SALT Spectropolarimetric Pipeline Comparisons

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Introduction

Blazars are a radio-loud sub-set of Active Galactic Nuclei (AGN), where the jet is aligned very closely to our line of sight and whose observed emission varies over drastically differing time scales [1]. The optical emission observed from blazars is often dominated by the polarised, non-thermal emission arising in the jet, but there is also an underlying unpolarised, thermal component arising from the host galaxy, dusty torus, and accretion disk components [2]. When a blazar varies between flaring and quiescent states, the relative strength of the thermal to the non-thermal emission components change.

The Spectral Energy Distribution (SED) of blazars shows two clear components: a lower energy component produced through leptonic synchrotron processes (ranging from radio to UV/soft X-ray regimes) and a higher energy component (ranging from X-ray to γ-ray regimes) which is believed to be produced through either leptonic or hadronic processes [3]. Optical spectropolarimetry observations coupled with multi-wavelength observations during both flaring and quiescent states can be used to disentangle the polarised and non-polarised components in the blazars SED, providing better constraints for the non-thermal particle distribution [4, 5].

To this end, spectropolarimetric observations of blazars during different states of activity were taken. In order to facilitate the blazar observations we have developed a supplementary pipeline to provide a more interactive approach to the wavelength calibration, and provide additional tools to improve the accuracy of the wavelength calibration for the O & E beam [6]. Here we present spectropolarimetric observations of a spectropolarimetric standard and the preliminary results for the blazars 3C 279, and 4C+01.02.

Observations

The spectropolarimetric observations were taken using the Robert Stobie Spectrograph (RSS) mounted on the Southern African Large Telescope (SALT) [7,8], in LINEAR mode under the programme ID 2016-2-LSP-001.

The spectropolarimetric standard, Hiltner 652, was observed on the 10th of June 2022 using PG0900 at a grating angle of 12.878° (covering a wavelength range of ~3350 - 6440 Å with a resolving power of R ~670 - 1040). The blazar 4C+01.02 was observed on the 8th of July 2016 using PG0300 at a grating angle of 5.375° (covering ~3200 - 8500 Å with R ~167 - 533). The blazar 3C 279 was observed on the 28th and 31st of March 2017 as well as on the 17th of May 2017 using PG0900 at grating angles of 12.5° (covering ~3300 - 6300 Å with R ~644 - 1011) as well as 19.625° (covering ~5800 - 8800 Å with R ~1149 - 1515).

The data was reduced using a modified version of the POLSALT pipeline [9], where the wavelength calibration of the O&E beams was done using IRAF [10] instead of the python based wavelength calibration method implemented in POLSALT. This provides more flexibility in fitting, in particular, the observations taken with PG0300 since there are few arc lines available for wavelength calibration. Additional tools to cross-check that the wavelength calibration is consistent across both beams have also been implemented.

