PROTO STAR

The NEWSLETTER of the

JAMES CLERK MAXWELL

TELESCOPE ~

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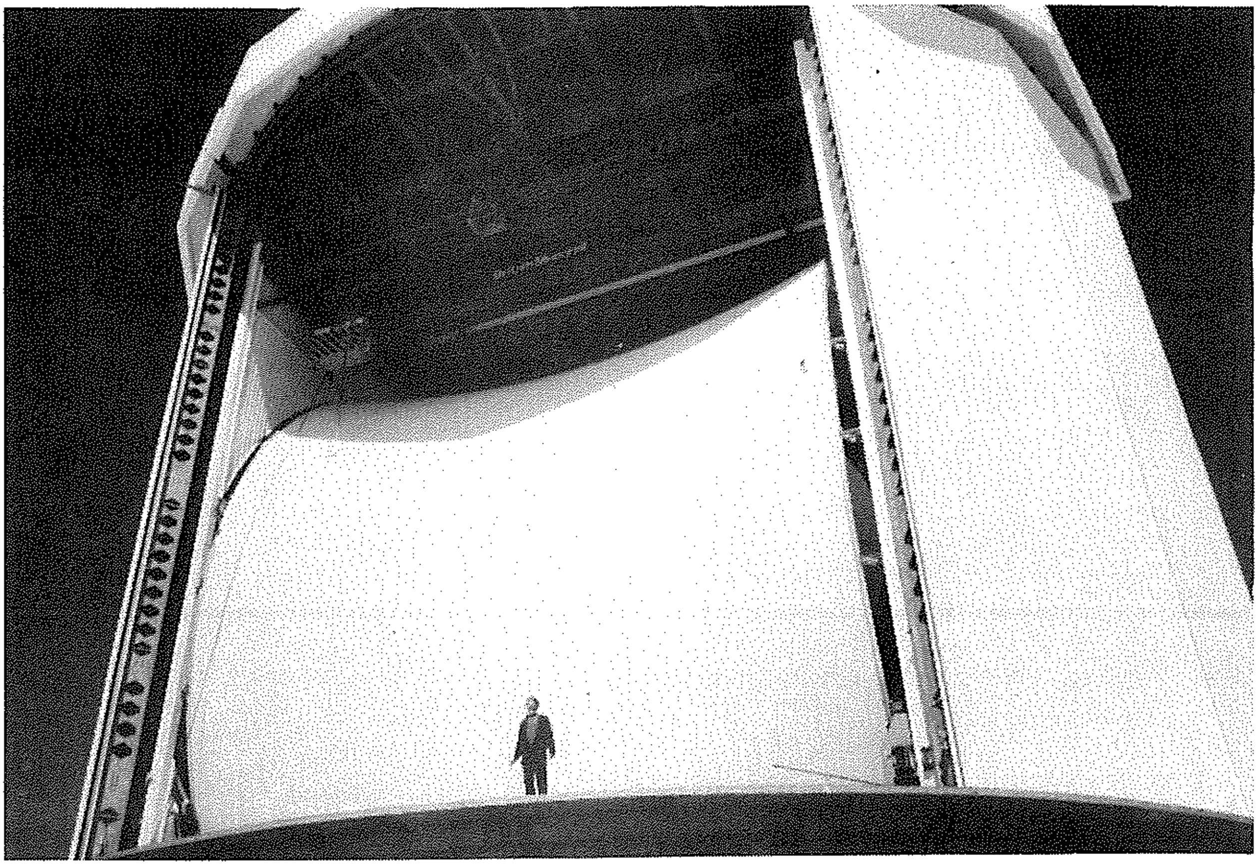

An unusual feature of the enclosure of the James Clerk Maxwell Telescope is the membrane of woven PTFE which can be raised to cover the viewing aperture. With the membrane in place the telescope is protected, during observing sessions, from winds up to 70km/hr and from the effects of solar radiation. The above photograph was taken earlier this year during installation of the membrane and shows Dr Jim Hall of the Rutherford Appleton Laboratory, who was responsible for the membrane, making his curtain call. The membrane absorbs such a small fraction of the submillimetre signal (<10%) that it will be in place for most types of observations although it can be removed when the weather is calm to enable sensitive broadband observations to be made which would be affected by the small amount of scattering that the membrane may cause. (Photograph courtesy of Dr J E Hall)

