The GTC gains high spectral resolution

HORuS, a new high-resolution spectrograph for the Gran Telescopio Canarias, will facilitate an expanded range of optical and near-infrared studies, explains Instrument Scientist Carlos Allende Prieto.

Ten years after the start of operations, the 10.4 m Gran Telescopio Canarias (GTC) on the island of La Palma is still the largest optical telescope in the world. In its first years the telescope had a single instrument, the imaging spectrograph OSIRIS (Optical System for Imaging and low-Intermediate-Resolution Integrated Spectroscopy). Now GTC has five instruments in operation, giving the telescope a wide range of capabilities to observe the Universe at optical and near-infrared wavelengths. Since March 2019 the cohort of GTC instruments has included the High Optical Resolution Spectrograph, HORuS, which allows spectroscopic observations with a broad spectral coverage (370–680 nm) and high spectral resolution ($R = \lambda/\delta\lambda = 25{,}000$).

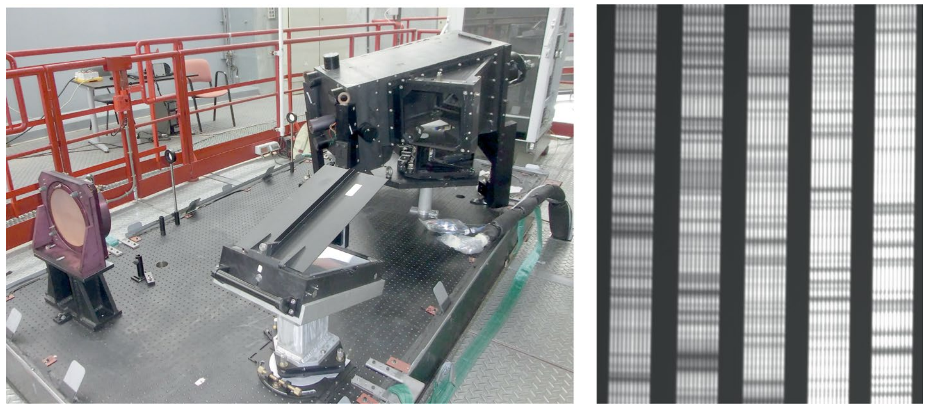

Fig. 1 | A view of and through HORuS. Left: HORuS in the Nasmyth platform of GTC. Right: a spectrum of solar light scattered through the Earth's atmosphere. Credit: Félix Gracia Témich (left panel).

HORuS, depicted in the left-hand panel of Fig. 1, was not built from scratch. Most of the components of the instrument have been at the Roque de los Muchachos Observatory, in La Palma, for 30 years, formerly integrated as the Utrecht Echelle Spectrograph (UES). UES operated on the 4.2 m William Herschel Telescope between 1991 and 2002 and, after decommissioning, the Isaac Newton Group donated the instrument to the Instituto de Astrofísica de Canarias, where it was upgraded with a new CCD and a fresh set of cross-dispersion prisms. The addition of a folding mirror reduced the original footprint substantially, allowing it to fit in the Nasmyth-B platform of the GTC, shared with OSIRIS. An optical fibre link with microlenses on both ends couples HORuS to the GTC.

The HORuS fibre link consists of an arrangement of 3 × 3 circular fibres giving a field-of-view of 2.1" × 2.1". The right-hand panel of Fig. 1 corresponds to an observation of the sky at twilight, showing how the solar spectrum is repeated in the nine fibres for each spectral order. The fibre array has too few fibres for meaningful spatially resolved observations, but it gives the instrument the ability to remain effective under mediocre seeing conditions. This is being exploited by multiple 'filler' programs on the queue-scheduled GTC that take advantage of observing conditions that cannot be used by other instruments.

Recycling most of the optical components brought about significant savings — the cost of building HORuS was about ten times lower than the price tag for similar instruments. It also reduced the human effort and construction time. The instrument was modified to become simpler, eliminating moving parts and adopting a commercial closed-circuit gas cooling system for the detector, making it essentially maintenance-free. The software packages for data acquisition and data reduction were created in-house, with simplicity as the main driver. The observing graphical interface has a calibration tab that allows the performance of full calibration (flat, bias, and wavelength calibration exposures) or wavelength-calibration-only sequences at the push of a button, illuminating the science fibres with calibration lamps.

HORuS enables science that could not have been done before with the GTC. Spectroscopy of stars provides radial velocities and detailed chemical abundances for many elements[1,2]. The point spread function is oversampled, giving very high signal-to-noise ratios in a single exposure for bright targets. This has proven useful for planetary transits, in which the signal from the planetary atmosphere can be detected in the ratio between spectra taken out of and in transit[3]. With an 8 × 2 pixel binning, the readout noise is low enough to explore targets as faint as $V = 17$ mag in a few hours. Thus, HORuS is being used for the study of globular clusters in nearby galaxies, since it has enough throughput and its resolving power matches the clusters' velocity dispersion. Other ongoing programmes with HORuS in the current semester include investigations of planetary nebulae, stellar streams, and the follow-up of extremely metal-poor stars identified from the commissioning observations of the Dark Energy Spectroscopic Instrument.

The observations carried out during commissioning, between November 2018 and March 2019, have recently been made public on the instrument's web site. After nearly two years of operations, HORuS will not be offered for the period March–October 2021, when OSIRIS will be moved from the Nasmyth-B to the Cassegrain focus. The Nasmyth acquisition and guiding (A&G) camera will also be upgraded at this time. Until now, we have been using OSIRIS to facilitate target acquisition for HORuS, but with these changes the acquisition will carried out with a new A&G camera. We plan to put HORuS back into operation in the Nasmyth focus in time for the following semester, starting in October 2021. ❐

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