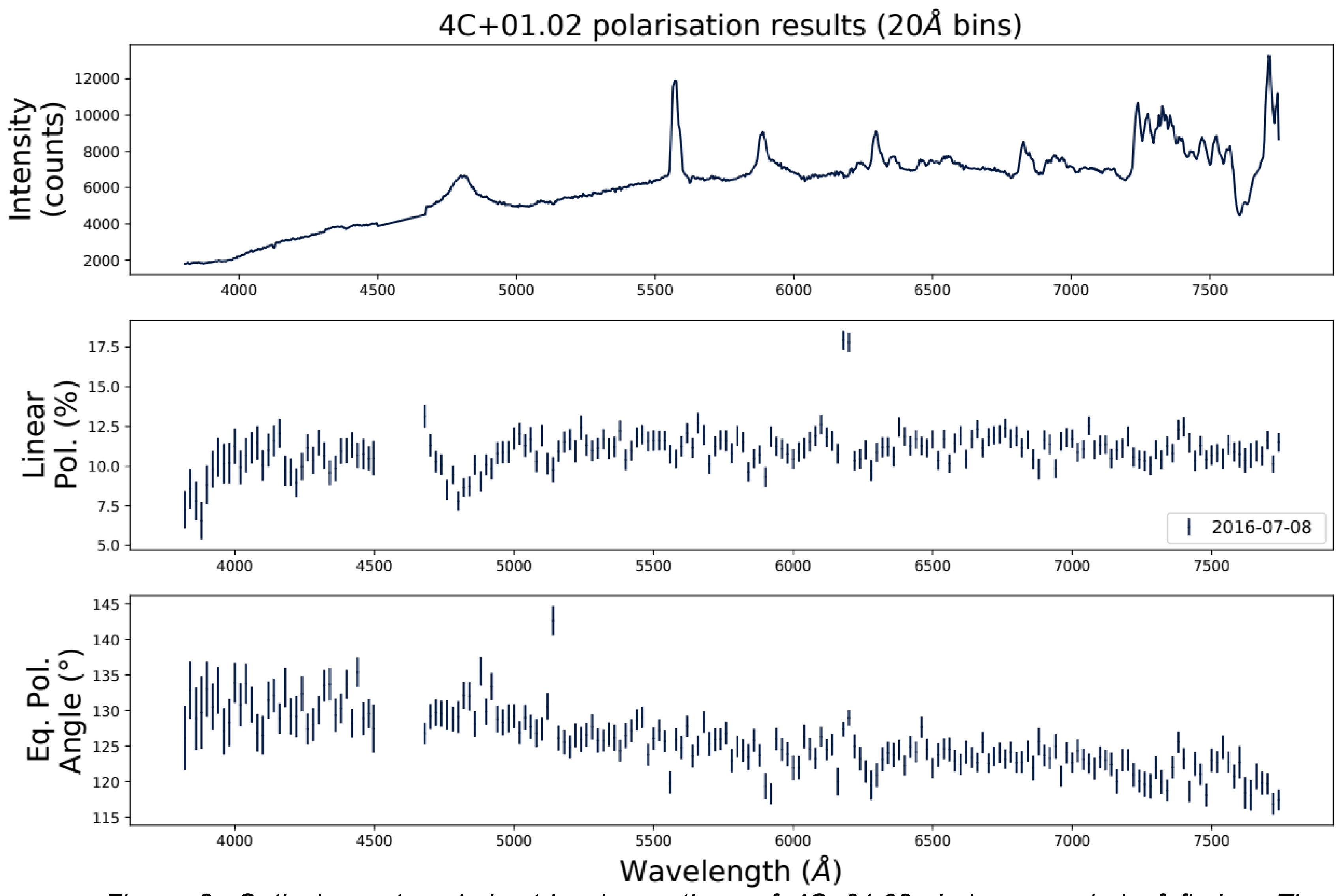

Figure 2: Optical spectropolarimetric observations of 4C+01.02 during a period of flaring. The relative flux calibrated spectrum for the grating angle 5.375° (top), the degree of polarisation (second from top), and the polarisation angle (bottom).

