PROTO STAR

NEWSLETTER
of the
James Clerk Maxwell
Telescope

Kulia I Ka Nu'u

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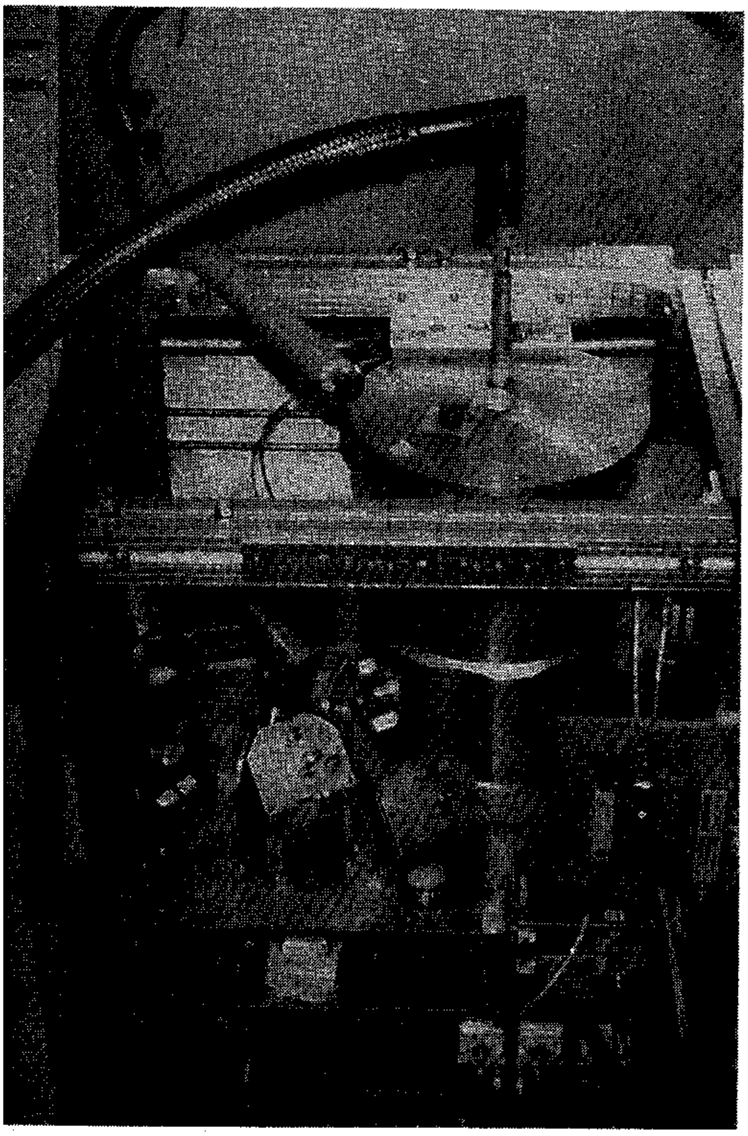

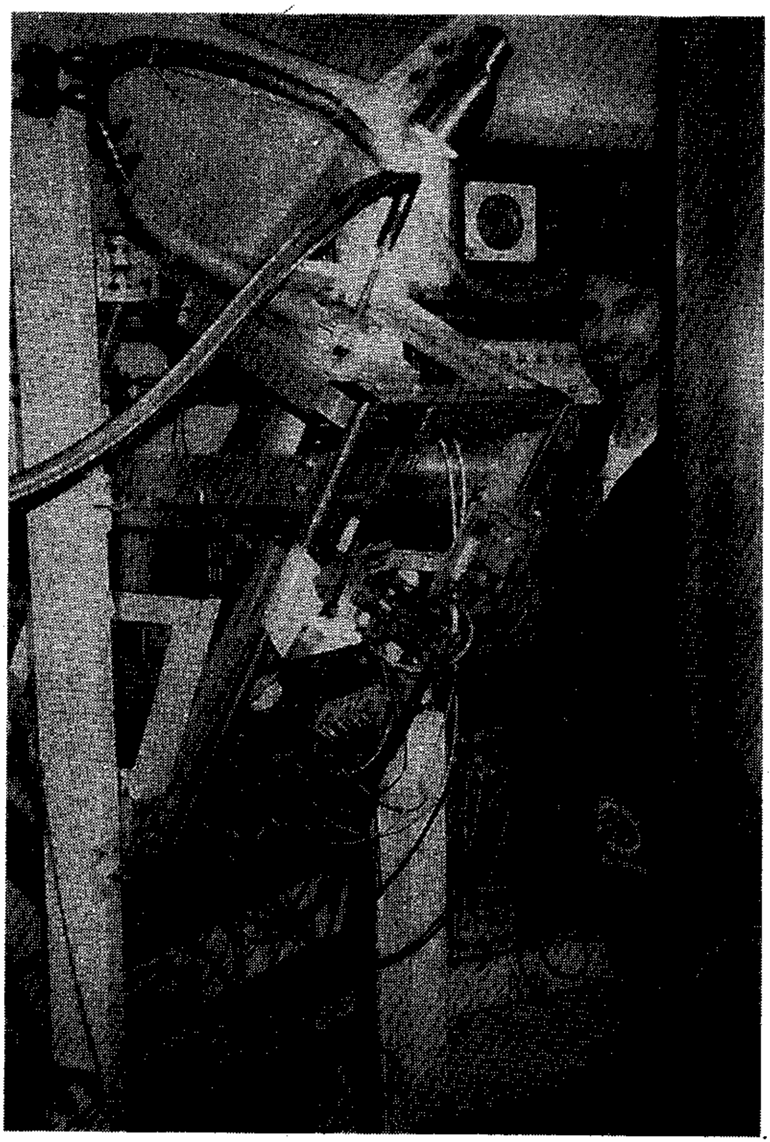

*Two views of Receiver C in the JCMT receiver cabin – and one of Dr Glenn White who, with Dr Rachael Padman, writes in this issue about the successful commissioning of the receiver at 492 GHz.*

## EDITORIAL

The Panel for the Allocation of Telescope Time (PATT) has devised an ingenious scheme for reducing the pressure on telescope time. Exploiting the fact that astronomers' metabolic clocks, operating on a six-monthly cycle, trigger at the appropriate time the ritual, frenzied activity that application deadlines require, PATT has changed to an irregular cycle; the Autumn deadline is being brought forward one month to September 30 while the Spring date, and this is the clever bit, remains unchanged at April 30. There will, therefore, be five months between the Spring and Autumn deadlines and seven between Autumn and Spring. Clearly many astronomers will have difficulty in adjusting to this PATT–lag (like the uncertainty faced by the public at large when clocks are moved forward/back one hour, some will get it wrong). So, if you plan to submit applications in October as usual (last minute by courier, of course) my advice is...don't.

The official reason for the change is more prosaic – administrative difficulties caused by the holiday season at the end of the year. Could be true, I suppose.

*Alex McLachlan*

## THE LATEST ADJUSTMENTS OF THE JCMT ANTENNA SURFACE

During the month of October 1989 there was another highly successful campaign to improve the surface accuracy, and hence the high frequency efficiency, of the JCMT. This article is a brief tribute to the efforts by numerous people involved with the task of figuring the JCMT dish. The whole adjustment is organised to have little noticeable effect to the users other than an improvement in antenna gain and it is perhaps understandable that many of the visiting observers have little appreciation of the planning, scheduling and agonising involved in the process.

There had been a considerable length of time since the previous move and many modifications and changes had been added to both hardware and software parts of the system. These updates were not restricted to the electronics crates and the source/receiver units but covered faster methods for data collection and reduction.

The source and receiver packages had been rebuilt entirely as independently phase–locked units. A new weather–proof box had been built for the source which was then re–positioned on the roof of the UKIRT. The receiver unit was permanently located in a convenient slot in the Cassegrain cabin. Extensive testing of both units showed increased dynamic range, stability, reliability and considerably easier startup.

The twelve electronic hardware crates which were previously scattered over several bays inside the Cassegrain cabin were re–sited in two locations on the cabin roof. This involved construction of special boxes to contain the individual crates and the manufacture of a highly complex wiring harness to get the signals to and from the 828 motors (3 on each of the 276 panels) and to the micro–computer. The stability and reliability of the wiring looms increased significantly due to this exercise and surprisingly few major problems remain with the integrity of the wiring system as a whole.

The techniques for measuring the surface were described in Protostar (March 1988) and will not be repeated. Briefly maps of the power distribution from the 94 GHz source are made at known de–focussings of the antenna. The maps usually contained 97 x 97 points with 40 arcseconds spacing, at a rate of 1 point per second, taking around 3 hours per map to complete. Using a new rapid scanning technique it is now possible to scan at speeds up to 10 points/second without loss of tracking accuracy thus reducing the time for a single map to well under 1 hour.

It is now possible to take many more maps in a single shift. Several different values of the focus can be used, larger maps can be made with closer spacing between points. In addition experiments by manually introducing distortions to the surface can be done in reasonable time, and repeated fast maps will be able to show thermal cooling of the dish after an average day and, more importantly, after a day of pointing towards the sun.

Considerable progress and enhancement to the software reduction suite has been made at MRAO using different algorithms and techniques. Previous reduction software was cumbersome and slow. Several hours of cpu time on a Microvax were typical. The errors reported were only the small-scale corrections required to step each adjuster to a predicted position on a perfect paraboloid. The new program runs to completion within 1 hour and can produce both small-scale (adjuster steps) and large-scale (coma, astigmatism, etc.) error values. It has been shown that these numbers give a true value for the surface rms error in agreement with those determined using the high frequency heterodyne receivers (RxG and RxC).

For the October run JAC staff were assisted by Richard Hills. The weather during the scheduled week was not cooperative. It included the first snowfall of the year and on several days it was not possible to see the UKIRT from the JCMT let alone try to take measurements. There were many bugs and glitches that had to be removed from the new arrangements which could not have been found until the whole system was operational. Several early adjustments degraded the figure whereupon the surface had to be restored and the final successful improvement occurred at almost the last hour of the last day. It remained for later commissioning runs and the RxG session to confirm the numbers from the reduction software.

The current situation is that the small-scale rms errors are 24 microns. The large-scale errors are 10 microns and look like astigmatic twist which will be difficult to remove. The rms total error thus derived is 29 microns. Exclusion of the 5 adjusters which require the largest moves reduces the former errors to 19 microns. These motors took no current and have since been investigated and repaired.

Major moves are not planned for the coming semester (R). It may be possible to move the 5 uncooperative motors into line. The dish will then have to be re-measured and the various beam and aperture efficiencies re-determined for each receiver.

