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ENHANCEMENTS TO AF2/WYFFOS ON THE WHT

I. Skillen,[1] L. Domínguez Palmero,[1] and R. Jackson[2]

Multiplexed spectrographs on 4m-class telescopes, with their large fields-of-view, excel in complementing and playing a supporting role to the 10m-class telescopes such as GTC. We describe a programme of enhancements to AF2/WYFFOS on the WHT which will allow it to remain competitive until the proposed new wide-field fibre spectrograph, WEAVE, begins operations on the WHT in 2017.

AF2 is the robotic fibre-positioner at the prime focus of the WHT, and can place up to 150 fibres over its one-degree field-of-view. The fibres are high-content OH fused silica, with diameters of 1.6-arcsec. They feed the WYFFOS spectrograph, which is located on the GHRIL Nasmyth platform. The spectral resolutions available are from ∼200 to ∼9500, over a wavelength range 350 nm to 1000 nm.

The WYFFOS design invokes a Baranne layout in which the dispersed light traverses back through the collimator at a shallow angle of $\sim 7^\circ$ to the incoming beam, on its path to the camera. This allows undispersed light reflected off the front of the broad-band-coated collimator optics to enter the camera as a ghost image of the slit unit. For the higher resolution gratings this becomes a significant fraction of the dispersed light, impacting both spectral extraction and signal-to-noise. We are in the process of acquiring blocking filters to attenuate the broad-band ghost light for the gratings most affected.

Roughly two thirds of AF2/WYFFOS useage is in the red, beyond a wavelength of ∼700 nm. The current WYFFOS detector is a mosaic of two blue-sensitive, thinned e2v-42-80 CCDs, with quantum efficiency ∼40% at 850 nm. It has degraded cosmetically, and fringes strongly, e.g. fringe amplitudes are ∼20% at 700 nm and ∼50% at 850 nm. We have purchased an e2v 230-84 4k×4k, red-sensitive, fringe-suppression CCD, which will be commissioned shortly. The low fringing properties and near-doubling of the red QE of this device will provide a significant boost to the performance of AF2/WYFFOS in the red.

The total peak throughput of AF2/WYFFOS (sky-to-detector) for the low resolution gratings is ∼6.5% in the R-band, falling to ∼1.6% in the B-band, and less than ∼1% in U-band. The visual-to-red performance compares favourably with, e.g. the contemporaneous original 2dF instrument on the AAT, but is worse in the blue and ultraviolet by a factor of at least two. This does not appear to be explained solely by the blue transmission of the fibres. We have begun an audit of the optical components to better understand overall system performance, and to identify if significant improvement is readily possible, particularly in the blue. This includes assessing throughput and ageing effects in the fibres such as focal-ratio degradation.

The scientific productivity of complex instrumentation is strongly linked to the availability of data reduction pipelines. An IDL-based pipeline has been developed to perform full reduction of AF2/WYFFOS data, including fibre-to-fibre sensitivity corrections and optimal extraction, with provision for quick-look, real-time analysis at the telescope.

The calibration unit for WYFFOS offers He, Hg and Ne arc-calibration lamps, and a tungsten continuum, flat-field lamp. The tungsten lamp does not produce sufficient flux in reasonable integration times in the ultraviolet to trace the fibres. We will shortly install a quartz-tungsten-halogen lamp, with a colour-balance filter to address this. Provision of a ThAr hollow-cathode arc lamp with its rich line spectrum is expected to improve radial-velocity precision in the red echelle orders by as much as a factor of two compared with the current Ne lamp. Generating adequate calibration lines in the bluest echelle orders is difficult; the current Hg lamp has only four lines in orders 6 and 7 combined. We are acquiring Cd and Zn lamps to improve calibration capability in these orders.

Light loss due to astrometric error or drift degrades throughput for point targets, and adapting observing strategy to sky position and conditions limits this loss. We plan to provide quantitative estimates as a function of hour angle, declination and seeing of maximum observing times before field reconfiguration is needed to limit fibre-aperture losses by differential atmospheric refraction across the field.

[1]Isaac Newton Group of Telescopes, Apartado de Correos 321, E-38700 Santa Cruz de La Palma, Tenerife, Spain (wji@ing.iac.es).

[2]Astrophysics Group, Keele University, Staffordshire, ST5 5BG, United Kingdom.