Results

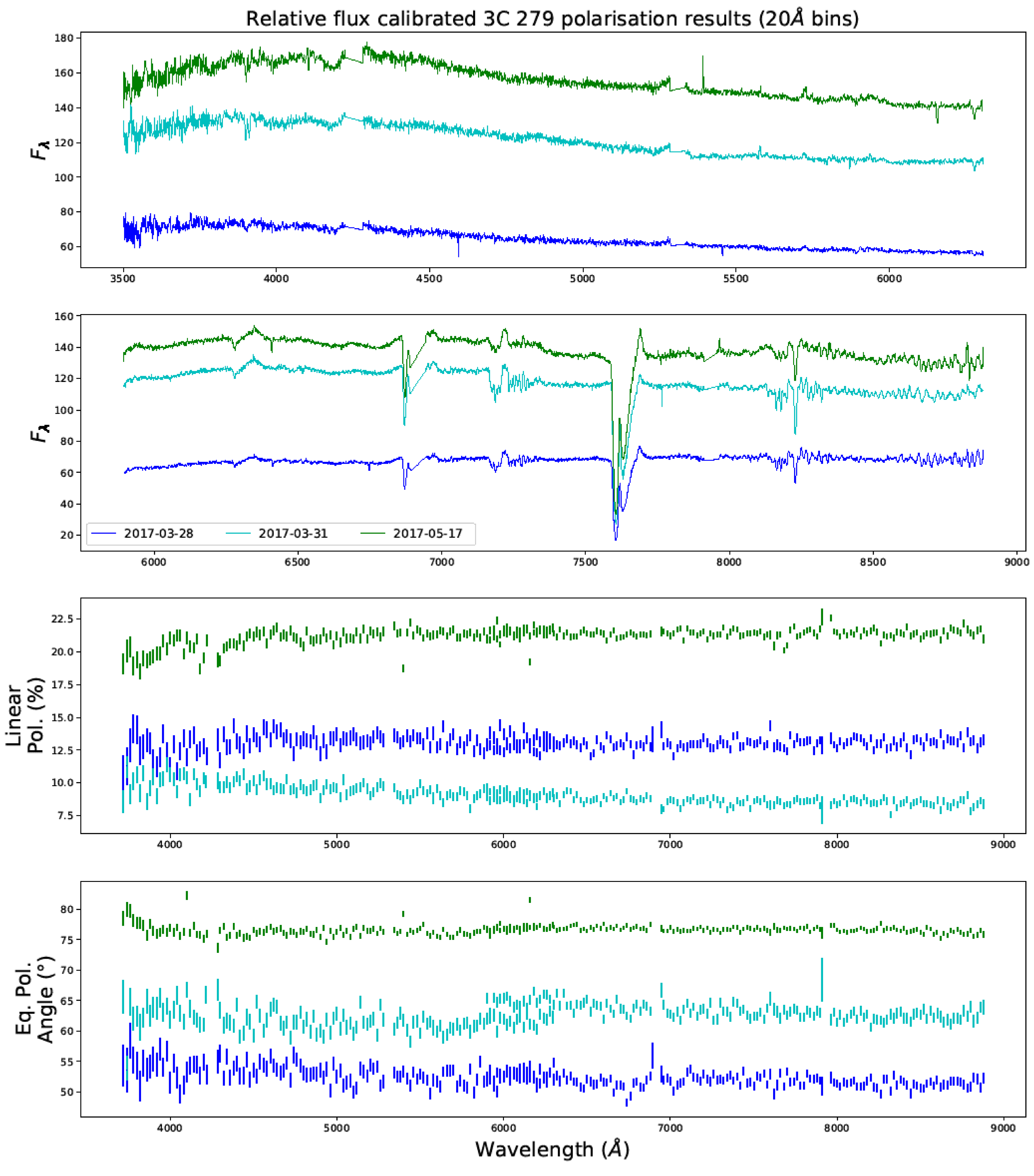

Figure 1: Optical spectropolarimetric observations of 3C 279 during two different periods of flaring. The relative flux calibrated spectra for the grating angles 12.5° (top), observed first at each epoch, and 19.625° (second from top), the degree of polarisation (third from top), and the polarisation angle (bottom).

