

## High-resolution studies of the twin jet in NGC 1052

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The radio loud galaxy NGC 1052 is being studied in an intensive multi-band campaign including X-ray brightness monitoring and spectroscopic observations, single-dish radio brightness monitoring at centimetre wavelengths, and a high-frequency very-long-baseline interferometry monitoring program. Here we present a progress report on our studies from this program. The final goal of our observations is to relate the findings from the high-resolution radio images with the observed variations in the X-ray regime, to address the accretion processes and their relationship with the radio jet activity.

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## 1. Introduction

The radio source NGC 1052 (at a distance of 21.6 Mpc) offers one of the best opportunities to study the nature of active galactic nuclei (AGN). This source is radio loud and can be classified as a Type 2 AGN. It shows a twin-jet system in east-west direction at VLA and VLBI scales, oriented close to the plane of the sky [1, 2]. Multi-wavelength VLBI observations have shown evidence for an obscuring torus at the central region of the source, hiding the inner part of the western jet at longer wavelengths [3, 4, 5]. This source has been monitored at the 2 cm Survey/MOJAVE programmes since 1995. A kinematic analysis of the sub-parsec scale morphology of the source shows apparent speeds of  $0.26c$  in the jet and the counter-jet [1, 6], with ejection of new features (or components) every 3 to 6 months.

## 2. The multi-band campaign

Evidence in support of an accretion-ejection event was provided by observations around epoch 2001.0 [7], where variations in the relativistic broad iron  $K\alpha$  profiles were seen before and after a VLBI component ejection. This motivated us to start a multi-mission campaign of observations of this source in mid 2005. Previous results have been reported in [8, 6]. Here we show further progress in this program.

### 2.1 X-ray observations

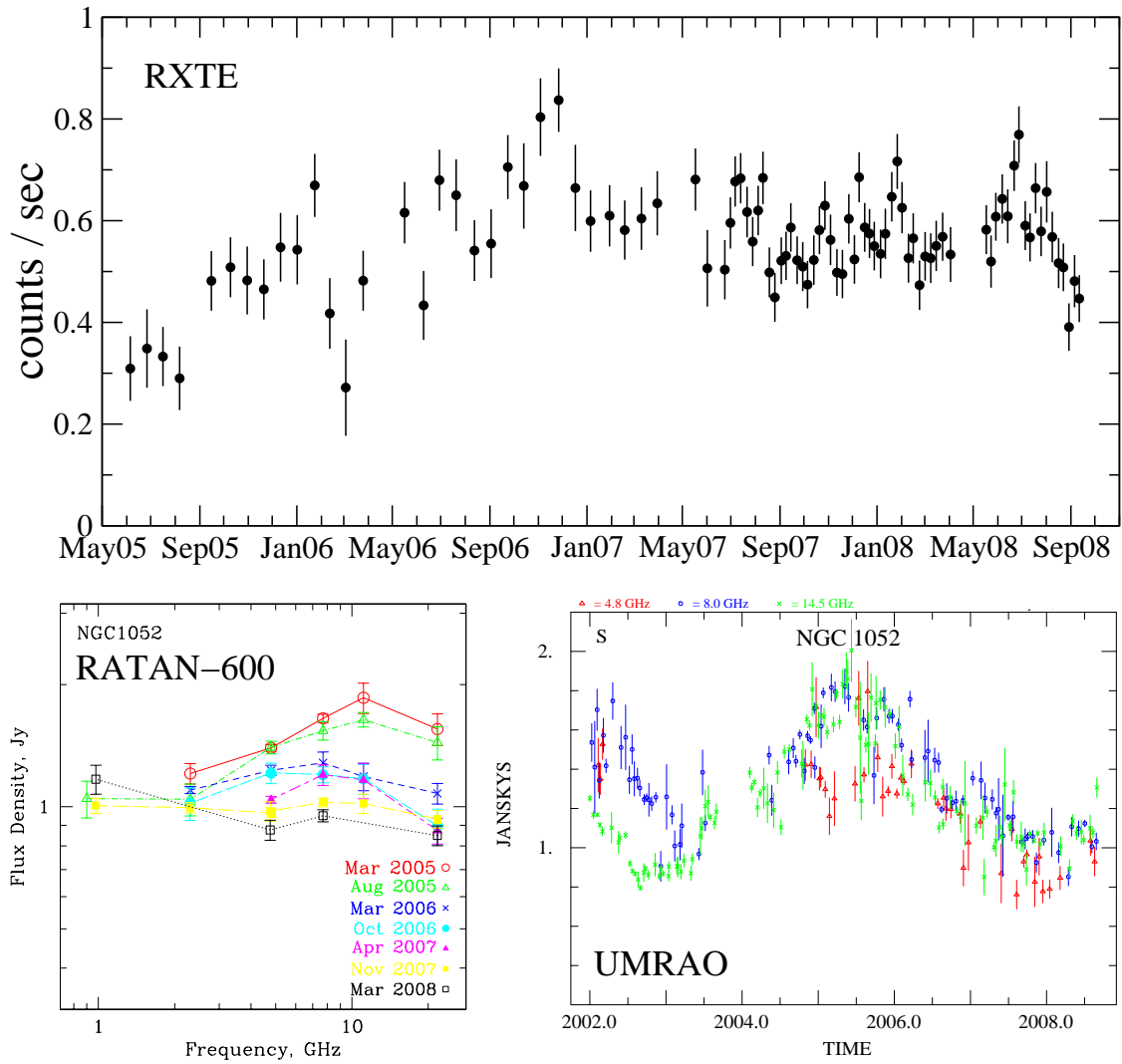
Our campaign includes:

