PROTO STAR

NEWSLETTER
of the
James Clerk Maxwell
Telescope

Kulia I Ka Nu'u

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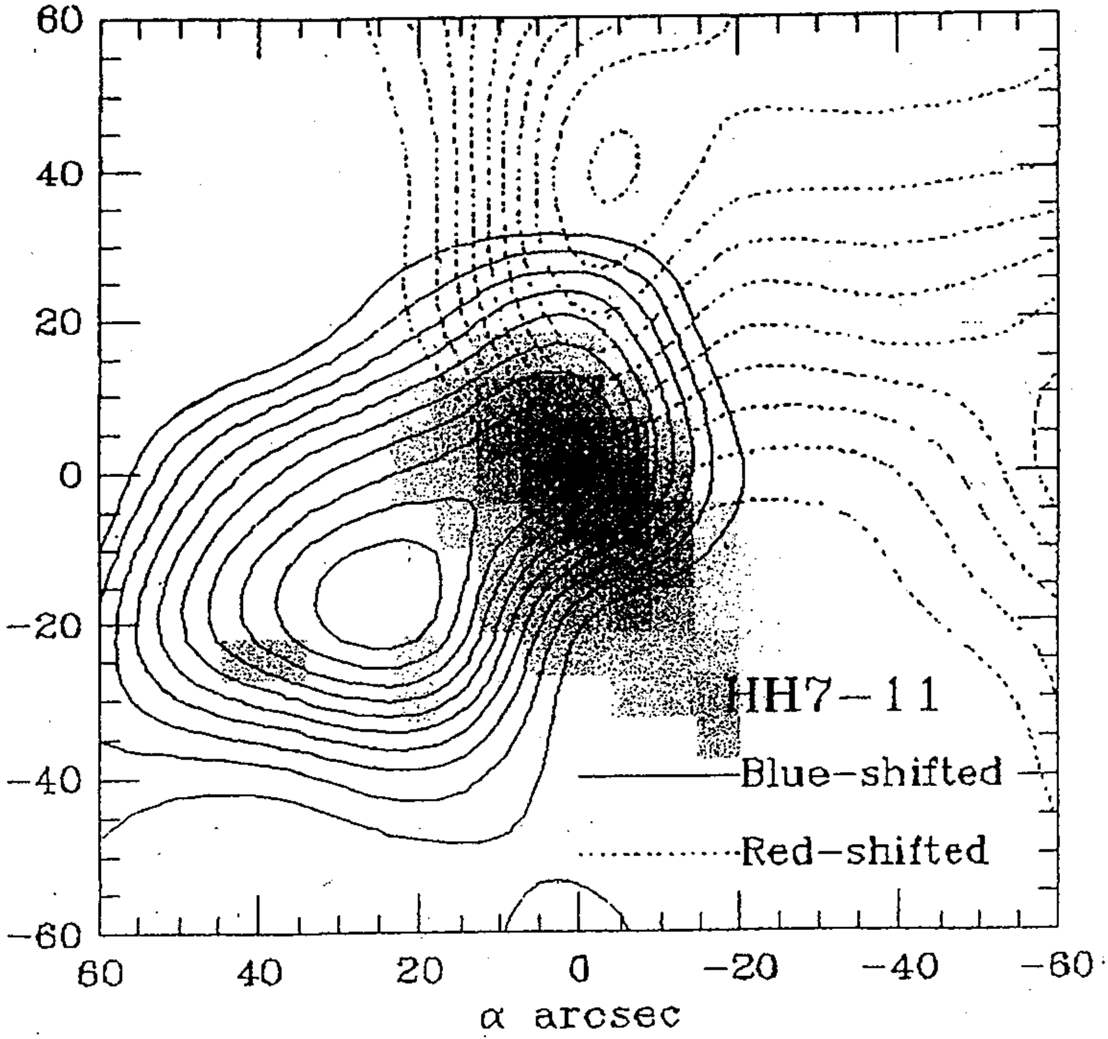
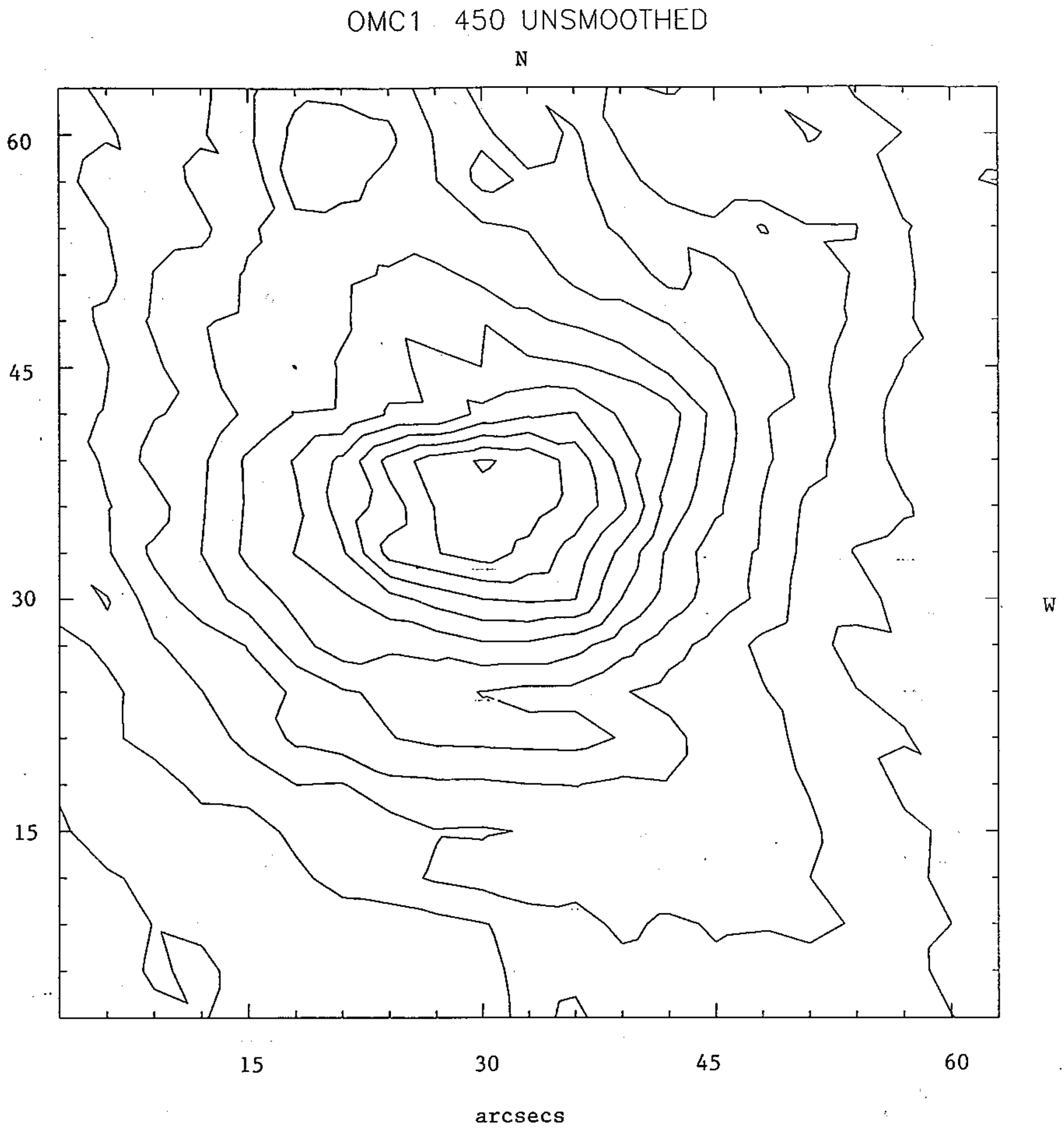


