempted to derive the space density of stars at the bottom of the main sequence. Such studies have been motivated by the desire to find sub-stellar objects (brown dwarfs) and/or to understand the possible density of such objects by the extrapolation of the mass function for objects above the hydrogen-burning limit to masses below the limit — the 'missing mass' problem. While the numbers of extremely faint red M dwarfs and/or brown dwarf candidates has increased dramatically, our understanding of their fundamental properties has not. In particular, the scales used to convert the optical or infrared colours into bolometric luminosities and effective temperatures (and by extension into estimates of the mass) are poorly defined. The surveys rely on (i) a colour measurement which changes uniformly with effective temperature and (ii) a bolometric luminosity arrived at from extant photometry and by fitting a blackbody curve through unmeasured parts of the stars' energy distribution. However, the observed spectra and the fledgling model synthetic spectra for cool stars are quite unlike blackbodies. Cool dwarfs stars are dominated by deep bands of water absorption at 1.4, 1.9, 2.7 and 4.4 microns — between the infrared photometric bands. This has strong implications both for measurement of colour and of bolometric luminosity. The measured colours will suffer different amounts of backwarming depending on the exact temperature, metallicity and gravity of the star. Moreover, because the broadband colours measure the flux output by the star in the atmospheric windows — that is, between the water bands — they are actually measuring the top of the flux distribution rather than a fit to it. Thus such methods (e.g. Berriman & Reid, *MNRAS*, **227**, 315) will have overestimated the bolometric luminosities output by these stars. In order to construct an accurate luminosity and mass functions for these cool stars it is first necessary to understand how their spectra behave with temperature, metallicity and gravity. We have taken 1 to 2.5 micron spectra of a sample of M dwarfs and brown dwarf candidates of similar metallicity but covering a range of temperature. Here we present a spectrum of VB10, the archetypal M7 dwarf (Bessell, *AJ*, **101**, 662). We identify the dominant molecular and atomic features, and discuss synthetic spectra from the latest model atmospheres.

Observations

VB10 is one of the coolest stars discovered by large area surveys attempting to quantify the mass density for low-mass stars. We observed it on 20 June 1991 and 5 May 1992 with the Cooled Grating Spectrometer 4 (CGS4, described in detail by Mountain et al., *Proc SPIE*, **1235**, 25) mounted in a closed-cycle cooled dewar on the UKIRT telescope. Our observations were made with a 58 x 62 InSb array which was moved in the spectrograph's focal plane in order to over-sample the spectrum.

Sky subtraction was performed by nodding the telescope approximately 30 arcsec up and down the slit. This ensured that during alternate 'object' and 'sky' observations the star remained on the detector. This is a standard technique on CGS4 and maximizes the on-source integration time.

For our run the 75 line per mm grating was used in six different configurations chosen to complete the wavelength range from 1 to 2.5 microns with some overlap between each spectral segment. Each grating position took approximately 20 minutes to perform; online data reduction allowed us to decide exactly when we had a sufficient signal to noise ratio.

Stars in the spectral type ranges F6 – G0 and A0 – 5 were used as standards for removing atmospheric transmission from the observations. These types of standard were chosen because they are relatively featureless; the only strong features are hydrogen recombination lines which are not observed in low-mass stars and so can usually be easily identified and removed.

Wavelength scales were calibrated using an internal argon lamp taken each time the grating was moved to a new configuration and in the J and H windows OH sky emission lines were used (following Ramsay et al., *MNRAS*, **259**, 271). Spectra were then extracted using the CGS4 data reduction system and routines from the FIGARO library supplied by STARLINK. Before using the spectra of our standard stars to correct terrestrial H_2O absorption in our target objects, several Paschen and

