THE UNITED KINGDOM INFRARED TELESCOPE
ANNUAL REPORT
1999

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January 2001
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UKIRT is operated by the Joint Astronomy Centre on behalf of the U.K. Particle Physics and Astronomy Research Council
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Back cover: True-colour mosaic of the Galactic Centre from observations made in the J, H, and K filters in July 1999 by A. Chrysostomou and C. Davis. The image covers a region extending about 5.0 x 4.5 arcmin.
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Introduction

S.J. Warren, Chairman, UKIRT Board

The previous annual report (1998) described the improvements brought about by the upgrades programme, and the splendid imaging performance that UKIRT observers now enjoy. The upgrades programme is all but complete and was a major milestone, but the efforts of the UKIRT staff to enhance further the performance and reliability of the telescope, the efficiency of operations, and the level of service, have continued through 1999. Principal among these has been the implementation of the first stage of the ORAC software system, and observers have been enthusiastic about the ease of use and the fast and sophisticated data reduction. Other advances have been the commissioning of polarimetry capability with IRPOL on the UFTI and CGS4 instruments, the acquisition of a new secondary mirror, the implementation of automatic telescope focus, and the first trials of flexible scheduling, which can be expected eventually to become the norm, allowing programmes that require exceptional seeing, or low water vapour column, to be implemented when the conditions allow. The fault rate over 1999 was only 2.6% of science time, and the observer reports show clearly that astronomers using UKIRT appreciate the high level of service provided by the staff. In 2000 the final element of the upgrades programme, cooling of the primary mirror, will be completed and observers can expect excellent image quality most of the time.

The interest in the near infrared continues to grow. There are two areas which have been particularly active, the detection of highly reddened distant galaxies (EROs, sub-mm galaxies, and obscured X-ray sources), and the study of brown dwarfs (the newly defined L and T classes). As reported under ``Scientific Highlights" astronomers using UKIRT have been at the forefront of these new fields as they have opened up.

Progress on Michelle was disappointing through 1999, but at the time of writing the corner has been turned. UKIRT has an active instrumentation programme, adapted to the advent of Gemini, that will keep the telescope in heavy demand at the opening of the new millennium.
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1. The United Kingdom Infrared Telescope

Situated at an altitude of 4194 m above sea level near the summit of Mauna Kea, the 3.8-metre UK Infrared Telescope is the world's largest dedicated infrared telescope. UKIRT is owned by the UK Particle Physics and Astronomy Research Council (PPARC), and operated by the Joint Astronomy Centre, Hilo, under the oversight of the UKIRT Board. Apart from an automatic 15% allocation to the University of Hawaii, time on UKIRT is awarded in peer-reviewed open competition to the world community by PPARC's Panel for Allocation of Telescope Time.

The purpose of UKIRT is to support high-quality fundamental observational research in astronomy. It does this by providing to its user communities infrared astronomical instrumentation maintained at the state-of-the-art through a vigorous programme sponsoring instrument development in the UK, by continually improving the performance and observational efficiency of the telescope and its existing instruments, by providing its users with comprehensive support of the highest quality, and by identifying opportunities to upgrade its existing instrumentation and software.

A comprehensive programme of upgrades, combined with an instrumentation programme tailored to the telescope's performance, has resulted in increased light grasp and spatial resolution for UKIRT. The instrument suite will always be characterized by high throughput and efficiency, and UKIRT's imaging and spectroscopy capabilities remain highly competitive on Mauna Kea. 1999 saw the completion of the first stage of a programme of advanced software development intended to improve the operational efficiency of UKIRT. 1999 saw the completion of all but one element of the UKIRT Upgrades programme; 2000 will see the final implementation of the last: cooling of the primary mirror. The secondary mirror, which suffered from lightweighting print-through and a considerable degree of trefoil aberration due to thermal effects in the mounting pads, was replaced with a new mirror which enables the imagers to deliver image quality fully in line with the wavefront delivered by the rest of the telescope. 1999 was the first full year of operation for the UKIRT Fast-Track Imager, which confirmed UKIRT's extremely good imaging quality. The year has also seen further improvements in our understanding of the telescope environment and its effect on performance. UKIRT's staff members are increasingly shared with the other JAC facility (the JCMT submillimetre observatory); the equivalent number of staff working at UKIRT remains approximately 30.
2. Scientific Highlights from 1999

UKIRT is used to provide data for a remarkably wide range of science programmes; highlights are identified below from the two semesters in 1999. The year was characterized by the widespread use of UFTI for programmes ranging from photometric studies at the bottom of the main sequence and beyond, to studies of morphological properties of galaxies at high redshift, and the followup of deep surveys with SCUBA on the JCMT and space-based X-ray surveys. UKIRT's image quality has been likened to HST/NICMOS by observers and its powerful infrared imaging capability complements the optical imaging possible on the 10-metre-class telescopes on Mauna Kea. A good example of this is the composite R,I,K image of Abell 851 produced by Smail and collaborators, shown in Figure 1, which used the Keck for the short wavelengths and UKIRT for the K-band.
CGS4 remains a workhorse for many other extragalactic programmes; this year saw the first results from a major near-infrared survey of nearby spirals (Hawarden (JAC) et al.) -- including the detection of a class of infrared-luminous galaxies whose nuclei exhibit H$_2$ line emission but few or no other lines. Very recently this has been confirmed in two objects showing Pa $\alpha$ weaker than 1-0S(1) and no detectable [FeII] emission.

Brown dwarf studies have been increasingly important for UKIRT over the last two years, both in terms of the production of candidate lists, their verification and their spectroscopic followup. 1999 saw good examples of all three of these areas. Lucas (then Oxford) carried out CGS4 spectroscopy to detect water vapour absorption in, and thus verify the nature of, the Orion brown dwarf candidates located with UFTI in the previous year; Leggett (JAC) and coworkers used CGS4 to detect water vapour and methane absorptions in objects detected in the Sloan survey; Jameson (Leicester) and collaborators used infrared colours from UFTI to confirm brown dwarf members of the Pleiades cluster; and Longmore and Casali (UKATC) used UFTI to push YSO surveys in the Ophiuchus dark cloud down to the brown dwarf regime.
Work on the early stages of star formation is a constant backdrop to UKIRT science. This year saw the combination of UKIRT's high spatial resolution with spectroscopy, producing the identification of spinning `microjet" structures near to a sample of these objects, which might be the key to the long-standing problem of carrying angular momentum away from the rapidly-spinning central object (Smith (Armagh) et al.).

Transient objects and targets of opportunity remain a UKIRT speciality, this year seeing the continuation of the long-term programme monitoring Sakurai's object. The development of the spectrum is now steadying, with little spectral structure and only a single helium line (probably formed outside the main ejecta shells) superposed on a strong, featureless dust continuum. We present in Figure 2 the time-development of the object's spectrum as determined from UKIRT spectroscopy over the last five years; the dramatic changes in the spectrum have been used to diagnose physical conditions in the ejecta (Evans (Keele) and collaborators). Secondly, the fast-moving asteroid 1999RQ36 was observed when at a distance of only 2.2 million km from the Earth, allowing its surface properties to be determined (Geballe (Gemini) observing the asteroid as a target of opportunity for Davies, JAC).