The region around a recently formed star as observed by the JCMT. Contours delineate regions of high velocity gas, observed in the J = 2–1 transition of CO using Receiver A. The grey shading shows the continuum emission from warm dust observed with UKT14 at λ = 1.1mm.

The dust emission is believed to arise from a dense, warm disk around the central star. The disk is diverting the outflowing gas into the two jets seen in CO. The blue shifted jet on the lower left is associated with a line of visible Herbig–Haro objects; the star itself is not seen optically. (Figure courtesy of Dent, Russell and Sandell.)



A 450 μm map of the Orion OMC–1 region made with UKT14 on JCMT with a diffraction limited beamsize of 7 arcsecs. The data are of very high S/N; the clump to the north–east of OMC–1 is real and is seen in interferometer continuum maps.

The map was made as a 21 x 21 pixel grid with 3 arcsec (one pixel) spacing and 3 seconds integration at each point in beamswitch mode with a throw of 150 arcsecs. Data were taken by Gear, Robson, Sandell, Hughes and Duncan.

FOREWORD

This issue of **PROTOSTAR** coincides with the end of the first semester of scheduled observing (Semester M in the PATT calendar) at the JCMT. The distinction of being the first scheduled observer fell to Dr S. Eales of the University of Hawaii. In view of the warning given in **PROTOSTAR** No. 3 by Adrian Webster, Astronomer in Charge of JCMT, about the difficulties that might be experienced, it is encouraging to read Dr Eales' comment in his Observer's Report that he was "pleasantly surprised that the telescope worked as well as it did". His comment about the bad weather that interrupted his observing run cannot be repeated here.

Recent visitors to the UKIRT and the JCMT will have noticed that the administrative offices in Hilo are no longer known as the UK Telescopes Headquarters. The new name is the Joint Astronomy Centre. So, please add JAC to the ever-increasing list of abbreviations that astronomers visiting the Big Island are expected to become familiar with - MKO, IRTF, CFHT, DHB......

Alex McLachlan, Editor

LETTER FROM HAWAII

Sitting at the JCMT making observations on the first day of the telescope's second semester seems a suitable time to review the first. It does indeed seem to be something of an occasion because an earthquake just occurred. Its strength was 4.5 on the Richter scale and it caused some excitement but no apparent damage. This is clearly an omen, but of what? Perhaps it is just a warning that when we finally put the telescope pointing right Madame Pele can easily put it wrong again.

The telescope has performed extremely well throughout the semester, and this clearly owes a lot to its designers and builders. There have, of course, been the minor problems one expects of new equipment, but no major problems have come to light. The setting of the surface panels to the desired figure has proceeded well, thanks principally to the holographic method (a.k.a. millimetre- wave metrology) developed by Anthony Lasenby and his colleagues in Cambridge, and partly to an LVDT instrument designed and built by Keith Raybould which is useful for setting panels which are too far out of place for the holography to be able to handle. It has been a delight to see the errors in the surface steadily decrease throughout the semester as the local team of Saeko Hayashi, Dick Carter and Graeme Watt have taken it through many iterations of measurement and adjustment. The current value of the rms error is the subject of active research: the holographic measurements suggest that the panel adjusters should be reset by 30 microns rms, and one would expect the surface errors therefore to be of this order of magnitude, but careful measurements of the aperture efficiency made last week by Adrian Russell with the 230 and 345 GHz heterodyne receivers are consistent with surface errors of 50 microns rms. It is not yet understood why these figures differ by this amount: perhaps the near-field holography is not sensitive to large-scale features of the dish, so we may have the panels set to a smooth surface which is not the desired paraboloid. Whatever the reason, it will not prevent further iterations of the method because it certainly does improve the figure. The next stage is to change the depth of the paraboloid in order to be able to move all of the adjusters on the panels in the outer ring: the problem here is that the dish was inadvertently set up too deep and some of the adjusters are at the limit of their travel. The rms errors in the surface cannot easily be reduced without moving these adjusters. The other equipment available for setting the panels, the measuring machine, was not used on the telescope during the semester but was instead assembled in the laboratory in Komohana Street for an investigation of why its accuracy was so much poorer than expected. Bill Smith and Geoff Douglas found two malfunctions within it which could well be the cause of all the trouble and which are fairly easily fixed. The machine is likely to be held in reserve as a backup should insurmountable difficulties arise in the holographic method.

The pointing accuracy of the telescope is not yet the success story that the surface accuracy has been. The observers all too often complain of errors up to ten arcseconds and sometimes more, and programmes involving photometry with UKT14 of sources too faint to peak up on have been particularly badly hit. A large amount of engineering time has been set aside this month for an investigation of what the underlying problems are, so it is hoped that, this problem will not last much longer.

The receivers are all in good shape. UKT14 has given steady service throughout the semester, and has improved quite spectacularly in sensitivity thanks to some new and improved filters provided by Peter Ade. The ability to open the aperture of this instrument wide enough to enclose the error pattern of the dish has enabled high-sensitivity maps to be made at 450 and 350 microns, even at a time when the telescope was nothing like diffraction-limited. It is greatly to Bill Duncan's credit that in this new semester half of the observing time has been granted to UKT14 proposals. With the agreement of the Users' Committees UKT14 is now regarded as an instrument on the JCMT; this should eliminate the risk inherent in carrying it back and forth between here and the UKIRT.

Receiver A gave steady and reliable service throughout the semester. It was upgraded in January when Dennis Bly, Rachael Padman and Gerald Lopez brought out and fitted the new components to give it a wide frequency coverage in the band from 220 - 280 GHz. Compared with its original version there are many more adjustments to be made and, although none of them is automatic, many of the staff are now sufficiently proficient that they can tune the receiver to a completely new frequency in five or ten minutes.

The signal mixer on Receiver B failed at the start of the semester, and this system was not ready in time for its first scheduled users. In November Bert Woestenburg came out from the Netherlands Foundation and installed both a refurbished mixer and a switch to protect it. This receiver has given good service since, with no major failures, and is well-adapted to exploit the 345 GHz band. This band is important to the JCMT because there is still less competition from other telescopes than at lower frequencies and because the sky of Mauna Kea is more often transparent in this band than not.

