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ORIGINAL ARTICLE

Evidence that the bursting component of the X-ray radiation from 3C 111 originates in the PC-scale jet

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Abstract Evidence is presented indicating that the bursting component of the X-ray radiation detected in the nuclear region of the active radio galaxy 3C 111 comes from the blobs ejected in the pc-scale jet and not from the accretion disc. After each new outburst the radio flux density associated with it increases to a peak in ∼1 year and then subsides over a period of 1–2 years with the flux falling off exponentially as the blob moves outward and dissipates. Similar peaks (bursts) are seen in the X-ray light curve and a cross-correlation between the two shows a very high correlation with the X-ray peaks leading the radio peaks by ∼100 days. A second cross-correlation, this time between the radio event start times and the X-ray light curve, also shows a significant correlation. When this is taken together with the long (∼1 yr) delay between the start of each ejection event and its associated X-ray peak it indicates that this bursting component of the X-ray flux must be associated with the ejected blobs in the pc-scale jet and not with the accretion disc. Because X-ray telescopes do not have the resolution required to resolve the accretion disc area from the pc-scale jet, this paper is the first to present observational evidence that can pinpoint the point of origin of at least those long-timescale X-ray bursts with durations of 1–3 yrs.

Keywords Galaxies: active · Galaxies: jets · X-rays: bursts

1 Introduction

Variable, radio loud active galactic nuclei (AGN) with their associated jets have been studied for more than 40 years. At radio frequencies tremendous advances in their understanding came with the better than 1 milliarcsec resolution of the VLBA which allowed disturbances propelled outward from near the central black hole to be tracked as they moved rapidly outward in a tightly confined jet. Similarly, advances came at X-rays when the *Chandra* telescope came on-line. Unfortunately, the resolution at X-ray wavelengths is much lower (0.5 arcsec) than with the VLBA. After 40 years of study the exact mechanism by which the jets are formed and the ejected material is accelerated is still unclear. Even the exact point of origin of the non-varying radio component of the AGN core radiation is still being debated, with e.g. Bell and Comeau (2010) presenting arguments favoring a core component centered on the accretion disc and others, e.g. Marscher et al. (2010), arguing for a core component located outside the accretion disc area in the base of the jet.

Variations in the total flux of AGN sources at radio frequencies were studied by Andrew et al. (1978) when large, single-dish telescopes were first coming on line. Before it was possible to map these sources with the milliarcsec resolution of the VLBA it was demonstrated by Legg (1984, see Fig. 1 below) that the flux bursts from different AGN sources, though differing slightly in time scale, had similarly shaped profiles. In each event the flux was observed to increase to a peak within ∼1 year and then decrease exponentially, falling below the detection limit within 1–3 years. Now, using the VLBA, individual bursts can be tracked at radio frequencies as separate plasma blobs that move away from the central object, reach a peak and then slowly dissipate over 1–3 years (Chatterjee et al. 2011, see their Fig. 6).

Before a complete understanding of what is happening in the nuclear region of these sources is likely to be achieved it is essential that the exact point of origin of the different radiation components be determined. One of the biggest uncertainties remaining is where the bursting component

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