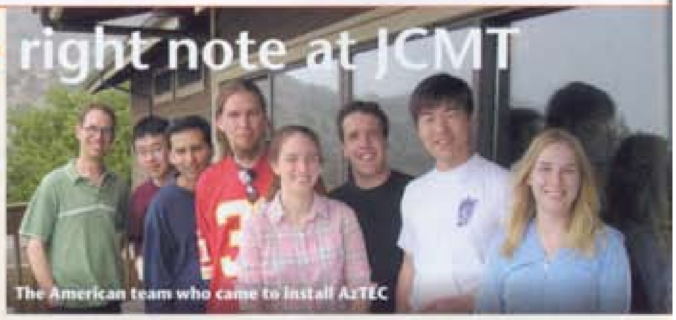
AzTEC camera hits the right note at JCMT

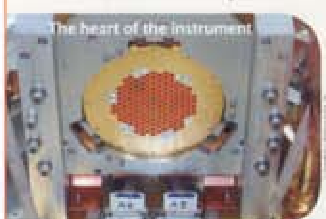
A new imaging detector spends quality time on the UK's submillimetre telescope



The American team who came to install AzTEC

The James Clerk Maxwell Telescope (JCMT) on Mauna Kea, Hawaii may be the world's largest single-dish telescope devoted to observing the sky at wavelengths around 1 millimetre, but it needs every square centimetre of its 15-metre dish and the most sensitive of detectors to capture these faint heat radiations. Whether they emanate from cold bodies in the Solar System, from the frigid depths of the interstellar medium, or from the most distant galaxies of the early Universe, gathering enough energy to make images at these wavelengths has been an enormous technological challenge.

This challenge has been superbly met over the past 9 years, not only by the JCMT's large collecting area but also by its sensitive detector array, SCUBA, built at the Royal Observatory Edinburgh (ROE). It was a huge loss, therefore, when SCUBA was decommissioned last July after a couple of years of ill-health, and roughly a year before its intended replacement by a new-technology detector – SCUBA-2 (*Frontiers* 15, p.6).



The heart of the instrument

The prospect of a year without being able to image objects at submillimetre wavelengths was more than astronomers could bear! Fortuitously, a suitable camera, AzTEC, became available at just the right time. Built by Grant Wilson and colleagues at the University of Massachusetts in Amherst, the National Astrophysics, Optics and Electronics Institute in Puebla, Mexico, the California Institute of Technology and the University of Cardiff in Wales, its final destination is the Mexican-US Large Millimeter Telescope (LMT), which is nearing completion at its site near Sierra Negra in Mexico. The telescope without a camera had found a camera without a telescope!

SCUBA stand-in

AzTEC's detector array is composed of 144 silicon nitride 'spider-web' bolometers (devices that detect heat), cooled by liquid helium, and optimised to work at a wavelength of 1 millimetre. The camera can see, at one go, a patch of sky (4 arcminutes) four times the size as that imaged with SCUBA. When coupled to the JCMT, each bolometer has a resolution of 18 arcseconds and is separated from its nearest neighbours by one and half times that amount. This means that to map out a full image, the instrument must rely on scanning techniques called 'jiggling' and 'rastering'.

AzTEC was scheduled to operate on the JCMT in November and December, and several members of the AzTEC team travelled to Hawaii to install and support the instrument during a stay that extended into January this year.

The observing programme included studies of molecular clouds, and star-formation regions, a survey of dust in the Andromeda galaxy (M31), studies of the environments of high-redshift galaxies and various cosmological surveys. Many of these programmes involved mapping relatively large areas of the sky – 2.5 x 0.5 degrees for the M31 programme, for instance.

The instrument performed brilliantly, with a sensitivity several times higher than that of SCUBA. We were lucky enough to have good weather and we essentially completed all 11 observational programmes that had been approved by the three national (UK, Dutch and Canadian) funding bodies, as well as two international programmes and two from the University of Hawaii. In all, we achieved a total of almost 700 hours of observations. Assessing the performance of the new instrument was also a continuous and important part of each night's activities.

