

## Arcminute Microkelvin Imager observations at 15.5 GHz of multiple outbursts of Cygnus X-3 in 2024

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### ABSTRACT

We report radio monitoring of Cygnus X-3 at 15.5 GHz during 2024 with the Arcminute Microkelvin Imager. Observations were made on 296 days throughout the year, and reveal five radio outbursts to multi-jansky levels, peaking in Feb, Apr, Jun, Jul and Aug. The brightest peak, with  $\approx 16$  Jy, was on Jun 27th.

*Keywords:* High mass X-ray binary stars (733) — Galactic radio sources (571) — Radio continuum emission (1340) — Variable radiation sources (1759)

Cygnus X-3 is a high mass X-ray binary which shows occasional giant flares at radio wavelengths, to flux densities of up to  $\sim 10$  Jy, or more. The first such burst was observed in 1972 (Gregory & Kronberg 1972), and there have been multiple similar flares since (e.g. see Johnston et al. 1986; Waltman et al. 1995; Fender et al. 1997; Mioduszewski et al. 2001; Corbel et al. 2012; Zdziarski et al. 2016; Egron et al. 2017 and Green & Elwood 2020 for further examples).

We report radio observations of Cygnus X-3 made during 2024 with the Arcminute Microkelvin Imager (AMI, Zwart et al. 2008; Hickish et al. 2018). The observations were made with the AMI ‘Large Array’ which is a radio interferometer consisting of eight 12.8-m diameter antennas. A single linear polarisation, Stokes parameter  $I + Q$ , was observed over a frequency range of 13 to 18 GHz.

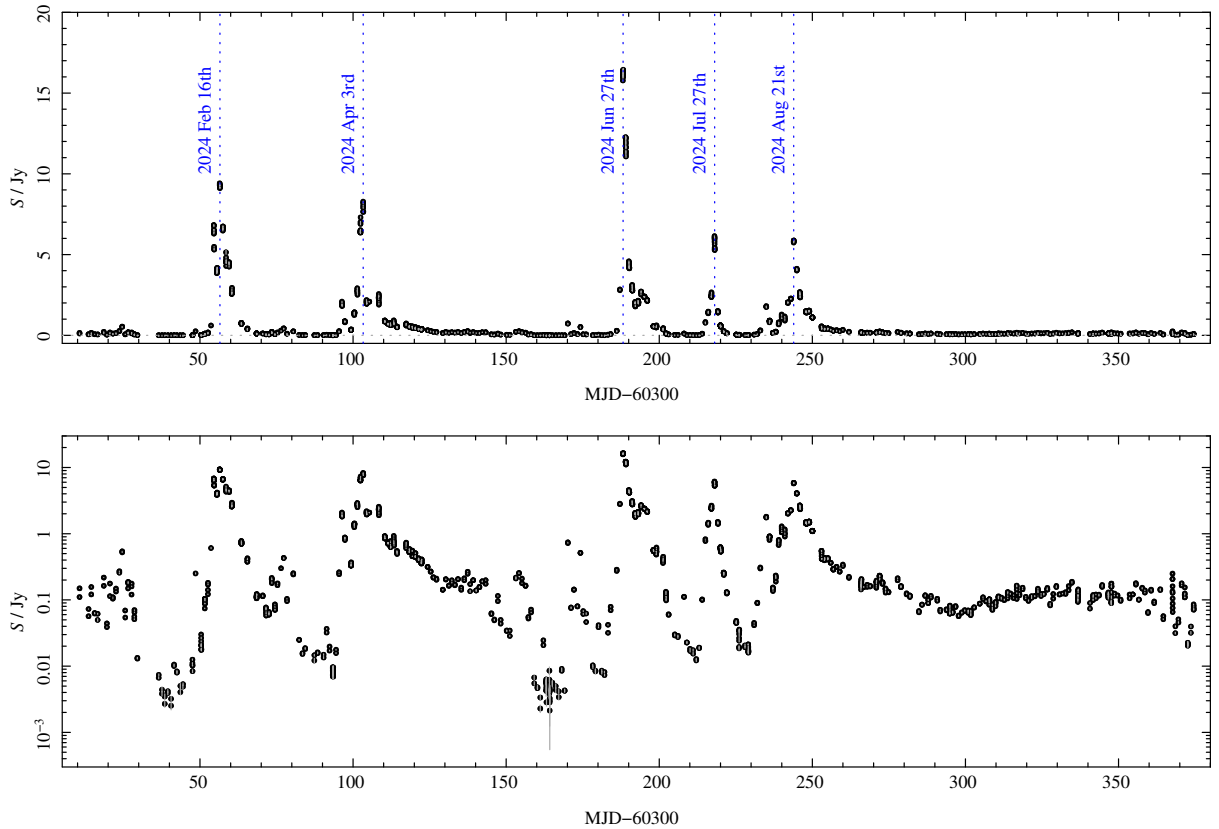
The observations consisted of multiple 10-min scans of Cygnus X-3, interleaved with 100-s observations of a nearby, compact calibrator source J2052+3635. Usually an observation consisted of two 10-min scans of Cygnus X-3, but longer observations were scheduled when the source was undergoing an outburst, or when other observations were being made (e.g. in X-rays with IXPE or XRISM, for example see Veledina et al. 2024). Observations were made on most days in 2024, with omissions due to bad weather (either high winds requiring the

