Spectropolarimetry observations of flaring blazars as part of the Southern African Large Telescope AGN Transient programme

NATURAL AND AGRICULTURAL SCIENCES
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B. van Soelen,[1,] J. Barnard,[1] J. Cooper,[1] R.J. Britto,[1] J.P. Marais,[1] T. Mbonani,[1] D.A.H. Buckley,[1,2] H.M. Schutte,[3] M. Böttcher[3]

1. Department of Physics, University of the Free State, Bloemfontein, South Africa 2. South African Astronomical Observatory, Observatory, Cape Town, South Africa, 3. Centre for Space Science, North West University, Potchefstroom, South Africa

Introduction

Active Galactic Nuclei, powered by the accretion of material onto a supermassive black hole, show non-thermal emission over a wide wavelength range and can power relativistic jets. For blazar sources, the line of sight is closely aligned with the direction of the jet propagation and the emission is greatly enhanced by Doppler boosting. Blazars can be sub-divided into BL Lacs and Flat Spectrum Radio Quasars (FSRQs) where the FSRQs show strong optical emission lines, arising from the surrounding broad line region (BLR), while for BL Lacs the optical emission is dominated by the non-thermal emission from the jets. This is the result of the higher accretion rates in FSRQs, resulting in a more luminous accretion disk and BLR [e.g. 1].

The Spectral Energy Distributions (SEDs) of blazars show two non-thermal components, a lower energy component extending from radio to X-rays, and a higher energy component from X-rays to gamma-rays. The lower energy component is produced through leptonic synchrotron emission, while leptonic and hadronic models have been proposed for the high energy component [e.g. 2]. In the leptonic scenario, the high energy component is produced through synchrotron self-Compton or External Compton emission, by the same electron population producing the lower energy synchrotron emission. However, at optical wavelengths the emission is a superposition of the non-thermal jet contribution and the thermal contribution from the accretion disc, BLR, dust torus and host galaxy. These components are difficult to disentangle, but polarization provides a method to separate the unpolarised thermal from the polarised non-thermal contributions [e.g. 3]

We have been undertaking a ToO observation campaign with the Southern African Large Telescope [4], since 2016 to observe blazars during flaring states to trace the evolution of the polarization. Here we present results from the overall SALT observing programme.

SALT Observing programme

The Southern African Large Telescope (SALT) is a 10-m optical telescope located near Sutherland, in the Northern Cape, South Africa. As part of the *Observing the Transient Universe* programme (2018-2-LSP-001, PI D.A.H. Buckley) we have observed gamma-ray flaring blazars using the Robert Stobie Spectrograph (RSS) [5,6] in LINEAR spectropolarimetry mode.

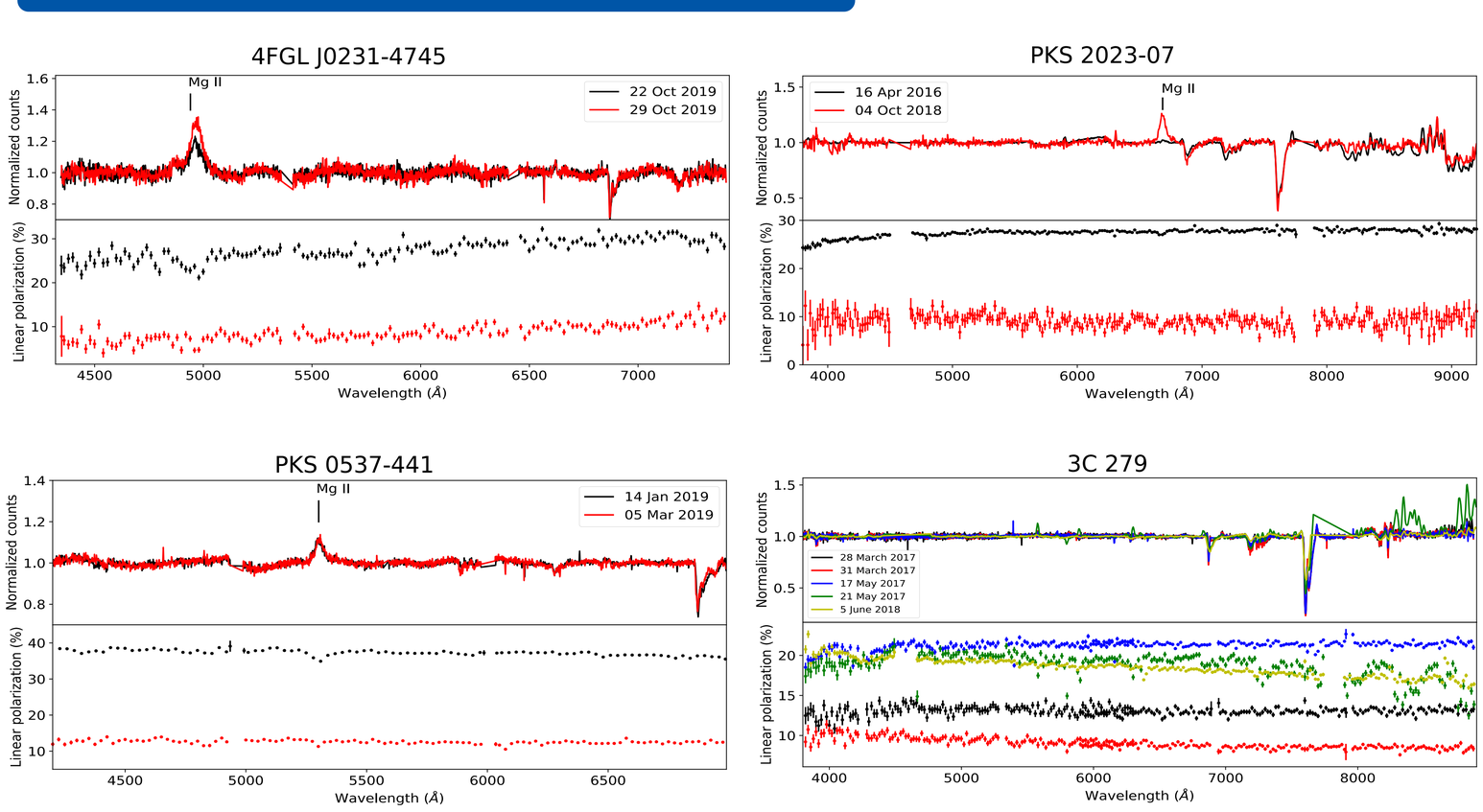
Observations have been taken using either the pg0300 grating, which covers the full optical range (R~200-500) or in two orientations of pg0900 covering 3200 – 6300 Å (R~600-1000) and 6000 – 9000 Å (R~1000-1500). Data was reduced using *IRAF* and the *polsalt* package [7].

