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Astro Space Center
RadioAstron Newsletter
Number 34
5 April 2018
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The RadioAstron AO-6 open science program: July 2018 – June 2019

The RadioAstron observations currently cover the fifth year of the open program within the approved AO-5 proposals. Starting from July 2018, the RadioAstron mission will move into the sixth year of its program, AO-6 observations will continue until June 2019. The sixth RadioAstron Announcement of Opportunity has invited proposals of the following two types: the "Key Science Program" (KSP) and "General Observing Time" (GOT). See for details the full set of announcement documents in `http://www.asc.rssi.ru/radioastron/ao-6/ao6.html`.

All proposal were evaluated by the RadioAstron Program Evaluation Committee (RPEC) which was appointed by the RadioAstron International Science Council (RISC). Results of the evaluation were approved by the RadioAstron project director Nikolai Kardashev. RPEC members for AO-6 are Matthew Lister (chairman, Purdue U., USA), David Jauncey (CSIRO, Australia), Alexander Pushkarev (CrAO, Russia), Olaf Wucknitz (MPIfR, Germany), Benito Marcote (JIVE, the Netherlands), and Liz Humphreys (ESO).

Below we list 13 accepted projects which have requested observations with RadioAstron during the AO-6 period in their submission order:

• GOT: "Visibility tracking of hyper-compact H2O maser spots for studying interstellar microturbulence", PI: Hiroshi Imai (Kagoshima Uni., Japan);

• KSP: "Monitoring of substructure in scattering disks of pulsar radio emission", PI: Carl Gwinn (UCSB, USA);

• GOT: "Two-dimensional mapping of the interstellar scattering screen for Crab pulsar", PI: Robert Main (CITA, Canada);

• GOT: "Episodic accretion and ejection in massive star formation as seen with RadioAstron in 22 GHz H2O maser line", PI: Olga Bayandina (ASC, Russia);

• GOT: "High angular resolution observations of bright "water fountains" and H2O stellar masers", PI: Mikhail Shchurov (ASC, Russia);

• GOT: "The peculiar AGN PKS 0521-365 under the space-VLBI lupe", PI: Eduardo Ros (MPIfR, Germany; Uni.Valencia, Spain);

• KSP: "Probing interstellar scattering with dense RadioAstron observations of refractive substructure in AGN", PI: Mikhail Lisakov (ASC, Russia);

• KSP: "A twenty-fold zoom into the structure of the bright enigmatic blazar AO 0235+164", PI: Leonid Gurvits (JIVE, Netherlands; TU Delft, Netherlands);

• GOT: "Measuring the Angular Sizes of the High-Velocity Components in the Megamaser NGC 4258", PI: James Moran (CfA, USA);

• GOT: "Zooming into the jet launching region of the radio galaxy Cygnus A", PI: Uwe Bach (MPIfR, Germany);

• KSP: "Probing the innermost regions of AGN jets and their magnetic fields", PI: Jose L. Gomez (IAA, Spain);
• GOT: "Multi-frequency synthesis of active galactic nuclei at 22 GHz", PI: Victor Zuga (ASC, Russia);
• GOT: "N113 – extraordinary water maser in star forming region in the Large Magellanic Cloud", PI: Andrej Sobolev (UFSU, Russia).

Among the approved projects, four got rank 'A' (the highest priority), seven — rank 'B', and two — rank 'C'. A total of 150 co-investigators represent 20 countries. The largest number of co-Is are from Russia, other countries with a high number of co-investigators include Germany, Spain, USA, Australia, and Canada.

Sun-sized water vapour maser spots in Cepheus A

RadioAstron detected the water maser emission at 22 GHz from Cepheus A on a baseline longer than 3 Earth diameters. This one of the nearest high-mass star-forming region, located at a distance of 700 pc. Further data processing reveals two distinct maser components at -16.9 and 0.6 km/s with an angular resolution of 66 μas. Their morphology is shown in Fig. 1. In relatively short ground baselines, the 0.6 km/s component appears in cross power spectrum as a single Gaussian. The space-ground spectrum shows two spectral features separated in velocity. They contain about 13% of the total flux density. This corresponds to two unresolved spots smaller than 15 μas in angular extent — about the size of the Sun at the distance of 700 pc. They are separated by 160 ± 35 μas or 0.11 astronomical units. This is the smallest structure ever observed in a Galactic maser. The observed structure most likely can be explained in the model of turbulent vortices shed by an obstacle in a flow.

These results are published by A.M. Sobolev, J.M. Moran, M.D. Gray, A. Alakoz, H. Imai, W.A. Baan, A.M. Tolmachev, V.A. Samodurov, and D.A. Ladeyshchikov, 2018, ApJ, 856, id. 60.

RadioAstron image of NGC 1275 reveals a wide and collimated jet structure on the scale of a few hundred gravitational radii

RadioAstron Nearby AGN Key Science Program has published its first results in *Nature Astronomy* (Giovannini et al. 2018, `https://www.nature.com/articles/s41550-018-0431-2`). A 22 GHz space-VLBI image of the recently restarted parsec scale jet in 3C 84, a radio source located in the giant elliptical galaxy NGC 1275 in the Perseus Cluster, transversely resolves the strongly edge-brightened young jet just 30 μas from the core – ten times closer to the central engine that in the previous ground-based studies. This corresponds to a de-projected linear distance of just a few hundred gravitational radii. Being able to resolve the jet and measure its collimation profile inside the acceleration region is important for testing the current jet formation models.