A large team is involved with the job of making surface adjustments. The major player has been Saeko Hayashi who shares the responsibility, along with myself, for ensuring that whatever is moved is only improved (!). Numerous JAC engineering staff (Rob de Haan, Peter Hekman, Sylvain Brazeau, Bill Reyes, Vernon DeMattos, Simon Craig and Steve Brooke) cope with the system design, construction and trouble-shooting. RAL staff (Dick Carter and Tony Eastwood) handled the electronics and wiring and led the effort to install the new crates. MRAO staff (Richard Hills, Anthony Lasenby and Dave Waymont) devised measuring techniques and provide a constant stream of improvements to these techniques.

*Graeme Watt*
*JACH*

RECENT RESULTS FROM THE JCMT

## 1. FIRST SUBMILLIMETRE CONTINUUM DETECTION OF A COMET

The comets are thought to be the most primitive objects in the solar system, with chemical and physical properties little changed from those acquired at the time of their formation. Scientific interest in the comets is centered on the belief that they may provide direct evidence concerning the physical and chemical conditions prevailing at the time of planet formation. We have recently obtained the first submillimetre continuum detection of a comet using the JCMT.

Comets consist of a solid nucleus, typically a few kilometers in size, which contains roughly equal mass fractions of volatiles (mostly water ice) and refractory material (in the form of "dust"). When heated by the sun, the volatile fraction sublimates, and the resulting gas expands to form an extended cloud around the nucleus (the "gas coma"). Because the nucleus has only very weak gravity, the gas in the coma is unbound, and streams into interplanetary space at roughly the thermal speed appropriate to the temperature of the nucleus. Refractory particles embedded in the nucleus become entrained in the streaming gas, and are themselves propelled into interplanetary space, forming the "dust coma".

Interest in cometary dust focuses on its possible connection to the interstellar dust. The general properties of the dust have been established from numerous ground based observations over the past few decades. Optical observations have been used to show that particles with a characteristic size $a \sim 1$ $\mu$m dominate the optical appearance of the dust coma, while particles about 10 times larger dominate the intensity of radiation emitted in the thermal infrared. Obviously, the cometary dust particles occupy a wide distribution of sizes; however, due to the scattering properties of the dust, the characteristic sizes derived from optical and infrared observations are heavily biased towards the wavelength of observation. Particles both much smaller and much larger than the optical and infrared weighted sizes must exist in comets, but they are poorly sensed by optical and infrared wavelengths.

One of the most surprising measurements from the Giotto and Vega Halley-encounter spacecraft concerned the size distribution of the dust grains. Impact counters on these spacecraft showed the size distribution to be such that the bulk of the mass of the grains was contained in the (rarest) largest particles. If applicable to all comets, this distribution would imply that optical and thermal IR wavelength observations provide a very poor estimate of the total mass of the cometary grains. Independent evidence for large particles in comets has been obtained from observations of the Zodiacal Cloud (a lense-shaped cloud of dust grains enveloping the inner solar system and thought to be produced by comets), from 12 cm radar observations of 2 comets, from the existence of meteor streams (which produce mm-sized meteors), and from IRAS observations of "trails" consisting of 100-$\mu$m and larger particles in the interplanetary medium.

Motivated by the spacecraft results on large particles, the author and Jane Luu (MIT) used the JCMT and UKT14 to search for submillimetre thermal emission from large cometary grains. The results of our observations of the bright periodic comet Brorsen-Metcalf are contained in Figure 1, which shows the first truly submillimeter ($\lambda <$ 1-mm) detection of a comet and the first submillimetre continuum spectrum.

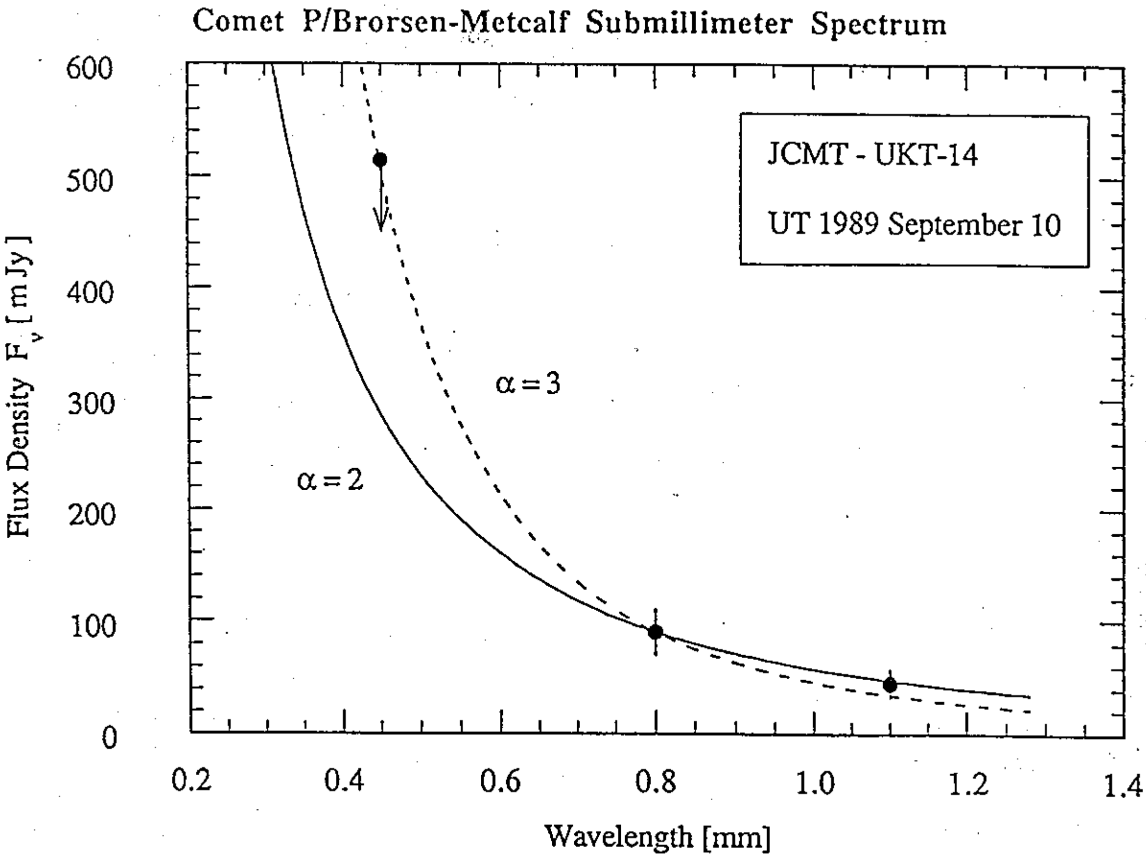


*Figure 1. Submillimetre continuum observations of P/Brorsen–Metcalf from the JCMT. The two lines represent spectral indices $\alpha$ = 2 (Rayleigh–Jeans) and $\alpha$ = 3, for reference. Evidently, the spectral index of the cometary emission is $\alpha$ = 3.*

The interpretation of the cometary emission is rather less complicated (and therefore less model–dependent) than the interpretation of submillimetre continua of interstellar dust. This is primarily because the geometry of the source and the temperature of the cometary dust are both well known. In molecular clouds, for instance, the kinetic temperature may be very low (T ~ 10 K), but small grains may be heated to very high temperatures (T ~ 1000 K) by the absorption of individual photons. Thus the temperature may vary by two orders of magnitude, depending on the details of the local radiation field. In comets, by contrast, the radiative temperature is already high (e.g. T ~ 450 K in the case of P/Brorsen–Metcalf), and single–photon heating can increase the grain temperature by only a factor of 2 (since cometary solids vapourise at T ~ 900–1000 K). Thus the maximum effects of temperature uncertainty due to single–photon heating of other effects are only of order a factor of two.

We have computed a suite of grain models to fit the data in Figure 1. We employ complex refractive indices for three representative materials; silicates, glassy carbon, and "tholin" (a structurally complex hydrocarbon). Silicates and carbon rich grains are known in comets from numerous ground–based and space–based observations. The models were evaluated using Mie theory, for a range of size distributions suggested by the Halley data. A sub–sample of the models is shown in Figure 2.

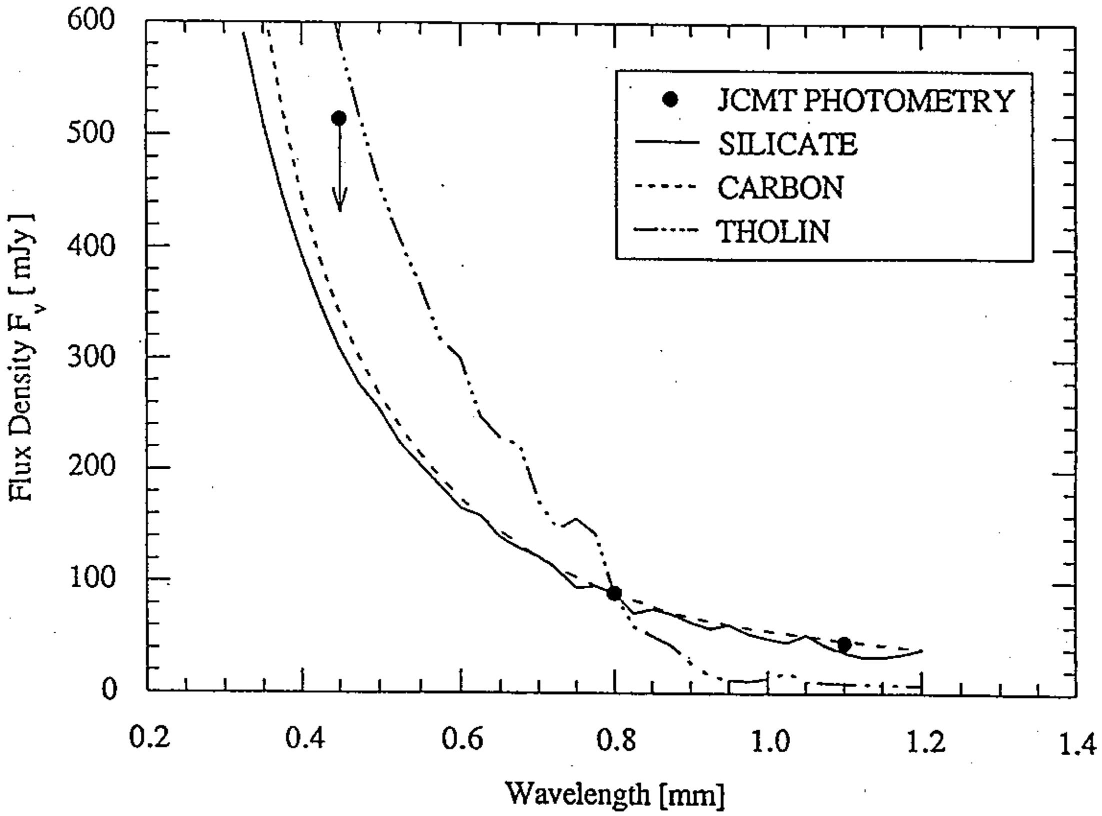


*Figure 2. Models of the submillimetre spectrum, normalised to the 0.8–mm datum. The models are for grains made of silicates, carbon, and tholin. The grains occupy a power law size distribution with index 4 and minimum and maximum radii $10^{-8}$m and $10^{-2}$m, respectively. Silicate and carbon grain models match the data, while the Tholin model violates the 3σ limit at 0.45–mm.*

The models are non–unique, but together they lead to two apparently firm conclusions about the cometary grains. First, the total mass within a 20" beam is in the range $10^9 - 10^{10}$ kg, from 1 to 2 orders of magnitude greater than estimated from near–simultaneous infrared data. The implied production rate is $10^4 - 10^5$ kg $s^{-1}$, comparable to Halley at its peak. This finding confirms our suspicion that optical/IR data can grossly under–estimate the cometary mass production. Second, Rayleigh particles ($a << \lambda$) produce spectra too steep to fit the data, suggesting that at least part of the measured emission emanates from large ($a \sim \lambda$) grains.

