Observations of possible jet formation in the binary blazar OJ287

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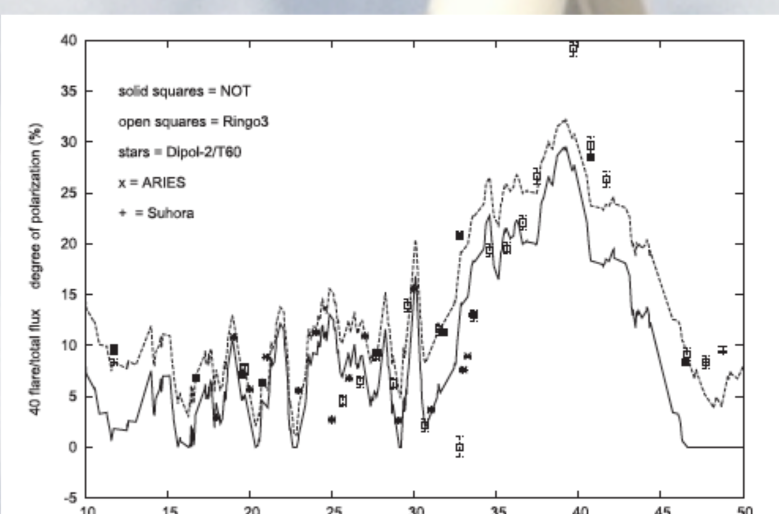
Abstract

In November- December 2015 the OJ287 binary supermassive black holes system under went a double peaked flare associated with the interaction of the secondary supermassive black hole of the with the accretion disk of the primary supermassive black hole causing a predicted flare in optical wavelengths (see Valtonen et al. ApJ letters, 819:L37, 2016 March). 20 days after the first flare, a second flare was observed, this was joined by a simultaneous optical degree of polarisation flare- the highest on record - reaching 43%. This first flare, with its low polarisation, is likely to be dominated by thermal emission which dilutes the non-thermal polarisation emission. The second flare is dominated by non-thermal emission. Here the possible causes of the two flares are discussed.



Polarisation light curve taken from the OJ287 black hole spin paper Valtonen et al. 2016.

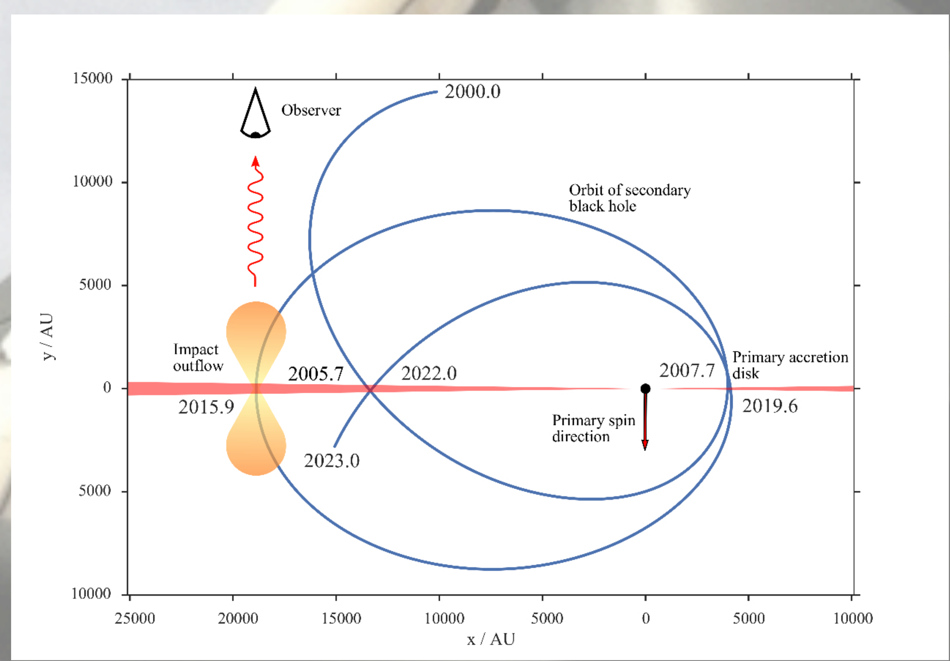


Diagram showing the orbit of the secondary supermassive black hole in the OJ287 binary system from 2000-2023. Taken from Valtonen et al. 2016.

