Performance of the SALT High Resolution Spectrograph

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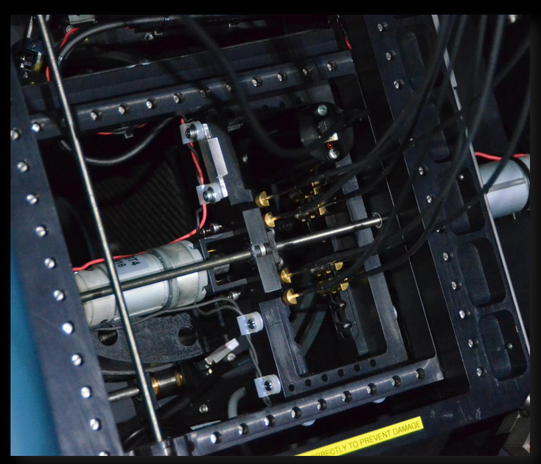
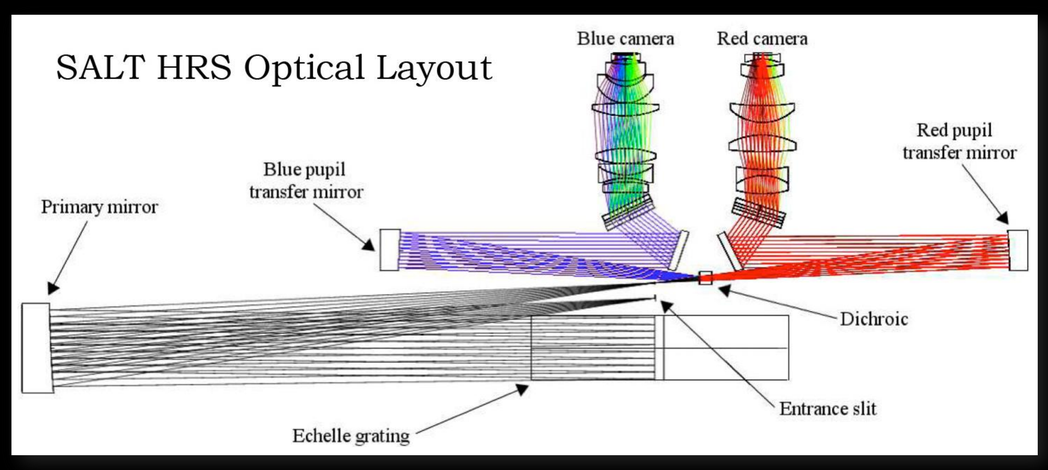
ABSTRACT

The Southern African Large Telescope (SALT) High Resolution Spectrograph (HRS) is a dual-channel, "white pupil" fibre-fed échelle with wavelength coverage from 370–890nm. Each of the four modes: Low (R~14000), Medium (R~40000) and High Resolution (R~65000), and High Stability (HS) for enhanced radial velocity precision at R~65000, have object and sky fibres. The HS mode includes a fibre double-scrambler and options to employ an iodine cell or simultaneous ThAr arc injection. LR has unsliced 500μm (2.2") fibres and optional nod-and-shuffle to improve background subtraction. MR (500μm fibres), HR and HS (350μm, 1.6" fibres) have image-slicers to increase resolution. Here we describe the instrument and report on its performance since first-light was achieved on 28 September 2013.