Solar-system highlights also include the determination of thermospheric temperatures on Titan, the detection of cloud formation on Uranus (UKIRT forecasting weather on an outer-solar-system object! - Geballe (Gemini) and collaborators) and the first detection of hydrated minerals on the surface of a stony asteroid (Davies (JAC) et al.).
Figure 2: Development of the energy distribution of Sakurai's object, note the strong He 1.08 µm line in emission in the later plots. Data courtesy of A. Evans.
3. Report on Operations

3.1. Summary

- UKIRT's fault rate improved by a full percentage point, with 2.6% of science time lost to faults in 1999 compared to 3.5% in 1998. This is a great achievement by UKIRT staff in a year which saw the full release of UFTI as a common user instrument, the completion of the UKIRT upgrades programme, and considerable changes to computing arrangements at the summit. Weather losses were similar to the previous year, at around the 10% and 20% level in the "A" and "B" semesters respectively.
- ORAC development continued to installation of the system with UFTI in October, followed quickly by a decision to attempt a "big bang" release including retrofitting to the legacy instruments in the summer of 2000.
- Emissivity varied considerably through 1999, and our ability to measure it improved at the same time with reflectometer and photometry giving good additional checks on its value.
- UKIRT's image quality remains high, with many nights delivering 0″3 seeing. The superlative seeing which characterized the entire month of September 1998 has not yet returned, but half-arcsecond nights remain commonplace, 0.7 arcsecond is poor, and steps are being taken to enable flexible scheduling of programmes with stringent seeing requirements.
- UFTI continues the trend toward smaller pixel sizes driven by the telescope's improved image quality. Some hardware problems, internal to the cryostat, were solved in-house and the instrument was being used with IRPOL by late 1999. This gives UKIRT a unique polarimetry capability on MK.
- ORAC-DR, the in-house part of the ORAC project, was the subject of considerable interest from other observatories and continued its development for UFTI and IRCAM data reduction.
- The MPIA Shack-Hartmann system was implemented by N. Rees. This system enables automatic focussing of the infrared instruments without reference to the infrared image quality, and also permits an independent, quick estimate of the atmospheric seeing.
- A recurring theme of reports filed by visiting observers is that the support afforded by UKIRT staff in 1999 was of the highest quality.
## 3.2. Telescope Usage

The following table summarizes telescope usage for the two semesters 99A and 99B, which cover the period February 1, 1999 to January 31, 2000.

<table>
<thead>
<tr>
<th>Semester</th>
<th>99A</th>
<th>99B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of nights</td>
<td>180.5</td>
<td>176.7</td>
</tr>
<tr>
<td>Eng. and Commissioning Time</td>
<td>28.0</td>
<td>28.8</td>
</tr>
<tr>
<td>Nights available for observing</td>
<td>152.4</td>
<td>147.9</td>
</tr>
<tr>
<td>Nights observed</td>
<td>87.3%</td>
<td>72.8%</td>
</tr>
<tr>
<td>Nights lost due to faults</td>
<td>2.5%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Nights lost due to bad weather</td>
<td>10.2%</td>
<td>24.5%</td>
</tr>
</tbody>
</table>
3.3. Telescope and Enclosure

In July 1999, the MPIA guider system was extended to allow rapid adjustment of telescope focus. This configuration employs a 2 x 2 Shack-Hartmann lenslet array to measure focus at 60 Hz. The individual measures are averaged and then applied, and the process repeated, over a series of increasingly long integrations, ending with 32 s. The whole process takes about 62 s, replacing a less reliable procedure taking tens of minutes, greatly enhancing the efficiency and convenience of focus checks. The procedure gives the best-focus position of the autoguider assembly as set for the particular instrument: this (internal) setting is carefully remeasured after each engineering period. As a byproduct the RMS focus variation (the "z-rms") is determined. This is a pure function of seeing, which can therefore be investigated independently of telescope and instrument performance. This was used to show a clear "dome seeing" dependence on the temperature difference between dome and outside air, and also to aid in the flexible scheduling experiments (see §3.6.3). A new secondary mirror was installed in June 1999. The previously installed mirror suffered from lightweighting print-through and a considerable degree of trefoil aberration due to thermal effects in the mounting pads; the new secondary has none of these aberrations. The typical RMS wavefront error has been reduced from 350 nm to about 180 nm, only about 30% from formal diffraction-limited performance at 2µm.

The dome ventilation system worked well throughout 1999; the protocol for operating this system is now firmly established. There were few problems with telescope control, apart from some imbalances which occasionally caused slewing difficulties at large airmasses. It was decided to prepare for future implementation of the JCMT's Portable Telescope Control on UKIRT by installing an interface to the existing TCS. Work on this system progressed very well, and the TCS is not a critical item in the plan to have ORAC working for all instruments in summer 2000. In the run-up to the arrival of Michelle, efforts were made to better characterize changes in the telescope emissivity. The measurement protocol was tightened considerably, and detailed investigations of the emissivity spectrum were begun. A hydrocarbon emission feature, possibly originating in the mirror covers, was identified, which might account for some few percent additional emissivity when the 150 grating is used to perform the measurement. The comparison between emissivity and photometric zero-points proved powerful in analyzing the causes of emissivity changes, and the patchy nature of photometric zero-point determinations (which are largely tied to standards nights) will be improved with increasing use of ORAC to control observations. Once ORAC is fully in place, all aspects of telescope performance assessment will be consolidated through continual, semi-automated monitoring of focus measurements from the Shack-Hartmann system, photometric zero points and the seeing FWHM from every standard-star measurement.

Finally, the UKIRT control room was refurbished in early August 1999. It is widely agreed that the new room is a great improvement, and it certainly conforms more closely to recognized ergonomic and health/safety standards.
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3.4. Instruments

3.4.1. CGS4 (1-5 µm multiple resolution spectrometer with 256 x 256 array)

GS4 operated extremely successfully throughout 1999, with only 0.5% of clear time lost to faults in semester 99A and 1.2% lost in 99B. Read noise was kept consistently low (40 electrons and below, down to 25 for long exposures). The new CVFs survived four thermal cycles without any sign of the crazing of which the manufacturers, OCLI, had warned. The 40 lines/mm grating remains the workhorse grating. The echelle was in use for one month at the beginning of 99A, but was replaced by the 150 lines/mm grating for the rest of the semester. The echelle was put back in place in November 1999 for the winter star-formation period. Two recurrent problems were cured during 1999: blackbody unit datum failures and inaccurate grating settings (cured by removing debris from the grating datum wheel brakes). A minor problem with the offset angle between the one and two-pixel slits manifested itself to the detriment of a polarimetry run in 99B; the method by which the offset angle is measured has been improved. Following the successful integration of UFTI with ORAC and the clear gain in efficiency offered by ORAC control, it was decided that CGS4 would be controlled by ORAC from May 2000 onward.