Interpretation of the new data is still underway, but it is already clear that the submillimetre region presents a new and valuable window on the cometary dust. An improved understanding of the large–particle production in comets will help our understanding of the Zodiacal Cloud, meteor streams and IRAS dust trails. There may also be important lessons for the interpretation of the dust disks recently detected around nearby solar type stars, particularly if these disks are produced in part by ejection of material from embedded extrasolar comets.

*David Jewitt*
*Institute for Astronomy*
*University of Hawaii*

RECENT RESULTS

## 2. RxC COMMISSIONING AT 492 GHz

In the previous edition of "Protostar" RP described the progress to date with receiver 'C', the dual polarization InSb common-user receiver for 461 and 492 GHz. As noted then, most of the residual problems were caused by "standing waves" between the receiver and secondary mirror, and the cure for this was thought to depend largely on having available a local oscillator signal of greater spectral purity – something which is not necessarily easy to obtain at 500 GHz! Thanks almost entirely to Dennis Bly's great efforts at MRAO, a system incorporating the necessary improvements was implemented on a very short timescale, and the receiver was recommissioned in November of last year. At the same time we took the opportunity to install an improved calibration load system (which gave us reference loads with emissivities much more nearly equal to unity), and to install a new lens in the dewar to improve the telescope illumination. We report with pleasure that all these improvements worked as intended, and that (as the accompanying figures show), RxC is now capable of yielding first class results at both 461 GHz (CO J = 4→3) and 492 GHz (atomic carbon $^3P_1$ – $^3P_0$ fine structure lines).

What we have actually done is to install temporarily a "kluge" version of the LO phase-lock system, using microwave components borrowed from MRAO and a minimum of new circuitry, just to test out both the diagnosis of the problem and the feasibility of a very wideband phase-lock circuit. The plan now is that, having ascertained that it all DOES work, a final system will be built and installed in the early part of 1990. We have not yet had time to analyse fully the various efficiencies, but it is likely that the new lens has further improved the aperture efficiency, while as a result of all the improvements we are now able to use the direct (3-load) calibration technique, which is somewhat more accurate than a chopperwheel (2-load) cal. under conditions of low sky transparency (once the apparent emission temperature of the sky is known).

The actual run was very straightforward, and was blessed by the start of one of the longest sustained periods of high sub-mm transparency ever recorded on Mauna Kea, which persisted well into the following RxG run. Additionally, the improvement of the surface accuracy from somewhere in the vicinity of 44 microns rms to around 30 microns yielded a 50% improvement in aperture efficiency, and the recent great improvements in the pointing also made our life much easier. We have confirmed that both detectors give about 500K noise temperature (DSB) at 461 GHz, rising to between 800 and 1000K at 492 GHz.

The improvements to the baseline are so pronounced that it is almost certainly possible to observe adequately in position-switched (PSSW) mode for all but the deepest integrations. With any luck the remaining modes will be implemented and tested during the first half of this year, and will then be available as standard. We have not yet successfully observed in either chopping (called, for arcane reasons, NOSW) or Beam-switched (BMSW) modes, although investigation of the spectral baselines suggests that these should work well as soon as the residual software bugs (which seem to lie in the grey area between the micro and the VAX) are sorted out. The remaining mode still to be implemented is the so-called TABLES mode, in which the micro, rather than performing a stepwise linear frequency sweep, steps in turn to each frequency stored in a table down-loaded from the VAX.

Under the best atmospheric conditions (perhaps 50% transmission at the zenith), integrations of 10 minutes are long enough to give useful spectra at the $C^o$ line, while at CO 4-3 even under less good conditions (say 20% transmission) integrations of 2 minutes are adequate for strong lines such as those toward Orion. Because of the excellent baselines and stability, extensive mapping is therefore possible in good conditions, but remember that with a beamwidth of 10-arcsec a fully sampled map of a 1-arcmin x 1-arcmin region will require ~170 spectra, so do plan your actual REQUIREMENTS in detail before you start integrating. Observing at these frequencies is difficult, and interested persons may care to contact either of us (at QMW or MRAO) first, to discuss ways in which their astrophysical objectives might best be realized.

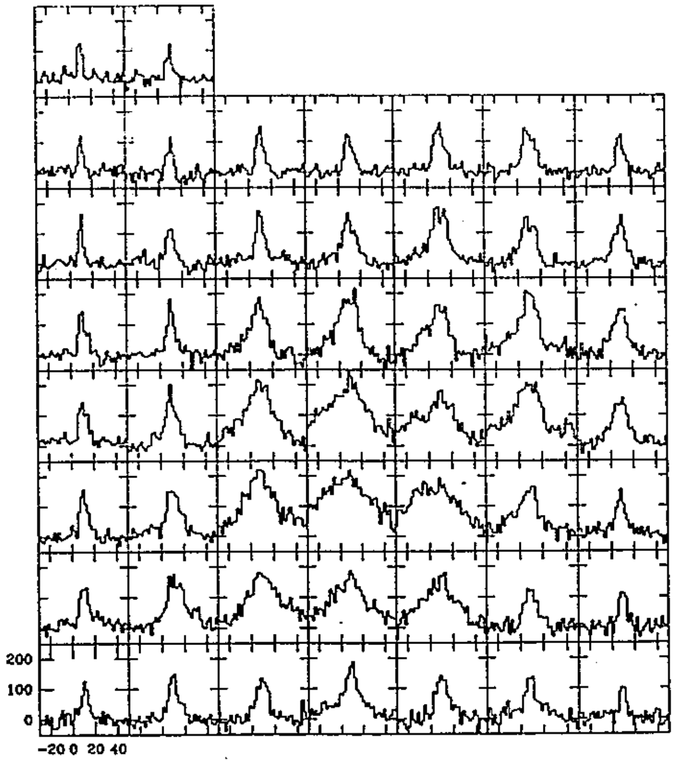


**Figure 1:** Map of the centre of OMC1 on a 10-arcsecond grid spacing in the CO J=4→3 line. The spectra have been binned to a resolution of 2 km/s, and divided by the main beam ("Jupiter") efficiency to give a main beam brightness temperature scale. This map took just over two hours to complete, with the transparency at the start being about 30% increasing to about 50% by the end.

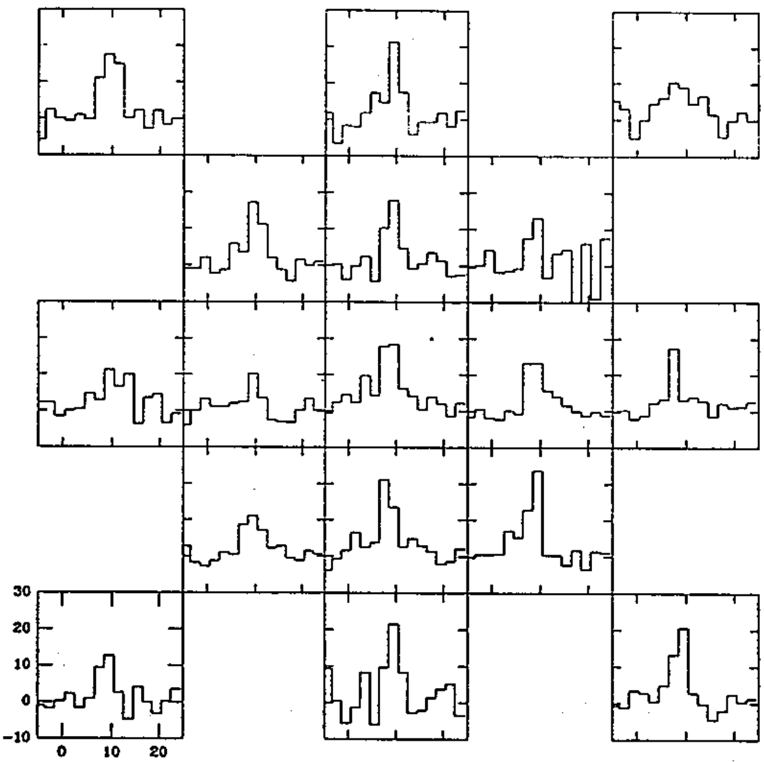


**Figure 2:** A map of the $^3P_1-^3P_0$ line of CI at the same position and grid spacing as the CO map of Figure 1. The spectra have once again been binned to a resolution of 2 km/s, and multiplied by 2.5 to yield the main beam brightness temperature scale. Because of the much lower antenna temperatures (by a factor of 10) the time required to reach this sensitivity is somewhat longer, even with reduced velocity coverage: in all it took about 4 hours to make this map with the transparency between 50% and 60% for most of that time. Some of the apparent "noise" in the baselines of two of the spectra is due to the presence of an LO "grolly", which should disappear in the final system.

