WEAVE
Design of the calibration unit for the WEAVE multi-object spectrograph at the WHT

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ABSTRACT
WEAVE is the next-generation spectroscopic facility for the William Herschel Telescope (WHT), offering multi-object (1000 fibres) and integral-field spectroscopy at two resolutions (R ~ 5000, 20000) over a 2.5 deg field of view at prime focus. WEAVE will (mainly) provide optical follow up of ground-based (LOFAR) and space-based (GAIA) surveys. First light is expected towards the beginning of 2016. Here, we describe the calibration unit, which will be adapted from an existing unit for the AF2+WYFFOS spectrograph (WEAVE’s precursor) at the WHT. We summarise the results from a thorough characterisation of current performance (e.g. intensity, stability and focal-plane coverage of illumination as a function of lamp type and wavelength). We then set out our plans for upgrading the unit and its control systems to meet the WEAVE science and operational requirements.

We conclude from this assessment that the upgraded AF2+WWFFOS calibration unit will meet the requirements for WEAVE.

The design of the WEAVE calibration unit is now complete.

Overview of calibration unit
The design of the WEAVE calibration module is based on the hardware installed in the WHT, currently in use for WYFFOS spectrograph. The current calibration unit is being adopted to meet the requirements for WEAVE.

- The lamps in the calibration unit illuminate the field-of-view at WHT Prime Focus via the tertiary mirror (M3). Light is thus fed into the WEAVE filters placed on the focal plane.
- Exposures obtained with these lamps are required to calibrate the science data, and also to monitor the long-term instrument quality.

Infrastructure
The calibration unit consists of:
- Lamp slide with 4 paddle holders:
  1. permanently occupied by continuum QTH (Quartz–Tungsten–Halogens) lamp
  2. permanently occupied by ThAr lamp
  3. 2 filters with 6 positions:
    - Neutral density filters (ND = 0.1, 1, 2, 3)
    - Colour filters
  4. Tertiary mirror (M3) mounting to “Broken Cassegrain” aperture as long as needed without interfering with observations

New control system
- The control of the calibration unit mechanisms will be integrated into the WEAVE spectrograph’s PAC (Programmable Automation Controller).
- A remote sub-controller integrates all calibration unit mechanisms and supports equipment (encoders, sensors, limit switches, etc.) with the spectrograph PAC, via Ethernet, as a single controller, without extra hardware.

Conclusions
The design of the WEAVE calibration module is now complete. It is based on the existing mechanisms currently installed at the WHT in use for AF2+WYFFOS. An exhaustive assessment of the current performance of the unit has been carried out, concluding that after some upgrades (new control system, new control strategy, new lamps) the module will meet the WEAVE science and operational requirements.

Mechanism speed
By implementing a new control strategy for the stepper motor, we have increased the speed of calibration unit mechanisms by a factor of 5 and improved performance, while keeping 100% of the hardware.

- Expected achievable speed ~40 rev/sec (linear speed ~0.20 m/s).
- Expected maximum time for any slide movement ~ 20 seconds, with 1 second for ramp up and ramp down of the motor speed.

View of the remote rack with impurity mirror unit setup in the laboratory.

Mechanism speed

Wavelength coverage
Example of an arc map for the ThAr lamp (R = 10000).

Our analysis of arc maps for all available arc lamps (ThAr, Ne, Hg, Zn, Cd) concludes that:
- ThAr lamp is the most suitable arc lamp for WEAVE.
- SiO arcs lines (10 nm for low-resolution)
- SiO arcs lines (25 nm for high-resolution).
- Ne lamp useful at the red in low-resolution.
- ThAr and Ne lamps provide satisfactory calibration for WEAVE at all wavelengths.

Focal-plane illumination
- Radial variation in illumination is < 5% over the 40 cm diameter field required by WYFFOS for QTH, Ne, Hg and Hg lamps.
- Exposure times < 30 sec provide the required Signal-to-Noise for QTH, Ne, Hg, Hg and Cd.
- The principal issue with conventional hollow-cathode (HCl) ThAr lamp:
  - Insufficient fill, especially in the blue lines => long exposure times.
  - Difficulty adjusting lamp for uniform illumination over the WEAVE 2-deg field => outer half of the field insufficiently illuminated
- New ThAr lamp from Photron Ltd. (Australia) has been purchased for WEAVE, which allows an excitation current 4 times higher. By careful adjustment of the lamp position within the reflector, we have found:
  - Improves flux 3x field (over conventional) => shorter exposure times.
  - Illuminates the WEAVE 2-degrees field with the required uniformity.
  - The reflector mount should undergo mechanical modifications to improve adjustability, stability and repetitability.

Repeatability of lamp intensity
The variation of lamp intensity with time was measured for all available lamps, including lamp switch-on times, brightness variations, warm-up times, and long term stabilization. Both integrated lamp flux and relative spectral arc line variation were analysed in detail.

- Largest variations in flux is typically in the first 30 sec after switching on, particularly in the Hg, Cd lamps.
- ThAr, Ne practically do not need warming.
- Small variation (< 15%), after warm-up, in relative line intensity over periods 15-20 minutes.

Weave Calibration Calibration unit

Bench of new ThAr lamp with optical filters, inserted in the calibration unit to allow optimal wavelength coverage.

ThAr lamp and special reflector installed in the calibration unit between other two conventional lamp reflectors.

Weave Calibration Calibration unit

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