3.4.2. IRCAM3 (1-5 µm camera with 256 x 256 array)

IRCAM was used for 15% of the PATT nights in Semester 99A, and in its re-engineered form for 4% of the PATT time in Semester 99B. After a cryogenically eventful semester in which compressor problems caused two warmups, IRCAM spontaneously warmed up the night before its final removal from the telescope for conversion to a smaller pixel scale appropriate for thermal imaging with the upgraded telescope. The new format was successfully commissioned at the start of semester 99B, and sensitivity appears to be good. Transformations between photometric systems (old IRCAM to TUFTI with new consortium filters) were determined and a programme to increase the number of L' standards was begun in semester 99B. The M-band performance is still being determined. IRCAM data are now reduced using ORACDR; recipes suited for high-background imaging were implemented during commissioning. There were two ongoing sources of faults with the instrument - a datum problem with one filter wheel and ALICE BDS errors. The ALICE electronics were refurbished in June as part of an ongoing investigation of this long-running problem (which was present at delivery of the instrument). While the IRCAM ALICE controller shows BDS errors, the CGS4 system does not, for reasons that are not yet understood. As the CGS4 ALICE produces lower read noise, that rack will be kept with CGS4 until such time as matching the noise performance becomes possible. Following the successful integration of UFTI with ORAC and the clear gain in efficiency offered by ORAC control, it
was decided that IRCAM would be controlled by ORAC from May 2000 onward.

### 3.4.3. UFTI (1-2.5 μm camera with 1024 x 1024 array)

UFTI was used for 32% of the PATT nights in Semester 99A, and for 37% of the PATT nights in 99B. The instrument was initially ``shared-risk" and shake-down of the system continued to the end of 99A. Documentation improved, the number of data reduction recipes increased, and operational procedures were consolidated, throughout the period. In April the polarimetry prism was installed. Re-engineering in January and April improved the reliability of the filter wheel mechanisms. Photometric transformations were determined to the old UKIRT Standards JHK system; work on the UFTI IZ system is ongoing. UFTI has demanding memory and processor requirements, particularly for large-area mosaics. This revealed itself in a number of failures of the summit data reduction (and some impact on other instruments' reduction systems), which were mitigated by installation of additional memory, the provision of "basic" reduction recipes which bypass some of the more advanced steps, and the installation of less leaky algorithm packages.

### 3.4.4. Accessories

1999 was an eventful year for polarimetry, with IRPOL commissioned in two new modes. Commissioning of IRPOL with UFTI took place in June 1999. At near-infrared wavelengths (J--K) the efficiency and instrumental polarization were measured to be good (around 99% and below 0.5% respectively). Polarimetry may be possible in the I and Z-bands if a suitable flat fielding method can be developed. IRPOL was also used, for the first time, with CGS4 and the medium-resolution (150 l/mm) grating in semester 99B. Some difficulty was encountered in aligning the orthogonally polarized (e- and o-) beams with the CGS4 slit, but this issue is now better understood and a more precise alignment procedure was developed. L- and M-band characterization measurements were obtained in 99B; these indicate that the (wavelength-dependent) efficiency levels are high: >90% in both bands. IRPOL remains a popular add-on facility with all of the instruments at UKIRT, and UKIRT's spectropolarimetry and imaging polarimetry capability remains unique on Mauna Kea. Of the 42 PATT proposals awarded time in 99B, 5 requested IRPOL (3 with CGS4, one of these -- a starred project -- at M-band); a sixth University of Hawaii project also used IRPOL with UFTI for 5 consecutive nights.

The 350 km/s Fabry-Perot interferometer was not used in 1999.

### 3.4.5. Visitor Instruments

Two visitor instruments saw time on UKIRT in 1999. MAX, the MPIA camera, returned to UKIRT in December 1999. This run was not a success instrumentally, with various communications problems preventing significant observing, and the team fell back to UKIRT facility instruments. MICS, the Japanese ten-micron imager/spectrometer, was not made available since the MICS team remains committed to COMICS development for Subaru. TRISPEC (PI: Sato) was not allocated time by PATT in Semester 99A. Further proposals were submitted for 00A, and it is likely that TRISPEC will see UKIRT time in February/March 2000. MIRAC (PI: Hoffmann) was not awarded time on UKIRT in 99A. It will be at the MMT for an extended period and is unlikely to come to UKIRT in 2000.
Highlights of the early part of the year included the continued development and improvement of UFTI data reduction recipes (including recipes for moving objects). In the summer of 1999, the Shack-Hartmann autofocus system was implemented, and considerable improvements were made to the mount servo. On the instrument side, software for TUFTI/IRCAM was commissioned. The UK mirror site of the UKIRT archive saw considerable traffic. The ORAC project, which will unify all future UKIRT data acquisition and reduction, continued its development and achieved initial delivery of the system for use with UFTI in October 1999. Essentially all software effort from October onwards went into the preparation for a “Big Bang” release, supporting all instruments including CGS4 and IRCAM, in mid-2000. This included significant work on the Telescope Control System as well as replacing the VAX-based instrument user interfaces.
3.6. Other Developments

3.6.1. Service Observing

Service observing is carried out on approximately nine nights per semester, a level agreed with the PATT UKIRT TAG. An analysis covering the period May 1999 - May 2000 produces the following results: during this 12-month period, 60 service applications were received. For a nominal 2.5 hours/project this amounts to 150 hours or about 15 nights. Given that not all nights are clear, the normal allocation is considered appropriate. Proposals were received from all over the world, from mainland USA (8 proposals), Germany (6), UK (35), India, Greece, Netherlands, France, Italy (1 each). 34 projects were deemed completed and at least some data were taken for another 23. Common themes included: brown dwarfs, often confirming SDSS candidates; monitoring of Supernovae; binaries and transients, especially X-ray transients; multiwavelength campaigns involving spacecraft; recovery of PATT projects via one-off calibrations or missing fields. Publications arise from the Service programme at a slightly higher rate than from normal UKIRT operations. This reflects the limited nature of the programmes carried out, the fact that in many cases the data are reduced by UKIRT staff, and the fact that many service programmes are key to completing papers based on work carried out at UKIRT and elsewhere.

