Curtin University

Real-time radio imaging of black hole jets

Research Field

Very Long Baseline Interferometry

Project Suitability

PhD

Project Supervisor

Associate Professor James Miller-Jones

james.miller-jones@curtin.edu.au

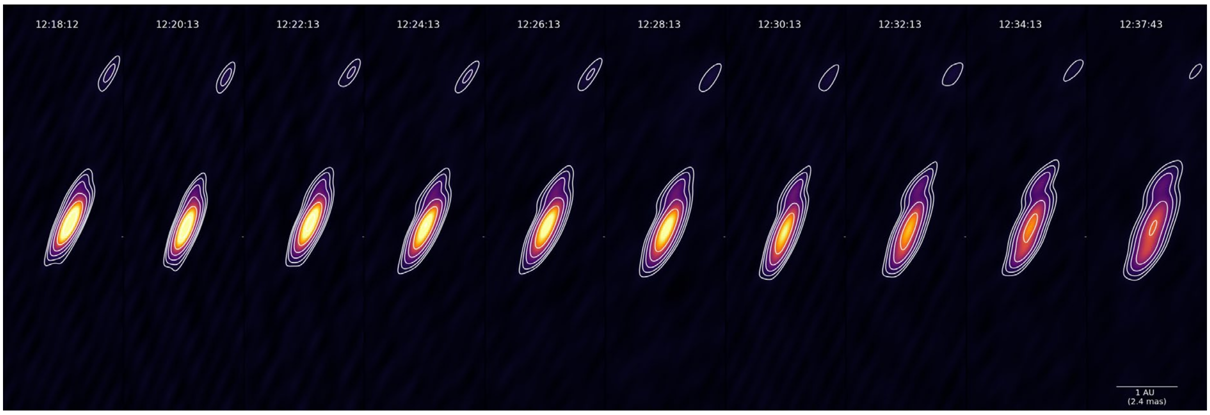
Co-Supervisors

Accreting black holes are known to launch powerful, relativistic jets that move away from the black hole at close to the speed of light. These jets provide a key source of feedback of energy and momentum to the surrounding environment. When a black hole is feeding sedately the jets are fairly steady, but when it accretes at higher rates the jets become more powerful but episodic, appearing as individual clouds of radio emission moving away from the black hole.

Using the technique of very long baseline interferometry (VLBI) we can zoom in on these powerful jets, tracking their motion as they move outwards. This technique involves combining the signals from multiple different telescopes separated by thousands of kilometres, and assembling an image from the combined data. This is the same technique recently used by the Event Horizon Telescope Consortium to take the first image of a black hole shadow, and can provide sufficient resolution for an observer in Perth to make out a coin located in Sydney.

At such high resolutions, the jets from nearby stellar-mass black holes can move significantly over the course of an observation, as well as brightening or fading. This violates the fundamental assumptions that go into imaging radio astronomical data (which assume a source that is constant over the timescale of the observation), and therefore requires new approaches. In one recent case, we split a four-hour observation up into two-minute chunks to observe the jets evolving in real time (as shown in the Figure). While this highly manual approach yielded new insights into the dynamics of the black hole jets, new imaging algorithms have recently been developed that could help to automate this process.

In this project, you will investigate the application of some of these new imaging algorithms to VLBI data on black hole X-ray binaries, aiming to provide higher-fidelity imaging of time-variable structures. This will allow you to extract new science from existing data sets, probing how jets evolve and propagate in real time. In cases where we can couple the time-variable jet behaviour to the changes observed in the inflowing gas around the black hole (as seen in the X-rays), we can aim to probe the universal link between accretion and ejection phenomena around black holes.



A montage of images showing the evolution of the radio jets in a stellar-mass black hole X-ray binary system, over a period of just 20 minutes. In this project, you will investigate the performance of new imaging algorithms for making high-fidelity images of moving and evolving jets.