HARP on the Nasmyth platform of the JCMT

Imaging the dynamics and chemistry of star formation

A novel camera operating at submillimetre wavelengths has just seen 'first light' on the James Clerk Maxwell Telescope (JCMT) in Hawaii.

At 15 metres across, the JCMT is the largest telescope in the world operating at sub-millimetre 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 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. SCUBA can however only observe the dust, which does not give any information on the chemical make-up or the dynamics of the clouds.

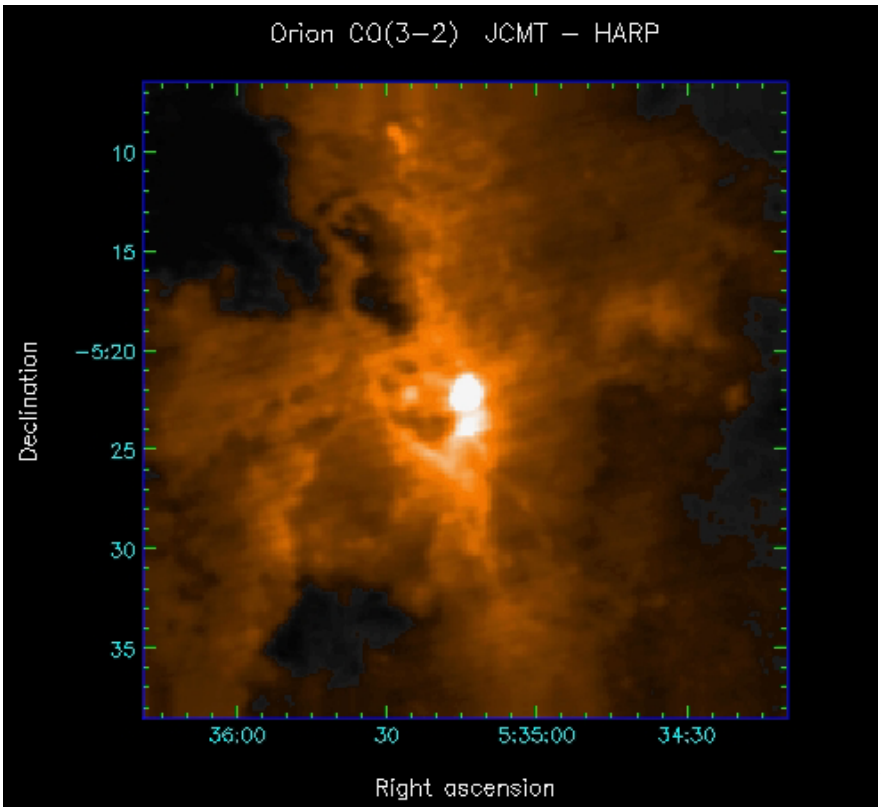
What was needed was a complementary instrument consisting of an array of detectors designed to map the clouds using the signals emitted by the molecules in the gas. Such a facility, offering simultaneous spectroscopy and imaging, is currently being commissioned on the JCMT. HARP, shown below, is a heterodyne 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. In addition, a

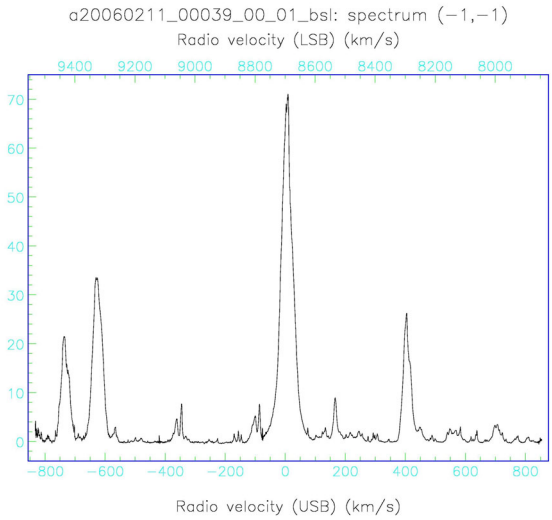
multi-channel autocorrelation spectrometer, known as ACSIS, has been installed to work in conjunction with HARP. Its job is to form the spectra and analyse the data in real time. ACSIS was built by the Dominion Radio Astrophysical Observatory in Penticton, Canada, and the UKATC. The Joint Astronomy Center 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.

During the commissioning period in February, HARP/ACSIS obtained the map around the Orion nebula shown below in just 40 minutes; with the previous instruments it would have taken the JCMT nearly a month of continuous observing to map this area of sky. 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.



Map made with HARP/ACSIS and (below) a single spectrum



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.