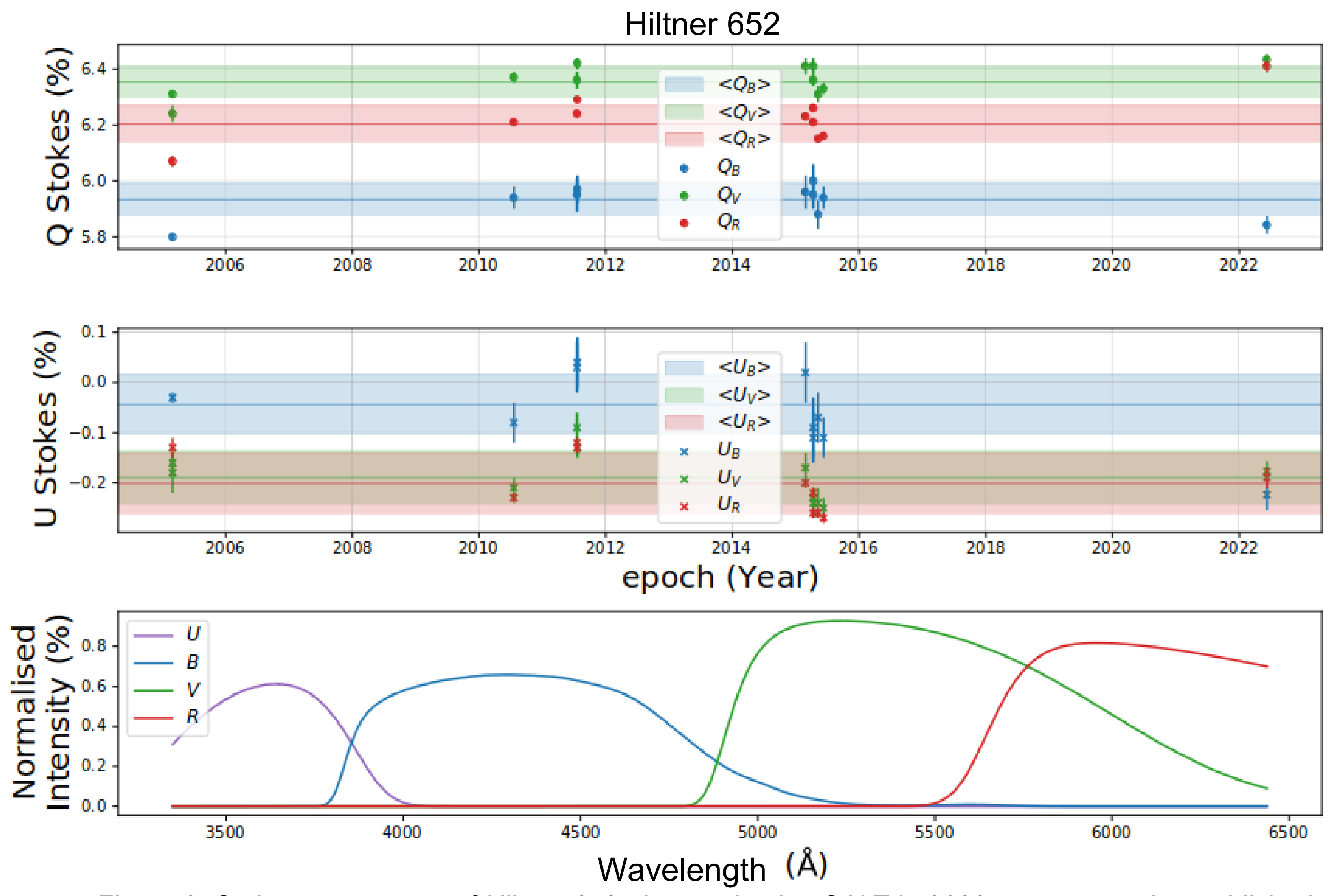

Figure 3: Stokes parameters of Hiltner 652 observed using SALT in 2022 as compared to published FORS1 [11] and FORS2 [12] Stokes parameters taken from 1999 to 2006, and from 2010 to 2016, respectively. Finally, the Johnson-Cousins filter pass-band's plotted against wavelength used by the POLSALT 'specpolfilter' method as covered by the observation configuration for Hiltner 652.

Conclusion

The Stokes parameters of Hiltner 652, a spectropolarimetric standard, fall within or near a 1σ level of previously published Stokes parameters over the course of multiple years. This shows that Hiltner 652 is not only a good standard for spectropolarimetric observations but also that POLSALT and the supplementary wavelength calibrations do not alter the calculation of the Stokes parameters.

The degree of polarisation and polarisation angle for 3C 279 shows clear variation at the different epochs but are still in good agreement for the different grating angles. This is a good indication that the more rigorous wavelength calibration procedure, implemented through IRAF, as compared to the current python implementation allows for better measurement of the polarisation results.

References

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