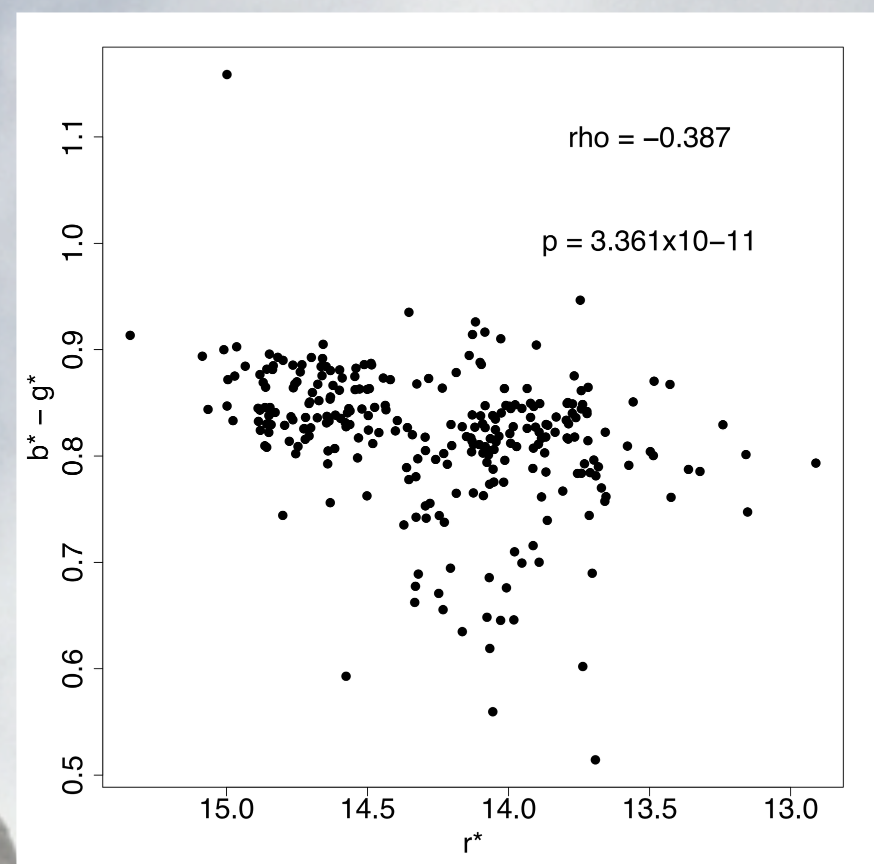
Spectral properties

The Ringo3 polarimeter consists of a rapidly rotating polaroid (one rotation every 2.3 seconds) which modulates the incoming beam of light and measures the intensity of light in the 8 different rotor positions in three cameras. The light is distributed to the three cameras via 2 dichroic mirrors resulting in three non-standard wavelength bands:

r* ('red') = 770 – 1000 nm

g* ('green') = 650 – 740 nm

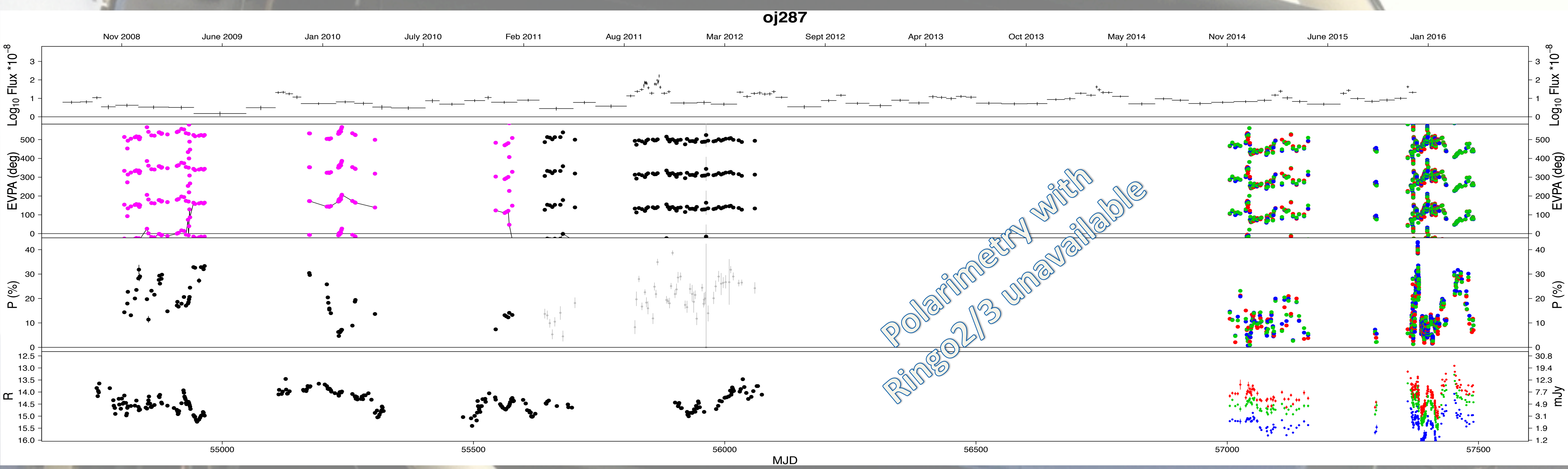
b* ('blue') = 350 -640 nm



The Figure on the right shows the spectral index b* magnitude - g* magnitude as a function of r* magnitude. The Spearman rank correlation coefficient rho and the p value (p) are shown on the plot and suggest a significant negative correlation of -0.387 for OJ287 over the Ringo3 observing period (thus far).

