Optical spectropolarimetry monitoring of flaring blazars

NATURAL AND AGRICULTURAL SCIENCES
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Introduction

Active Galactic Nuclei (AGN) are the central active cores of some galaxies, powered by the accretion of material onto a central supermassive black hole. AGN display non-thermal emission across the entire electromagnetic spectrum, and can power relativistic jets [1]. Blazars are a radio-loud subclass of active galactic nuclei with relativistic jets closely aligned with our line of sight, resulting in relativistic emission observed across multiple wavelength bands. These sources are extremely variable; often exhibiting rapid flares over all wavelengths.

Blazars can be subdivided into two different types, namely flat-spectrum radio quasars (FSRQs) and BL Lac type objects (BLLs). FSRQs show strong emission lines originating in the broad-line region (BLR) of the AGN, whereas BLLs display featureless spectra dominated by non-thermal jet emission. This is due to the FSRQs having higher accretion rates and therefore having more luminous accretion disks and BLRs [2].

Blazar spectral energy distributions (SEDs) are characterised by a double-humped structure, where the lower-energy component (radio through UV or soft X-ray) is powered by leptonic synchrotron emission, and the high-energy component (X-ray through gamma-ray) is powered by either leptonic inverse Compton scattering or hadronic processes [3]. At optical wavelengths, there is also an underlying thermal contribution to the SED from the accretion disc, BLR, dust torus, and host galaxy [4], making it difficult to disentangle the different components and their contributions to the emission.

Optical spectropolarimetry is a useful tool in disentangling the emission, as it separates the thermal (non-polarised) components from the non-thermal (polarised) component. Through collaborations with the South African Astronomical Observatory (SAAO) [5], we have access to two different long-term observation programmes to observe transient blazars and trace their evolution from flaring to none-flaring state. We present results on the degree of linear polarisation evolution from flaring to non-flaring state for a selection of blazars along with more long-term observations of both an FSRQ and BLL to investigate blazar-variability.

SALT Observing Programmes

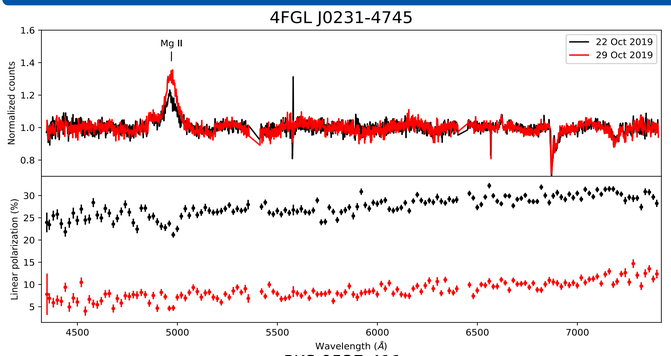
The Southern African Large Telescope (SALT) is a 10-m optical telescope near Sutherland, in the Northern-Cape, South Africa. As part of the *Observing the Transient Universe* (2018-2-LSP-001, PI D. Buckley) and *Untangling variability in blazars through spectropolarimetry and RMHD simulations* (2019-2-MLT-001, PI B. van Soelen) programmes, we have observed gamma-ray flaring blazars using the RSS spectrograph [6,7] in LINEAR spectropolarimetry mode. Observations have been taken using either the pg0300 grating or two orientations of pg0900. Observations have been undertaken since 2016 and a summary of observations is shown in Table 1. Notable observations of flaring blazars are shown below, along with the long-term monitoring of two sources.

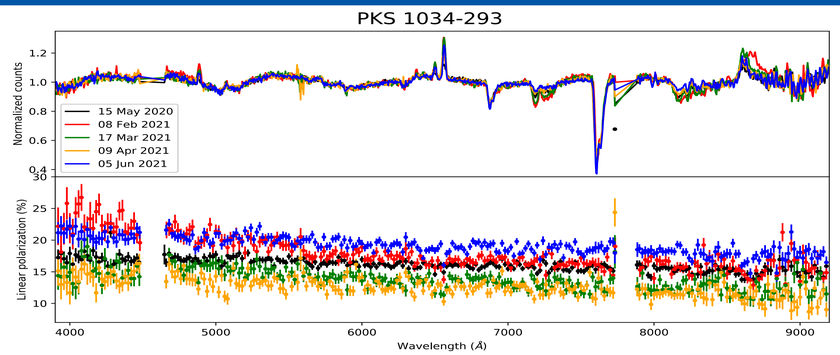
Table 1: Representative sample of FSRQ and BL Lacs observed in both of the SALT observing programmes (2016-June 2021). The mean linear polarisation is measured between 4000 Å - 8000 Å.