The backend spectrometers are both in better condition than at the start of the Semester. The Kent correlator has been equipped with improved filters, video amplifiers and other components, and is believed to be working better than ever. The Dutch Acousto-Optical Spectrometer has had both lasers replaced and both the low- and high-resolution channels now work, although the source of spurious noise in the former has yet to be identified.

Software is still in the forefront of the struggle, with too few staff trying to meet too many demands from too many directions. The telescope is certainly much more easy to use than it was but there are still too many areas in which more effort is required.

Overall, the productivity of the telescope in its first semester has been gratifyingly high. Quite clearly, first-rate observations have been made and all the staff out here are determined to improve the quantity and quality still further. An important factor behind the high morale out here is the consistent support that the users have given to those working in Hawaii and to what they are doing. This partnership between the users and the staff of the JCMT is a great strength of the entire project; long may it continue.

Aloha and Mahalo,

Adrian Webster,
Mauna Kea Summit,
1st March 1988.

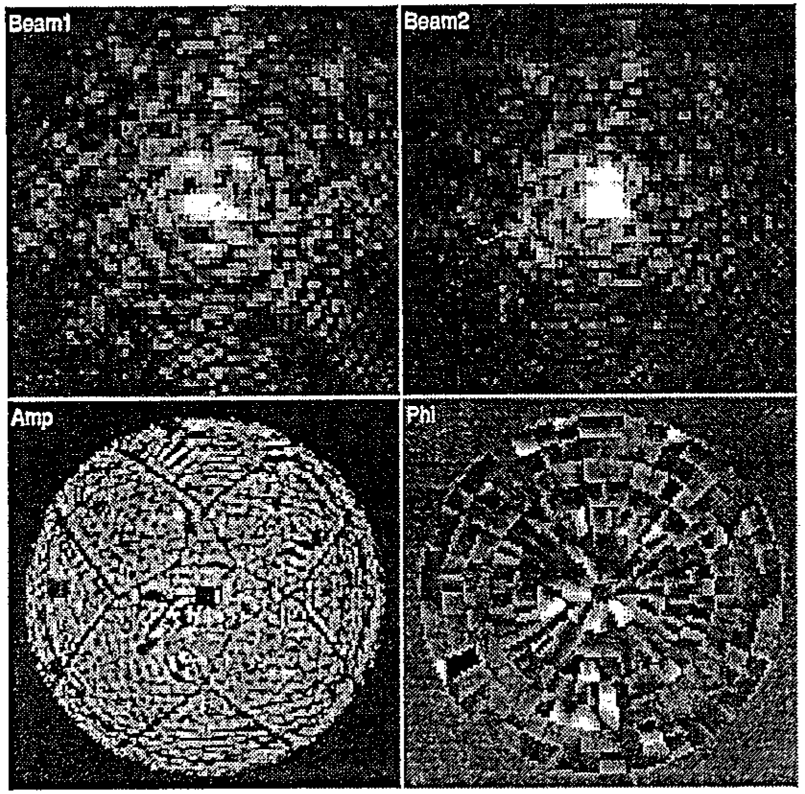
RECENT PROGRESS ON MEASURING AND SETTING THE DISH

It was clear right from the beginning of the project that one of the most difficult tasks would be finding a way of measuring and setting the dish to the high accuracy needed to make it work well at submillimetre wavelengths. (Remember that with coherent detectors an rms accuracy of something like a twelth of a wavelength is necessary to give a reasonable efficiency.) One problem was that a huge range of methods for measuring dishes had been suggested and many had been tried, but in practice none had demonstrated the required accuracy of around 20 micrometres rms. An approach that we decided to follow was one involving the construction of a "measuring machine" with a probe mounted on a long arm which is attached to the centre of the dish. The probe can be driven to any point on the surface and its position recorded by means of laser beams. The development of this device proved difficult, and it was not until a rather late stage in the installation programme that it was ready for operation on the telescope, but it did provide the initial setting of the surface and this was used to make the "first light" observations at 230 GHz. The accuracy was however somewhat disappointing and getting it set up on the telescope took several days and required the removal of the secondary mirror and its tetrapod. It was therefore clear that a more convenient and more accurate method was needed.

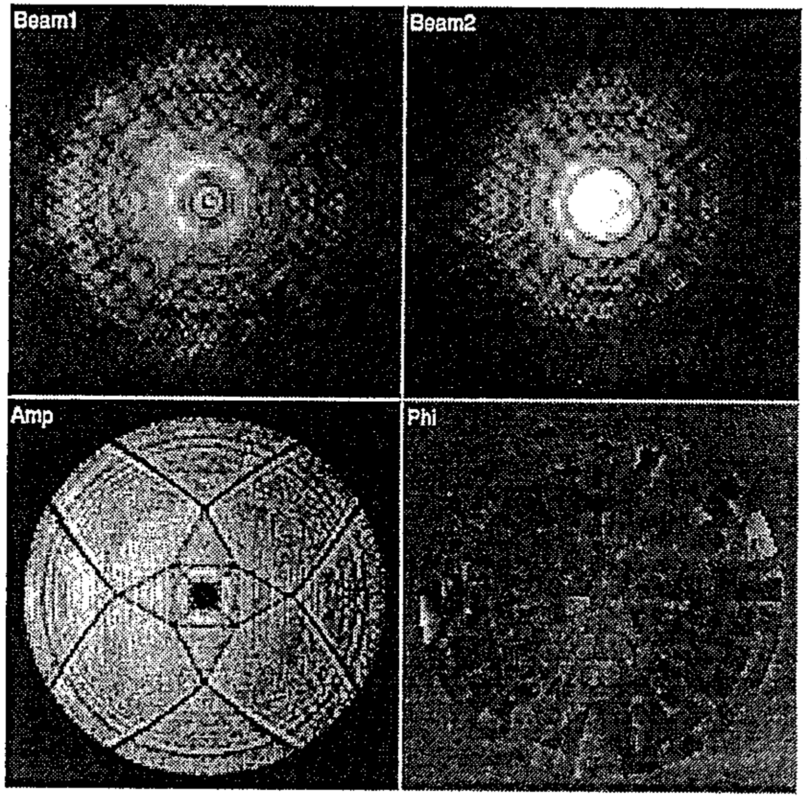
The most attractive alternative type of measurement appeared to be what has often been called "holography". In fact the method has little to do with holography and it is perhaps better to call it millimetre–wave metrology, which is a bit of a mouthful but does draw attention to its essential feature – that one measures the shape of the reflecting surface with the same type of waves that one wishes to observe. This is of course exactly what the makers of optical telescopes have done for hundreds of years: they use the distortions of optical images to determine the errors in the surface of the mirror. However because of the very deep curvature of the dish (f/D = 0.36) and the lack of millimetre–wave detectors that form images, it is not possible for us to use methods that are directly analogous to the classical optical tests.