3.6.2. Reactive Scheduling

In semester 99A, 10 nights were allocated for reactive recovery of "$\text{\textasciitilde starred}$" projects (U/99A/17 Eales and U/99A/61 Cotter), for an ongoing commitment to the "$\text{\textasciitilde starred}$" LT46 project to monitor Sakurai's object, and to compensate projects over-ridden by GRBs etc. Approximately half this time was required to complete the two in-semester programmes. The remainder was distributed between overridden programmes, targets of opportunity, UFTI training and engineering. In semester 99B 12 nights were allocated for reactive recovery, 10 of which were allocated to "$\text{\textasciitilde starred}$" projects (U/99B/08 Eales and U/99B/49 Hodgkin) and the LT46 project. The two new programmes required considerable reactive recovery; these observations were carried out by T.Kerr, T.Hawarden and C.Davis. The effectiveness of the reactive scheme is clearly demonstrated by the completion statistics on these two programmes: given the original scheduled time only, Eales' programme would have achieved only 17% completion; by the end of the semester, it was 77% complete. Similarly Hodgkin's proposal was 100% complete by the end of the semester while classically it would have been only 36% complete.

3.6.3. Flexible Scheduling

Two experiments investigating the requirements of flexible scheduling on the basis of weather conditions were carried out in semester 1999B. The objective was to meet the needs of relatively demanding (better than 0.5" seeing) imaging programmes by flexing them against observations with less stringent requirements. In one case the "$\text{\textasciitilde most demanding}$" observer was present and was expected to fall back to a less demanding project if required. In
the other case the reverse situation applied. In one case the alternate project was a mixture of observations drawn from the service-observing queue, in the other it was a self-contained project of basically similar observations. For each run the absent PI was asked to supply a detailed observing plan for review by the actual observer. In addition a set of guidelines was established, setting out the rules for switching between projects and determining how any time lost would be charged to each project. Overall the experiment was successful: the two projects requiring good seeing obtained more data in appropriate conditions than they would have done in a traditional fixed schedule. The flexing process also allowed a better match of observing windows with target RAs for all the projects involved. A number of lessons were learned which must be applied to further developments in this area. The JAC overhead was about 50-60% greater than would have been required to support a single observer who made their own target lists, wrote their own tapes etc. To mitigate this overhead through use of software tools will be a key to any future flexible scheduling of UKIRT.

3.6.4. Newsletter

The Newsletter was published twice, preceding PATT deadlines, edited by C. Davis.
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4. Approved Programme

UKIRT's approved development programme provides for maintenance of UKIRT's outstanding imaging performance after the completion of the upgrades programme, reduction in telescope emissivity, and the development of new instruments. In the longer term potential development strategies focus on UKIRT's role in support of the large new telescopes now coming on line.

4.1. Completion of the UKIRT Upgrades Programme

The outstanding imaging performance demonstrated in the seeing monitoring programme in 1998, which yielded a median image FWHM of 0.433" between February and October 1998, and an unparalleled median FWHM of 0.265" over the month of September, has not been matched in 1999. Though images of 0.3" to 0.4" have occurred regularly, the expectation of performance has been in about 0.5" and the quarter-arcsec images of 1998 are now suspected to be a legacy of the El Nino weather pattern of 1997-1998. Nevertheless efforts have continued to ensure that the intrinsic performance of the telescope is maintained and improved.

4.1.1. New Secondary Mirror

The replacement secondary mirror, provided like its predecessor by the Max Planck Institute for Astronomie, Heidelberg, was installed on 14 June. Tests immediately confirmed that the production process for the new mirror has been successful. Because it was deliberately made oversized and ground down to the specified diameter after figuring, the mirror shows no signs of a turned-down edge. Acid-etching of the rear surface for stress-relief after lightweighting has removed all trace of print-through from the latter process. New mounting pads had been designed to be athermal, to avoid the temperature-dependent distortion caused by the original design; this too has been successful and no trace of the R^3 and R^5 trefoil distortions caused by the thermal stress are seen.

The main residual defect of the telescope optics is now spherical aberration. It appears that the primary mirror exhibits some residual spherical aberration (we have very little on-telescope test data for the primary mirror alone, since UKIRT does not have an accessible prime focus) and this may have been partially corrected by aberration of opposite sign induced by the thermal stresses in the old secondary. Currently most of the dynamic range of the active primary control system is devoted to correcting this aberration; about 180 nm RMS remains. The residual aberrations of the telescope now probably limit its deliverable Strehl ratio (ratio...
of central intensity in a delivered image to that in a perfect image) to around 0.77 at the K band. The current performance is therefore very close to the goal of the Upgrades Programme (an intrinsic Strehl ratio of 85% at 2.2 µm, corresponding to a total RMS wavefront error of 142 nm). The effects of this small residual wavefront error will only be discernable in the very best seeing; nevertheless further improvements are possible. Two spare sets of the new mounting pads were ordered; one of these will be installed in the "old" secondary mirror after it too has had its rear side etched for stress-relief to remove the print-through. This should leave the "old" secondary with the turned-down edge as its only significant optical defect; it can then be employed as a temporary replacement for the new secondary while the latter is upgraded, probably by ion-figuring, to remove the residual spherical aberration. High-performance (low emissivity) coatings, even experimental ones, can be contemplated: there are obvious advantages to having a spare secondary!

4.1.2. Automatic Focussing

Most factors degrading telescope performance can be constrained to individual insignificance, so that no one defect is obviously governing the image quality. Focus, however, is normally determined directly from image quality. This virtually ensures that focus errors are the largest optical aberration, since they are identified by detection of appreciable image degradation. Consequently we have sought for some time to constrain focus errors as far as possible (in 1997 implementing automatic stabilisation of focus against temperature changes and telescope elasticity effects). Even so, checking focus at the start of a night is a time consuming process, and since the correcting model has its limitations, it must be repeated during the night if the best image quality is to be secured. An auto-focus facility, which allows fast and objective focus measurements which do not depend on image quality, was therefore implemented when the new secondary was installed. This is a facility of the Fast Guider, and substitutes a 2 x 2 lenslet array for the single re-imaging lens used for normal tip-tilt fast-guiding. This produces four sub-images, each formed by a quarter of the telescope aperture, on the guider CCD. The radial separation of the four sub-images is a measure of the focus setting of the telescope. This hardware function was in fact provided with the Fast Guider on its original delivery by the MPIA, when the intention was to implement adaptive focus correction of the images, i.e. the removal of seeing-induced focus errors (expected to be the largest component of tip-tilt corrected seeing). In the event the short-term focus excursions were often found to be too large to be accommodated by the dynamic range of the piezoelectric actuators and the attempt to implement adaptive focussing was abandoned.

As now implemented by N. Rees, the new facility determines the telescope focus at 60 Hz and averages the result over 32 s, before applying the averaged correction to the Z-position of the secondary through the hexapod positioner which supports the tip-tilt assembly and the secondary itself. This facility enables fast, objective, focus measurements to be made whenever convenient during the night. If a bright enough guide star is employed (the working limit is around V = 14), active focus and fast tip-tilt corrections can be applied continuously. This has not been a common mode of operation, but focus checks are now routinely done when pointing is checked on a "nearstar", as the whole process takes about a minute, and is unobtrusive to the observer. The corrections determined by the autofocus system are relative, and must still be calibrated for each instrument. This is done during engineering time, using analysis of image properties away from best focus, and is repeated at intervals of a few months.