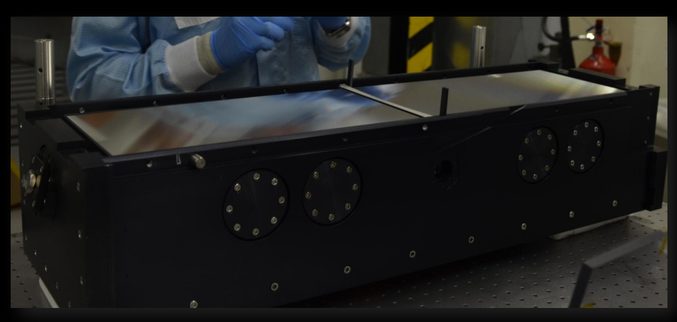
SALT HRS Hardware

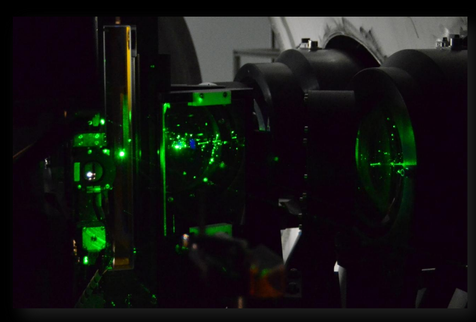


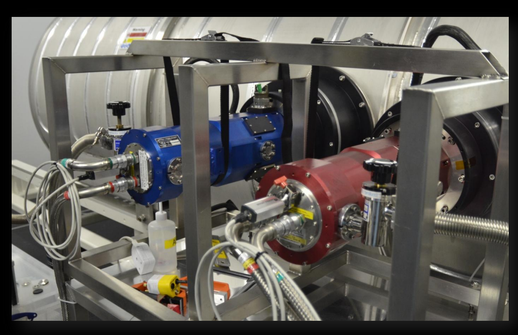
The Fibre Instrument Feed (above left) at prime focus couples the HRS fibres to the telescope. The brass ferrules are attached to translation stages for mode pair selection (vertical) and object/sky fibre separation (horizontal) adjustment. The HRS is enclosed in a steel vacuum tank (above right), which is bricked inside a Styrostone enclosure for insulation against the destabilizing effects of temperature and air pressure variations. The room temperature is also controlled within 0.5°C.

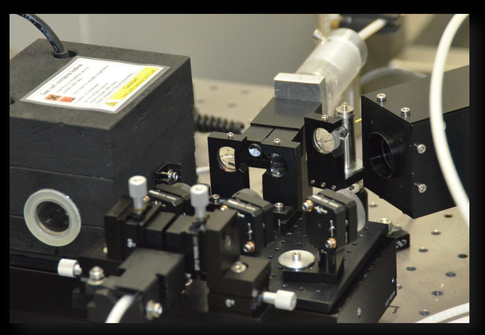


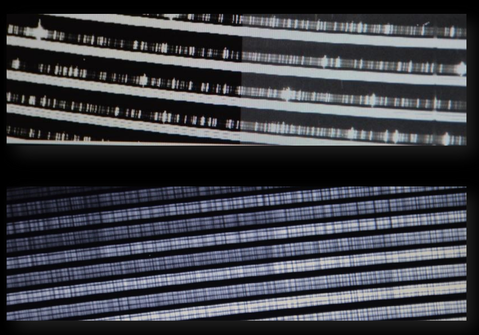
The R4 échelle is a mosaic of two identical 214mm x 400mm gratings on a single Zerodur substrate (below left). The exposure meter pick-off mirror fits in the gap between them so no starlight is wasted. The dichroic beam-splitter cross-over is at 555nm so a green laser is used to align both channels (below right). The cameras, a VPH grating cross-disperser and the image-slicer optics are shown at the bottom.











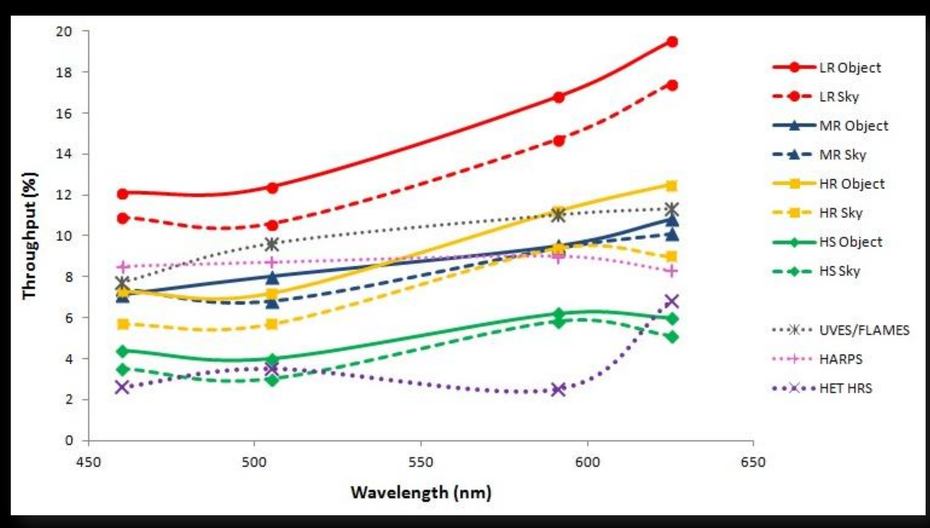
A linear stage on the high stability bench outside the tank (above left) selects the various options: directing ThAr light into either HS fibre for internal arcs (above centre), simultaneous ThAr injection into the sky fibre during an observation (above top right) and inclusion of an iodine cell in the beam (above bottom right).

