PROCEEDINGS OF SCIENCE

Probing Microarcsecond structure in Active Galactic Nuclei

Cliff Senkbeil*
University of Tasmania, Australia
E-mail: cliffs@utas.edu.au

David Jauncey
Auatralia Telescope National Facility, Australia

James Lovell
University of Tasmania, Australia

Simon Ellingsen
University of Tasmania, Australia

Giuseppe Cimò
Joint Institute for Very Long Baseline Interferometry in Europe, The Netherlands

Active Galactic Nuclei have been observed to exhibit apparent radio flux density variability on a range of time scales from hours to years. The most rapid cm-wavelength variability on timescales from hours to days has been shown to be caused by interstellar scintillation through measurements of an annual cycle in the characteristics of the variability of a number of AGN, as well as through the measurement of a significant time-delay in the pattern arrival times at widely spaced radio telescopes. The presence of interstellar scintillation implies the presence of microarcsecond-scale structure in the scintillating source.
Using the Ceduna radio telescope at 6.7 GHz we have been monitoring, on a quasi-continuous basis since 2002, the flux density of several scintillating sources. The project aims to study the compact structure and microarcsecond evolution of these sources. In this paper we present the light-curve and timescale analysis of AO 0235+164.

From Planets to Dark Energy: The Modern Radio Universe
1^{st}-5^{th} October 2007
The University of Manchester, United Kingdom

*Speaker.

PoS(MRU)131

1. Introduction

Active Galactic Nuclei have been observed to exhibit apparent radio flux density variability on a range of time scales from hours to years. The most rapid cm-wavelength variability, on timescales from hours to days, has been shown to be caused by interstellar scintillation through measurements of an annual cycle in the characteristics of the variability of a number of AGN, as well as through the measurement of a significant timedelay in the pattern arrival times at widely spaced radio telescopes [1]. Interstellar scintillation occurs when radio waves from a bright compact component of a radio source are scattered by the interstellar medium, producing an interference pattern at the observer plane. The motion of the observer through this pattern produces the observed flux density variations as a function of time [2]. The presence of interstellar scintillation implies the presence ofmicroarcsecond scale structure in the scintillating source [3].

Using the Ceduna radio telescope at 6.7 GHz we have been monitoring the flux density of several scintillating sources, on a quasicontinuous basis since 2003 [4]. The project aims to produce lightcurves which study the compact structure and microarcsecond evolution of these sources using Earth Orbit Synthesis [3].

2. Flux Density variability of AO 0235+164

In 2005 the 6.7 GHz flux density of AO 0235+164 increased from 1.0 to 2.4 Jy within four days, followed by decease back to 1 Jy with approximately the same time scale (Figure 1). Flux density changes on this time scale are common and have also observed by the MASIV Survey [5] and by Kraus et al (1999) [6]. The scale of the variation in 2005 is unique in that the flux density of the source more than doubled in a short time scale, and the flux density of the source dropped below the mean during the variation (Figure 2). The light curve of AO 0235+164 over the entire lifetime of the monitoring program shows that the source starts to flare near the end of 2005, coincident with the short period, large amplitude variation (Figure 2). Are these events linked? What is the cause of the rapid variation and what is it telling us about the initial conditions of the flare?

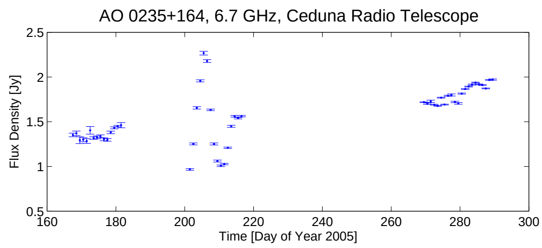

Figure 1: The 6.7 GHz light curve of AO 0235+164 highlighting the rapid variability that occurred in late 2005. The light curve illustrates the rapid increase and then decrease in flux density with a timescale of approximately four days.

3. Origin of the rapid, high amplitude Variability

If intrinsic in nature, the rapid variation seen in AO 0235+164 implies a brightness temperature of $\sim 2 \times 10^{17}$ K, which exceeds the inverse compton scattering limit of 10^{12} K [7] by five orders of

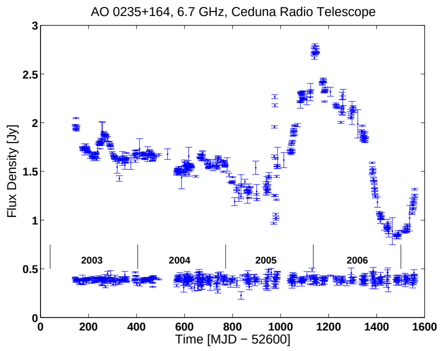

Figure 2: The light curve of AO 0235+164 at 6.7 GHz of the entire Ceduna Flux Density Monitoring program. The lightcurve shows the flare during 2005 2006.

magnitude. A Doppler booting factor of 160 is required for the intrinsic brightness temperature to be 5×10^{10} K (the equipartition value) in the source frame and is much larger than typical Doppler boosting factors derived from typical VLBI observations [8]. An intrinsic interpretation therefore seems unlikely.

The fact that the variation falls below the mean flux density of the source and that the source is known to scintillate at much lower amplitude on other occasions suggests that interstellar scintillation is the more likely cause. Regardless of cause though, both interpretations require a bright, extremely compact component to exist in AO 0235+164 at 6.7 GHz over a period of order one week.

How can such a component be seen at 6.7 GHz at the early stages of the flare when emission is expected to be absorbed? Could the rapid variation be caused by an Extreme Scattering Event [9]?

References

[1] Bignall, H. E, Macquart, J.P., Jauncey, D. L, Lovell, J. E. J, Tzioumis, A. K, & KedzioraChudczer, L: 2006, ApJ, 652, 1050.

[2] Narayan, R., 1992, The Royal Society, 341, 151.

[3] Macquart, J. P, Jauncey, D. L., 2002, ApJ, 572, 786.

[4] McCulloch, P. M, Ellingsen, S. P, Jauncey, D. L, Carter, S. J. B, Cimo, G, Lovell, J. E. J & Dodson, R. G., 2005, ApJ, 129, 2034.

[5] Lovell et al., 2003, AJ, 126, 1699.

[6] Kraus, A, Witzel, A, Krichbaum, T. P., 1999, New Astronomy Reviews, 43, 685.

[7] Kellermann, K.I. Pauliny-Toth, I.I.K., 1969, ApJ, 155, L71.

[8] Readhead, A.C.S., 1994, ApJ, 426, 51.

[9] Senkbeil, C. E., et al, in press.