FOREWORD

One of the benefits of delaying the publishing schedule of a newsletter is that when an issue eventually appears there is more news to report. So it is with this issue of PROTOSTAR. In spite of the declared intention to publish every six months it is almost two years since the last (and first) issue. This has been largely due to the fact that the people best placed to report progress have been fully occupied making it. So industrious have been the project team, contractors and all concerned with the project that despite the inevitable hiccups and delays the formal handover to the Royal Observatory Edinburgh (ROE) for the start of the operational phase is still planned for 1 April 1987. As it is hoped to start observational programmes on that date this newsletter contains a lot of information for potential users on how to apply for observing time and on the expected performance of the receivers. Actual performance details of telescope and receivers will, of course, be published in future editions of the PROTOSTAR. It is also intended to make information more quickly available by placing it in data files that can be accessed via the STARLINK computer network; the file [JCMT]ACCESS.DOC on the Edinburgh node will give details of how this may be done.

THE JAMES CLERK MAXWELL TELESCOPE

Since the last issue of PROTOSTAR the telescope has acquired a new name. It is no longer the "UK/Netherlands Millimetre-wave Telescope" but the "James Clerk Maxwell Telescope". Naming the telescope after this great physicist is particularly fitting not only because he discovered the equations governing the electromagnetic radiation which the telescope collects for study but also because he established the kinetic theory of gases which describes so well the microscopic conditions in the molecular clouds of the Milky Way. Clerk Maxwell was, moreover, an astronomer, albeit a theorist; as a young man he proved mathematically that the rings of Saturn cannot be continuous, solid structures but must consist instead of large numbers of small bodies in similar orbits. The telescope which bears his name will be operated by the Royal Observatory Edinburgh so it is a fine coincidence that Clerk Maxwell himself was a Scot from Edinburgh, having been born there in 1831.

An interesting feature of his name is that Clerk is not a second forename but is part of the surname. Indeed it is the more important part, so Maxwell's Equations and the Maxwellian Distribution are somewhat misnamed and might more properly be referred to as Clerk's Equations and the Clerkian Distribution. This is so because James's father was John Clerk, and in Scotland one usually takes one's father's surname. The extension of the name came about because John's ancestors had twice married heiresses of the Maxwell family in the eighteenth century and he was in consequence in a position to inherit their estate in Galloway, in southwestern Scotland. The estate was, however, protected by a stipulation that it could only be owned by a Maxwell, in order to keep it in the family. James's father elegantly side-stepped this difficulty by changing his name to John Clerk Maxwell and James inherited both the name and the estate; indeed, much of his scientific writing was done there. Aside from any light it may cast on the Scottish legal system, this digression demonstrates that it is not quite proper to refer to the new instrument as the Maxwell Telescope or MT; the correct form, which we have been asked to use by his family, is the James Clerk Maxwell Telescope or JCMT.

PROGRESS SINCE OCTOBER 1984

Since the previous issue of PROTOSTAR:

The prefabricated telescope enclosure was erected on site in 1984 and fitted out during 1985. The telescope structures were erected for test purposes at the manufacturers premises in the Netherlands in April 1985 and then dismantled and shipped to Hawaii where they arrived in July 1985. Reassembly was completed in September 1985 and the telescope finished, apart from the surface panels and secondary mirror system, by the end of the year. Fitting of the panels and installation of drive systems and electrical systems were completed by February 1986. In the same month the membrane which serves as a wind-blind and sun-shield was installed (see photograph on front page). The secondary mirror was installed in May 1986.

CURRENT STATUS AND FUTURE PROGRAMME

Commissioning of the telescope and peripherals is well advanced. The telescope has been driven satisfactorily in azimuth and elevation. Pointing tests on stars are being carried out by means of an optical telescope fitted with a TV camera. Radio frequency tests will follow satisfactory alignment of the surface panels. Each of the 276 panels is mounted on three adjusters which contain stepping motors. These are driven under computer control and allow the panels to be moved in steps of three microns over a range of one centimetre. Correct alignment of the panels is essential to the efficient performance of the telescope particularly if full advantage is to be taken of the improved accuracy achieved in the manufacture of the panels; the surface error of the panels is 11 microns rms whereas the specification required 25 microns rms.