- *RXTE* observations once every three weeks until 2007.4 and weekly since then: preliminary results are shown at the top panel in Fig. 1
- *XMM-Newton* deep spectroscopy in 2006.3 (complementing earlier measurements in 2002.62), and further observations approved for 2008.7 and 2009.2
- *Swift* observations with XRT imaging in 2007.05, 2007.59, 2008.74, 2008.81, 2008.82, 2008.83, and 2008.92, and BAT continuous hard X-ray (14–194 keV) monitoring
- *Suzaku* spectroscopical observations on 2007.54: these results are presented in [9], showing a narrow core and a broader component of Fe- $K\alpha$  emission robustly detected at 6.4 keV, together with a soft, thermal emission component below 1 keV.

### 2.2 Radio observations

Our observations include single-dish and interferometric measurements as follow:

- Very Long Baseline Array (VLBA)  $\lambda 2$  cm imaging observations in the framework of the 2 cm Survey/MOJAVE programmes [10, 11, 12], separated by several months (those observations are being performed since 1995)
- VLBA  $\lambda 1.3$  cm and  $\lambda 0.7$  cm imaging observations separated by six weeks since 2005.19: preliminary images of these observations are shown in Fig. 2



**Figure 1:** Brightness variability in NGC 1052. *Top:* X-ray light curve taken by *RXTE* since 2005. A rising phase is shown in late 2005 and late 2006, followed by a variable, non-flaring state since early 2007, and a dip in August 2008. This dip, if the source is similar in behaviour to 3C 120 (see [14]), could herald a new VLBI component. *Bottom, left:* RATAN-600 single-dish radio spectra of NGC 1052, measured during our observation campaign. The flux density axis shows values in logarithmic scale between 0.316 Jy and 3.16 Jy. *Bottom, right:* UMRAO single-dish radio light curves.

- Effelsberg single-dish flux density observations at seven wavelengths from  $\lambda 21$  cm to  $\lambda 1$  cm
- RATAN-600 single-dish flux density observations at six wavelengths from  $\lambda 30$  cm to  $\lambda 1.3$  cm every four months (see [13] for details): spectra measured at different epochs during our monitoring programme are shown at the left panel in Fig. 1, where changes are visible at high frequencies, and no variations are observed at the lower ones, where the inner part of the jet is self-absorbed
- University of Michigan Radio Astronomy Observatory (UMRAO) single-dish flux density observations at  $\lambda 6$  cm,  $\lambda 4$  cm and  $\lambda 2$  cm—light curves at these frequencies is shown in Fig. 1.

