Not green cheese, then?

What is the Moon made of? A UK-led instrument – part of ESA's SMART-1 lunar mission – should soon be able to answer this question


The D-CIXS instrument

Surprisingly, we still do not know the overall elemental composition of the Moon. The NASA Apollo missions landed in basins where the lunar surface had been considerably changed by impacts. This means that the rocks they brought back to Earth are not actually representative of the primordial highland material making up most of the Moon's surface. Now, thanks to new technology, scientists will be able to map the true global composition of the lunar surface remotely from the orbiting SMART-1 spacecraft, using a novel imaging spectrometer. It works by detecting the characteristic spectra of X-rays emitted from elements in the Moon's crust when solar X-rays shine on its surface.

D-CIXS spectrometer

The instrument – D-CIXS – has been built by an international team led by Manuel Grande of the Rutherford Appleton Laboratory. Because the lunar X-rays are extremely weak, D-CIXS is designed to collect as many photons as possible in order to build up the spectra. Even so, only about 1000 photons are detected per 50 square kilometres of lunar surface. The team has made use of microfabrication technology borrowed from the semiconductor industry to create a detector consisting of a very thin metal grid which can collect X-rays according to the direction from which they came. Such a device is light and compact enough to be put aboard SMART-1, along with the other instruments making up its payload.

SMART-1, which will be launched in March, is the first of ESA's missions designed to test advanced technologies. Its main role is to demonstrate a new type of propulsion, solar electric propulsion, (*Frontiers* 13, p.30) on the way to the Moon. When it gets there, it will orbit the Moon for 6 months. If all goes well, this technology will be used in deep-space projects such as the BepiColombo mission to Mercury, and indeed, Professor Grande and his team have proposed to build a CIXS device to map X-rays from Mercury and its aurora.

In the meantime, D-CIXS will map the main constituents of moon rock – magnesium, silicon, aluminium and calcium – across the lunar surface. The data will provide valuable information on how the Moon formed, in particular whether it has the same origin as the Earth.

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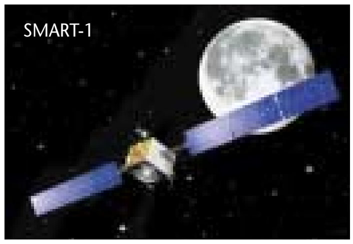

SMART-1

Observing the stars at high-speed

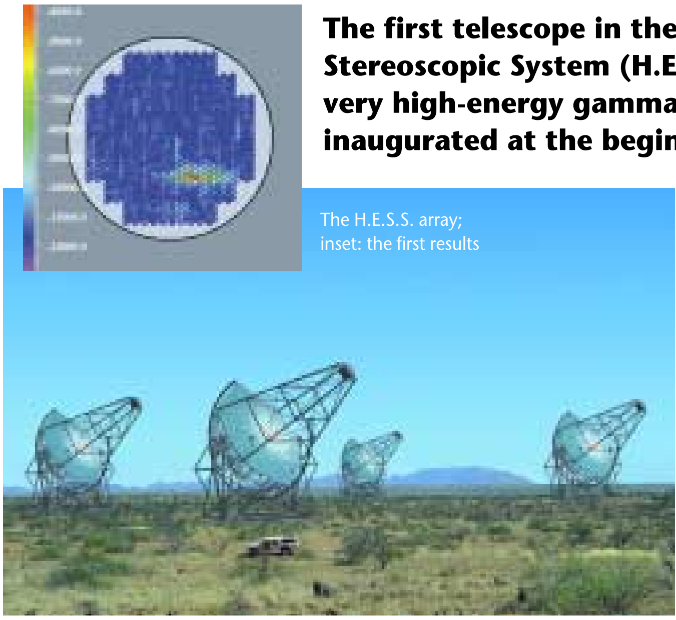

The ULTRACAM instrument

The William Herschel Telescope is not only seeing more clearly with the NAOMI adaptive optics system (see p.10) but can also register images more quickly with a new camera, ULTRACAM, capable of taking up to 1000 pictures a second at three different wavelengths simultaneously. ULTRACAM, which is based on advanced CCD technology, was built by teams from the Universities of Sheffield and Southampton in collaboration with the UK Astronomy Technology Centre.