4.1.3. Pure-Seeing Monitoring

A bonus offered by the auto-focus system is a parameter which is a sensitive measure of "pure" seeing. This is the RMS of the focus fluctuations measured by the autofocus system during the averaging period mentioned above. The resulting parameter, $Z_{rms}$, is analogous to the output of a Differential Image Motion Monitor (DIMM), the standard site-assessment tool used world-wide, and is independent of the telescope
optical performance. $Z_{rms}$ is therefore useful for investigation of local seeing effects and their dependence on conditions, without the potential complication of telescope defects, tracking errors, etc.  

### 4.1.4. Emissivity Monitoring and Improvement

A concerted effort to improve the monitoring of telescope emissivity with CGS4 was undertaken in 1999. After careful verification of the effects, e.g. of taking sky measurements during dark time or at dawn, and calibration measurements with dome and DVS open and closed, an automated script was introduced for rapid, efficient measurement of emissivity at the end of nights on which CGS4 is used. This employs two measurements with the echelle grating and takes only a few minutes. Emissivity measures are now available on a roughly weekly basis, providing a denser database of measures than previously available. The results are adequate to allow monitoring of the evolution of the dichroic performance, for example. Efforts to use the 150 l/mm grating at times when the echelle is not in the spectrometer have been less successful, and the results are not yet considered reliable. The overall emissivity measurements have been supplemented by the use of a reflectometer/scatterometer, with which the accessible surfaces (primary mirror and dichroic) are monitored, and changes resulting from CO$_2$ cleaning can be quantified.

### 4.1.5. Primary Mirror Cooling

The primary mirror cooling system made considerable progress. A trial run late in the year demonstrated overall functionality but revealed several problems with the delivery of cooling power, with coolant piping integrity and control issues. These are being corrected.
4.2. Instrumentation Development

The instrumentation programme evolved over the year, as momentum built on the newly-approved UIST imager-spectrometer project, and the design study for the Wide Field Camera (WFCAM) demonstrated that this highly innovative instrument was a genuine option. WFCAM has stimulated widespread interest, and received formal approval in January 2000.

4.2.1. Michelle

The integration phase of the project commenced successfully in late 1998 with verification of optical design performance and array properties which were compatible with multiple readouts to reduce noise, but became seriously delayed by problems with almost all mechanical sub-systems, most notably with the grating exchange drum. Initial ``sticking'' problems associated with ice formation were alleviated by careful outgassing at the start of each cooldown, and the installation of getters at vulnerable locations. However it became clear that design defects were also contributing. A problem-solving ``tiger team'' was assembled in July. They, and the project team, addressed these and other issues including poor vacuum performance, high background light levels on the detector, difficulty in cooling the detector in the fully-assembled cryostat and underpowered stepper motors. In the last case it was found that design changes in these motors had invalidated the standard degreasing procedures for cryogenic operation, leading to demagnetisation. Diversion of effort to Michelle from other projects began. Electrical and thermal short-circuits to the detector mount were identified and rectified, bringing the array temperature low enough for progress to be made in its characterisation. Measured read noise levels within a factor 2 of the delivery goal were measured. The high background fluxes were found by seeking light leaks with a light bulb, correction of these reduced the background levels to a level which allows satisfactory performance for imaging and low-resolution spectroscopy on UKIRT (and Gemini). Further improvement were recognised to be essential and efforts were planned for the new year. By November 1999 the project had slipped a total of 43 weeks relative to the baseline set in September 1998 and was approximately £2053 k over budget.

4.2.2. The UKIRT Imager Spectrometer UIST

As noted in the last Annual Report, UIST received formal approval in January 1999 for a cash limit of £2884 k including contingency. Good progress was made early in that year and the cryostat was assembled and successfully vacuum tested in April. Effort availability became a concern in mid-year as the problems with Michelle began to draw resources from the other UKIRT projects. The project continued contracting out
sub-systems to the maximum degree, which has stood it in good stead in the climate of effort shortage, but later in the year cost estimates had climbed to a level which appeared close to the cash limit. A re-assessment of ATC accounting processes resulted in the allocation of additional funds, averting the crisis; the pressure on effort later began to make an underspend in FY 1999/00 seem likely. 4

Cooldowns commenced in May and the problems identified were solved without major impact on the project schedule. The optics stage reached the desired operating temperature and difficulties in getting the detector array down to optimum working temperature were overcome. Acquisition and operation of an engineering-grade detector allowed verification of the optical performance. Detailed design of the Integral Field Unit was completed and manufacture commenced late in the year. Several measuring runs on UKIRT investigated internal flexure of the Instrument Support Unit, which will not support UIS but will be responsible for feeding it its input beam. (With spectrometer slits as small as 0.25" very little flexure can be tolerated if the goal of continuing observations for at least an hour before checking on pointing is to be realised.) Initial results are encouraging, and major modifications of the ISU may not be necessary. The UIS project entered the new millenium in good shape apart from the unknown impact of Michelle upon its effort requirements.

4.2.3. Wide-Field Camera (WFCAM) and Large-Scale Surveys

WFCAM is a 1-2.5 µm wide-field imager able to cover about 0.25 square degree (900 square arcminutes) in a single exposure. It will utilise its own dedicated topend with articulated `tip-tilt" F/9 secondary. The large cryostat will be located ahead of the primary mirror, on the central plug. It uses a Schmidt-type design to feed a corrected image to a mosaic of four 2k square HgCdTe arrays. Up to 8 filters will be available: J, H and K filters (from the new `Mauna Kea" filter set) will be the core wavelengths but `z" (around 950 nm) and narrow bands, plus a blanking filter, will be included. The facility is expected to be able to provide S/N=3 to K=20 over one square degree in one hour. Design details were firmed up and an advanced Conceptual Design Review (CoDR+), with international participation, was held in Edinburgh in August. The review panel strongly endorsed the scientific potential of the instrument and also the proposed design, recognising its innovative nature but concluding that the proposal was fully practicable. The project team's approach to contingency planning was particularly appreciated. The prospect of WFCAM, which will for several years be the most powerful facility in existence for wide-field IR surveys, has generated extensive interest world-wide. In Japan plans were developed for collaborative involvement, leading to a science meeting at the National Astronomical Observatory of Japan in Tokyo in April. Proposals for surveys were canvassed from the UK and Japanese communities, and by year's end Japanese involvement in both the science and the data processing looks certain. A survey consortium is being the Cambridge Wide Field Astronomy unit. Interest in collaboration was expressed by groups in Canada and Germany. The project was submitted for Council approval at the year's end; approval was received in January 2000 at £4346 k.
5. Longer-Term Plans

5.1. Multi-Object and Integral Field Spectroscopy

At the November 1999 UKIRT Board meeting the Head of Operations identified wide field spectroscopy as the most likely development path for the longer term future of UKIRT. It was considered that there was insufficient access to powerful widefield spectroscopic capabilities in the near IR to complement WFCAM and the VISTA project (neither of which will provide any spectroscopic capability), while initially Gemini will be concentrating on small-field observations exploiting its high-resolution performance, especially with adaptive optics. Four possible options were considered:

- A Giant Integral Field Unit (GIFU). With the telescope remaining at F/36, a field of 1.5 arcmin would be covered by an image-slicing system giving 0.5" pixels at spectral resolution R around 4000. This would require four separate channels (probably four individual spectrometers) each equipped with a 4k x 4k array or mosaic (possible developments for the NGST). This would be an expensive but extremely powerful instrument. (Some thought was given to alternative ways of effecting such a truly giant IFU. e.g. by the use of large fibre bundles. The resulting design was deemed impractical.)
- A Multiple Integral Field Unit (MIFU). At F/36, a system of 10-30 Multiple Deployable Integral Field Units (which have been the subject of a successful design study at the UKATC for Gemini and NGST) would exploit a field of about 6 arcmin. The deployable IFUs have an ‘optical trombone’ design providing cold optics suitable for low-background work out to 5 µm. Several (probably 4) parallel unit spectrographs would be required. A UKIRT prototype for a Gemini system, using a single spectrometer, is an attractive possibility.
- A variant on the above would incorporate a change of the default F/ratio to F/16 (long considered on grounds of compatibility with Gemini as well as access to a larger FOV). This could offer a 19 arcmin field to the deployable IFUs.
- Some thought has also been given to a more traditional multi-slit system. The UKATC has produced outline designs for a system allowing cold masking plates to be employed and exchanged on a daily basis. Technological developments for the NGST may permit non-mask-based approaches, using solid-state micro-mirrors or micro-apertures to substitute for mask plates.

5.2. Adaptive Secondary Mirror (ASM)

An adaptive secondary remains of interest for the long-term future of UKIRT. Unfortunately supporting work at UCL for such a facility was not supported in the 1999 grants round and it is not clear that further progress will be possible.
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6. Financial Statement

The total expenditure on UKIRT in the 1999/2000 financial year (April 1999 to March 2000) was £3603.7 k, of which £1916.7 k ($3249.2 k) was for operations and £1687.0 k ($2859.8 k) was for the development programme (new instruments).

<table>
<thead>
<tr>
<th>1999/2000</th>
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</thead>
<tbody>
<tr>
<td>OPERATIONS</td>
</tr>
<tr>
<td>$ (k)</td>
</tr>
</tbody>
</table>

1. Mauna Kea Observatory

1.1. Office machinery and furniture 1.5
1.2. Utilities, telephones 87.0
1.3. Telescope maintenance and development 16.1
1.4. Electrical and electronics 18.5
1.5. Building maintenance and development 41.4
1.6. Road maintenance/snow removal 29.8
1.7. Cryogens and related equipment 86.9
1.8. Vacuum and laboratory equipment 14.4
1.9. Instrument maintenance and improvement 65.5
1.10. Computer systems 10.9

Sub total (1) 372.0

2. Mid-Level (Hale Pohaku)

2.1. Accommodation charges 72.9
2.2. Mauna Kea Support Services 21.6

Sub total (2) 94.5

3. Joint Astronomy Centre (Hilo)

3.1. Office supplies and equipment 13.0
3.2. Telecommunications and postage 12.1
3.3. Utilities 35.1
3.4. Miscellaneous administration, publicity, hospitality 9.5
3.5. Safety, first aid 11.4
3.6. Workshop equipment 8.5
3.7. Library 7.4
3.8. Building maintenance and improvements 23.3
3.9. Vehicle purchases and maintenance 42.7

Outturn

$ (k)

3.10. Computer systems 66.2
3.11. Computer networks 21.1
---
Sub total (3) 250.3

4. Local Staff

4.1. PPARC staff costs 773.5
4.2. Consultancy and recruitment 30.3
4.3. RCUH staff costs 1442.8
---
Sub total (4) 2246.6

5. Travel, Training, Conferences, Publications

5.1. Conferences, observing, publications 41.8
5.2. Training 16.5
5.3. Management travel 43.9
---
Sub total (5) 102.2

6. Development Program Management 26.9

7. ORAC (UK) 156.7
<table>
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<th>DEVELOPMENT</th>
<th>Outturn (k)</th>
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<td>Small projects</td>
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<tr>
<td>Michelle</td>
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<td>UIST</td>
<td>1382.9</td>
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<td>WFCAM</td>
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Appendix A: List of Publications

A total of 80 refereed journal publications acknowledging UKIRT data were published in 1999. Some papers contain data contributed by more than one instrument on UKIRT. In such cases the contributions of the instruments are taken as equal in the first table.

PUBLICATIONS BY INSTRUMENT

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<th>Number</th>
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<td>CGS4</td>
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<td>54</td>
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<tr>
<td>CGS3</td>
<td>4.8</td>
<td>6</td>
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<tr>
<td>IRCAM</td>
<td>26.9</td>
<td>33</td>
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<tr>
<td>UFTI</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>UKT</td>
<td>1.8</td>
<td>2</td>
</tr>
<tr>
<td>Visitor</td>
<td>2.5</td>
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PUBLICATIONS BY SCIENTIFIC CATEGORY

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<td>37</td>
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<td>Galactic</td>
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<td>54</td>
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<td>6</td>
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<td>Instrumentation</td>
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PUBLICATIONS BY JOURNAL

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<tr>
<td>Monthly Notices of the RAS</td>
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<td>44</td>
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<tr>
<td>Astrophysical Journal</td>
<td>22</td>
<td>27</td>
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<tr>
<td>Icarus</td>
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<td>Publ. Astr. Soc. of the Pacific</td>
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<td>4</td>
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<td>Astronomical Journal</td>
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<tr>
<td>Nature</td>
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Refereed publications in 1999


Foster, M.J., Green, S.F., McBride, N. & Davies, J.K., 1999, Icarus, 141, 408, NOTE: Detection of water ice on 2060 Chiron


Frayer, D.T., Ivison, R.I., Smail, I., Yun, M.S. & Armus, L., 1999, AJ, 118, 139, Submillimeter imaging of the luminous infrared galaxy pair VV 114


305, 125, ASCA observations of deep ROSAT fields - IV. Infrared and hard X-ray observations of an obscured high-redshift QSO


Owen, T.C., Cruikshank, D.P., Dalle Ore, C.M., Geballe, T.R., Roush, T.L. & de Bergh, C., 1999, Icarus, 139, 159, *Composition, physical state, and distribution of ices at the surface of Saturn*


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Appendix B: Time Allocations

UKIRT PATT time continued to be oversubscribed. The ratio of the total number of nights requested to the number of nights allocated was 2.08 in 99A and 2.82 in 99B. In the following list of successful applications only the principal investigator is given, although in nearly every case the projects are collaborative efforts. The grouping by instrument and scientific category of the telescope time awarded was as follows. Where a proposal requested more than one instrument these have been given equal weight in the first table.