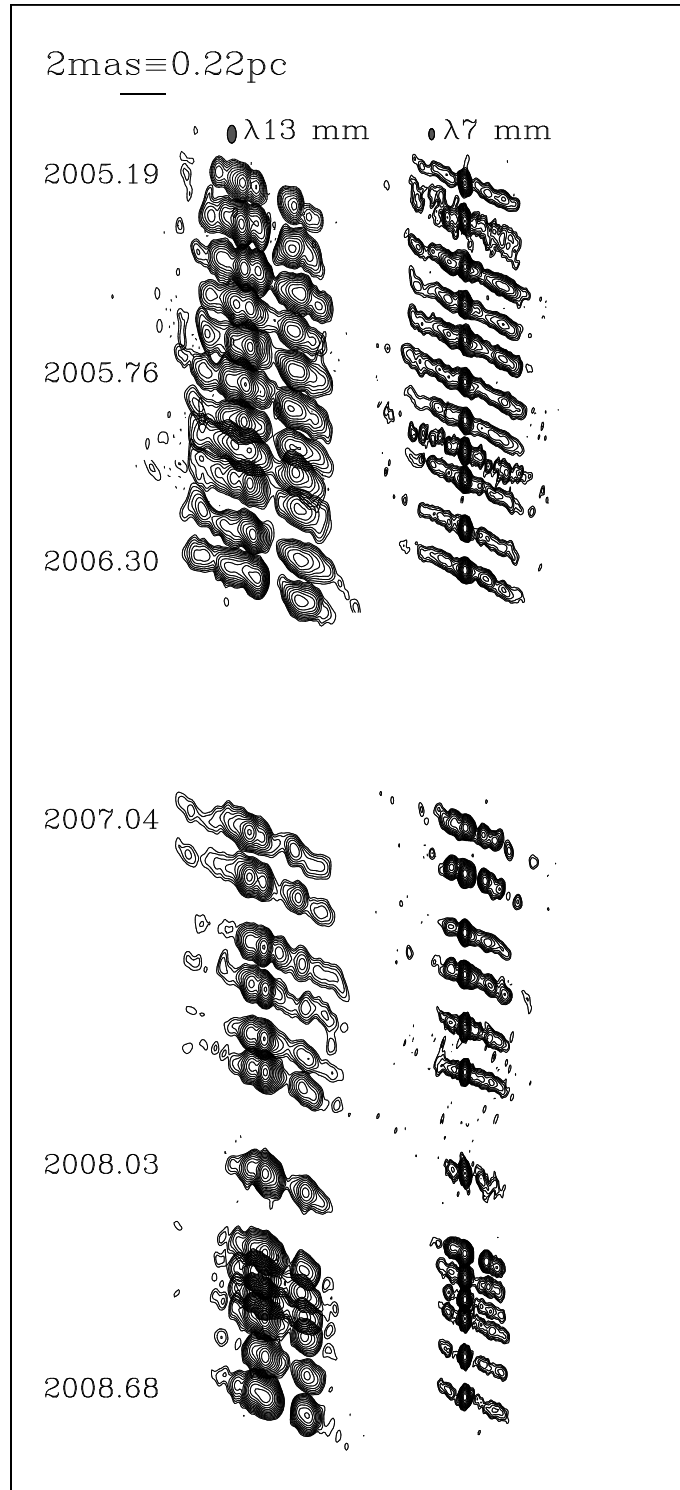
### 3. Discussion

Our campaign is providing radio light curves showing a quiet radio phase without bright flares since 2005. The UMRAO light curve shows the beginning of a rising phase in mid 2008, which gives hints of a new flare in the radio source. From the VLBA  $\lambda 1.3$  cm and  $\lambda 7$  cm radio images, two new features appear at the base of both jets, beginning to be visible after the first months of 2006. The X-ray curve shows dramatic drops in the X-ray light curve in February 2006, December 2006, and August 2008. A direct relationship between the appearance of new features and the dips in the X-ray emission has still to be studied in detail. Further progress in this campaign will include a detailed kinematic analysis of the observed radio features, after astrometric registration of those images, and the connection of these radio variations with the putative changes in the X-ray spectra.

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**Figure 2:** Preliminary VLBA images of NGC 1052. The alignment is arbitrary, to the emission gap at the  $\lambda$ 1.3 cm and to the brightness peak at  $\lambda$ 0.7 cm.

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