Radio astronomers on the other hand have for some time been using methods which exploit the Fourier transform relationship between the far–field pattern of a telescope and the phase and amplitude of the field in the aperture of the dish. The basic idea is to use two antennas, each with its own receiver, to observe a distant source. This can be an astronomical object or a transmitter on the ground or on a satellite. One of the antennas observes the source directly to give a reference signal while the other is scanned across the source in both directions so that the phase and amplitude of the antenna pattern can be measured. The Fourier transform is then used to calculate the phase and amplitude of the field in the aperture. Provided the source is essentially a point, the true phase arriving at the dish must be uniform, so that the measured phase must be the result of the irregularities in the surface. This method has been used to measure a number of radio telescopes including the dishes of the 5km array at Cambridge. It is particularly convenient to use with aperture synthesis telescopes because the necessary reference antenna and receivers which measure phase as well as amplitude are of course already available. When one is trying to measure a single dish like JCMT, however, a fair amount of work would be needed to provide a reference signal and to measure the phase, particularly at the very high frequencies needed to obtain the 20 microns accuracy that we seek.

Recently Dave Morris of IRAM pointed out that it should be possible to obtain all the necessary information from measurements of amplitude only, especially if the beam pattern was measured at more than one setting of the focus. He showed that a method called the Misell algorithm, developed originally for similar problems in X–ray crystallography, could be used to "recover" the phase from the amplitude data. Because of the great simplification of the hardware this allowed (which is particularly important when one is trying to work on Mauna Kea) this approach seemed very promising. Two students at Cambridge, Devinder Sivia and Chris Hajevassiliou, looked at various aspects of the



JCMT Surface - April 1987



JCMT Surface - January 1988

Fig. 1 *94 GHz Fresnel–region measurement.*

Top: observed amplitude of diffraction pattern of dish for two different amounts of defocussing.

Bottom: derived phase and amplitude in the telescope aperture. The range of phase displayed is ± 1 radian or ± 0.25 mm of surface error.

Fig. 2 *As Figure 1. Most recent data.*

problem. In particular their simulations showed that if one brought the millimetre–wave source relatively close to the dish – into the Fresnel region – then one should be able to find the right solution unambiguously and the signal to noise ratio required on the amplitude measurements would not be too severe. In fact it appeared that if the errors were about one per cent of the signal, at a wavelength of 3 millimetres an accuracy in the measurement of the surface of about 10 microns might be achieved. Investigations of the errors involved in calculating the Fresnel patterns by simple approximations also indicated that the minimum distance between the source and the dish should be about half a mile – almost exactly the distance from JCMT to UKIRT.

To test the method we put together a source and receiver using 31 GHz equipment borrowed from the 5km telescope. This was set up at the site and after a huge struggle with the software (involving Jon Fairclough, Sidney Kenderdine and Rachael Padman amongst others) to make the telescope scan and take data simultaneously we obtained the first beam maps. A new version of the Misell algorithm was developed which used the fact that the dish was made of panels which were known to be accurate. This produced the sets of adjustments that were needed to bring the dish into the correct shape. The JCMT is equipped with motorised adjusters that can be moved on command from the VAX, so in principle the actual setting of the surface is very quick and easy. In practice there was a further mighty struggle (this time involving Dick Carter in particular) to get this system working reliably. After a number of attempts it was found that the surface was indeed improving as a result of this process.

In view of this success it was decided to go ahead and purchase the components necessary to make similar measurements at 94 GHz. This appears to be about the best frequency to use because the wavelength is short enough to provide high accuracy but fluctuations in attenuation should not be large enough to cause serious problems. This equipment was put together in March 1987 and after some development it was able to produce good maps of the out of focus beam: see the two upper panels of Figure 1. The fact that the patterns are rather like optical speckle images is an indication that the surface was still pretty rough at that time! The analysis programme was however able to make some sense of them as can be seen from the lower two panels which show the phase and amplitude in the aperture deduced from the beam patterns. Remember that although the programme has been told that the dish is made of panels, it knows nothing about the shadows caused by the tetrapod legs which show up clearly on the amplitude pattern. The phase map indicated an rms surface error of about 130 microns at this stage. For panels which have a slope of more than half a wavelength the programme cannot find the right solution and instead it puts fringes into the amplitude pattern. These panels have to be set roughly right by eye or with a "mini–measuring machine" which measures the offsets between adjacent panels.

A few rounds of measurement and adjustment quickly reduced the errors to about 80 microns, but after that progress slowed down. It became clear that the method wasn't giving quite the right answer. In particular we could see on some of the images that features such as the shadows of the legs were displaced. We then realised that because we had not measured the phase and because we were working in the near field, small pointing errors could cause the algorithm to move the image around over quite a wide range, so we could end up moving the wrong panel to correct an error. A more sophistocated program was therefore written which fitted the pointing errors and also allowed for focusing errors. This produced much more rapid convergence, with only the minor drawback that the data processing now takes about as long as the data collection (about 6 hours for the big maps shown).

Recently most work has gone into fixing the remaining faults with the adjusters and sorting out their true positions relative to their datum points so we can get back to the correct shape if it becomes misadjusted – we don't want to have to start again from scratch if there is a computer glitch! Now that all this is working satisfactorily Graeme Watt and Saeko Hayashi have carried out some further rounds of measurement and adjustment and this has brought the indicated rms error down to around 30 microns as shown in Figure 2. In fact there are still a few rogue adjusters which are on the limit of their travel. This is because we have not yet reset the whole surface to bring it to its design focal length. When these are allowed for it is seen that the repeatability of the method is now about 15 microns. This is not to say that the accuracy of the dish is even as good as 30 microns, because there are certainly still systematic errors present. The rings in the amplitude pattern are caused by diffraction by the secondary mirror. This particular effect has been calculated and taken into account in setting the surface, but there almost certainly other effects involved - such as the bright ring around the central hole - that have not yet been understood and corrected for.

We do know from recent 450 micron observations of Mars (Fig. 3), which showed a "clean" beam at the difraction limit of about 7 arc seconds (well the sidelobes were about 10 dB down), that the surface must be pretty good, but we do not yet have measurements of the aperture efficiency at a high enough frequency to say what the real rms surface error is. It does seem likely that with a certain amount of more work on the measurement method and on the adjusters the original goal of 35 microns rms under benign operating conditions (in practice this means when the temperature is stable) will be achieved.