Observations have been undertaken since 2016 and a representative sample is shown in Table 1. Notable results of some observations are shown below.

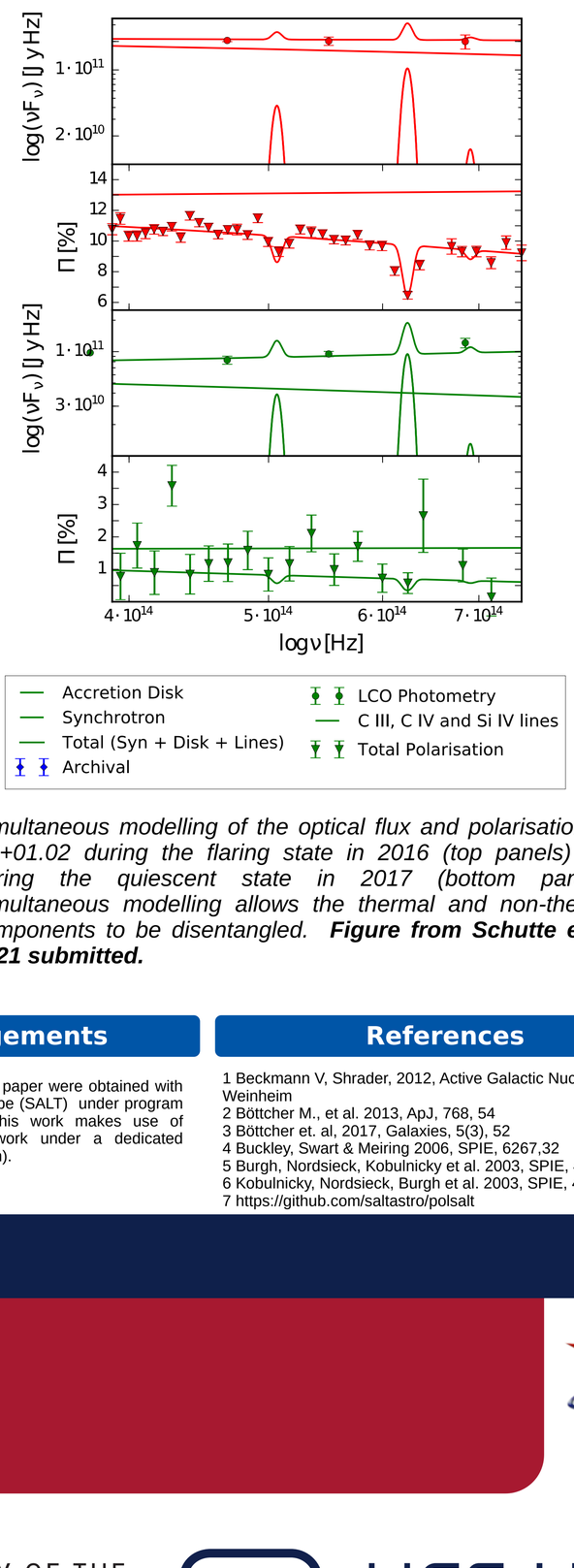
Table1: Representative sample of FSRQ and BL Lacs observed since 2016. The mean linear polarization is measured between 4000 Å - 8000 Å.

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
3C279	FSRQ	28/03/2017	13.3
		31/03/2017	9.5
		17/05/2017	21.1
		21/05/2017	17.8
		05/06/2018	18.9

Results



Example of four sources observed during different states, showing the change in polarisation. For 4FGL J0231-4745 and PKS 2023-07, there is a clear change in the strength of the Mg II line between high and low polarisation states, showing how during flare states the non-thermal component becomes more dominant.



Simultaneous modelling of the optical flux and polarisation for 4C+01.02 during the flaring state in 2016 (top panels) and during the quiescent state in 2017 (bottom panels). Simultaneous modelling allows the thermal and non-thermal components to be disentangled. ***Figure from Schutte et al. 2021 submitted.***

Conclusion

The SALT ToO programme has been successful in measuring the change in polarisation of a number of FSRQ and BL Lac sources. Combined with multi-wavelength observations and modelling this allows the thermal and non-thermal components to be disentangled. A paper presenting a detailed analysis of 4C+01.02 during 2016 and 2017 has recently been submitted (Schutte et al. 2021), where optical spectropolarimetry and photometry has been used to tightly constrain the mass of the central black hole.

Acknowledgements

Some observations reported in this paper were obtained with the Southern African Large Telescope (SALT) under program 2012-2-* (PI: D.A.H. Buckley). This work makes use of observations from the LCO network under a dedicated transient program (PI: B. van Soelen).

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vansoelenb@ufs.ac.za | **www.ufs.ac.za**

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