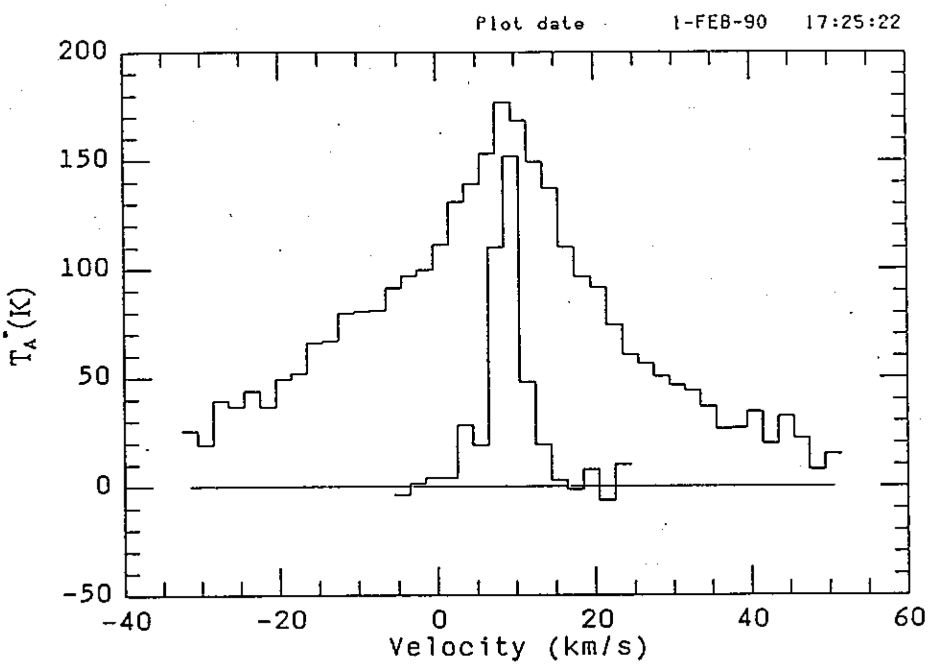


Figure 3: Overlay of the CO 4–3 and CI $^3P_1$–$^3P_0$ spectra at OMC1. Both have been convolved with a 30–arcsecond beam for comparison with previous lower resolution results. The CI spectrum has also been multiplied by a further factor of 10 to aid the comparison. Note that even in this size beam the peak brightness of the CO exceeds 170 K, with the ridge or spike component almost entirely obliterated by the high velocity plateau emission.

Finally, we would like to acknowledge and thank Bob Barker, Hugh Gibson and Richard Prestage for their hard work both before and throughout the run. As already noted Dennis Bly's efforts were crucial to achieving acceptable performance from the system, while Matt Griffin and Tony Scivetti at QMW, and Anthony Murphy, Nick Johnson and John Rogers at MRAO, all made very substantial contributions. We also thank Jay Tsutsumi and his team for their willing help at the start of the run, coming as it did directly on the heels of the heavy engineering session, prior to the RxG run and concurrently with daytime observations of comets, all of which made it very difficult to do much sensible preparation at the summit.

*Rachael Padman, MRAO* (RACHAEL @ UK.AC.CAM.PHY-RAVX)
*Glenn White, QMW* (GJW @ UK.AC.QMC.STARLINK)

***RP's footnote:*** In the previous article I stated that all previous observations of the 492 GHz neutral carbon line had been made with the 90cm telescope of the KAO. Following the appearance of that article Al Wootten of NRAO sent me some papers I should have seen detailing his CI observations at the IRTF, so apologies to Astro Al and his collaborators for my oversight.

## 3. THE RxG RUN IN DECEMBER 1989

A combination of several periods of excellent weather, a readjusted telescope surface, and modifications to RxG conspired to bring short–submm (~700 GHz or ~430 lm) observations to a near–routine state at the JCMT last December. Most of the PATT–scheduled projects were substantially completed, with high points the first detection of a short–submm isotopic line ($^{13}CO$ J=6→5), the first detection of the bulk material in an external galaxy at these wavelengths ($^{12}CO$ 6–5 in M82), and large–scale maps of submm line emission from the envelopes of young and evolved stars (HH7–11, Cep A, and IRC+10216). In addition, we made measurements of the 700 GHz beam shape and efficiency and verified the telescope's surface improvement from October's holography run.

### Technical Aspects

*Beamshape and efficiency*

Limb–scan measurements across Jupiter's edge yielded new values for beam efficiency and resolved the overall beam shape. One immediate result was that the surface adjustment improved coupling to Jupiter–sized sources (42") by roughly a factor of two. Jupiter's large diameter allowed us to characterize both the narrow diffraction and broad error beams. Comparison of theoretical 2–D convolutions of composite Gaussian beams and a disk showed that the 690 GHz JCMT beam is well represented by an 8" FWHM "diffraction spike" with ~85% of the peak amplitude and a broader 40" FWHM "error beam" with ~15% peak amplitude. This error beam is very likely a characteristic of the telescope's surface, although some effect of not perfect focussing cannot be excluded. The large amount of integrated power in the error beam, 80%, had not been detected earlier because of the large beam's low coupling to the small sources we typically observe at the JCMT. The effective Gaussian main beam efficiency for the composite beam is 0.32, which is a noticeable improvement from Summer 1989. Unfortunately no small size planets were available to determine the characteristics of the narrow diffraction beam more precisely. It is important to realize that even small future improvements in the dish surface accuracy will result in substantial improvements in beam efficiency, in particular in increasing the fraction of the power coupling to the diffraction beam. A more detailed report covering the efficiency and beamshape measurements is available from MPE.

*Pointing and tracking*

The pointing was generally very good after initial peaking on pointing standards with UKT14. Rapid changeover between UKT14 at the left Naysmith focus and RxG at the right Naysmith has proven to be an extremely effective and essential way to point for RxG observations. As before, the tracking was generally good over periods of hours.

*RxG Performance*

Recent changes to RxG have been new setups for specific projects: a laser LO line for the 661 GHz $^{13}CO$ 6–5 line, and a broadband low–IF–frequency mixer matching network for extragalactic $^{12}CO$ 6–5 work (resulting in about 20% higher sensitivity of the receiver). Incremental changes and repairs have improved RxG's ease of use as well; in particular, the laser instability described in an earlier issue of Protostar was traced to a cracked part in one of the lasers and repaired, and a full set of documentation for data analysis and calibration is available. Receiver temperatures are now routinely near 3000 K (DSB) for most lines and occasionally lower.

## Astronomical Highlights

### *Detection of the $^{13}CO$ $J=6\to5$ Line*

Over the past few years, observations revealed the presence of bright submm CO lines from regions of star formation, presumably associated with outflowing winds or intense UV radiation. Model calculations indicated that these $^{12}CO$ lines were optically thick, arising in regions with typical temperatures of a few hundred Kelvins and particle densities above $10^4$ $cm^{-3}$. The detection of the optically thinner $^{13}CO$ line from a variety of sources not only confirms these model results, but permits a more accurate measure of the actual column densities (Figure 1 shows the $^{13}CO$ $J=6\to5$ line toward Orion IRc2 as an example). The $^{13}CO$ 6–5 lines from several photodissociation regions (PDRs) are typically about half as bright as the $^{12}CO$ 6–5 lines, so the amount of warm molecular material in these PDRs is substantial. These results are extremely difficult or impossible to explain with present theoretical models for the chemistry and excitation of molecules in PDR's.

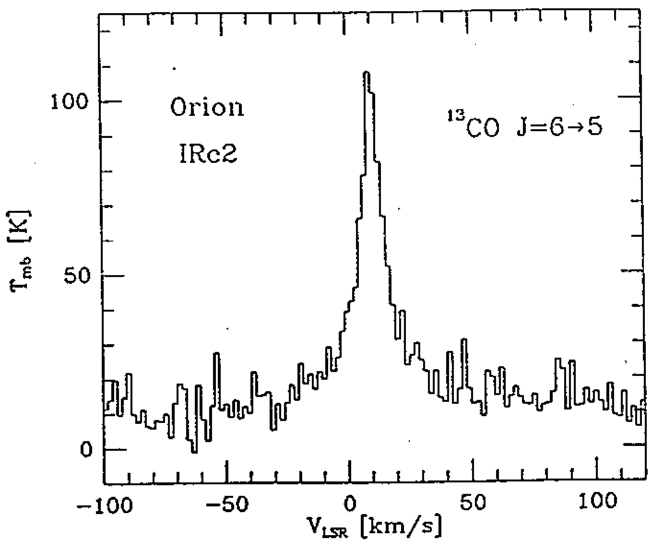


*Fig.1: The first detection $^{13}CO$ $J=6\to5$ spectrum towards Orion IRc2 (Graf et al., Ap.J. Letters, submitted).*

### *The Temperature of M82's Interstellar Medium*

The discovery of unexpectedly large amounts of warm gas in our Galaxy showed that the conventional picture of the ISM underestimated the temperature of at least some molecular clouds, and that a representative cloud temperature might be somewhat above the 10 K deduced from mm-wave observations. Finding a representative cloud temperature on global scales is important for understanding the cloud energetics and because this representative temperature enters directly in galactic mass estimates deduced from CO 1–0 observations. Submm observations of very luminous external galaxies, such as the starburst galaxy M82, yield ensemble properties of excited molecular material. Figure 2 shows the detection of the CO 6–5 line from part of M82's nucleus. Combined with mm-wave and long-submm lines, the CO 6–5 intensity indicates gas kinetic temperatures of about 30 to 100 K, close or above the dust temperature. M82's ISM is not optically thin or at a very high temperature, but is probably complex and composed of several different components along the line of sight, much like Galactic star formation regions.

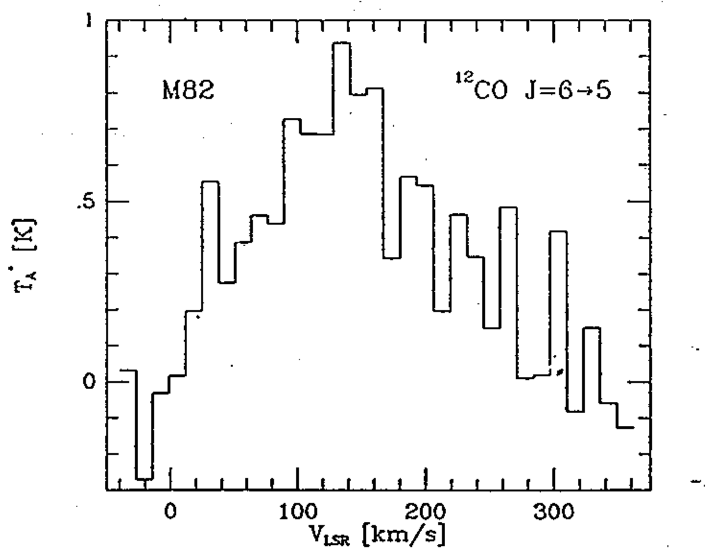


*Fig.2: ${}^{12}CO$ J=6→5 spectrum towards the star-burst galaxy M82 (Harris et al. 1990, in prep.).*

*Old Stars*

Figure 3 shows the main result of one of the projects that RxG supported during the December 1989 run: a ${}^{12}CO$ J=6→5 map of the well studied, nearby (300 pc) carbon star IRC+10216 (Sahai, van der Veen and Stutzki, 1990 in prep.). Careful pointing checks during the observations make us believe that the offset between the CO emission peak and the position of IRC+10216 is real. It would then correspond to a similar asymmetry, though on a smaller scale, in a recent near-IR image of IRC+10216 taken at ESO (see ESO Messenger #55, March 89, le Bertre et al.). In view of the important implications for the mass loss process, these results nicely demonstrate the unique possibility of short-submm JCMT spectroscopic observations to trace the warm and/or dense molecular component at very high angular resolution, comparable to that achieved with mm-wave interferometers.