<table>
<thead>
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<th>TIME AWARDED BY INSTRUMENT</th>
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<th>99B</th>
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<td>IRCAM/TUFTI</td>
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<table>
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<th>TIME AWARDED BY SCIENTIFIC CATEGORY</th>
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<th>99B</th>
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<tr>
<td>Extragalactic</td>
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<td>19</td>
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<tr>
<td>Galactic</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td>Solar System</td>
<td>4</td>
<td>5</td>
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Awards 1999A

**Casali**
ATC/ROE Edinburgh
The IMF and brown dwarfs in Ophiuchus

**Castro-Tirado**
IAA-CSIC Granada Spain
The galactic microquasar GRS 1915+105

**Clark**
University of Sussex
X-ray binaries: probing the circumstellar environment

**Cotter**
University of Cambridge
High-z lensed and binary quasars
<table>
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<td>Davies</td>
<td>Size-colour relationship in the Kuiper belt</td>
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<td>JAC Hawaii</td>
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<tr>
<td>Davis</td>
<td>H\textsubscript{2} excitation in protoplanetary nebulae</td>
</tr>
<tr>
<td>JAC Hawaii</td>
<td></td>
</tr>
<tr>
<td>De Propris</td>
<td>The chemical evolution of elliptical galaxies</td>
</tr>
<tr>
<td>Univ. of New South Wales Australia</td>
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<td>Done</td>
<td>FeII emission in the Seyfert galaxy NGC 4151</td>
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<td>Durham University</td>
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<td>Eales</td>
<td>The Canada-UK sub-mm survey and elliptical galaxies</td>
</tr>
<tr>
<td>Cardiff University</td>
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<tr>
<td>Gledhill</td>
<td>The envelopes of protoplanetary nebulae</td>
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<tr>
<td>University of Hertfordshire</td>
<td></td>
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<tr>
<td>Gledhill</td>
<td>Circumstellar structure of protostars in $\rho$ Oph</td>
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<td>University of Hertfordshire</td>
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<tr>
<td>Hawarden</td>
<td>A complete sample of IR-selected galaxies</td>
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<tr>
<td>JAC Hawaii</td>
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<td>Hirst</td>
<td>IR imaging of narrow-line Seyfert Is</td>
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<td>University of Leicester</td>
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<td>Bright sub-mm galaxies behind Abell 1835</td>
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<td>University College London</td>
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<td>Ivison</td>
<td>The morphology of sub-mm bright EROs</td>
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<td>University College London</td>
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<td>Jackson</td>
<td>The redshift of B1933+503</td>
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<td>University of Manchester</td>
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<td>Johnstone</td>
<td>Extended emission line gas around $z \sim 2$ quasars</td>
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<td>Kerr</td>
<td>Solid CO in the $\rho$ Oph molecular cloud</td>
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<td>JAC Hawaii</td>
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<td>Lacy</td>
<td>Spectroscopy of $z \sim 1$ luminous radio galaxies</td>
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<td>Oxford University</td>
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<td>Lucas</td>
<td>Deep imaging of ISO star formation fields</td>
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<td>Lumsden</td>
<td>The near-IR extinction law</td>
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<td>Mchardy</td>
<td>Very faint red X-ray sources: obscured QSOs?</td>
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<td>University of Southampton</td>
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<tr>
<td>Miller</td>
<td>The structure of high-redshift elliptical galaxies</td>
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</table>
Mobasher - Ellipticals in high-redshift clusters
Imperial College London

Mobasher - Stellar populations in Coma cluster ellipticals
Imperial College London

Puchnarewicz - Extending the continua of AGN into the IR
Mullard Spece Science Lab.

Rawlings - The most distant radio galaxies
Oxford University

Ryder - The circumnuclear starburst in M100
JAC Hawaii

Simpson - The ultraviolet continuum in quasars
Subaru Telescope Hawaii

Smail - Optical-infrared imaging of distant clusters
University of Durham

Trafton - Hydrogen dimers in the spectrum of Uranus
McDonald Observatory Texas

Walker - Possible satellites of Gliese 229B
University of British Columbia

Wilkinson - Redshifts of gravitational lens parent samples
University of Manchester

University of Hawaii 1999A

Barger - Bright sub-mm galaxies behind Abell 1835
Hodapp - Kinematics of outflow shock fronts
Imanishi - Black-hole driven activities in IR-luminous galaxies
Owen - The surface of Charon
Sanders - ULIGs in the IRAS 1 Jy sample
Tholen - The trans-Neptunian objects

Awards 1999B

Antonucci - Are narrow-line radio galaxy quasars in the sky plane?
UC Santa Barbara

Bowey - 2.3 µm M-OH band of hydroxylated silicates in YSOs
QMW College London
Catalan
Keele University
Common-envelope binary evolution

Chrysostomou
University of Hertfordshire
Do cold grains align in the Taurus dark cloud?

Chrysostomou
University of Hertfordshire
Maping the magnetic fields towards YSO outflows

Cotter
University of Cambridge
High-z lensed and binary quasars

Davies
JAC Hawaii
Optical-IR colours of distant asteroids

Davis
JAC Hawaii
Tracing shock evolution along protostellar jets

Davis
JAC Hawaii
Mapping molecular microjets from protostars

Dunlop
University of Edinburgh
The evolution of quasar host galaxies from z=4 to the present

Eales
Cardiff University
The Canada-UK sub-mm survey and elliptical galaxies

Edge
University of Durham
The brightest cluster galaxies in a complete X-ray sample

Edge
University of Durham
Molecular hydrogen emission in central cluster galaxies

Emerson
QMW College London
Spectral types of T Tauri stars from near-IR spectra

Emerson
QMW College London
Veiling in T Tauri stars: Pa β time-series

Fassia
Imperial College London
Late-time spectroscopy of the type IIn SN 1998S

Geballe
Gemini Observatory Hawaii
H_3^+ in new environments

Griffith
Northern Arizona University
Weather on Titan

Harries
University College London
Spectropolarimetry of evolved luminous stars

Hodgkin
Leicester University
Brown dwarfs in open clusters

Ivison
University of Edinburgh
The environment of high-redshift radio galaxies
University College London