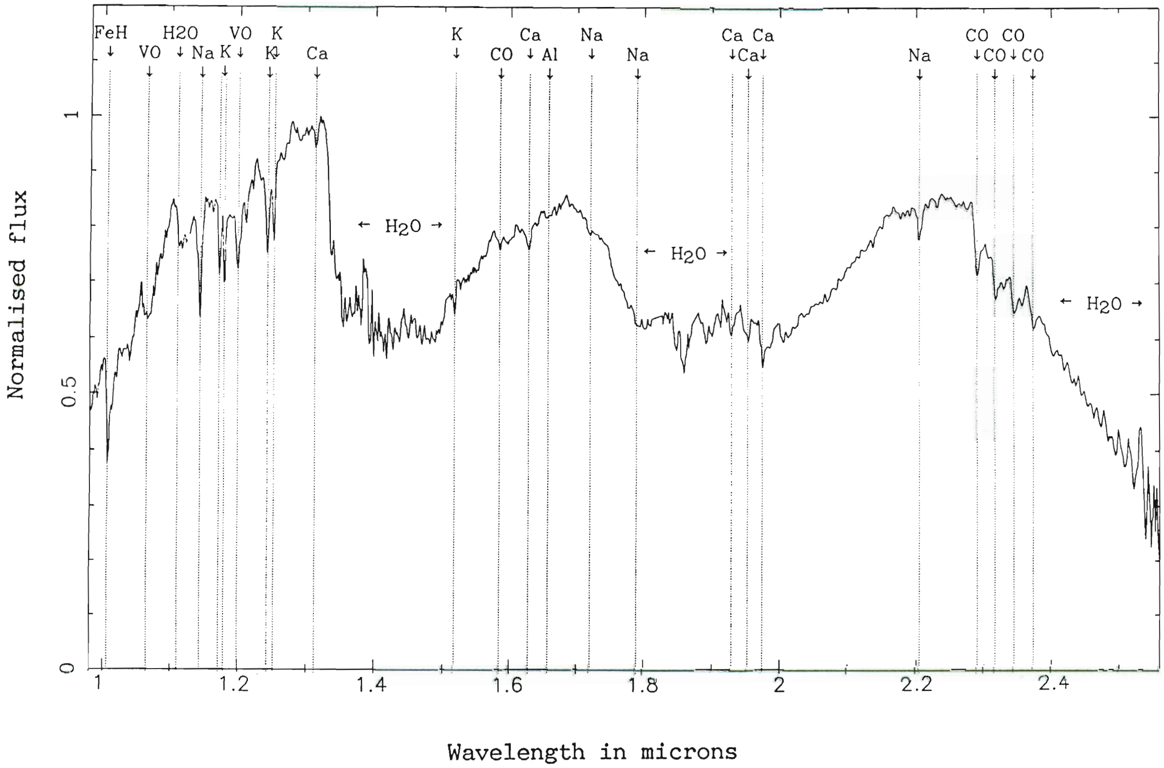

Figure 1. Normalised flux (F_ν) of VB10 from 1 to 2.5 microns.

Brackett series absorption lines were interpolated across. The target object spectra were then divided by the standard star spectra and multiplied by a blackbody spectrum for the T_{eff} appropriate to that standard star. The segments from the different grating configurations were joined together by equalising the fluxes in their respective overlapping regions. The combined spectra of VB10 are plotted in Fig. 1 as normalised flux (F_ν) versus wavelength. In addition to the deep broad water absorption bands the resolution of the spectrum is sufficient to show a number of other prominent molecular and atomic features. Such features will be vital in determining the metallicity of cool dwarf stars which have so far only been determined by using space motions (e.g. Leggett, *ApJ*, **82**, 351).

Towards a temperature scale for M dwarfs

VB10 is an M7 dwarf very close to the hydrogen burning limit, its temperature is estimated to be 2600 K (Bessell, *AJ*, **101**, 662) or 2875 K (Kirkpatrick et al. *ApJ*, **402**, 643) making it one of the coolest known dwarfs. Due to the high dry site of Mauna Kea and the sensitivity of CGS4 we were able to measure the depth of these absorption bands between the J, H and K windows. The spectral identifications marked in Fig. 1 came from observations of M giants (Chauvill, *AA Suppl*, **2**, 181), α Orionis (Vieira, Uppsala Astronomical Observatory, Report No. 32) and an infrared solar line list by Hall (Atlas of infrared spectra of the solar photosphere and sunspot umbrae, Kitt Peak National Observatory).

One of the major aims of our study is to establish a reliable temperature scale for M dwarfs. The spectrum of VB10 does not resemble a blackbody curve. We derive its temperature using the latest generation of model atmospheres (Allard 1993, in preparation) to be 2800 ± 150 K. This temperature is higher than that derived using blackbody fits but close to that determined using 0.65 – 1.45 micron spectra and Allard's models (Kirkpatrick et al., *ApJ*, **402**, 643). Preliminary results for other stars in our study also indicate generally higher temperatures than are given by blackbody fitting. Using the bolometric magnitude from Kirkpatrick et al. our temperature for VB10 agrees well with the theoretical main sequence derived from evolutionary models (e.g. Dorman et al, *ApJ*, **342**, 1003). The large uncertainty in our derived temperature arises from the poor fit of the models through the H band flux distribution. We suspect that this arises from inadequate input of molecular opacities, in particular, that of the water molecule for which only low resolution laboratory measurements are available. This should soon be improved once the first full quantum mechanical calculations (Miller et al., in preparation) are completed and incorporated into the model atmospheres.

Once we have derived bolometric luminosities and effective temperatures for our sample we will suggest a new scale correlating them with photometric colours. In addition, the progression of atomic and molecular features with spectral type in our sample indicates features that are particularly sensitive to temperature which can be used as discriminants for brown dwarf candidates.

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