Observing with the New High-Speed Camera ULTRACAM on Melipal

British astronomers[1] have opened a new window on the Universe with the recent commissioning of the Visitor Instrument ULTRACAM on the VLT).

ULTRACAM is an ultrafast camera capable of capturing some of the most rapid astronomical events. It can take up to 500 pictures a second in three different colours simultaneously. It has been designed and built by scientists from the Universities of Sheffield and Warwick (United Kingdom), in collaboration with the UK Astronomy Technology Centre in Edinburgh.

ULTRACAM employs the latest in charged coupled device (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 special because they are larger, faster and most importantly, much more sensitive to light than the detectors used in today's consumer electronics products.

In May 2002, the instrument saw "first light" on the 4.2-m William Herschel Telescope (WHT) on La Palma. Since then the instrument has been awarded a total of 75 nights of time on the WHT to study any object in the Universe which eclipses, transits, occults, flickers, flares, pulsates, oscillates, outbursts or explodes. These observations have produced a bonanza of new and exciting results, leading to eleven scientific publications already published or in press.

To study the very faintest stars at the very highest speeds, however, it is necessary to use the largest telescopes. Thus, work began two years ago preparing ULTRACAM for use on the VLT.

"Astronomers using the VLT now have an instrument specifically designed for the study of high-speed phenomena", said Vik Dhillon, from the University of Sheffield (UK) and the ULTRACAM project scientist. "Using ULTRACAM in conjunction with the current generation of large telescopes makes it now possible to study high-speed celestial phenomena such as eclipses, oscillations and occultations in stars which are millions of times too faint to see with the unaided eye."

Figure 1: The ULTRACAM instrument mounted on the visitor focus of Melipal (UT3).

The instrument saw first light on the VLT on May 4, 2005, and was then used for 17 consecutive nights on the telescope to study extrasolar planets, black-hole binary systems, pulsars, white dwarfs, asteroseismology, cataclysmic variables, brown dwarfs, gamma-ray bursts, active galactic nuclei and Kuiper-belt objects.

One of the faint objects studied with ULTRACAM on the VLT is GU Muscae. This object consists of a black hole in a 10-hour orbit with a normal, solar-like star. The black hole is surrounded by a disc of material transferred from the normal star. As this material falls onto the black hole, energy is released, producing large-amplitude flares visible in the light curve. This object has magnitude 21.4, that is, it is one million times fainter than what can be seen with the unaided eye. Yet, to study it in detail and detect the shortest possible pulses, it is necessary to use exposure times as short as 5 seconds. This is possible with the large aperture and great efficiency of the VLT.

These unique observations have revealed a series of sharp spikes, separated by approximately seven minutes. Such a stable signal must be tied to a relatively stable structure in the disc of matter surrounding the black hole. The astronomers are now in the process of analysing these results in great details in order to understand the origin of this structure.

[1] The ULTRACAM team is composed of Vik Dhillon, Stuart Littlefair, and Paul Kerry (Sheffield, UK), Tom Marsh (Warwick, UK), Andy Vick and Dave Atkinson (UKATC, Edinburgh, UK). For the installation on the VLT, they received support from Kieran O'Brien and Pascal Robert (ESO, Chile). The ULTRACAM project page can be found at *http://www.shef.ac.uk/~phys/people/vdhillon/ultracam*

Another series of observations were dedicated to the study of extrasolar planets, more particularly those that transit in front of their host star. ULTRACAM observations have allowed the astronomers to obtain simultaneous light curves, in several colour-bands, of four known transiting exoplanets discovered by the OGLE survey, and this with a precision of a tenth of a per cent and with a one-second time resolution. This is a factor ten better than previous measurements and will provide very accurate masses and radii for these so-called "hot-Jupiters". Because ULTRACAM makes observations in three different wavebands, such observations will also allow astronomers to establish whether the radius of the exoplanet is different at different wavelengths. This could provide crucial information on the possible exoplanets' atmosphere.

