**The Orion nebula in infrared**
This is what we would see if our eyes were sensitive to light at wavelength two and a half times longer than they can actually detect. The inset image is made up of three frames taken with UFTI through filters at 0.9, 1.2 and 1.6 micrometres and combined together. The main image shows the core of the Orion Nebula imaged in the 2.1-micrometre emission line of molecular hydrogen which traces the explosive events accompanying starbirth

# Ugrading UKIRT

*Ingenious new technology and instrumentation will ensure that the UK's Infrared Telescope continues to do ground-breaking astronomy*

**Patrick Roche**

The 3.8-metre UK Infrared telescope (UKIRT) on Mauna Kea, Hawaii is 20 years old. A combination of clever design and a need to minimise costs led to it being built with many features that are now recognised as essential for good telescope performance. For example, it has a relatively thin and lightweight primary mirror with an active support system, a very small telescope enclosure (which minimises the volume of trapped air), and is built on the finest developed infrared observing site in the world.

Over the past five years, astronomers have implemented a programme of improvements to the UKIRT telescope to increase the sharpness of the images and to ensure that they are not degraded by the telescope performance or by turbulence in the telescope dome. Central to this goal has been the installation of a new articulated secondary mirror whose position is adjusted under computer control to ensure that it remains properly aligned with the axis of the primary mirror as the telescope moves around the sky. The secondary mirror is also tipped and tilted many times a second to correct for imperfections in telescope tracking and buffeting by wind. This action also provides some correction for the image-wander produced by atmospheric turbulence. The secondary mirror system was provided in a collaboration between the Max Planck Institute for Astronomy in Heidelberg, Germany, the Astronomy Technology Centre at the Royal Observatory Edinburgh and the Joint Astronomy Centre in Hawaii.

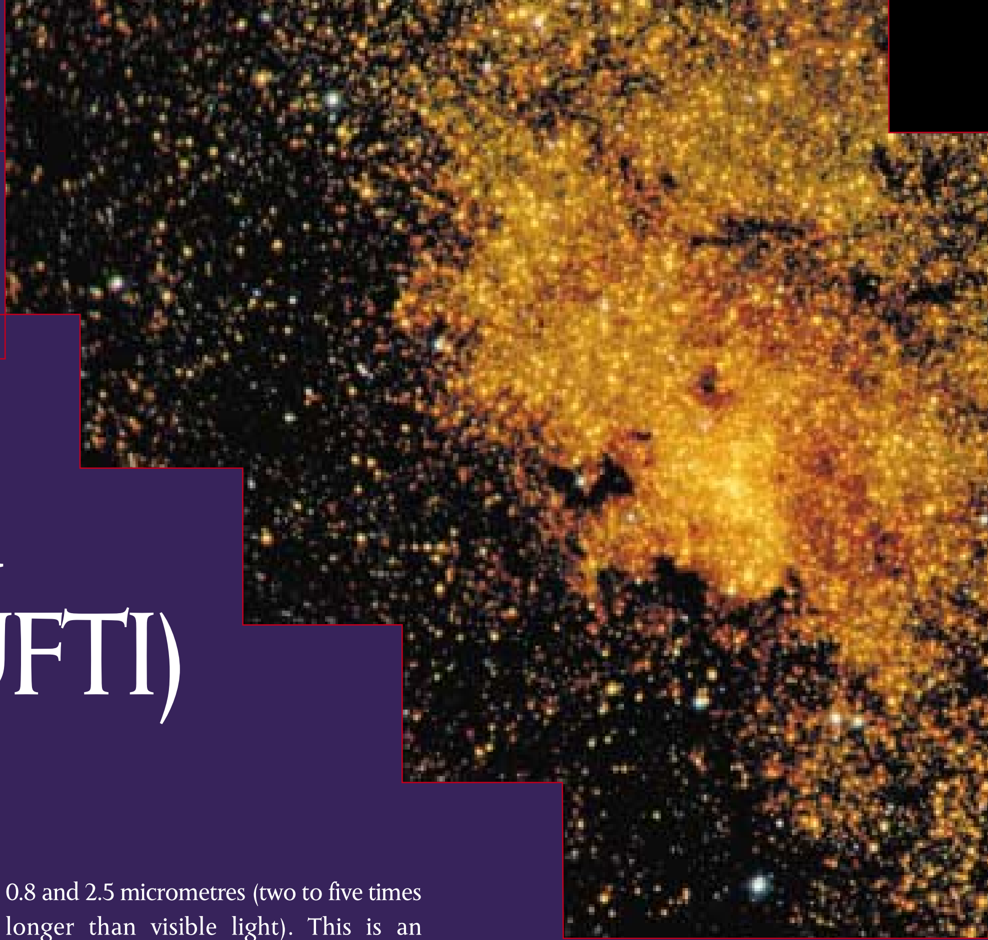
The upgrades to the UKIRT telescope and dome mean that images less than 0.5 arcsec across are obtained routinely and images smaller than 0.25 arcsec are seen under the best conditions. These are some of the best images obtained with any ground-based telescope.