The techniques being used in setting the panels and measuring the surface accuracy include laser interferometry, holography and photogrammetry. The three systems will provide complementary data on the ability of the surface to achieve and maintain a defined paraboloid at different elevation angles of the telescope. In the following summary of the telescope specification the adopted surface accuracy is 50 microns rms from all causes, which would give coherent performance in frequencies up to 375 GHz; the improved surface finish is expected to raise the upper limit considerably.
Telescope formal specification:

Primary mirror diameter		15m
Blockage of primary (geometrical)		<5%
Frequency range	optimised	75-375 GHz
	useful	23-1000 GHz
Sky coverage (over full 360° azimuth)		5-89°.5
Pointing accuracy	absolute	5 arc secs
	tracking	2 arc secs

INSTRUMENTS

The frequency range over which the telescope will operate coherently is such that it will be possible to exploit the difficult atmospheric windows which are only partly open at high, dry sites such as Mauna Kea but completely closed at sea level. The windows expected to be available to the JCMT are shown in Figure 1: an early use of the telescope will be to determine the actual transmission and widths of the windows. Figure 1 illustrates the astronomical importance of the various windows and helps to explain the choice of frequency in the design of the detectors described below.

The receivers (front ends) and spectrometers (back ends) currently in use during the commissioning of the telescope will be augmented by others for the start of the operational phase. The following instruments are scheduled to be available for use on 1 April 1987; they include a bolometer continuum receiver on loan from the nearby UKIRT Observatory.

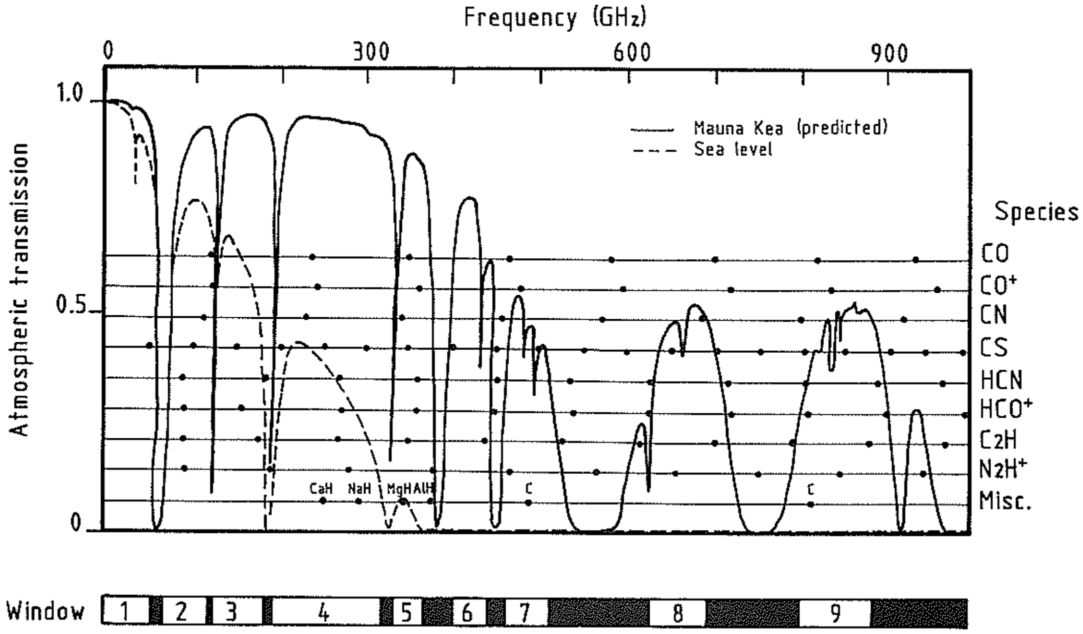

Figure 1: The frequencies of the millimetre transitions of some interesting light molecules related to the atmospheric windows.