antennas to be stowed, or heavy rain, which makes accurate calibration not possible), or technical issues. The data were processed using standard procedures, using the `reduce_dc` package (e.g. Hickish et al.). The flux density scale was established from short observations of the standard calibrator source 3C286 which were made on most days, together with the ‘rain gauge’ measurements made during the observations which were used to correct for varying atmospheric conditions (see Zwart et al.). The data were flagged: (i) automatically to eliminate bad data due to various technical problems and interference; (ii) manually, to eliminate remaining interference and some periods with heavy rain. The interleaved observations of J2052+3635 provided the phase calibration for each antenna in the array throughout each observation. The amplitudes of the J2052+3635 observations were also used to check and adjust the day-to-day flux density scale. The day-to-day flux density scale variations are thought to be less than 5 per cent. When Cygnus X-3 was bright during a flare (above 0.3 Jy), the observations were phase self-calibrated on a timescale of 10 min. Flux densities were derived for each 10-min scan, for 8 broad frequency channels covering 13 to 18 GHz, and then a power law fit was made to obtain a flux density at 15.5 GHz.

Figure 1 shows the 15.5-GHz light curve of Cygnus X-3 from these observations. This shows the results from 296 observations made in 2024, with flux densities for 1407 10-min scans. This shows five large outbursts, with flux densities  $> 5$  Jy, which peaked on 2024 Feb 16th, Apr 3rd, Jun 27th, Jul 27th and Aug 21st. During 2022 and 2023 similar monitoring observations of Cygnus X-3 with AMI did not detect any large outbursts, with the emission typically being at  $\sim 0.1$  Jy.

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**Figure 1.** Radio light curve of Cygnus X-3 at 15.5 GHz during 2024 from AMI observations. The top and bottom panels show, respectively, the flux density plotted linearly and logarithmically. Each data point is a 10-min average. Statistical error bars are plotted, although these are usually smaller than the size of symbols. The vertical lines on the top panel show the dates of the peaks of the outbursts.

69 The 2024 observations of Cygnus X-3 shown in Fig. 1 shows  
 70 that the outbursts are preceded by periods when the emission  
 71 is fainter than the usual level of  $\sim 0.1$  Jy for several weeks, as  
 72 has been seen previously (e.g. [Zdziarski et al. 2016](#)).  
 73 For most of the last three months of the 2024 Cygnus X-  
 74 3 has shown little variability at 15.5 GHz from day-to-day.  
 75 However, towards the end of the year did show more variation  
 76 day-to-day. Also, during the  $\approx 1.8$  h observation made on  
 77 Dec 23 Cygnus X-3 showed clear variation. It started with

78  $\approx 0.10$  Jy, brightened to  $\approx 0.26$  Jy over the next  $\approx 0.4$  h, and  
 79 then faded to  $\approx 0.07$  Jy.

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