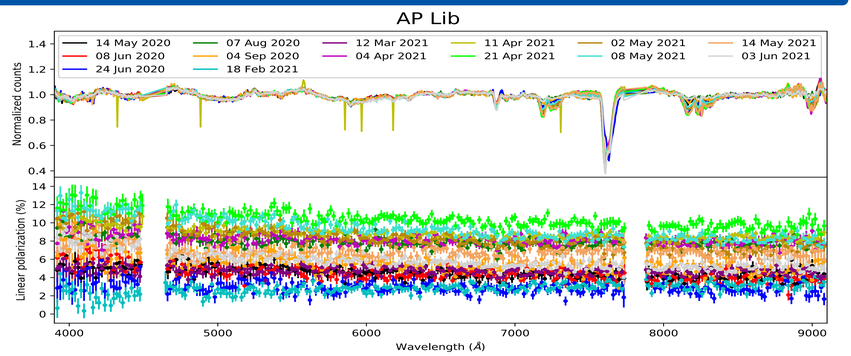
Target	Type	Obs. Dates	Mean Pol.
4FGL J0231 4745	FSRQ	22/10/2019	27.5
		29/10/2019	8.7
PKS0208-512	FSRQ	05/12/2019	27.4
		19/12/2019	5.3
PKS0537-441	BLL	14/01/2019	37.4
		05/03/2019	12.6
PKS0837+012	FSRQ	16/03/2021	10.6
PKS2023-07	FSRQ	16/04/2016	27.5
		04/10/2018	9.1
PKS0907-023	FSRQ	19/01/2017	5.1
PKS0426-380	BLL	17/01/2017	10.8
		20/02/2017	10.9
PKS0447-439	BLL	21/02/2017	5.1
TXS0506+056	BLL	14/10/2017	10.7
		20/10/2017	8.6
PKS0131-522	FSRQ	19/11/2017	7.8
		22/11/2017	6.4
PKS0346-279	FSRQ	09/02/2018	18.2
PKS0035-252	FSRQ	20/07/2018	2.6

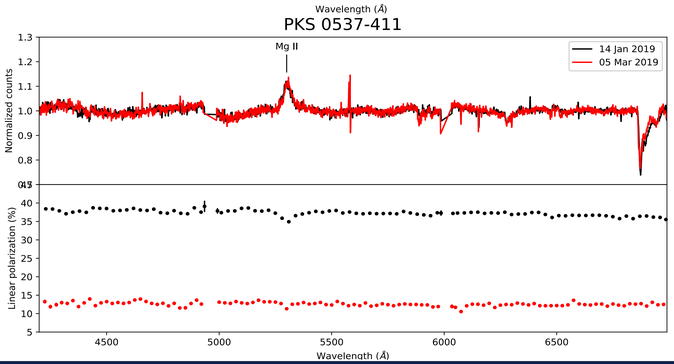
Target	Type	Obs. Dates	Mean Pol.
AP Lib	BLL	14/05/2020	5.3
		08/06/2020	5
		24/06/2020	3.4
		07/08/2020	8.9
		04/09/2020	6.3
		18/02/2021	3.4
		12/03/2021	5.2
		04/04/2021	8.5
		11/04/2021	9.1
		21/04/2021	11
		02/05/2021	8.6
		08/05/2021	9.6
		14/05/2021	7.1
		03/06/2021	6.2
PKS1034-293	FSRQ	15/05/2020	16.2
		08/02/2021	17.9
		17/03/2021	13.8
		09/04/2021	12.7
		05/06/2021	19.1

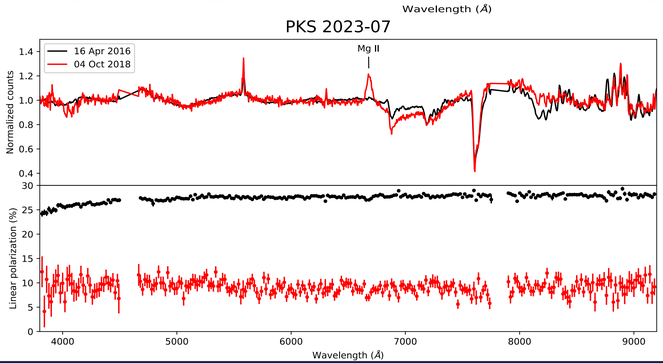
Results











Discussion and Conclusion

To date, we have successfully measured the change in polarisation of a number of blazars (both FSRQ and BLLs) during flaring and non-flaring states. We have, for approximately one year, been monitoring AP Lib and PKS 1034-293. Neither source has shown a large change in polarisation over the observation period. AP Lib, a BLL, shows a lower mean polarisation (3-12%) compared to PKS 1034-293 (12-20%), an FSRQ. These observations will be complemented by optical photometry observations from the LCO telescope network to improve flux calibration. These long term polarisation studies are important for disentangling the underlying emission processes in relativistic jets.

References

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