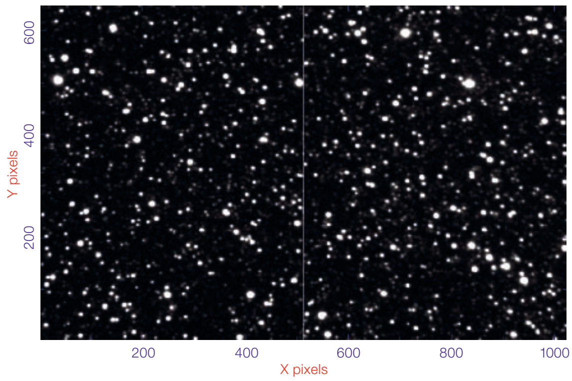

Figure 2: First light with ULTRACAM on the VLT: The field of the transiting extrasolar planet OGLE-TR-56b. The image shows only a portion of one of the three ULTRACAM CCD chips. Thousands of such one-second images were obtained in order to derive an accurate light curve of the transit at three different wavelengths, thereby enabling an accurate determination of the radius of the planet.

The camera is the first instrument to make use of the Visitor Focus on Melipal (UT3), and the first UK-built instrument to be mounted at the VLT. The Visitor Focus allows innovative technologies and instrumentation to be added to the telescope for short periods of time, permitting studies to take place that are not available with the current suite of instruments.

"These few nights with ULTRACAM on the VLT have demonstrated the unique discoveries that can be made by combining an innovative technology with one of the best astronomical facilities in the world", said Tom Marsh of the University of Warwick and member of the team. "We hope that ULTRACAM will now become a regular visitor at the VLT, giving European astronomers access to a unique new tool with which to study the Universe."

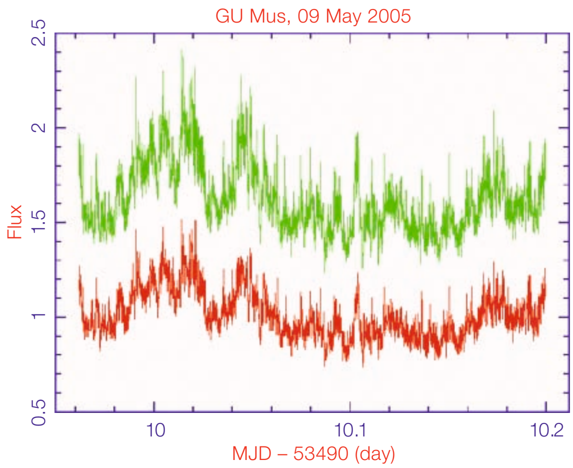

Figure 3: Light curves of the black hole GU Muscae. This figure shows an early scientific highlight from the first few nights of the ULTRACAM observing campaign on the VLT: light curves in the *I*- (red) and *G*-band (green) of the quiescent black hole X-ray transient GU Muscae. This object consists of a black hole in a 10-hour orbit with a normal solar-like star. The black hole is surrounded by an accretion disc of material transferred from the solar-like star. As this material accretes onto the black hole, energy is released, and this is evident from the large-amplitude flares visible in the light curves. What was not expected, however, is the series of sharp spikes that can be seen, and which are separated by approximately seven minutes. Such a stable signal must be tied to a relatively stable structure in the accretion disc.

The next run with ULTRACAM on the VLT is currently scheduled for November 2005, and plans are under way for a third run sometime during 2006. Anyone interested in applying for time on the instrument should contact one of the authors in the first instance. (Any such observations also require the approval of the OPC.)

(Based on ESO Press Release 17/05)

Figure 4: The ULTRACAM commissioning team in the VLT control room at first light. From left to right: Pascal Robert (ESO), Ariel Lopez (ESO), Kieran O'Brien (ESO), Andy Vick (UKATC), David Atkinson (UKATC), Paul Kerry (Sheffield), Vik Dhillon (Sheffield), Stuart Littlefair (Sheffield), Andreas Kaufer (ESO), Tom Marsh (Warwick).