AzTEC has now gone back to Amherst and all the data obtained are being analysed. However, those of us lucky enough to have already glimpsed some of it know that, in those 3 months at the JCMT, our guest will have made a major contribution to submillimetre astronomy. When the results are released later this year, they will provide a lot of excitement in many fields of astronomy.

We now eagerly await SCUBA-2 and its potential over the coming years to provide further technological and scientific progress in submillimetre astronomy. Meanwhile, prepare to be amazed by the results from a highly productive short-term visitor - AzTEC!

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First light for HARP/ACSIS

The JCMT has a novel camera for mapping star formation

At 15 metres across, the JCMT is the largest telescope in the world operating at submillimetre wavelengths. These are radio waves with frequencies greater than 300 gigahertz, which is 3000 times higher than those used for VHF radio. An exciting use of the JCMT is to detect the faint emission from the relatively cold and dark parts of the Universe, for example, the clouds of dust and gas molecules that eventually condense into new stars in our own and other galaxies. JCMT's SCUBA instrument has already provided remarkable images of these diffuse objects (*Frontiers* 12, p.16). SCUBA can, however, observe only the dust, which does not give any information on the chemical make-up or the dynamics of the clouds.

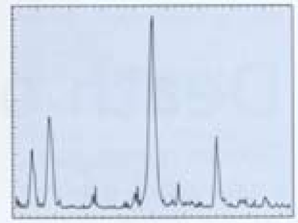
What was needed was a complementary instrument consisting of an array of detectors designed to map the clouds using their molecular emissions. Such a facility, offering simultaneous spectroscopy and imaging, is currently being commissioned on the JCMT. HARP, shown below, is a heterodyne array, each element of which operates on the same basic principle as a radio receiver, but at far higher frequency and with much greater sensitivity. It has 16 superconducting detectors, and is the first such heterodyne array to operate at a wavelength of 0.85 millimetres. HARP was built at the Astrophysics Group of the Cavendish Laboratory in

Cambridge, with key subsystems being provided by the Dominion Astrophysical Observatory in Victoria, Canada, the UKATC in Edinburgh and the Delft University of Technology in the Netherlands.

A new spectrometer

In addition, a 'multi-channel autocorrelation' spectrometer, known as ACSIS, has been installed to work in conjunction with HARP. Its job is to form the spectra and analyse the data in real time. ACSIS was built by the Dominion Radio Astrophysical Observatory in Penticton, Canada, and the UKATC. The Joint Astronomy Centre in Hawaii has also installed a new state-of-the-art control system on the JCMT. Taken together, these new facilities will increase the data rate from the telescope by as much as a thousand times!

HARP/ACSIS can map molecular gas in molecular clouds throughout the Universe rapidly and with great sensitivity. The system will be particularly useful for studying the processes that transform a giant and diffuse molecular cloud into a fully-formed star. But instead of producing flat, two-dimensional images of these targets, it will provide a three-dimensional data-cube, in which the third dimension is frequency. From these data, it will be possible to probe the densities, chemistry and the gas motions across a whole molecular cloud complex.



Orion imaged in carbon monoxide emission lines with a typical spectrum (right)

During the commissioning period in February, HARP/ACSIS obtained the map around the Orion nebula shown above in just 40 minutes. The image shows complex and detailed structures where the cloud is being heated or destroyed by stellar winds, jets and ultraviolet radiation. At every point in the map a spectrum is recorded like the one shown beside the image. In this case there were more than 90,000 such spectra in the data-cube.

With HARP/ACSIS on the JCMT, astronomers will now be able to make systematic studies of the molecular emission from large areas of the sky, rather than just studying a few individual spectra; several large-scale surveys of complete clouds and star-forming regions are already planned with this facility.

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