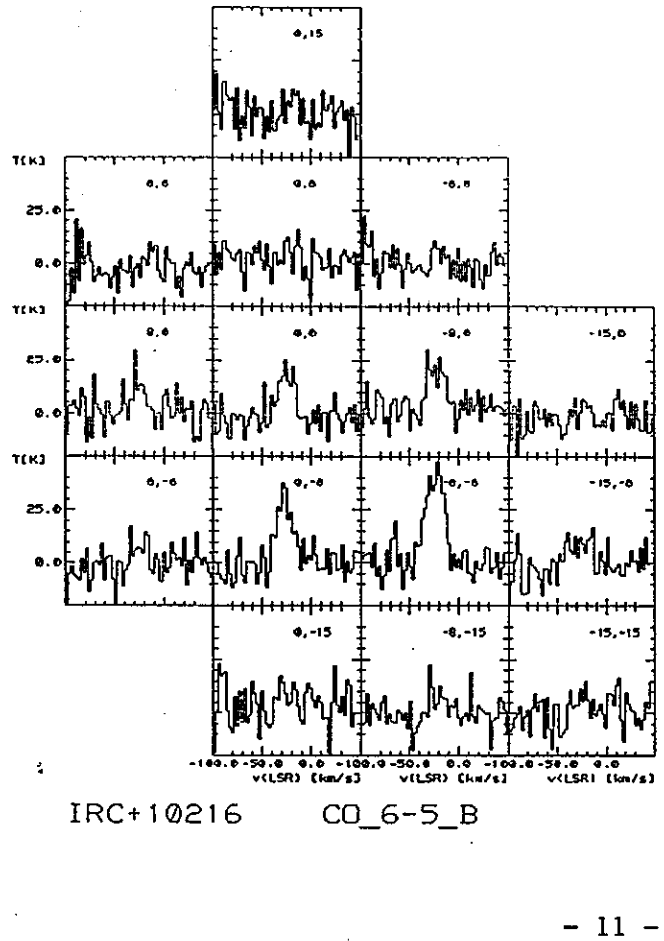


*Fig.3: ${}^{12}CO$ J=6→5 map around the carbon star IRC+10216 (Sahai et al. 1990, in prep.). The peak emission is shifted towards the SW of the star. Careful pointing checks during the mapping make us believe that this offset is real.*

*Jurgen Stutzki*
*MPI*

## REPORT ON THE PATT MEETING FOR SEMESTER R (March'90 to Aug.'90)

**Venue**

The semester R PATT meeting was held in Bristol on Jan. 9–10, 1990. I was ably helped by Wil van der veen (ROE) in my task as JCMT Tech Sec.

**Statistics**

Proposal Statistics for Semester R (March '90 to August'90):

| | | |
|---|---|---|
| Number of JCMT proposals received: | 104 (inc. 2 long-term ones) | |
| Number with OTH PI | 15 | |
| Number with UK PI | 56 | |
| Number with CDN PI | 25 | |
| Number with NL PI | 08 | |
| Fraction of PI: UK /(UK+CDN+NL) | | 63% |
| Fraction of PI: CDN/(UK+CDN+NL) | | 28% |
| Fraction of PI: NL /(UK+CDN+NL) | | 09% |
| Number of line proposals | 62 | |
| Number of cont. proposals | 49 | |
| Number of 16h nights requested | 274 | |
| Number of PATT nights available | 116.5 | |

Time Awards for Semester R (in 16h nights):

Of 104 JCMT proposals that were considered, 53 were awarded time ( = 51%). A typical award is for 4 8h–shifts. The distribution of nights is:

| | | |
|---|---|---|
| Nights awarded to Hilo Eng./Comm. Time: | 51.0 | |
| Nights awarded to Hilo Discret. time : | 3.0 | |
| Number of nights taken by U. Hawaii : | 13.5 | |
| Number of PATT nights awarded to OTH : | 23.5 | |
| Number of PATT nights awarded to UK : | 56.6 | (60.9% of UK+CAN+NL) |
| Number of PATT nights awarded to CAN : | 23.0 | (24.7% of UK+CAN+NL) |
| Number of PATT nights awarded to NL : | 13.4 | (14.4% of UK+CAN+NL) |
| | ------- | |
| Total number of 16h-nights in Semester: | 184.0 | |

**Details of Engineering, Commissioning, and Discretionary Time Awarded in Semester R to the Joint Astronomy Centre Hilo**

In addition to all the 8h–daytime shifts, the JACH was allocated 54 nights for the following activities:

| | | | |
|---|---|---|---|
| 1. | Heavy engin. | 19 | 16h-nights |
| 2. | Pointing | 7 | |
| 3. | Metrology | 1 | |
| 4. | Calib. | 5 | |
| 5. | UKT14 calib. | 4 | |
| 6. | SIS testbed | 5 | |
| 7. | RxB2 | 5 | |
| 8. | UKT14 polarim. | 1 | |
| 9. | Sutton SIS setup | 1 | |
| 10. | Rec. G setup | 1 | |
| 12. | Rec. A setup | 1 | |
| 13. | Rec. C setup | 1 | |
| 14. | Discret. 2% | 3 | |
| | | --- | |
| | total: | 54 | 16h-nights |

The total of 54 nights (29.3% of the 184 nights in Semester R),is 6% down on the previous semester.

**Specific JCMT PATT recommendations**

Note a : Beam–switching is now available to all (officially released).

Note b : A High frequency back–up of Scheduled low frequency observations can be done for appropriate programmes.

Request no.1 : Proposers should check their Right Ascensions; do NOT submit a proposal if the sources are NOT visible in the coming semester!

Request no.2 : Indicate in proposals the RA (hh,mm,ss) and DEC (dd,mm,ss), or else PATT will NOT consider your proposal as COMPLETED (your proposal will not be considered at all, unless there is a good reason why this request is inappropriate).

**General Session (with representatives of all the telescope projects):**

Status quo: The new Swindon PATT Team (D.Mitcham, I.Midson, M.Morton) agrees to have refereeing of PATT proposals. All proposals will continue to be refereed.

Change no.1: The attempts to mail anything from Swindon over the December – Christmas period in preparation of the early January PATT meeting are over. This meeting is now moved to early December. There is no change to the observing semester dates, no change to the July meeting.

BUT..AND PLEASE NOTE.. THE AUTUMN PROPOSAL DEADLINE IS MOVED TO 30 SEPT.

Change no.2: In regards to the JCMT proposals involving Ph.D. theses, with a definite Ph.D. deadline, these proposals will be automatically rescheduled in the advent of being wiped out by bad weather or bad instruments on Mauna Kea. A 1–page summary of what was done/happened is required.

Change no.3: Effective immediately, there is no need anymore for a UK refereeing of UK proposals to non–UK telescopes in major locations with equivalent refereeing (Nobeyama, VLA–27km, Kitt Peak–12m, Onsala–30m, Bonn–100m, etc).

Next meeting: provisionally Tue. 10 and Wed. 11 July 1990, in Swindon, UK.

*J.P. Vallée*
*JCMT Tech Sec*
*NRCC at ROE*

JCMT Scientific Time allocations for Semester R
(in 8h-shifts)

Baas, F.
Continuum mapping of NGC6334 I(N) (3 shifts)

Casali, M.M.
Submillimetre observations of the pms population in Serpens (3)

Danchi, W.C.
Molecular gas in unusual T Tauri stars (2)

Danchi, W.C.
Dense gas in the central regions of bipolar outflow sources (4)

Dent, W.R.
Investigation of the dust emissivity law as a function of temperature (3)

Dent, W.R.
Submillimetre continuum observations of SgrA* and the molecular ring (5)

Dent, W.R.
The molecular outflow associated with HH80-81 (3)

Doyle, J.G.
A pilot study aimed at detecting M dwarfs in the millimeter region (1)

Emerson, J.P.
Submillimetre mapping of young stellar objects in Ophiuchus (5)

Feldman, P.A.
Search for $^{16}O^{18}O$ in G34.3+0.1 and other dense molecular clouds (5)

Gear, W.K.
The kinematics of dense gas around the protocluster DR21(OH) (3)

Genzel, R.
A first study of short submm CO emission from external galaxies (6 )

Graf, U.
High angular resolution submm CO study of the M17 SW Photodissociation interface (5)

Griffin, M.J.
The millimetre/submillimetre brightness temperature spectrum of Titan (4)

Harrison, R.A.
A Solar survey and prominence study (2)

Hills, R.E.
High frequency observations of the galactic centre (9)

Hughes, D.H.
High resolution submillimetre continuum mapping of the interacting galaxies M82 and NGC3628 (4)

Israel, F.P.
CO in nuclei of northern galaxies (7)

Israel, F.P.
CO structure of NGC 604 (6)

Jewitt, D.
Large particles in comets (5)

Sandell, G.
Mm/submm photometry and mapping of bipolar outflow sources (5)

Sandell, G.
Submillimetre observations of compact and ultracompact HII regions (4)

Sandell, G.
A detailed continuum study of IRC+10216 - monitoring and mapping (2)

Sandell, G.
Search for continuum emission of pms stars (6)

Sanders, D.B.
Submillimeter continuum observations of optical and infrared quasars (5)

Skinner, C.J.
Sub-mm continuum emission from extreme carbon stars (1)

Sutton, E.C.
Chemical differentiation in the molecular cloud OMC-1 (5)

Sutton, E.C.
Submillimeter Line Observations of CRL 2688 (3)

Tacconi, L.J.
CO J=3-2 observations of galaxies with and without spiral density waves (8)

Taylor, A.R.
Circumnebular CO in young planetary nebulae (5)

Tilanus, R.P.
CO J=3-2 Observations of selected molecular clouds in the Spiral Arms of M83 and M51 (2)

van der Veen, W.E.
Mass loss on the agb as a function of time (6)

van der Veen, W.E.
CO 3-2 observations of selected agb stars (3)

Webster, A.S.
Recombination line masers (2)

White, G.J.
Neutral carbon across ionisation fronts and molecular cloud cores (8)

Zhou, S.
Dust emission from T Tauri stars and young stellar objects (5)

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## APPLICATIONS FOR TELESCOPE TIME: ARRANGEMENTS FOR SEMESTER S

For Semester S (Sept 1990 – Feb 1991) the closing date for applications will be April 30, 1990. Postal applications should be sent to:

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

Enquiries may be made by telephone (0793 411198) 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 North America copies of the application forms can also be obtained from:

Dr J.M. MacLeod
Radio Astronomy Section
Herzberg Institute of Astrophysics
100 Sussex Drive
Ottawa
Ontario K1A 0R6

The new application form attached to the September 1989 issue of this newsletter should be used.

Please make sure that you included the full RA and Dec of your sources.

All applications will be refereed as usual.

In Semester R, about two dozen nights were awarded to OTH (astronomers outside the UK+CAN+NL partnership or the University of Hawaii).