<u>Summary of Receiver Specifications</u>

1. Heterodyne Systems

i) Front End "A" (230 GHz CO J = 2-1 line).

Detectors: Two Schottky-diode Mixers accepting orthogonal linear polarizations. Closed cycle cooling to 15K.

Receiver Noise Temperature: about 700K Single Sideband on each channel.

Frequency Coverage: approximately 1 GHz at each of 222 and 230 GHz, with 500 MHz instantaneous bandwidth.

Optics: f/12 input to match offset Cass on JCMT. Full facilities for calibration, alignment and chopping against a cold load are provided. The LO coupler is a dual polarizing Michelson interferometer and the single sideband filter is a Fabry-Perot.

Local Oscillator: frequency-tripled phase-locked Gunn oscillator.

Intermediate frequency: 4 GHz cooled FET amplifiers.

Control and Monitoring: Microprocessor connected to VAX by GPIB.

Comment: It is hoped that the receiver noise temperature will be about 700K in each channel, giving the same sensitivity as a single channel system with 500K. The best result in the literature at this frequency is just under 400K.

Enhancement of Front-end "A" for the operational phase.

The 230 GHz commissioning receiver will be equipped with new mixers, multipliers and LO sources to cover as much as possible of the band from 220 to 280 GHz. Additional remote control features will be added to allow at least small frequency changes to be carried out from the computer.

ii) Front End "B" (345 GHz receiver)

Detectors: Schottky-diode mixer with closed-cyle cooling.

Receiver Noise Temperature: approximately 800K Single Sideband at 345 GHz, rising to 1000K near the edges of the band.

Frequency Coverage: 320 to 370 GHz Instantaneous bandwidth 500 MHz at 345 GHz.

Optics: To match f/12 JCMT Cass focus. Ambient and hot loads for calibration. Folded Fabry-Perot LO coupler.

Local Oscillator: Phase-locked Carcinotron with remote high-voltage supply.

Intermediate Frequency: 1.5 GHz cooled FET amplifiers.
Control and Monitoring: Fully-automated remote-control of all major functions. GPIB compatible.

Comments: This is the system which was to have been used on UKIRT. At 345 GHz the sensitivity should be state-of-the-art and the level of automation is higher than has been achieved anywhere else.

2. Bolometric System (UKT14 - to be loaned by UKIRT)

Detector: Single He3-cooled Composite Ge Bolometer. Detector sensitivity (NEP) < 5 x 10^{-16}W/root Hz.

Typical System Sensitivity on Telescope: (1 sigma 1 second) < 0.25 Jy. This figure depends on many factors including the frequency, bandwidth and the stability of the atmosphere. It does not include the absorption due to the atmosphere so that in the shortest wavelength windows the actual sensitivity will be substantially lower than this.

Frequency Coverage: 150 to 1000 GHz (2mm to 0.3mm). There will be 8 remotely-selectable filters covering all the main atmospheric windows with a mix of broad filters (for maximum sensitivity) and narrow ones (for best precision in measuring source spectra and characterising the telescope).

Optics: f/35 to match both UKIRT and the Nasmyth focus of the JCMT. Chopping secondary is essential.

Polarimetry: a rotating-grid polariser is nearing completion which will enable UKT14 to carry out polarimetry on either telescope.

Data Acquisition: commercial lock-in amplifier and integrator connected to the VAX by GPIB interface.

Comment: This is one of the most advanced bolometric mm/submm receivers in existence. Even on Mauna Kea the sensitivity will normally be limited by atmospheric fluctuations rather than by detector noise, except in the longest-wavelength windows.

3. Backends.

i) Digital Auto-correlator

This is the digital auto-correlator which has been in use on UKIRT for several years. It will be modified to provided GPIB compatibility.

Digital section: 1-bit correlator, 512 channels, 95 MHz clock rate. Can be run in 1, 2, 4 or 8 sections. Built-in micro-processor and storage for ON and OFF spectra. Minimum integration time 1 sec (at present).

IF section: 8 channels each 45 MHz wide with 40 MHz spacing. Input frequencies 190 to 510 MHz.

