Single-Dish Monitoring of the Radio Emission from Quasar J0450-8101

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1 Introduction: Quasars and Blazars in the Radio

Most compact radio sources have variable flux-density. They are thought to be powered by accretion onto a supermassive black hole in the centre of a distant galaxy. The variability is not generally periodic, and thought ultimately to be related to the accretion process. The variability provides important constraints on the physical process powering the emission at radio as well as at other wavelengths. Many such sources show flaring behaviour in high-energy (X-ray and gamma-ray) emission.

Although they are often compact, many such sources also show variability in their morphology when examined with the high resolution available with Very Long Baseline Interferometry (VLBI). In fact one of the major discoveries was that they often eject components moving with apparent speeds faster than the speed of light. The explanation is that these sources consist of an accretion disk around a black hole, with a mass of millions or billions of solar masses, and highly relativistic jet and counterjet along the rotation axis of the accretion disk. The radio emission is produces almost exclusively by the jet, and in most cases we see those objects where the jet is aligned near to the line of sight, and consequently the emission is highly Doppler boosted. Components, often called “blobs” are periodically ejected along the jet, and travel outwards at relativistic speeds. Due to the relativistic time-compression, the motion of these blobs appears to observers at lines of sight near the jet-axis to occur faster than the speed of light. It is these blobs that are responsible for the radio flux density variability.

However, many questions remain to be understood in detail. For example, what is the relationship between flares and variability at X- and gamma-rays and the radio? Why are some sources near-constant while others vary over a substantial range?

One important piece of observational data that can be used to constrain the theoretical models is the nature of the variability in the total radio flux density, which is generally a function of the observing frequency. To this end, the flux density of the source should be monitored at several frequencies, which for strong sources can be done with single-dish observations, for example using the Hartebeesthoek Radio Astronomy (HartRAO) observatory dishes. Note that the flux density so measured is the total over the whole of the relativistic jet, which can be resolved, if at all, only with VLBI observations. See Aller et al. (2006) and Aller et al. (2011) for a brief introduction to the monitoring of some such sources at
cm-wavelengths.

We can combine the information on the variation in the radio with theoretical models and study the differences between the source classes. Often radio observations are combined with data from other wavelengths, such as infra-red, optical and X-rays. Having datapoints from several frequencies, we can create the spectral energy distribution (SED) of the source.

Many such sources are often used as calibrator sources in the radio because they are generally quite compact, bright, and being at cosmological distances, will have essentially no proper motion.

One such source is the quasar J0450-8101. It is a blazar, which is a particularly compact and energetic quasar with emission over a wide range in wavelength, with infra-red optical and X-ray emission in addition to the bright radio emission (Massaro et al., 2009). It is at a redshift of 0.44. In radio, it is frequently used as a calibrator source for Southern-hemisphere VLBI observations. Multi-epoch VLBI observations show that J0450-8101 had a flare in 2009 and the flux density grew by more than a factor of 5. Even though most quasars are variable, there are few that are as violently variable, making J0450-8101 of especial interest.

HartRAO astronomers already use the 26m radio telescope at Hartebeesthoek to follow the changing radio emission at multiple frequencies from several extragalactic sources lying at Southern declinations where there are few radio telescopes available for this work. The measurement of the flux density is mostly accomplished by “drift scans” where the telescope does not track the source across the sky, and the flux density is determined from the variation as the source drifts through the telescope beam, which allows separation of the source from the background emission.

We want to add J0450-8101 to the list of sources monitored at HartRAO. However J0450-8101 is a very deep south object, having a declination of $\sim -81^\circ$ declination and monitoring of the source using normal drift scans will likely not work as it will drift through the telescope beam too slowly.

## 2 This Project

This project would consist of devising an observing strategy for a low-declination source, and carrying out observations of J0450-8101 using the HartRAO 26-m telescope, to obtain a sequence of flux-density measurements for J0450-8101. The observing strategy would also be useful for flux-density observations of any other far-south sources. The project will also involve the reduction and calibration of the multi-frequency data obtained with the 26-m telescope. To deal efficiently with the volume of data, the data reduction needs to be fully automated.

Once sequences of flux-density measurements are available from single-dish observations, preferably at several frequencies, they can be compared to the changes in the structure as determined from existing or newly proposed VLBI observations that will help in understanding the shock formation and the structural changes in the shock component. The basic data reduction package used for radio VLBI data is AIPS.
References