Papers based on data obtained at the JCMT should carry an acknowledgement or a footnote mentioning "The James Clerk Maxwell Telescope is operated by the Royal Observatory Edinburgh on behalf of the Science and Engineering Research Council of the United Kingdom, the Netherlands Organisation for Scientific Research and the National Research Council of Canada".

Please send a preprint copy to S.J. Bell–Burnell (ROE, Edinburgh).

*J.P. Vallée*

## POINTS FOR PATT APPLICANTS FROM THE CHAIRMAN OF THE JCMT TIME ALLOCATION GROUP

### A) Student Projects

As mentioned in Jacques Vallée's report, there is a something new to think about in the case that you are applying for time on JCMT for observations that form an important part of a Ph.D. thesis. We are concerned that such thesis work might be endangered by spells of bad weather or equipment failures, and we want to provide some extra protection for it by agreeing in advance that when a run is largely wiped out more time will be allocated. However, in order to obtain this protected status, the proposal will need to be of a somewhat higher standard than is necessary just to get time. I expect we will need to develop the procedure for doing this over several rounds, but for the next deadline I propose the following:

1) If you wish to participate, then when you fill in the application form put "Thesis-Work Status Requested" in large letters in section 14. Obviously the answer to question 14(i) should be Yes and the other details requested should be given. PATT will take into account that this request has been made in reaching a decision as to whether time is to be allocated. Because of the greater commitment of telescope time that this represents, they will require a higher standard to be met than for a standard application. (This is not intended to be a huge additional barrier to student projects, but we feel it is necessary to have some extra margin if we are to be fair to people who are not working with students. We trust that unsuitable projects will not be turned into "thesis-work" and we do not expect to see individual students' names appearing on unreasonably large numbers of proposals.)

2) If you get time but your run is essentially wiped out by bad weather or the breakdown of instruments, first apply to the astronomer in charge of the telescope to see if any time is available in the current semester. If not you should write to PATT (ie the Executive Secretary), well before the next meeting, explaining what happened and asking for more time. Give the PATT reference number and specify that is was thesis work. Because of the positions of sources it may not always be possible to schedule the make-up time in the next semester, but the idea is to fit it in as soon as is practical.

**Several notes at this point:**

(i) As extremely dry conditions only occur about 30% of the time, it is very unlikely that PATT will grant Thesis-Work status to a programme which has to have such conditions for all or even most of its observing. For high-frequency observations you must ensure that you have a back-up programme that will provide good material for the thesis. Time will not be made up automatically if conditions are just average-to-poor.

(ii) Similarly it is not realistic to set up the research programme so that every part of the observing has to be carried out successfully. It is not intended that this mechanism be used where only part of the data is lost. If you get some reasonable fraction of the data you should be in a good position to submit a fresh application. You can of course apply for protection on this too.

(iii) There is no compulsion to apply for this; we remain happy to see observations for students' theses in standard applications.

### B) Filling out the forms.

Some applicants are not bothering to fill out the sections on List of Principal Sources and Related Applications/Publications. We don't want people to go to unreasonable efforts over these but it is often helpful for us to know things like whether previously scheduled observations were successful, so do try to give relevant information. Leaving them blank will inevitably tend to get your proposals lower grades.

### C) Dates for observing.

As was also mentioned by Jacques Vallée we are still wasting a good deal of effort all round on proposals that cannot be done because the sources are not available. I gave a table of which month to observe in an earlier Protostar. Here is an alternative way of looking at the same thing. If I have got it right, the times given are the local transit times for sources at even values of RA in the last week of each month. In between (for the odd values of RA) are symbols to indicate whether observing is practical for that month. Obviously this depends on whether you have just one source or group of sources at a single RA, so that you need to spend the whole shift on them and they have to transit near the middle of the shift, or you have a range of RA's so you only need that particular object to be available for a few hours. The table can't take account of things like sources at extreme declinations, so you need to allow for those yourself, but I hope this will prevent a few more mistakes.

Table of time of transit

(Time given is approx HST on 26th of month)