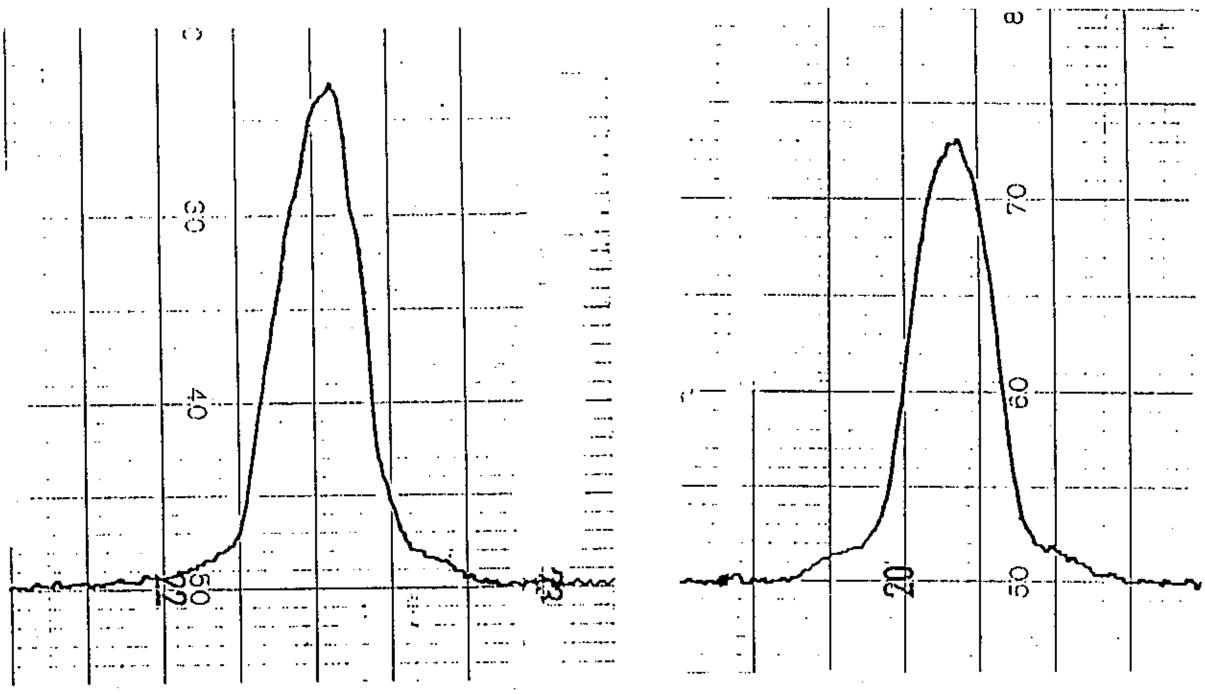


Fig. 3 *The two beam profiles at λ = 0.45 μm obtained by scanning the telescope across Mars (apparent diameter 5 arcsecs) whilst chopping the secondary mirror. The measured beam FWHM is 7 arcsecs. (Data obtained by Robson, Gear and Duncan in early February, 1988.)*

Richard Hills and Anthony Lasenby, MRAO, Cambridge.

APPLICATIONS FOR TELESCOPE TIME: RESULTS FOR SEMESTER N

1. *Allocations*

The following is the list of applicants who have been allocated JCMT time during Semester N (March–August 1988).

Proposal	PI	Time awarded (hours)
3	Little	2 x 8
6 & 13	Hayashi	3 x 8
8	Robson	2 x 16
10	Goldsmith	2 x 8
11	Hasegawa	4 x 8
12	Wright	2 x 8
16	Rucinski	2 x 8
18	Hauschildt	4 x 8
19	Israel	3 x 16
24	Clegg	3 x 16
25	Green	5 x 8
27	Heske	2 x 8
28	Coleman	2 x 16
29	Pottasch	2 x 16
32	Ziurys	3 x 16
33	de Jong	3 x 8
36	White	5 x 8
38	Emerson	4 x 8
39	Rowan–Robinson	4 x 16
40	Richardson	4 x 8
45	Avery	4 x 8
47	Waters	2 x 8
52	Griffin (dark clouds)	3 x 16
53	Griffin OH/IR stars	2 x 16
56	Smith	3 x 8
57	Boland	3 x 8
58	Boland	3 x 8
60	Watt	3 x 8
63	Sandell	4 x 8
64	Sandell	3 x 16
68	Lawrence	2 x 16
69	Cunningham	2 x 8
70	Gear	2 x 16
74	Mountain	5 x 8
76	Williams	2 x 16
79	Dent	2 x 8
84	Sahai	3 x 8
85	Redman	4 x 8
87	MacDonald	3 x 8
88	Edelson	2 x 8
90	Woodsworth	4 x 8
91	Hughes	3 x 8
95	Jaffe	4 x 8
104	van der Hulst	6 x 8
107	Scott	3 x 8
109	Padman	2 x 16
112	Scott	4 x 8
113	Lasenby	8 x 8
114	Fairclough	2 x 8

Proposal	PI	Time awarded (hours)
116	Avery	2 x 8
118	Walsh	2 x 8
LTM/N/1	Gear	2 x 8

2. *An analysis of the above results*

Now that the PATT meeting for JCMT semester N has passed, and proposal assessment for the second full semester has been completed, it may be of interest to astronomers in the partner countries to hear how they fared in the fight for telescope time. Unfortunately, when a telescope is oversubscribed by a factor of 4.3, and does not queue proposals, many of the proposals have to be rejected or each will get only a small portion of the time they requested. This semester 116 JCMT proposals were submitted to SERC and fifty–two were awarded time. Many were awarded no more than 2 or 3 half nights.

When averaged over several semesters, each country's share of the available time is expected to be approximately equal to each country's percentage of ownership, which is in the ratio

UK/CDN/NL = 55/25/20.

A comparison listing of the JCMT time allotments to each partner country for semesters M (Sept. 1987 to Feb. 1988) and N (Mar. 1988 to Aug. 1988) is shown in the accompanying table. In calculating the percentages both the principal investigator and the collaborators were taken into account using the algorithm suggested by the JCMT Board. Semester L carryover time was added to each respective country's share as appropriate. Although there has been a big increase in the time allotted to The Netherlands this semester, Canada is still some distance from realizing its 25% share. It should be pointed out that the number of proposals from Holland was up sharply from the previous semester, whereas the number of Canadian proposals was down. To be fair, it was my impression during the PATT meeting that considerable effort was made by the TAG panel to give each partner country its fair share of time, and that Canada lost out simply because Canadians submitted so few proposals. The person or persons responsible for the increase in the number of proposals from The Netherlands deserve to be applauded. On the other hand, just why Canadians are not submitting proposals certainly needs to be investigated.

The fact that Canadian university astronomers were not being allowed JCMT travelling expenses when the semester N deadline arrived, might be part of the problem, but the easy access that all Canadian astronomers have to American telescopes must also be a contributing factor. With the tremendous competition for JCMT time the fact that most Canadian astronomers are well behind their British counterparts in submm experience must make preparing JCMT proposals somewhat less attractive. However, more Canadian proposals are needed if the PATT–TAG is going to be able to allot Canada its fair share of time.

Finally, for those U.K. astronomers who felt they would lose a significant portion of telescope time when Canada joined the partnership, the following is noted. Fifty–five percent of the present 16–hour night is close to eighty percent of the previous 12–hour night. Since Canada joined, U.K. astronomers have received 75.5% of the available 16–hour nights, or, 12.1 hours per available night.

