STSM Visit Report

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Period: from 17/02/2014 to 22/02/2014
COST Action: MP1104
Visitor: Dr. José L. Gómez, Instituto de Astrofísica de Andalucía-CSIC (Spain)
Host: Dr. Andrei Lobanov, Max-Planck-Institut für Radioastronomie (Germany)

Purpose of the STSM
How relativistic jets are launched from the accretion disk surrounding the supermassive black holes that power active galactic nuclei (AGN) is probably one of the most important questions related to jet physics. Obtaining a better understanding of this issue requires probing the innermost regions of AGN jets, but this is limited by the insufficient angular resolution provided by existing, ground-based, VLBI arrays. The space VLBI program RadioAstron provides the first full-polarization observations of AGN jets on baselines larger than one Earth diameter, yielding the highest angular resolution measurements of magnetic field properties in the near-black hole environment to date. The STMS visit was aimed to develop the tools for the calibration of the instrumental polarization and imaging techniques in order to exploit our RadioAstron Key Science Project (KSP) "Probing the innermost regions of AGN jets and their magnetic fields". With a theoretical angular resolution of up to $\sim$20 μas, polarimetric and Faraday rotation synthesis analysis of the RadioAstron KSP data will allow to construct 3D maps of the magnetic field structure and strength of the innermost jet regions, through which we intend to obtain a better understanding of the role played by the magnetic field in the launching, collimation, and acceleration of AGN jets.

Work carried out during the STSM
During the Early Science Program and first year of RadioAstron operations, our polarization KSP (co-PIs Lobanov & Gómez, involving also $\sim$30 researchers in 14 different institutions) has performed RadioAstron observations – in connection with the ground arrays VLBA (+GBT, VLA), EVN, LBA, and KVN – of a modest sample of the brightest, strongly polarized AGN, which includes 0642+449, BL Lac, and 3C 273, with further observations scheduled during 2014 of 3C 279 and OJ 287.

During the STMS visit we have analyzed our RadioAstron observations of the quasar 0642+449, corresponding to the first polarimetric space-VLBI observations to date. The observations were carried out at a frequency of 1.6 GHz and baselines lengths between one and three Earth diameters in order to maximize the chances for the detection of the polarized signal from the ground-space baselines. Indeed, the analysis of the data shows clear detections of the space-ground cross-hand fringes throughout the whole experiment, even for mid-size ground telescopes. Most importantly, our analysis reveals that RadioAstron has a modest instrumental polarization (leakage terms) of the order of few percent, therefore confirming the polarimetric capabilities of the space antenna, of great relevance for the future success of the mission, and our KSP in particular.

Main results obtained
We have obtained the first polarimetric image from space-VLBI observations to date, shown in Fig. 1. The quasar 0642+449 is characterized by having a very compact structure

and relatively high polarization, as best required for our test observations. Our space-VLBI observations provide an angular resolution of ~ 0.8 mas, about four times better than what can be achieved with ground-based arrays. The improved resolution reveals an elongated structure in the radio emission of 0642+449, more clearly visible in polarization. Observations from our KSP at higher frequencies and longer space-ground baselines should allow to obtain polarimetric images of the innermost regions in AGN jets with a theoretical angular resolution of up to $\sim 20\mu$as.

Future collaboration with host institution

We expect a fruitful and long collaboration between our groups at the Instituto de Astrofísica de Andalucía and the Max-Planck-Institut für Radioastronomie as part of our joint RadioAstron polarimetric Key Science Project.

Foreseen publications

A publication confirming the detection of the polarization signal, reasonably low instrumental polarization and overall RadioAstron polarization capabilities, as well as the first polarimetric image will be submitted to a top-tier peer-reviewed journal in the following months.

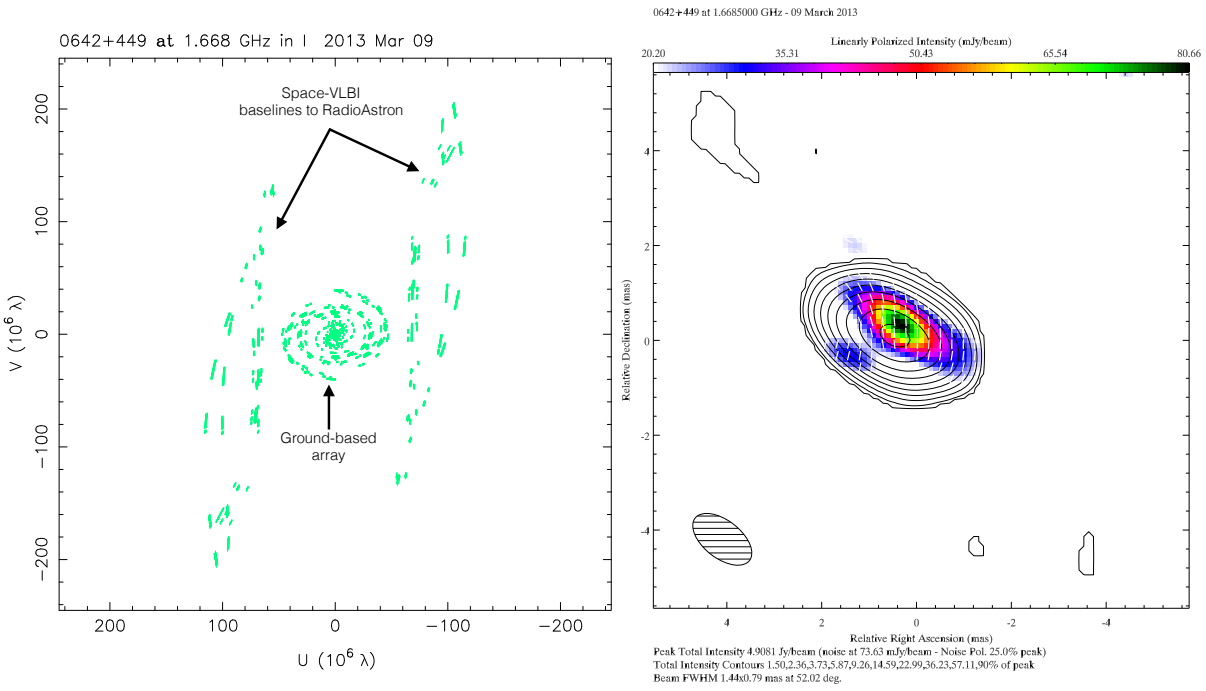

Figure 1: RadioAstron space-VLBI observations of the quasar 0642+449 obtained at a frequency of 1.6 GHz in March 9th, 2013. *left:* uv-coverage, showing the ground-based and space-VLBI baselines. *right:* Contours show total intensity, colors the linearly polarized intensity, and white bars the electric vector position angle – subject to calibration of the absolute orientation.