**** means sources not realistically available at all.
.... means available for part of a shift only.

```
        Jan  Feb  MAR  APR  MAY  JUN  JUL  AUG  Sep  Oct  Nov  Dec
RA    |----|----|----|----|----|----|----|----|----|----|----|----|   RA
 24 -   16   14   12   10   08   06   04   02   24   22   20   18   - 24
     | ***************..........         ......         ........... |
 22 -   14   12   10   08   06   04   02   24   22   20   18   16   - 22
     | **********..........         ......         ..........****** |
 20 -   12   10   08   06   04   02   24   22   20   18   16   14   - 20
     | *****..........         ......         ..........*********** |
 18 -   10   08   06   04   02   24   22   20   18   16   14   12   - 18
     | ..........         ......         ..........**************** |
 16 -   08   06   04   02   24   22   20   18   16   14   12   10   - 16
     | .....         ......         ..........****************..... |
 14 -   06   04   02   24   22   20   18   16   14   12   10   08   - 14
     |          ......         ..........****************.......... |
 12 -   04   02   24   22   20   18   16   14   12   10   08   06   - 12
     |     ......         ..........****************..........      |
 10 -   02   24   22   20   18   16   14   12   10   08   06   04   - 10
     | .....         ..........****************..........           |
 08 -   24   22   20   18   16   14   12   10   08   06   04   02   - 08
     |          ..........****************..........         ...... |
 06 -   22   20   18   16   14   12   10   08   06   04   02   24   - 06
     |     ..........****************..........         ......      |
 04 -   20   18   16   14   12   10   08   06   04   02   24   22   - 04
     | .........****************..........         ......           |
 02 -   18   16   14   12   10   08   06   04   02   24   22   20   - 02
     | ....****************..........         ......                |
 00 -   16   14   12   10   08   06   04   02   24   22   20   18   - 00
RA    |----|----|----|----|----|----|----|----|----|----|----|----|   RA
        Jan  Feb  MAR  APR  MAY  JUN  JUL  AUG  Sep  Oct  Nov  Dec
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Pretty restrictive isn't it? Spare a thought for the poor people who have to do the scheduling!

D) **Length of runs.**

We are still concerned that observing is being parcelled up into too many small pieces. This is inefficient in many ways – travelling, instrument changes, administration and so on. We don't want to set a minimum time allocation because clearly there are some important scientific programmes that only need a modest amount of observing, but we would like to encourage people to tackle substantial pieces of work and to ask for enough to time to have a reasonable chance of completing them in one go. We realise that it is not always easy to make the case in one page, but there is always the mechanism of sending supplimentary material which goes to the referee and assessors. Please avoid sending a number of parallel proposals for different parts of the same project.

*Richard Hills*
*MRAO*

## CALL FOR COMMENTS ON SUPERDRY WEATHER AT THE JCMT

The JCM management is interested in establishing an Override facility to maximise the high–frequency science done at the JCMT in the event of superdry weather on Mauna Kea, Hawaii, at the expense of lower frequency observations.

The observations on Mauna Kea in the submillimeter wavelength range could be the particular forte of the JCMT, and they should be pushing the thrust in the long–term instrumentation to higher and higher frequencies.

The JCMT Board is keenly interested in the experience of people and of telescope directors on such matters dealing with Weather monitoring and Override facility: what they do, how they do it, etc.

**a) Weather–Monitoring Instrumentation (WMI):**

Questions to some experienced instrumentalists/astronomers led to some preliminary answers (a 0th draft report is in preparation, summarising the answers from Cambridge, London, Garching, Santiago).

**b) Program–Overriding Policy (POP):**

Questions to some experienced telescope directors/astronomers led to some preliminary answers (a 0th draft report is in preparation, summarising the answers from the AAT, CFHT, SEST, ESO, UKIRT, Schmidt, La Palma).

All readers of Protostar are hereby INVITED to comment on WMI and POP as soon as possible, by e–mail to:JPV@UK.AC.ROE.STAR

*J. P. Vallée*

RECEIVER NEWS

The following instruments should be available to users on the JCMT during semester S (September 1990 - February 1991)

Heterodyne (spectral line) receivers:

The band 220 - 280 GHz: receiver A1.

This receiver nominally covers the frequency range 220 - 280 GHz. Two mixer sets are used to achieve this range: A1(lower) operates well up to 240 GHz, while A1(upper) is better at frequencies above 240 GHz. Frequencies somewhat outside this range may be accessible with some degradation of performance. Two Gunn oscillators are required presently to cover the upper band. Receiver A1 is a dual-channel device, and thus is receptive to both polarizations. However, for the most of the last year or so Receiver A1 has been operated in a 'hybrid' mode, i.e. with one mixer from each frequency range. Although this mode offers flexibility with minimum risk to the equipment, observations are possible in only one frequency band at a given time, and thus only single polarization observations can be accommodated. This situation is likely to continue through semester S unless proposals specifically requiring both polarizations are received and accepted by PATT. A single-sideband filter should be available for those users requiring rejection of the image sideband; it should be specifically requested in the proposal.

Typical double sideband receiver temperatures at the band centres are 440 K and 650 K for the lower and upper bands respectively, corresponding to single sideband system temperatures of about 1100 and 1600 K respectively in the best cases. Receiver temperatures increase with distance from the band centres; at 272 GHz and above receiver temperatures are 1000 K and greater.

320 - 370 GHz: receivers B1, B2 and B3.

The single channel (polarization) Schottky-mixer receiver B1 remains in use at the JCMT. During the latter part of semester R, two new receivers covering this range will hopefully be commissioned: B2, a common-user dual-channel Schottky mixer system to be built by MRAO and RAL, and B3, an interim dual-channel SIS receiver developed by the HIA/Kent/RAL consortium. Since neither receiver is scheduled to be commissioned by the time of the relevant PATT meeting, it is not possible to promise their availability in semester R, and users should not assume in their proposals that this will be the case. The SIS receiver will in any case be made available on a best-efforts basis. Because of the arrival of these two new receivers, it is unclear whether the collaboration with Ed Sutton and his group in this frequency band will continue into semester S. Until receiver B2 is fully commissioned, B1 will be retained as the backup.

Receiver B1 has continued to have serious problems, in addition to being somewhat noisy by today's standards. Two carcinotrons are being used, one to cover the higher frequencies, and one for the lower range. Neither work to their original specifications any longer. The better mixer is currently undergoing repairs and good results have been very recently reported for it by Bert Woestenberg, while the less good mixer has given receiver temperatures which are considerably worse than is usually attainable. If all is working well, the lower frequency limit of the receiver is about 326 GHz and it has been used at frequencies as high as 372 GHz, where the limiting factor is the atmosphere, due to an absorption band around 373 GHz. Typical double-sideband receiver temperatures at the band centre should be about 800 K, and may be somewhat better in places, corresponding to single sideband system temperatures of about 2500 K under good conditions, increasing away from the band centre.

Receiver B2 is scheduled to be commissioned at the JCMT in July 1990. However, at present no information is available on its tuning range or receiver temperature, since the mixers are not finished. If one were to conservatively assume a tuning range of 330 to 360 GHz, with a receiver temperature of 700 K, one would probably not be far off the mark.

Tests of a 245–GHz prototype SIS receiver in May 1989 proved very successful; some of the hardware for this receiver forms part of the 345–GHz SIS receiver (B3). Again, no firm information on tuning range and receiver temperature will be available until after the scheduled commissioning run at the JCMT in August 1990. The design goal is to achieve a receiver temperature of 300 K (DSB) across the 330 - 360 GHz band. For comparison, the Sutton group SIS receiver has given DSB receiver temperatures of 280 K at 330 GHz, rising to 775 K at 357 GHz.

460 - 490 GHz; receiver C1.

Receiver C1 is a heterodyne receiver for the 450 to 500 GHz waveband, using InSb 'hot electron' bolometers as mixers. Because of the finite time constant of this form of mixing, the practical single–sideband IF bandwidth is a little less than 1.5 MHz. It is therefore necessary to 'sweep' the local oscillator frequency across the line to obtain a spectrum. This leads to the major consideration when planning observations with this type of receiver: if one observes a spectrum covering n channels the effective system temperature will be be increased by the factor sqrt(n). Since the mixers respond to both sidebands the normal resolution is somewhat less than 3 MHz (about 2.6 km/sec), but higher resolutions can be obtained by switching in filters (with double–sideband widths between 500 kHz and 4 MHz) in the IF chain. Two mixers, sensitive to orthogonal linear polarizations, are provided.

Receiver C1 underwent extensive commissioning tests during June and November 1989. As a result of these tests, the Joint Astronomy Centre has accepted the receiver for astronomical observations during semester R, in a strictly limited sense until further notice: only CO J=4–3 (461.04 GHz) and neutral carbon $^3P_1-^3P_0$(492.16 GHz) observations can be accommodated. The standing waves which plagued the earliest observations have been essentially eliminated and mixer improvement at 492 GHz realised, and further work to complete the receiver will be carried out during semester R. Observers should be aware that although the operation of C1 is straightforward, the atmosphere prevents useful observations for more than one–half of the time on average, so that users should be prepared with a suitable backup programme. Typical receiver temperatures are 500 K at 461 GHz, and about 700 K at 492 GHz. This leads to total system temperatures, after accounting for atmospheric and telescope losses, of (very) approximately 7000 and 10000 K per channel.

**The 690 and 800 GHz windows: Receiver 'G'**

Thanks to the continuing arrangement with Reinhard Genzel and his group at the Institut fuer extraterrestrische Physik in Garching, it is likely that Receiver G will be offered once again for users in Semester S. Interested users should contact either Prof. R. Genzel or Dr. J. Stutzki to arrange collaborative efforts. As described in 'Protostar' (Sept. 1988) the instrument is largely self–contained. Because LO power is provided by an infrared–pumped laser, only certain discrete frequencies can be accessed, in the regions around the CO J=6–5 and 7–6 lines at about 690 and 800 GHz respectively. Three laser lines are used commonly: $^{15}NH_3$ (802.986 GHz), HCOOH (692.951 GHz) and $CH_3I$ (670.463 GHz). Other possibilities are available, and individuals wishing to observe at other frequencies should first check with the MPE group. In the 800 GHz region, the HCN and $HCO^+$ (J=9–8) lines can be observed, along with the neutral carbon ($^3P_2-^3P_1$) transition. It is useful to note that the J=6–5 transition of CO is much easier to detect than the CO(7–6) line, since the telescope is considerably more efficient at the lower frequency. In general the IF bandwidth is about 1 GHz, with coverage in the IF between 1 and 10 GHz, with some gaps. Two 'on–board' 500 MHz AOS's having spectral resolutions of 1 MHz are provided.

Since July 1989 Receiver G has been mounted on the right Nasmyth platform of the JCMT, where its installation no longer requires the removal of the UKT14 bolometer system. 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. It is likely that a period of about one month in semester S will be set aside specifically for observations with Receiver G; interested users should develop proposals with this in mind, and be aware that a low-frequency back-up proposal requesting no time (Protostar, Sept. 1989, p. 12) is also required.

**Spectrometer Backends**

Currently only one spectrometer can be expected with confidence to be in use at the telescope: AOSC is an acousto-optical spectrometer which offers a resolution of about 330 kHz and a total bandwidth of 500 MHz. Developments to the microcomputer code have lead to the availability of spectral line observing using the chopping secondary mirror. The use of this technique shows a major improvement to baselines and a reduction in sky contributions to the noise level, which are particularly evident in the 320 – 370 GHz window.

**Approximate rms sensitivities after 30 minutes integration.**

Below is a table of rms noise in Kelvin after a total observation time of 30 minutes (this assumes 15 minutes on source, 15 minutes on a reference position). The actual elapsed time will be greater, depending on the efficiency of the observing technique used. In general one can expect to spend of the order of 25% more time in telescope movement and software overheads. The rms noise values are critically dependent on atmospheric conditions, and scale directly with system temperature. The system temperatures quoted should be achieved under good conditions, and will rise rapidly as the weather worsens. Thus these numbers should be taken as a guide only.

| Frequency (GHz) | Receiver | T(rx) (K) | T(sys) (K) | Resolution (MHz) | Rms noise (K) | Notes |
|---|---|---|---|---|---|---|
| 230 | A1(lower) | 440 | 1100 | 0.33 | 0.09 | |
| 270 | A1(upper) | 1000 | 2500 | 0.33 | 0.21 | |
| 345 | B1 | 800 | 2400 | 0.33 | 0.20 | |
| 362 | B1 | 1200 | 3900 | 0.33 | 0.32 | |
| 461 | C1 | 500 | 25000 | 3.00 | 0.7 | 1 |
| 492 | C1 | 700 | 39000 | 3.00 | 1.1 | 1 |
| 690 | G | 3000 | 45000 | 1.00 | 2.1 | |
| 810 | G | 4000 | 70000 | 1.00 | 3.3 | |

Note: (1) This assumes a total of 50 channels in the spectrum and 1 MHz filter "channels"; narrower resolutions are available (see above).

*Note added in proof:*

When considering line sensitivities with integration time, it is possible that there are contributions which do not obey Gaussian statistics, which can arise due to fluctuations in sky noise and RF reflections in the telescope. In any case, PATT does not award time on a single point for more than a few hours. The usual method of obtaining a better result is to combine a number of measurements of a few hours each and obtain the standard deviation of the signal from the set of signals.

Continuum Observations:

UKT14

The UKT14 bolometer system will be available in Semester S with the standard full range of filters to permit observations at 2, 1.4, 1.1, 0.85, 0.8, 0.6, 0.45 and 0.35 mm. Sensitivities range from typically 0.2 Jy/sqrt(Hz) at the longer wavelengths, through to 10 Jy/sqrt(Hz) or more at the highest frequencies under good photometric conditions. Only about 30% of all nights allow one to achieve meaningful results at 450 and 350 microns, however. A major problem until the present has been obtaining good calibration of UKT14 data; the introduction of in-line chopper-wheel calibration (under continuing development during the current semester) should remove much of this difficulty.

*Note added in proof:*

When considering UKT14 sensitivities with integration time it is necessary to be aware that, for this receiver, the dominating source of noise is the sky. Because sky noise does not obey Gaussian statistics the signal-to-noise is unlikely ever to improve by integrating longer than about five minutes. The usual method of obtaining a better (more accurate) result is to combine a number of short measurements of, say, five minutes each and obtain the standard deviation of the signal from the set of signals, ignoring the reported 'rms' values in each case. There are other factors which make it difficult to produce a table such as that shown above for the heterodyne receivers; the best I can do is to recommend to a visiting observer that he/she obtains the most recent calibration factors from Goran Sandell.

UKT14 polarimeter

Commissioning tests continue with a polarizing rotating waveplate attached to UKT14. If these tests are successful, it may be possible to carry out submillimetre continuum polarization observations with the JCMT in Semester S. Pending extensive tests to determine instrumental limits, no suggestions can be offered as to the sensitivity of the polarimeter to source polarization.

A Note on Telescope Performance

Adjustments of the telescope surface late in 1989 appear to have improved the efficiency of the telescope still further: the mean surface rms accuracy over the whole 15-m diameter of the JCMT now seems to be as good as 30 microns. For this figure, at the longest wavelengths (using, say, Receiver A1), the beamwidth and beam efficiency are about 21 arcsec and 0.80 respectively, at 460 GHz the corresponding numbers are about 11 arcsec and 0.62, while at the highest frequencies in use (around 800 GHz) they fall to 6 arcsec and 0.28.

The rms pointing errors are presently slightly better than 2 arcsec in both azimuth and elevation; because of the increasing use of the JCMT at higher frequencies, effort will continue to go into reducing these errors still further in the near future when test time is available.

*Henry Matthews*
*JACH*

## SOFTWARE NEWS

The following article by Rachael Padman about SPECX is the first, I hope, in a regular series about the principal software packages used in the processing of JCMT data. If you have a favourite program other than SPECX (POPS perhaps?) I would be glad to hear from you too.

*Editor*

## SPECX CORNER

### HISTORY

Since SPECX is, for better or worse, the reduction program operating "on-line" at the JCMT, and for many users is still the only program they have capable of providing data reduction facilities for their GSD spectra, I thought it might be sensible to spend some time discussing the history and philosophy of the program, and in this issue at least to dwell a bit on the current state of the program and its likely development over the next one to two years.

SPECX originated at MRAO as a data reduction package for spectra taken with the MRAO/RAL/QMC/UKC receivers at UKIRT -- the first version was written in an extreme hurry over Christmas of 1979 to allow me to get some spectra plotted for a talk in early January (having arrived back from the telescope with the first ever UKIRT submm data only 10 days previously). The only plotting device was a Benson pen plotter! Philosophically SPECX developed first as a synthesis of Colin Spratling's PDP-11 program MANIP, written at QMC as the on-line analysis program for the receiver, and Paul Rayner's program SPCRED, then in use on the Cyber 7600 at CSIRO in Sydney, whence I lately come. Incidentally, the name arose as these things do in a very innocent way; it was originally called SPEC, but then latter versions became SPEC1, SPEC2 etc. In order to avoid having to do global substititions all the time I changed it to a generic name, and as SPECN was less euphonious than SPECX, SPECX it became. Since SPECX was written on a NORD computer, it seemed appropriate to use the Nord style of command processing, and the minimum-matched multi-word command names have survived until now (about the only part of the program that has).

All this preamble is by way of establishing that the early use was for intensive reduction of a very few, very hard-won spectra -- what was needed was a fast response to commands, most of which did very little computing (hence the choice of a monolith), while there was never going to be any amount of actual data involved (the mapping software wasn't sketched out until 1982, and even then a big map consisted of 9 spectra). It was then transferred to the VAX, improved and proliferated during my 2-year stay in Berkeley, and had become quite a useful package by the time I returned to MRAO in 1984.

So how (and why!) did it get to be the JCMT package. The simple answer is that once it had been decided to use the GSD data format (GSD stands for Global Section Datafile by the way, and is not to be confused with GSDD, which is the General Single Dish Data format that describes what it is we keep in the GSD files - got it?), SPECX was the only program we had that we understood well enough to modify to read GSD data. We did have a copy of POPS from Kitt Peak, but that was a fairly old product by that time and would have been very hard for us to modify, while packages like CLAS, Figaro etc either did not exist or existed only in embryo form, and were not obviously suitable for our needs. In any case, there was a lot of other software to be written for JCMT, and since it only took a few days to modify SPECX to read the GSD files that was what I did, and that gave us a way of looking at the first spectra. Since then it has just been a matter of momentum: it is always easier to keep modifying something you have than to make a cold start with something you don't have yet... I will come back at the end to discuss the various options we now have with regard to both SPECX and other packages.

**Current state and version 6.0**

The JCMT represents a quantum leap in the UK's mm–wave data–gathering ability. We now regularly collect rather big spectral–line maps (requiring several Mbytes of storage for the cube), containing perhaps a few hundred to a thousand spectra, and it is I guess fairly obvious to most people the biggest single deficiency of SPECX is its command language. The current form (as of V5.4) is very intensely geared to reduction of a limited number of spectra, and was designed to be user–friendly in the sense that the command names and prompts are as self–explanatory as possible (I recognize that I have strayed into dangerous territory here – perhaps I should add the rider "in my opinion"). In V5.4 I attempted to eliminate most of the nastiest bugs (of which I was aware), and also provided an experimental DO command to allow automatic processing of larger numbers of spectra. Still, something more was called for.

I have over this last Christmas therefore written a new command language geared toward this particular program and using the same basic syntax as already existed. In fact nearly all the code was already there in the general terminal i/o routines that look after the command files, prompting the terminal and translating your input, and except for a little tidying up this has remained unchanged. What I have added is a layer of new commands, plus a symbol table for both predefined and user–defined variables, together with a general expression evaluator to allow you to do arithmetic. All the data and header can now be accessed directly via statements like