In order to take full advantage of these upgrades, a new camera (see Box1) has been built to provide a state-of-the-art infrared imaging system, and a new imaging spectrometer (see Box 2), to be installed soon, will revolutionise spectroscopy on UKIRT. ➤

**UKIRT at sunset**
The new top-end structure containing the tip-tilt secondary mirror can be seen inside the dome while the dome vents that eliminate the build up of warm turbulent air around the telescope are opening

feature

# The UKIRT Fast Track Imager (UFTI) camera



Box 1

➤ A state-of-the-art infrared camera has been delivered to UKIRT to exploit the excellent image quality that is now obtained routinely at the telescope. Astronomers are delighted with the dramatic new images of many astronomical objects that have been obtained over the past year. They have revealed new details of structures in previously observed objects and allowed previously unseen objects to be detected.

The UKIRT Fast Track Imager (UFTI) camera operates at wavelengths between 0.8 and 2.5 micrometres (two to five times longer than visible light). This is an increasingly important spectral window for several reasons:

- The redshift effect, whereby light from distant receding objects is moved to longer wavelengths, means that if we want to compare distant galaxies with nearby objects, we must look at them at long wavelengths. Visible light emitted from galaxies at distances greater than 10 billion light years is detected by us in the infrared.
- Interstellar dust blocks our view at short wavelengths, but is much more transparent in the infrared. For example, along the path from the centre of our Galaxy, dust absorbs and scatters very effectively so that only one photon in one million million penetrates through to the Earth at a wavelength of 0.5 micrometres, but 1 in 30 makes it through at 2 micrometres.
- Cool stars make up most of the stars in most galaxies, and they emit most of their light at infrared wavelengths.
- Planets are cooler still, so the infrared is the natural place to try to detect them as well as molecules and the dust particles from which they were formed.

**Rear view of UFTI mounted on UKIRT**
The instrument is suspended from the mirror cell. Light enters the cryostat at the bottom left and is collimated by a diamond-turned aluminium mirror located in the blue tube at lower right. The closed-cycle cooling system is contained in the aluminium trusses at middle right. The instrument and mounting frame weighs about 140 kilograms

The camera was installed on UKIRT in October 1998 and has now been used for a number of scientific programmes, producing excellent images and enthusiastic responses from visiting astronomers. One of the first images obtained with UFTI to investigate young stellar objects was obtained by Phil Lucas and Patrick Roche in the astrophysics group at Oxford University (see previous page). The sharp images and fine pixel scale of UFTI allows us to probe deep into the cores of star-forming regions.

The new camera was built in a collaboration between Oxford University, the Astronomy Technology Centre (ATC) in Edinburgh, Cambridge University and the Joint Astronomy Centre (JAC) in Hawaii. At its heart is a state-of-the-art infrared detector array with more than 1 million sensitive infrared diodes made by Rockwell. The detector is controlled by custom electronics combined with a CCD controller from LSR-Astrocam, modified

# The UIST imager spectrometer

**Box 2**

by the Institute of Astronomy, Cambridge. The camera was built, integrated and tested at Oxford, following an outline design developed at the ATC. The telescope interface was developed at the JAC and the ATC. All of the optics and supporting structures are mounted inside a vacuum cryostat and cooled to a temperature of about 65K. The detector is operated at a temperature of 80K.

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A view of the UKIRT telescope top-end, showing the new secondary mirror and support structure, and the dome aperture

A new instrument for the near-infrared wavelength region is currently under development at the UK ATC in Edinburgh. It combines capabilities for imaging and for spectroscopy to create a versatile instrument for UKIRT.

UIST (the UKIRT imager spectrometer) will greatly enhance the existing facilities when it is delivered in May 2001. The instrument incorporates an infrared detector array with one million pixels, 16 times more than the array used in the existing UKIRT spectrometer, CGS4. The detector material is indium antimonide, sensitive to light with wavelengths from 1 to 5 micrometres and is being manufactured by the Raytheon Infrared Center for Excellence in Santa Barbara, California.

The layout of the instrument is shown in the figure below. For operation at these wavelengths, the entire instrument, which weighs 750 kilogrammes, is cooled to 70K. Most of the optical components are lenses, with the exception of a 'periscope' to make the instrument more compact and an image-rotator which orientates the spectrometer slit on the sky. All of the optics are located in modules, which contain the mechanisms and wheels that allow different apertures (slits or imaging apertures), filters, 'grisms' or camera lenses to be selected. The grisms act as a grating and prism in concert to produce a spectrum on the array allowing rapid switching between imaging and spectroscopy.

UIST will also contain an 'image slicer', developed in consultation with Durham University. The image slicer is so named because this device optically 'slices' an astronomical object such as a galaxy and passes all the light from the source into the spectrometer. Spatial information is preserved so, for example, conditions in the outer arms of a galaxy can be compared with those in the nucleus. A more conventional spectrometer uses a long slit to sample an object along one axis, giving only limited information. The UIST with its image slicer is expected to revolutionise spectroscopy at UKIRT allowing the interaction between stars, dust and gas in complex objects to be observed in detail.

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**UIST mechanical layout**
A view of the telescope top-end, showing the new secondary mirror and support structure, and the dome aperture