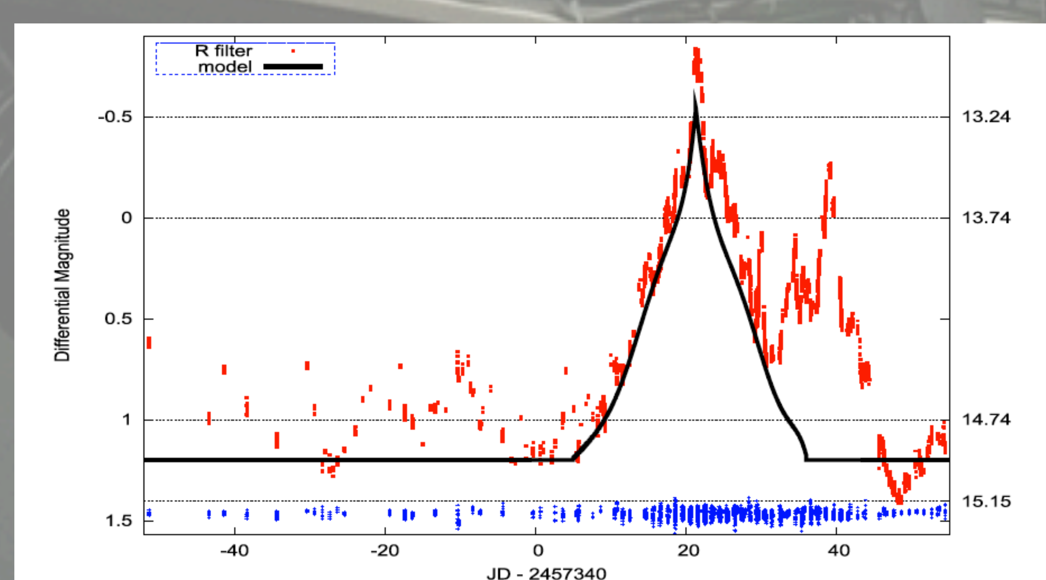
This correlation suggests that the source shows a 'bluer' when brighter property, like many BL Lac blazars. The spectral properties of the source during the flaring period have also been studied and show significant negative correlations of a similar value to the overall value of -0.387. This suggests that the contribution from red (i.e. jet emission) and blue (accretion disk and/or high energy jet emission) does not change drastically during the SMBH impact on the accretion disk.

Light curve



Interpretation

The first flare is predominantly thermal and shows low degree of polarisation. This suggests that any of the regular primary jet non-thermal emission is diluted by the increase in thermal emission from the impact of the secondary supermassive black hole (SMBH2) on the primary's accretion disk and that there is no associated polarised emission from the impact. The impact of the SMBH2 causes a 'bubble' of gas from the accretion disk to tear away and expand. As the bubble cools it becomes transparent at optical wavelengths and produces the shape of the peak in the optical flux (Valtonen et al. 2010).



To explain the second, strongly polarised, non-thermal flare there must be an ordered magnetic field or magnetic reconnection to create such high polarisation. While it is possible that the polarisation flare is from the primary jet in OJ287, it is not possible that this is caused by the impact due to light crossing times across the accretion disk. It may be coincidental that the primary jet flares shortly after the impact, however, the second strongly polarised peak is also present during the 1984 outburst which would suggest the events are connected.

We therefore lean toward associating the strongly polarised flare with the SMBH2 and its impact with the accretion disk. It is possible that the gravitational influence of the SMBH2 accretes matter from the primary accretion disk and creates a relativistic jet which is orientated toward the observer, or, the magnetic fields associated with SMBH1 and SMBH2 interact and create polarised emission by magnetic reconnection. With the simultaneous Fermi gamma-ray data we can see that the gamma-ray flux stays low and only increased marginally at the time of the flare. This would suggest that the high polarised emission is not associated with magnetic reconnection as this would create a shock and high energy gamma-ray emission.

Future work

We continue to monitor OJ287 along with a sample of 20 blazars with the Ringo3 polarimeter on the Liverpool Telescope and also Fermi gamma-ray telescope data. We are exploring the spectral properties of the blazars during periods of quiescence and flaring to understand the differences between the Flat Spectrum Radio Quasar (FSRQ) and BL Lac-type blazars. The fundamental physical differences between these sources are their accretion disk luminosity, visual differences are seen in the core and lobe brightness in FRI and FRII galaxies which are though to be FSRQ and BL Lacs respectively and optical differences in the presence and absence of optical emission lines (FSRQs and BL Lacs respectively).

Studying the spectral changes in blazars help to explore the contributory components of the source and can lead to constraints of jet and accretion models.

We would like to include additional multiwavelength photometric observations to our dataset, particularly UV space-based observations during the next impact.

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