Percentage of available time allocated

	Semester M	Semester N
UK	83.8%	69.2%
Canada	10.2%	14.1%
Netherlands	5.6%	16.7%

Morley Bell

NEWS FROM THE PANEL FOR THE ALLOCATION OF TELESCOPE TIME (PATT)

1. *Availability of new instruments*

It was decided by the PATT–Time Allocation Group (TAG) panel at its meeting in January 1988 that, at least for the foreseeable future, new instruments for use on the JCMT would not be advertised as being available for general use until after their commissioning. In other words, the first consideration of whether or not an instrument is ready to be released will be made by the TAG at the first PATT meeting following the instrument's commissioning.

2. *Length of JCMT Proposals*

Astronomers are reminded once again that standard typescript must be used when submitting proposals and that the "scientific justification" portion of the proposal must be kept to one page. Several people are still submitting proposals that exceed the limit and this usually does more to annoy the assessors than it does to improve the scientific case. Diagrams can be included on a second page but we cannot guarantee that anything more than that will be read by the assessors. These dedicated scientists get no pay for their work and with approximately 120 JCMT proposals to evaluate each semester they are already extremely overworked.

3. *JCMT proposal assessment*

The following has been prepared for those astronomers who are interested in what happens to their proposals between the time they submit them and the time they receive their results. SERC has identified six external astronomers who have agreed to act as assessors. When each proposal is received it is first sent to a competent external referee who, hopefully, has significant experience in the particular field of astronomy discussed in the proposal. This usually means 'the competition'. His comments are taken into account by the assessors. Each assessor examines all the proposals, although only one-third are assessed by him in detail. Each assessor assigns each proposal a grade. The assigned grades are then weighted and averaged and each proposal receives a final rating. The ratings are used as a guide for discussions during the PATT–TAG meeting. Proposals with ratings that fall in the top one-third usually get awarded telescope time. Those that fall in the bottom one-third hardly ever do, and those in the middle third get talked about a lot. Rating proposals is not an easy job when a telescope is oversubscribed by a factor of four. Think about it.

Morley Bell

APPLICATIONS FOR TELESCOPE TIME: ARRANGEMENTS FOR SEMESTER O

For Semester O (September 1988 – February 1989): the closing date for applications will be April 30, 1988. Postal applications should be sent to:

The Executive Secretary, PATT
SERC
Polaris House
North Star Avenue
SWINDON SN2 1ET

Enquiries may be made by telephone (0793–26222) or Telex (449466). Application forms may be obtained from the above address, as also may sets of Notes for the Guidance of Applicants. Those who have not previously applied for telescope time on SERC telescopes are strongly advised to obtain copies of these Notes.

In Canada copies of the application forms can also be obtained from the Radio Astronomy Section of the Herzberg Institute of Astrophysics.

INSTRUMENTATION AVAILABLE ON THE JCMT IN SEMESTER O

The following is a brief description of the instrumentation that will be available on the JCMT in semester O. It is an excerpt from a manual recently prepared in Hawaii by Henry Matthews and others, entitled "An Introduction to the James Clerk Maxwell Telescope – A First Guide for the Potential User". Its length (19 pages) prevents its complete publication in **PROTOSTAR** but copies can be obtained from ROE, the JAC in Hilo, the HIA in Ottawa and from certain locations in the Netherlands (see the contribution by Bill Dent). It will also be accessible via the Starlink computer network.

In the coming semester ('O'), for which the deadline for receipt of proposals is April 30, the following receivers should be available: A(220–280 GHz) and B(320–370 GHz) for spectral line observations, and UKT14 for continuum photometry and mapping between 2mm and 350 microns (150–870 GHz). One autocorrelation spectrometer, and two acousto-optical spectrometers will provide a range of frequency resolutions for spectral line work, between 0.1 and 1 MHz, and maximum total bandwidths of 320 and 500 MHz, respectively.
The following table lists approximate values for several frequency-dependent telescope and atmosphere parameters.

Frequency (GHz)	**Wavelength (mm)**	**Aperture Efficiency**	**Beamwidth (arcsec)**	**Atmos. trans.**	**Nights (%)**
150	2.0	0.68	20	0.97	90
230	1.3	0.64	23	0.96	90
345	0.87	0.58	14	0.88	70
492	0.61	0.48	10	0.43	30
690	0.43	0.32	~7	0.38	30
870	0.34	0.20	~6	0.44	30

POINTING

The rms pointing accuracy of the telescope has been derived from extensive radio measurements combined with boresight observations of bright stars to provide basic structural parameters. The latest pointing model gives pointing to about 5 arcsecs (rms). During an observing run it is necessary to check the pointing fairly frequently, and some allowance (say, 20%) for such measurements should be made when calculating the total time required for a program.

RECEIVER PARAMETERS

	Frequency Range (GHz)	Instant. Bandw. (MHz)	T(Rx) (DSB) (K)	T(sys) (SSB) (K)	Beamwidth (arcsec)	Polarization
A(lower)	216-250	500	270	1200	22	dual
A(upper)	250-280	500	400	1200	21	dual
B	320-370	500	1000	2200	16	single

UKT14 - FILTER PROPERTIES

Filter Name (mm)	Wave-length (micron)	Centre Freq. (GHz)	Bandwidth (GHz)	Aperture (mm)	Beamwidth (arcsec)	NEFD Jy/sqrt(Hz)
2.0	2000	150	40	65	19	
1.1	1100	264	75	65	19	0.3
WBMM	940	320	240	65		
0.8	761	394	103	47	14	0.5
0.6	625	480	119	36		
0.45MB	438	685	84	27	7	
0.35BB	345	870	249	21	6	20

Morley Bell

THE HETERODYNE RECEIVERS

1. *Estimating integration times and sensitivities for Heterodyne instruments*

During the last semester it became clear that many observers and potential users of the JCMT use inconsistent methods for calculating integration times. In order to calculate the integration time needed to reach a certain sensitivity it is necessary to know several parameters for the receiver and the telescope. The rms noise on a spectrum is given by

$$\delta(\mathrm{Tr}^*) = \frac{2.0 * \mathrm{Tsys} * \mathrm{K}}{\mathrm{sqrt}(\tau * \mathrm{B}) * \eta_{\mathrm{fss}}}$$

The parameters used are as follows:

i) The backend degradation factor, K

This is a fudge factor to allow for the fact that a 1-bit digital correlator significantly increases the noise on a spectrum. For the Kent correlator K is about 1.4 and for the AOS K is 1.0.

ii) The total integration time, τ

This is the TOTAL integration time including the time spent on the reference position. At the moment all observations must spend equal amounts of time on the reference ("off") position and on the source ("on"). Of course τ does not include any observing overheads.