Instrument Performance

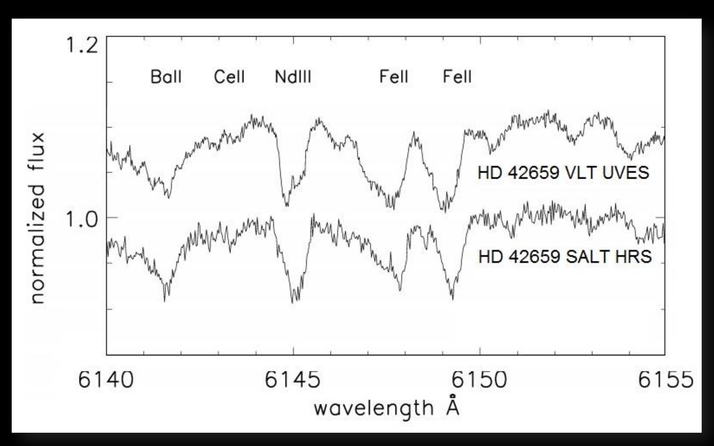
ThAr arc lines were used to measure the spectral resolution over the two channels. The table gives the mean resolving powers at the blaze wavelength of each order.

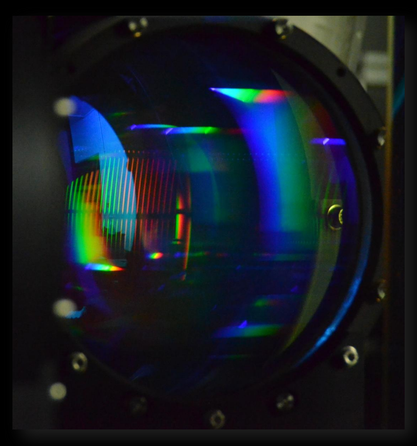
Mode	Resolving Power Red	Resolving Power Blue
Low Resolution	14000	15000
Medium Resolution	39600	43400
High Resolution	73700	66700
High Stability	64600	66900

The end-to-end throughput of the four modes was measured before routing the fibre cable to the SALT Payload. Narrow-band LEDs with peak wavelengths at 460, 505, 591 and 625nm (two/channel) were powered by a stabilized current source. Each fibre input was illuminated with a 50μm spot at F/4.2, to simulate the output focal ratio of the telescope. The total input flux was measured with a calibrated photodiode and aperture photometry performed on the CCD images to determine the output from each fibre. The results are plotted below, along with estimates from exposure time calculators for similar high resolution spectrographs.



Instrumental stability is crucial for SALT HRS to compete with similar high resolution spectrographs. The temperatures of components on the optical bench are monitored constantly and kept within a ~0.01K range. The HS mode's internal ThAr arcs are used to monitor the line profiles. Flux and FWHM measurements meet the specifications of 10% rms and 1% rms, respectively, for any 12 hour period. We are still improving thermal insulation and temperature regulation in the spectrometer and instrument room, but can already achieve <10 m/s rms.





The plot above compares UVES and SALT HRS data of a roAp star obtained during the Science Verification (SV) phase. The instrument is now available to the SALT community for charged science observations! ☺

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