Comment: We believe this was the first "hybrid spectrometer" to be constructed with a substantial number of channels. This technique of combining digital sections to form a very wideband backend is now being taken up elsewhere. The use of 1-bit digitisation is equivalent to an increase of about 50% in the noise.

ii) Acousto-optical Spectrometer (AOS)

Channels: Two channels operating simultaneously, each sampling 1024 spectral points. Input centre frequencies both 250 MHz.

Broad Channel: 500 MHz bandwidth, 1 MHz resolution.

Narrow Channel: 50 MHz bandwidth, 100 kHz resolution.

Control and readout-out: Built-in microprocessor. GPIB connection. Highly temperature stabilised to give good baselines.

Comments: This is the backend built to go with the 345 GHz front end. It is similar to AOS's recently constructed elsewhere although it is exceptionally compact and well-stabilised.

4. IF System

Channels: Total 4 to accommodate 2 dual-channel receivers. Amplification, down-conversion, cabling to the control room with slope compensation, plus level setting and regulation are provided for each channel.

Input frequency: Two channels at 4 GHz, two at 1.5 GHz.

Bandwidth: 1 GHz.

Outputs: Detected total power plus down-converted signals to drive the Correlator and the AOS. Microprocessor control and monitoring with GPIB connection to VAX.

APPLYING FOR OBSERVING TIME ON THE JCMT

Time on the JCMT will be allocated competitively. Astronomers wishing to use the telescope should first complete a standard form of proposal and then send it in for assessment by a group of their peers known as the Panel for the Allocation of Telescope Time (PATT). This is the standard way of obtaining time for astronomical projects on the JCMT and should be followed by all applicants whether they are from the United Kingdom, the Netherlands, the University of Hawaii or the wider astronomical community. A separate proposal is required for each distinct astronomical project but there is no limit to the number of proposals which an individual or a consortium may submit. The function of PATT is to check each proposal for feasibility, to compare its scientific merit with that of other proposals and to award observing time accordingly.

If the demand for the SERC's other telescopes is any guide it is likely that the JCMT will be oversubscribed, with more time being requested than is available. In that case not all the proposals can be granted time and even those which are favoured may be awarded less time than was requested. PATT awards a length of time to a proposal and the Astronomer-in-Charge (AIC) of the telescope schedules the actual dates. This he does with regard to such constraints as availability of the necessary equipment, the accessibility of the astronomical targets and the prior commitments of the observers; the PATT application form contains sections for applicants to give their preferences on the last two topics.

PATT operates on a cycle of six months duration. Each year is divided into two semesters: 1 March-31 August and 1 September-last day of February respectively. The Panel convenes twice annually in order to allocate time for the following semester. Applications may be sent to PATT at any time but there are deadlines which must be met if they are to be considered for a particular semester. These deadlines are:

7 November for the following March-August semester
7 May for the following September-February semester.

The plans for the operational phase of the telescope call for it to be used for 16 hours a day, seven days a week. Potential users should note, however, that the amount of time likely to be available in the first semester will be much less than that planned for later semesters when the telescope will have been fully commissioned. There are two reasons for this. First, the earliest date on which common-user observations can commence is one month after the canonical start of the semester, so at most five months will be available instead of the usual six. Second, there will be an unusually large amount of discretionary time allocated for engineering purposes to the Astronomer-In-Charge; this amount has not yet been determined but it is not likely to be smaller than 30 percent.

The postal address to which applications should be sent is the following:-

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.

PATT has been in existence for many years and the way in which its present structure may best be altered in order that the new telescope be included in its deliberations is under discussion. The details are not yet decided but it does seem possible that a subset of the Panel will be constituted specifically to handle applications for both telescopes in Hawaii, the JCMT and the UKIRT.

IMPORTANT: Applications which are intended to be considered for the first semester in which the JCMT will be operational, Semester L (1 April-31 August 1987), must be received by the PATT Secretariat in Swindon on or before 7 November 1986.

RESTRICTIONS: When planning their submissions, PATT applicants should be aware of the following restrictions on the use of the telescope and the instruments.

i) The RF properties of the telescope depend critically on the accuracy of the surface, which is not yet known, so it is not yet possible to say what the telescope efficiency will be at the time of the first observations. The performance will undoubtedly be better at long wavelengths than at short and can be expected to improve with time, especially at the short wavelengths. Potential users of UKT14 who require diffraction-limited performance are advised to consider the JCMT only for the long wavelengths in Semester "L" and to apply for UKIRT time for the short.

