The Innermost AGNs with Future mm-VLBI

I. Agudo\textsuperscript{1}, T.P. Krichbaum\textsuperscript{1}, U. Bach\textsuperscript{1}, A. Pagels\textsuperscript{1}, B.W. Sohn\textsuperscript{1}, D.A. Graham\textsuperscript{1}, A. Witzel\textsuperscript{1}, J.A. Zensus\textsuperscript{1}, J.L. Gómez\textsuperscript{2,3}, M. Bremer\textsuperscript{4}, and M. Grewing\textsuperscript{4}

\textsuperscript{1} MPIfR, Auf dem Hügel 69, 53121 Bonn, Germany
\textsuperscript{2} IAA(CSIC), Apartado 3004, 18080 Granada, Spain
\textsuperscript{3} IEEC/CSIC, Edifici Nexus, C/Gran Capitá, 2-4, E-08034 Barcelona, Spain
\textsuperscript{4} IRAM, Grenoble, 300 Rue de la Piscine, 38406 Saint Martin d’Hères, France

1 mm-VLBI, Astronomy at the Highest Resolution

More than 40 years since the discovery of the AGNs, there are still fundamental questions related to the nature of these intriguing objects. In particular, the accretion processes onto their super-massive black holes and the mechanisms through which their relativistic jets are formed, accelerated and collimated are still not well understood. Great effort has been made during the last decade to push the mm-VLBI technique to progressively shorter wavelengths, offering the best tool to observe the innermost regions of the jets and study the physics involved in their behaviour.

At present, the most sensitive mm-VLBI instrument is the Global mm-VLBI Array, composed of the Effelsberg, Plateau de Bure, Pico Veleta, Onsala and Metsähovi stations, in addition to eight of the ten VLBA antennas (for more details see \url{http://www.mpifr-bonn.mpg.de/div/vlbi/globalmm}). The Global mm-VLBI Array reaches a baseline sensitivity of 80–100 mJy (adopting 20 s coherence time, 100 s segmentation time and a sampling rate of 512 Mbps [2bits]). This yields an image sensitivity of 1–2 mJy (for 12 h of observation and a duty cycle of 0.5). With these characteristics the number of sources which could be imaged with high dynamic ranges ($\geq$100:1) is nowadays larger than 100.

In an attempt to obtain a deeper knowledge of the physics in the innermost regions of jets in AGNs, we have started a VLBI monitoring, at 3mm, of some of the brighter-most sources. Fig. 1 represents some of the images from these observations (still in progress). The images demonstrate the capability of the Global mm-VLBI Array to study the innermost jet structures with an angular resolution better than 50 $\mu$as.

2 The Future: Higher Sensitivity and Image Fidelity

In order to achieve a better quality of images and increase the number of sources that can be observed, a further increase in sensitivity is still needed. To do that, the most direct way is to increase the collecting area of the present interferometer. For the near future, ALMA, the GBT, the LMT, CARMA, SRT, Yebes, Nobeyama and Noto are some of the most sensitive stations suitable to participate in mm-VLBI. This future array, together with the present Global mm-VLBI
Array, would achieve baseline sensitivities of up to 5–10 mJy (assuming 1 Gbps recording rate and 100 s segmented integration time), and an image sensitivity better than 0.1 mJy. These estimates predict a large increase, by a factor of 10!, respect to the present Global mm-VLBI Array levels of sensitivity. In addition, continuous development of VLBI will provide standard recording rates of at least 2 Gbps in the next years, which will increase the expected sensitivities by an extra factor $\geq \sqrt{2}$. Further significant improvements in coherence time can be reached by atmospheric phase correction methods.

But the proposed future array will not only influence the sensitivity. The new stations will also largely improve the UV-coverage, and so the image fidelity. The addition of ALMA will improve the UV-coverage for sources with low declination (less than 20°) and facilitate the VLBI imaging of the Galactic Centre source SgrA*. With these improvements, dynamic ranges of $\geq$1000:1 could be easily obtained. This will place mm-VLBI at comparable levels of sensitivity and image fidelity than present day cm-VLBI.

3 Science with Future mm-VLBI

The expected improvements in sensitivity and image fidelity would impact our knowledge of the physics of jets and central engines in AGNs. It would be possible to obtain high quality images of the innermost regions in the jets. This would facilitate, for several hundreds or even thousands of compact sources (i) to investigate the MHD physics in strong gravitational fields, (ii) to study the formation, initial acceleration and collimation of relativistic jets, (iii) to probe their initial magnetic field configurations (via polarimetry) and (iv) to infer the properties of the super-massive black holes and their immediate vicinity.

Fig. 1. 3mm-VLBI images of NRAO150, Cygnus A, 3C 120 and 3C 84.