```
do m 1 no-map-pts
from-map m
do n 1 npts(1)
data(n) = 1.5*data(n)*2.718↑tau
enddo
add-to-map
enddo
```

```
int-time = 3500
```

and

```
set-map-size 100, 100*(ny*dy)/(nx*dx)
(actually equivalent to s-ma-siz 100 0 !)
```

which (I hope) are fairly self–explanatory (farewell to that awful ED–SPEC–HEAD command!) Also included are a structure IF/ELSEIF/ELSE/ENDIF with relational expressions, ASK, DECLARE and PRINT commands and a RETURN command. There is no claim that SCL (the new command language) is the ultimate in such products, and I make no excuse for re–inventing the wheel thus, but it was fun, very educational (for me), and I think will make life easier, particularly for people with big data sets. For my point of view it means that I can continue to give people elsewhere copies of SPECX to play with WITHOUT having to give them all of ADAM and the Starlink environment, which makes life easier for non–UK users.

V6.0 also incorporates a number of more minor bug fixes and alterations, most of which are aimed at standardizing the prompts for particular commands. While it is nice in interactive mode to be prompted for other information that might be required (which file to read from if more than one seems to be OK, for example), this is disaster in a batching or command–file environment, so a lot of these niceties have had to go. Mistakes now generate errors that cause the command or command file to be abandoned – no more of this "sorry I didn't like that, do you want to try again?", although it may be possible in a later version to put some of this back for interactive input only. I hope that V6.0 will be available at JCMT by the middle of the year (the real problem is documenting all these changes), and on Starlink (in GKS form) not long after.

There is one more major set of improvements required before the program really settles down, and this is to allow error and frequency arrays to be carried around with the data. AOS frequency scales are intrinsically always slightly non–linear, while the TABLES mode of operation for RxC will generate data which don't even pretend to be regularly sampled. The same set of changes will, I hope, include rather more data in the map file for each spectrum, to allow the use of a sensible average command on map-file data, and will change from an actual stack of spectra to a stack of pointers, thus allowing spectra of arbitrary length to be processed. These improvements will I hope all be implemented before next Christmas, and should be available shortly after that.

**Whither?**

Or why not switch to Figaro? Starlink does employ one programmer (not me), whose workload is dictated by the Radiastronomy SIG, to work on (amongst other things) JCMT related matters. Chris Flatters during his tenure of this job worked mainly on AIPS things, while Paul Harrison has been working full time on tranplanting the JCMT-specific functions from NOD2 to Figaro, and is just about ready to begin testing this seriously. It was the SIG's opinion that this was a much higher priority than Figaro-ing SPECX, while it seems likely that the main thrust of Paul's efforts will now have to switch back to longer wavelength work again for a while at least. In other words - the main reason is manpower. It would in fact be relatively easy to ADAM-ize the main functionality of SPECX, since I think even the order of the arguments in the GENLIB terminal input routines is the same as those in the Starlink routines (no, I don't know which were written first). This is thus one option, and would probably be somewhat easier than going the full hog and putting everything we need into an existing program.

The availability of JCMT FITS tapes (at least I believe they are available), and the recent definition of a binary FITS, suggest that another set of options now includes running other packages, such as IRAM's CLAS, which should then find it relatively easy to import our data. Personally I think that it would be a good idea to have other packages available in this way, on Starlink at any rate, but I am not so sure there is room for more than one "on-line" package at the telescope, and I think this an area that merits more debate (which package should that be, and what do we expect from it?). So I'm ending this first SPECX column by suggesting as a suitable subject for "letters to the editor", the requirements for the next spectral line package.

Most of the sensible documents on this subject so far in fact originate at NRAO, which has recently been undergoing a similar sort of soul-searching. I will send my copies of these to Alex McLachlan at ROE, from whom those interested in pursuing the subject further may obtain analog copies. In the meantime, although I am not offering to act as an on-line debugging and information facility, I would like to hear from users of SPECX regarding both bugs and new facilities you'd desparately love to see, and if this generates sufficient interest we could discuss these in future editions of this column (which I hope will be somewhat shorter, now that the preliminaries have been disposed of).

*Rachael Padman*
*MRAO*

## POINTS OF VIEW

Dear Editor

In the last issue of Protostar Matthews and van der Veen raised the question of efficient use of good observing conditions. This idea has been discussed several times before, when, as far as I know, it has always been concluded that such "Flexible scheduling" systems can only work well when remote observing is introduced. For example the SERC Panel on "Remote Observing and Time Allocation" considered these things in section 10 and Appendices G and H of its "ROTA report" issued in November 1983. Its Appendix G is in fact a copy of "Multiple Scheduling of UKIRT: Making the best use of the best time" written by Tim Hawarden and discussed by the UKIRT Users Committee in July 1982 as paper UUC(82)16. At that time sub-mm photometry was carried out on UKIRT so the same issues as for JCMT continuum observing now were thought of then.

So my message is twofold:

1) People should build on the work that was done by and the arguments put forward in the 1983 ROTA report.

2) The first thing to do is probably to work on getting remote observing going, then we can make good use of it by active scheduling.

Yours etc.

Jim Emerson
(Chairman UKIRT Users Committee)

Dear Editor,

Thank you for printing Henry and Wils' wide-ranging article in your "Points of View" column. Whilst agreeing with many of their suggestions (for example, those for streamlining the proposal process), I am unhappy with the final conclusion/suggestion that we will not have adequate scientific support unless we accept both increased numbers of JACH support staff, AND forcible collaboration with these scientists.

Emotive phrasing was used, but it would be wise to bear in mind a few hard facts about the JCMT operation. First, the support scientists ARE actually being paid to do their job, and experience at other telescopes (operating at all wavelengths), is that many support scientists subtantially further their scientific careers by acting in this role. Second, considering here just the UK aspect of this issue, it is clear that every additional UK support scientist employed at JACH represents, for example, roughly 2 fewer postdocs in the Universities. Thus there is a strong pressure for University researchers to resist an increase in JACH complement beyond the minimum required actually to do the job.

At many telescopes (UKIRT amongst them) there is every incentive for outside observers to collaborate (voluntarily!) with the local support scientists. If this does not apply at JCMT (as would seem to be the case), then we should consider why this is so. My own opinion is that astronomers tend to do a games–theoretic type of calculation before expanding the scope of a collaboration –– Is the reduction in my "share" of the scientific kudos offset by the increased scientific payoff obtained through the collaboration? This includes what I might call a "baseline" term –– Other possibilities for an individual university researcher have already been reduced by the mere construction and operation of the facility, and so a certain minimum return is expected in return for this payment, as of right (i.e. not subject to additional payments in the form of involuntary collaborations).

To put this somewhat abstract construction into more concrete terms, there seem to be two main issues at JCMT. First, the baseline costs of an observation in terms of lost home-funding, effort etc, are already very high (The effort expended by many members of the UK millimetre wave community in the planning, construction and commissioning phases enters into this also). Second, the incremental payoff obtainable by collaboration with local staff is at present not very high, one reason being that too few of the support staff have much experience of mm or submm observing at other established instruments.

The argument presented by Henry and Wil seems to depend greatly on the uniqueness of JCMT as a common user facility. Although JCMT IS at present a unique instrument, its operation is not different in substance from those of many other telescopes. The 12-metre at Kitt Peak has only one or two support scientists, is about 70 miles from a home base offering a similar range of outside activities to Hilo, yet seems to operate with much less expectation of ADDITIONAL return to the local staff. Similar comments might be made about the newer IRAM 30-metre telecope. So the only way in which JCMT differs substantially is in the increased pressure for remote and service observing generated by the somewhat fickle weather conditions at high frequencies.

In my experience many instrument builders measure their success, or lack of it, according to whether or not it is possible for other people to take good data with the instrument WITHOUT requiring a collaboration with its creator(s). I am surprised that the same attitude does not extend to the operation of larger facilities, such as the JCMT. That is, instead of the support scientists viewing themselves as (poorly paid) surrogate observers, living a life of servitude (Henry's phrase), it would surely be better for them to concentrate on improving the system performance, both technically and logistically. I for one would like to see the JCMT support scientists tackling the problems discussed in Henry and Wils' note, by devising an effective and workable flexible scheduling strategy, by removing the uncertainty from "standard" low frequency observing, and by making true remote observing (NOT this eavesdropping nonsense) available as soon as possible. I would expect that they would thereby obtain a measure of both personal satisfaction and professional recognition.

Yours etc.

Rachael Padman

## SOLAR ECLIPSE 1991

An Announcement of Opportunity for the use of the JCMT at the time of the eclipse will be issued towards the end of May 1990. If you are interested in receiving this AO and have reason to believe that you are not on our mailing list you are advised to contact the JCMT Section at ROE.

*Alex McLachlan*

**DIARY**

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