iii) The channel bandwidth, B

This is the effective resolution of the backend in Hz. For the AOS two resolutions are available - 1.0 MHz and 0.1 MHz. For the Kent correlator 90, 180, 360 and 740 KHz resolutions modes are available. If you intend to bin the data down to a lower resolution in data reduction, then it is OK to use the larger bandwidth.

iii) The system noise temperature, Tsys

This is the single sideband noise temperature of the receiver as a whole. This represents the noise equivalent temperature of the receiver when detecting an astronomical line in only one sideband. It includes all losses which are thought of as part of the receiver and all losses due to the telescope and the atmosphere. Tsys must be calculated from the receiver noise temperature and the measured losses of the sky:

$$\mathrm{Tsys} = \frac{2 * (\mathrm{Trec} + \mathrm{Tsky} + \mathrm{Ttel})}{\eta_{\mathrm{sky}} * \eta_{\mathrm{tel}}}$$

Where Trec is the double sideband receiver noise temperature; it is the noise temperature which we shall always quote in Protostar. Tsky and Ttel account for the additive noise from the lossy sky and telescope. Usually their additive effect is small compared with the receiver noise. The factor of two is used to convert from double to single sideband noise temperatures; under some circumstances a more complicated conversion may be necessary.

iv) The sky transmission, η_{sky}

This is the transmission of the sky at the airmass of the observation. It can be estimated from the transmission curves presented in the second issue of Protostar. For extrapolation of the zenith transmission to other airmasses the zenith optical depth, τ_{zen}, must be calculated from

$$\eta_{\mathrm{sky(zen)}} = \exp(-\tau_{\mathrm{zen}}).$$

The transmission at airmass A is given by

$$\eta_{\mathrm{sky(A)}} = \exp(-\tau_{\mathrm{zen}} * \mathrm{A}).$$

The loss temperature Tsky can be deduced from

$$\eta_{\mathrm{sky}} = 1 - \mathrm{Tsky/Tm},$$

Where Tm is the mean brightness temperature of the sky (about 260 K). Typical values of Tsky are 20K (at 230 & 270GHz) and 50K (at 345 GHz).

v) The telescope transmission, η_{tel}

Also referred to as η_1, this efficiency accounts for ohmic losses in the telescope and for rearward spillover. η_{tel} can be thought of as the fraction of the beam from the receiver which would get onto the sky if it was a transmitter. For receiver A and receiver B η_{tel} has a constant value of 0.93. The loss temperature Ttel associated with this efficiency is 18 K for both receivers.

vi) The forward spillover and scattering efficiency, η_{fss}

This efficiency corrects for the fraction of the beam on the sky which is not within the diffraction or error beams. At JCMT we use the moon to measure η_{fss}, so it is defined as the fraction of the beam on the sky which is contained within the solid angle of the full moon. For receiver A η_{fss} is approximately 0.7 and for receiver B it is 0.8 although more data are needed to determine the values more precisely.

The spectra which will be presented to you by the JCMT data acquisition software will be calibrated in the Ta* scale (i.e. corrected for atmospheric and telescope losses only), to convert to the internationally accepted Tr* scale it is necessary to divide by η_{fss}.

The parameters needed to estimate sensitivities will be updated in forthcoming issues of Protostar.

2. *The current status of receiver A*

Receiver A has recently been upgraded to incorporate a fully tuneable local oscillator. This covers the the frequency range 217.5 to 280.5 with 3 GUNN oscillators. The actual frequencies of the GUNNs are listed in table 1. The range of frequencies which can be reached can be calculated from

$$F_{obs} = 3.0 \times F_{Gunn} \pm 3.94 \text{ GHz}$$

The actual frequency coverage is affected by the useable bandwidth of the mixers as well as the LO. Table 2 lists the noise temperature of the two lower band A(L) mixers and one of the the upper band mixers A(U). At the time of writing only one A(U) mixer is available.

The normal mode of operation of the receiver will continue to be either A(L) or A(U); this means that programs requiring both bands must submit two proposals. Also note that for the present a GUNN change in the middle of the night will not be allowed.

Note that only the first stage of the reciever A upgrade has been implemented so far. This means that it is still not possible to observe lines less than about 1 km/s wide.

Table 1: The tuning range of the new LO

GUNN no:	GUNN frequency range	LO frequency range	Observing frequency range
A1	72.500 - 81.400GHz	217.5 - 244.2GHz	213.6 - 248.1GHz
A2	79.500 - 93.100	238.5 - 279.3	234.6 - 283.2
B1	89.200 - 93.500	267.6 - 280.5	263.7 - 284.4

Table 2: Noise temperature data

LO frequency GHz	Trec (DSB) Ch A	Ch b	
220.5	369	784 K	
223.5	316	575	
226.5	304	445	
229.5	339	362	
232.5	414	386	A(L)
235.5	616	491	

LO frequency GHz	Trec (DSB) Ch A	 Ch b	
238.5	850	652	
241.5	-	1022	
244.5	-	2324	
240.0	794		
243.0	663		
246.0	630		
249.0	652		
252.0	532		
255.0	616		
258.0	540		A(U)
261.0	599		
264.0	600		
267.0	650		
270.0	773		
273.0	1165		
276.0	2044		

3. *The current status of receiver B*

Receiver B was astronomically commissioned in early December 1987. Due to limitations on the operating voltage of the high voltage power supply, the frequency range of the local oscillator is 320 to 356 GHz. This translates to 318.5 to 357.5 GHz at the observing frequency. At present the resolution with which the LO frequency can be set is ± 0.3 MHz. A new synthesiser is being purchased to solve this problem.

The noise temperature of the receiver is higher than originally advertised in Protostar. The DSB receiver temperature has been measured as follows:-

LO frequency	Trec (DSB)
332.0 GHz	910 K
344.0	930
347.0	1060
356.0	1200

Adrian Russell, JAC

DOCUMENTS AVAILABLE FOR THE JCMT

Various documents describing the JCMT, its common-user instruments and their current status are available in the JCMT directory on the Starlink VAX at ROE. This directory also contains the current schedule as well as some information about calibrating data, calculating observing times etc. An updated list of all the documents can be found in the file

REVAD::DISK$USER1:[JCMT]JCMTDOCS.LIST

The list of documents currently available is as follows:

Description	Location
General intro to JCMT receivers	[JCMT.DOCS]RECEIVERS.DOC
Receiver B	[JCMT.DOCS]RECEIVERB.DOC
Heterodyne calibration procedures	[JCMT.DOCS]HET_CAL.DOC
UKT14 - instrument	[JCMT.DOCS]UKT14.DOC
UKT14 - calibration	[JCMT.DOCS]UKT14_CAL.DOC
Dutch AOS backend	[JCMT.DOCS]AOSD.DOC
Kent correlator	[JCMT.DOCS]CORREL_KENT.DOC
Description of dish, chopper, pointing	[JCMT.DOCS]DISH.DOC
Description of the building	[JCMT.DOCS]BUILDING.DOC
Current system news:receiver performance,etc.	[JCMT.DOCS]JCMT_STATUS.DOC
How to calculate observing time required	[JCMT.DOCS]OBSTIME.TUT
JCMT schedule for the current semester (M)	[JCMT]JCMTSCHED_M.DOC
JCMT schedule for the next semester (N)	[JCMT]JCMTSCHED_N.DOC
JCMT detailed schedule for March	[JCMT]JCMTSCHED_MARCH.DOC
NOD2 - continuum data analysis package	[JCMT.DOCS]NOD2.DOC
SPECX - spectral line analysis package	[JCMT.DOCS]SPECX.DOC
How to get to Hawaii, apply for observing time, transport, equipment, the climate on Mauna Kea, etc.	[JCMT.DOC]HAWAII.DOC

These documents are available to Canadian astronomers on the Bulletin Board operated by HIA.