The high-speed imaging will allow astronomers to study some of the most extreme astronomical objects in the Universe – compact binaries, pairs of stars containing very dense bodies such as white dwarfs, neutron stars and black holes. These objects suck material away from their larger companions onto an accretion disc. By observing the ultra-rapid changes in light from these systems due to the

A new era in detecting gamma-rays from the ground

The first telescope in the High Energy Stereoscopic System (H.E.S.S.) array to detect very high-energy gamma-rays was officially inaugurated at the beginning of September



The H.E.S.S. array; inset: the first results

Situated in the Khomas highland region of Namibia (an area originally shortlisted for the site of the European Southern Observatory), the project is the result of a large collaboration including contributions from both Europe and Africa. The principal European nations contributing are Germany, France and the UK. The UK institutions involved are the University of Durham and the Open University, both supported by a PPARC grant.

The telescope has already recorded its first engineering data and the information will soon start to flow in earnest. This facility represents the state of the art in very high-energy gamma-ray astronomy, achieving sensitivity and spectral resolution far in excess of its predecessors. This telescope is the first of four that will make up H.E.S.S. phase I, which should be complete in 2004. The telescopes detect the faint flashes of Cherenkov light (*Frontiers* 5, p.5) caused by the interaction of high-energy gamma-rays in the upper atmosphere. Careful imaging of the light produced in a number of telescopes simultaneously allows the original arrival direction and energy of the gamma-ray to be determined.

Extreme astrophysics

The H.E.S.S. array will allow astronomers to probe the most extreme astrophysical environments, including supernova remnants, pulsars and the jets of active galaxies. It will be able to detect sources down to a few thousandths of the output of the Crab nebula (a supernova remnant) from energies of 100 giga-electronvolts (GeV) upwards. Pulsars may be detectable down to around 30 GeV, using the characteristic pulsations to identify a signal when the small amount of light generated makes it difficult to use the images to their full effect.

We still have much to learn about the physics of these extremely energetic processes, and detailed observations in this energy band will be crucial in advancing our understanding, especially if they are accompanied by simultaneous observations at other wavelengths. In addition to all this, we hope that H.E.S.S. observations may finally indicate where cosmic rays are being accelerated. Careful study of the spectra of active galaxies should yield measurements of the intergalactic background infrared radiation, which will be significant for models of galaxy formation.

If we are lucky, it may even be possible to identify the signature gamma-rays produced by the annihilation of the lightest stable super-symmetric particle in the Galactic centre or halo – simultaneously measuring the particle mass and identifying this significant component of dark matter in the Universe (*Frontiers* 13, p. 21). The results from this new instrument will thus be of interest to people studying a wide range of astrophysical systems.

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eclipsing effects of the matter swirling round the compact object, astronomers can measure their size and mass. They can also measure the temperature by making observations at different wavelengths.

Improved CCD detector

ULTRACAM employs the latest in CCD detector technology in order to take, store and analyse data at the required sensitivities and speeds. CCD detectors can be found in digital cameras and camcorders, but the devices used in ULTRACAM are larger, faster and most important, much more sensitive to light than the detectors used in today's consumer-electronics products. Work started on the instrument during the summer of 1999, when the project was awarded £300,000 of funding by PPARC. The project was completed on budget and ahead of schedule in May 2002, when the instrument saw 'first light' on the 4.2-metre William Herschel Telescope on La Palma.

As well as successfully commissioning the instrument, the project team also acquired the first scientific data on white dwarf stars, showing that the instrument is working to specification.

The first images taken with ULTRACAM: the globular cluster M13 in the constellation Hercules (left); the spiral galaxy M51 in the constellation *Canes Venatici* (the Hunting Dogs)