**Justtanont**
Water ice in extreme OH/IR stars

Stockholm Observatory

**Kerr**
The ratio of solid to gas-phase CO in the Taurus cloud

JAC Hawaii

**Lucas**
Spectroscopic follow up of brown dwarfs in Orion

Oxford University

**McCall**
CH$_3^+$ in the diffuse interstellar medium

University of Chicago

**Mobasher**
M/L ratios of ellipticals in high redshift clusters

Imperial College London

**Oudmaijer**
Disks around massive YSOs

Imperial College London

**Pinfield**
Praesepe's mass function at the bottom of the main sequence

Queen's University of Belfast

**Rivkin**
3m spectra of hydrated asteroids

University of Arizona

**Roche**
Detection of extrasolar planets and brown dwarfs

Oxford University

**Ryder**
Circumnuclear starbursts in NGC 1300 and NGC 7469

JAC Hawaii

**Seigar**
Near-IR properties of the disks of spiral galaxies

University of Ghent Belgium

**Shahbaz**
The supernova event in V404 Cygni

Oxford University

**Smail**
Obscured starburst galaxies in z=0.4 clusters

University of Durham

**Tanvir**
Rapid followup of GRB error boxes

IoA Cambridge

**Trafton**
Uranus' thermosphere and ionosphere: the solar connection

McDonald Observatory Texas

**Uttley**
The X-ray variability/bulge luminosity relationship for AGN

University of Southampton

**Ward**
The nature of the most IR-luminous galaxies

University of Leicester

**Wright**
Interstellar dust in edge-on spiral galaxies

ATC/ROE Edinburgh
Uncovering the clock in WZ Sagittae

Circumstellar disks during post-AGB

Optical and infrared imaging polarimetry survey

Kinematics of outflow shock fronts

Dust absorption towards possible type-2 quasars

A new sample of intermediate-z ULIGs

Planet crossing asteroids

Cosmology from high redshift supernovae
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Appendix C: Committee Membership

I. UKIRT BOARD

Dr. S.J. Warren  Imperial College London
(chair)
Dr. M. Coe  University of Southampton
Dr. T.M. Gledhill  University of Hertfordshire
Dr. R. Jameson  University of Leicester
Dr. S.L. Lumsden  University of Leeds
Dr. I.R. Smail  University of Durham
Dr. T. Herbst  Max Planck Institute fur Astronomie, Germany
Dr. R. McLaren  University of Hawaii
Mr. C.G. Brooks  Astronomy Division, PPARC

II. UKIRT PATT TIME ALLOCATION GROUP

Dr. G. Fuller  UMIST, Manchester
(chair)
Dr. C. Chandler  MRAO, Cambridge
Dr. P. Maxted  University of Southampton
Dr. S. Rawlings  Oxford University
Dr. I. Smail  University of Durham
Dr. N. Tanvir  Cambridge University
Dr. G. Wright  Royal Observatory Edinburgh
Dr. J. Davies  Joint Astronomy Centre
(technical secretary)
Appendix D: UKIRT Staff

Names flagged with * are shared between UKIRT and either JCMT or Gemini.

Dr. A.J. Adamson  Head of UKIRT Operations
S.L. Arakaki*  Head of Instrument Support
T. Carroll  Telescope Systems Specialist
D.D. Chan  Electronic Engineer
T.C. Chuter*  Head of Electronic and Electrical Systems
Dr. M.J. Currie  Data Reduction Software Engineer
Dr. J.K. Davies  Support Astronomer
Dr. C.J. Davis  Support Astronomer
V.A. DeMattos*  Mechanical Technician Supervisor
T.E. Dorward*  Finance Assistant
M.K. Dougherty*  Engineering Secretary
F. Economou  Software Engineer
D.A. Fuselier*  Computer/Information Systems Manager
V. Gonsalves-Nases*  Accounts Clerk
S.Y. Hamamoto*  Scheduler/Receptionist
M. Hauschildt-Purves  Software Engineer
Dr. T.G. Hawarden  Head of UKIRT Development
M. Horita*  Senior Mechanical Technician
R.D. Kackley  Software Engineer
Dr T.H. Kerr  Support Astronomer
<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>N.I. Kobayashi</td>
<td>Senior Mechanical Technician</td>
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<tr>
<td>Dr. O.P. Kuhn</td>
<td>Research/Operations Support Astronomer</td>
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<tr>
<td>Dr. S.K. Leggett</td>
<td>Support Astronomer</td>
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<tr>
<td>B.M. Leite</td>
<td>Human Resources Assistant</td>
</tr>
<tr>
<td>W.P. Light</td>
<td>Head Of Administration</td>
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<tr>
<td>A.M. Lucas</td>
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</tr>
<tr>
<td>L.A. Marcer</td>
<td>Finance Officer</td>
</tr>
<tr>
<td>J. Meguro</td>
<td>Mechanical Design Engineer</td>
</tr>
<tr>
<td>I.L. Midson</td>
<td>Human Resources Manager</td>
</tr>
<tr>
<td>D. Milar-Okinaka</td>
<td>Fiscal/Administration Assistant</td>
</tr>
<tr>
<td>K.E. O'Connell</td>
<td>Mechanical Technician</td>
</tr>
<tr>
<td>R.N. Oliveira</td>
<td>Mechanical Technician</td>
</tr>
<tr>
<td>I. Pain</td>
<td>Mechanical Engineer</td>
</tr>
<tr>
<td>N.P. Rees</td>
<td>Head of Software and Computing Services</td>
</tr>
<tr>
<td>Prof. E.I. Robson</td>
<td>Director</td>
</tr>
<tr>
<td>D.J. Shutt</td>
<td>Chief Engineer</td>
</tr>
<tr>
<td>E.M. Sison</td>
<td>Mechanical Technician</td>
</tr>
<tr>
<td>E.G. Starman</td>
<td>Lead Electronic Engineer</td>
</tr>
<tr>
<td>H.P. Stilmack</td>
<td>Computer/Information Systems Manager</td>
</tr>
<tr>
<td>F.S. Teramoto</td>
<td>Accounts Payable/Receivable Clerk</td>
</tr>
<tr>
<td>J.H. Tsutsumi</td>
<td>Site Supervisor</td>
</tr>
<tr>
<td>Dr. W.P. Varricattu</td>
<td>Research/Operations Support Astronomer</td>
</tr>
<tr>
<td>M.W. Wagner</td>
<td>Electronics Technician</td>
</tr>
<tr>
<td>T. Wold</td>
<td>Telescope Systems Specialist</td>
</tr>
</tbody>
</table>
# THE UNITED KINGDOM INFRARED TELESCOPE ANNUAL REPORT 1999

## Appendix E: Addresses

<table>
<thead>
<tr>
<th>Addresses</th>
<th>Telephones/Faxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint Astronomy Centre</td>
<td>JAC telephone (day)</td>
</tr>
<tr>
<td>660 N. A'ohoku Place</td>
<td>JAC telephone (night)</td>
</tr>
<tr>
<td>University Park</td>
<td>JAC Senior Management Fax</td>
</tr>
<tr>
<td>Hilo</td>
<td>JAC General Fax</td>
</tr>
<tr>
<td>Hawaii 96720 USA</td>
<td>Hale Pohaku JAC Office</td>
</tr>
<tr>
<td></td>
<td>Hale Pohaku JAC Fax</td>
</tr>
<tr>
<td></td>
<td>UKIRT</td>
</tr>
<tr>
<td></td>
<td>UKIRT Fax</td>
</tr>
</tbody>
</table>

email: i.surname@jach.hawaii.edu
UKIRT home page: http://www.jach.hawaii.edu/UKIRT/home.html