In the Netherlands the following individuals have kindly agreed to make copies available to Dutch astronomers:

Groningen:	Dr van der Kruit
Leiden:	Prof. Butler Burton
Dwingeloo:	Dr Wim Brouw
Utrecht:	Dr Jaap van Nieuwkoop
Amsterdam:	Prof Teije de Jong

If you have any problems finding these documents or want further information please contact me (REVAD::WRFD or wrfd@uk.ac.roe.star). Paper copies are available on request.

Bill Dent

THE JCMT TEAM AT ROE

The two vacant slots in the JCMT organogram shown in the previous issue of PROTOSTAR have now been filled. Dr Bill Dent has transferred to the JCMT "home end" at ROE from the "sharp end" in Hawaii and Dr Richard Prestage will be giving up his present position at Jodrell Bank to join us in April.

THE JCMT USERS' COMMITTEE

The JCMT Users' Committee is the principal channel of communication between the telescope users and the project. The present members of the Committee are:

Professor R.D. Davies, NRAL (Chairman)
Professor E.I. Robson, Lancashire Polytechnic
Dr L.T. Little, Kent University
Dr P.F. Scott, MRAO
Dr T.J. Millar, UMIST
Dr D. Nadeau, Montreal
Dr E. Seaquist, Toronto
Professor Dr W.B. Burton, Leiden
Dr ir H. van de Stadt, Groningen
Dr G. Wynn-Williams, Hawaii

The next meeting of the JCMTUC will be held on April 26, 1988 at Radiosterrenwacht Dwingeloo, Netherlands.

INSTRUMENTATION PROGRAMME

In July 1987 an Announcement of Opportunity to participate in the JCMT instrumentation programme was distributed within the United Kingdom, Netherlands and Canadian communities. Despite the relatively short timescale allowed for preparing proposals the response was excellent, with a total of 11 proposals being received, ranging from relatively small R&D projects to full-blown detailed proposals for major common-user instruments.

All proposals were sent to referees and were subsequently discussed by the Technical Assessment Panel, whose brief was to discuss the technical merit of each proposal, and the User Committee, which discussed the scientific priorities of the instrumentation programme. Finally the JCMT Board considered the final package arrived at before giving financial approval.

Of the proposals for common-user receivers, work has begun: at Royal Observatory, Edinburgh on designing SCUBA, a large continuum array instrument which will work at 450 and 850 μm; at Mullard Radio Astronomy Observatory and Rutherford Appleton Laboratory on RxB2, a dual-polarization 320-370 GHz Schottky receiver; at Netherlands Foundation for Radio Astronomy on developing 460-500 GHz Schottky mixers for an upgraded RxB and an 8-element 345 GHz SIS array; and at Herzberg Institute of Astrophysics, RAL and Kent University on building a test 230 GHz receiver which will be a prototype for a common-user instrument.

Of the proposals for R&D work, contracts have been laid with Kent for development of Pb alloy SIS mixers, HIA/Alberta University, for planar array development and RAL for multiplier development. In addition several other R&D projects are undergoing revision or negotiation and are expected to lead to further contracts.

The overall success of the AO, despite tight time constraints was very encouraging and bodes well for the future health and vitality of the JCMT instrumentation programme.

Walter Gear

PROBLEM PAGE

Spring approaches and once more astronomers put pen to paper in pursuit of their hearts' desire. Will you be one of the many who will experience the pain of rejection? For sympathy, or advice on how to improve your standing with those whom you seek to impress, write to Uncle Al. Here is one cri de coeur:

Dear Uncle Al

A comment about the latest Protostar (No. 4). I realise that you are only the poor editor but yours was the first Starlink address that I found.

The 'Tips for your JCMT proposals' are extremely helpful; perhaps you can persuade Messrs Avery and MacLeod to contribute a piece in the next Protostar on 'How to condense your JCMT proposals into one A4 page for PATT'. Unless applicants can put context of observations, current state of knowledge, what has been done before, how will observation transcend previous work, is JCMT the best/only telescope and why, why are observations important, how will applicant analyse and interpret the data, how will applicant deal with radiative transfer (or similar) problem, justify source list, number of frequencies or molecular lines, provide sensitivity calculations, provide details of how line/continuum strengths are estimated, details of calibration sources, AND photos, maps etc. ALL into one A4 page I'm sure PATT people will blow a fuse.

Unless of course we can submit a proposal on an A4 sheet of microfiche????

Ah well – apologies for taking up your time with such a long moan! Back to taking every second word out of my draft proposals .....AND I bet the bleep!bleep! *still won't give me any time!!!!!*

Yours Sincerely

Frustrated

PS. That's not you in the picture on the bottom of p.14 is it?

Dear Frustrated

I can see lots of heads nodding in agreement as your letter is read throughout the astronomical community; your situation is not uncommon. It is quite possible that your proposals meet the two main PATT requirements of good science and technical feasibility but fail simply because of pressure on telescope time. If this is the case, then re-submission will enhance the probability of success. So, keep trying. Remember, faint heart never won (Apex) fare, laddie. You must, however, cast a critical eye over your proposals and be prepared to accept that they might, just might, be less than perfect; the feedback you get from PATT should give you some pointers. A friend of a friend has told me that some good scientific proposals fail because they are badly written. PATT may have made life more difficult by reducing the scientific case to one A4 page but clearly a lot of people cope successfully. By the way, microfiche is not acceptable; neither is shorthand.

When you eventually get time on JCMT you will be expected to have a medical examination to confirm your fitness to work at 14,000 ft. I hope you will take the opportunity to have your eyesight tested. Your question about the hula dancer indicates the need for such a test. The person you refer to is quite obviously Jocelyn Burnell "moonlighting".

Good luck
Uncle Al

DIARY

April 30, 1988: Last date for receipt of applications to PATT for Semester O (September 1988 – February 1989).

June 27–30, 1988: The Sixth UCL Astronomy Colloquium
"Millimetre–wave Astronomy"
Cumberland Lodge, Windsor Great Park.

October 3–6, 1988: URSI Symposium on Submillimetre and Millimetre Wave Astronomy.
Kona, Hawaii.

STARLINK Directory for JCMT News

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