(ii) It is not a minor matter to transport UKT14 from the one telescope to the other so this procedure will be carried out as infrequently as possible, and perhaps only once per semester. It follows that no proposal should be made which calls for the use of UKT14 on both telescopes; two separate trips to Hawaii may be necessary so two separate applications should be made.

(iii) Whilst mixers will be provided on Receiver A which will cover the whole band from 220-280 GHz, it is not yet clear whether the local oscillator system will also cover the whole band or only a few important transitions. It is hoped that information will be available before the PATT deadline; if so, it will be placed on STARLINK. It is in any case likely that the following three transitions will be covered, albeit only in the most common isotope: CO (2-1), HCN (3-2) and HCO+ (3-2).

(iv) Changing the frequency of Receiver A from the lower half-band (220-250 GHz) to the upper (250-280) or vice-versa will involve changing the mixer blocks within the cryostat. This is a major procedure which will be carried out as infrequently as possible, and perhaps only once per semester. In consequence, no PATT proposal should be submitted which requires observations at frequencies both above and below 250 GHz; two proposals are required instead. No such restriction applies to frequency changes within either half of the band.

(v) The frequency stability of one of the commercial components in the phase-lock loop of the local oscillator in Receiver A is disappointing and will result in narrow spectral lines being broadened artificially by something between 0.5 and 1 km/s. It is planned to replace this component with something better, but this may not be possible in time for the first observations. The broadening is too slight to degrade most types of observation but studies requiring the highest possible frequency resoltuion, such as detailed measurements of line profiles in quiescent dark clouds, may not be feasible.

(vi) For Receiver B there are no restrictions on the frequencies which may be requested in a single PATT application, but users are asked to plan their observations in such a way as to reduce the number of frequency changes to a minimum. The reason is that every time the frequency is changed a backshort in the mixer block is adjusted, and this component suffers from mechanical wear which steadily degrades the performance of the receiver until the backshort has to be replaced in another major piece of open-cryostat surgery.

(vii) The carousel membrane is made of a material, woven PTFE, which was carefully chosen for its high transmission at millimetre wavelengths and for its efficiency in reflecting solar heat and light. The presence of the membrane in the telescope beam should have a negligible effect on the great majority of observations so it is planned that the standard observing configuration will be with the membrane in place. Raising or lowering the membrane requires time and effort and causes wear, and will be done as infrequently as possible. Users who wish their observations to be made with the membrane out of the way should therefore make a strong case for its removal in their proposals to PATT. They should also be aware that there are likely to be extra constraints on the use of the telescope with the membrane removed.

PERSONNEL

Dr Adrian Webster has transferred from ROE to Hawaii and is now the Astronomer-in-Charge of the JCMT. His successor as head of the JCMT section at ROE is Dr Jocelyn Burnell.

Also destined for posts in Hawaii are new recruits Dr Graeme Watt and Mr Adrian Russell while the ROE team will be strengthened with the appointment of Dr Walter Gear.

THE JCMT USERS' COMMITTEE

The JCMT Users' Committee was set up to give advice to the SERC on the scientific development and exploitation of the telescope. It is the principal channel of communication between the telescope users and the project, and potential users may find it of value to know who the present members of the Committee are:

Professor R.D. Davies (Chairman), Manchester
Dr P.A.R. Ade, Queen Mary College
Dr J.M. Brown, Oxford
Professor W.B. Burton, Leiden
Dr A.M. Flett, Aberdeen
Dr J.H. Hough, Hatfield
Dr R.D. Joseph, Imperial College
Dr G.H. Macdonald, Kent
Dr P.F. Scott, Cambridge
Dr H. van de Stadt, Utrecht
Dr G. White, Queen Mary College
Professor D.A. Williams, UMIST
Dr G. Wynn-Williams, Hawaii

DIARY

7 November 1986: Last date for applications to PATT for semester March-September 1987.

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