It was found that the jet in 3C 84 is surprisingly wide (Fig. 2), with a transverse radius greater than 250 gravitational radii. This implies that either the bright outer layer rapidly expands closer to the black hole or that this "sheath" is launched from the accretion disk.

Another major result of the paper is that the previously found, almost cylindrical collimation profile on the scales larger a few thousand gravitational radii extends down to a scale of a few hundred $r_{\rm g}$. It indicates a flat density profile of the external confining medium. The authors propose that the recently restarted jet in 3C 84 is shaped by shocked material of a cocoon forming around the jet — just like the kiloparsec scale jets are recollimated in a cylindrical shape before they enter the leading hot spot.

The observations were made during a perigee passage in September 2013. In addition to Space Radio Telescope, more than two dozen ground radio telescopes, including the European VLBI Network together with the Russian Kvazar network, the Korean VLBI Network, Kalyazin and the NRAO telescopes Very Long Baseline Array, the Green Bank Telescope, and the phased Very Large Array, participated in the experiment.

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`The RadioAstron project is led by the Astro Space Center of the Lebedev Physical Institute of the Russian Academy of Sciences and the Lavochkin Scientific and Production Association under a contract with the Russian Federal Space Agency, in collaboration with partner organizations in Russia and other countries.`

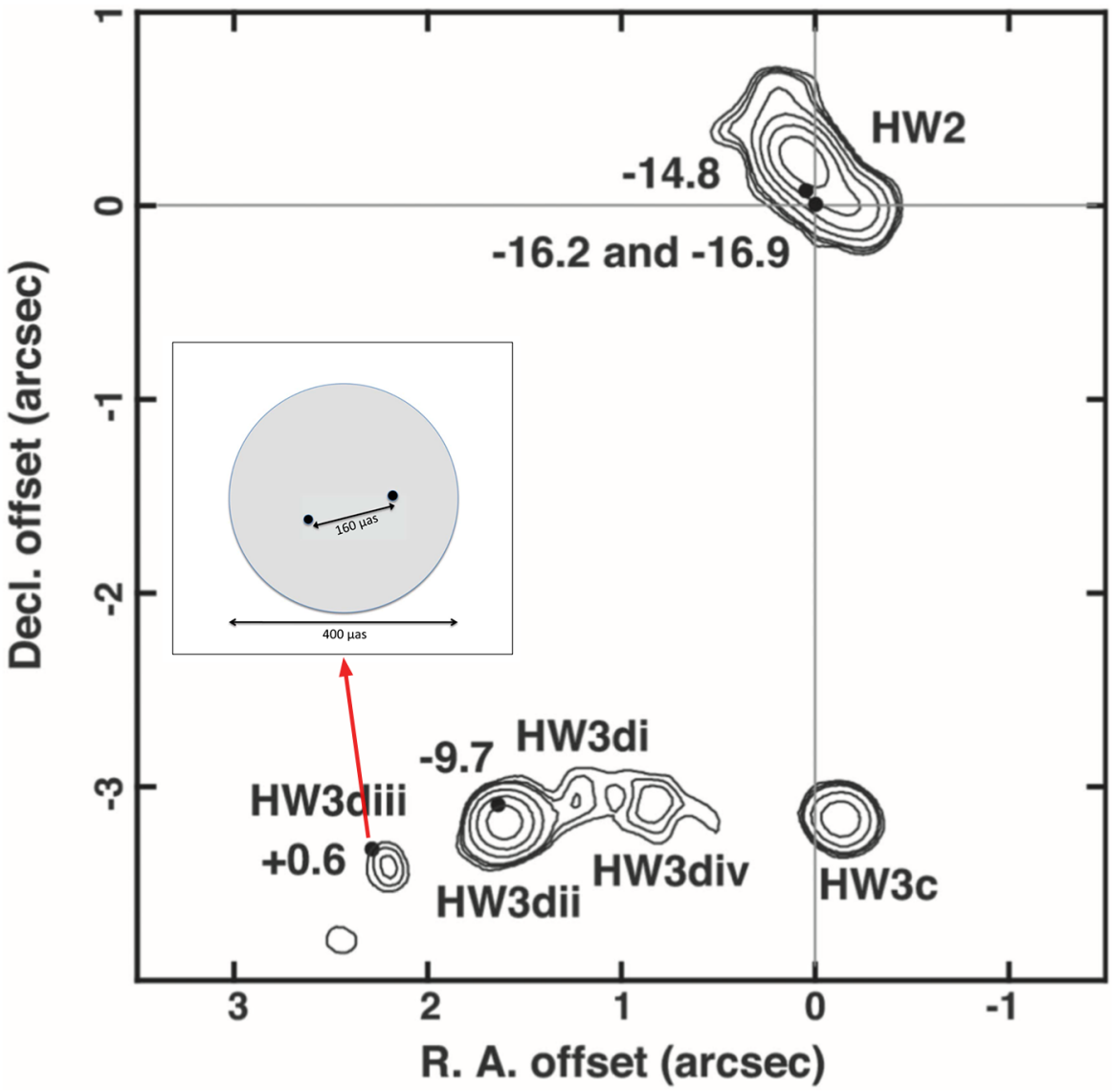

Figure 1: The central part of the star-forming region Cepheus A. The contours show the extent of the continuum components taken from the 1.3 cm VLA image (adapted from Torrelles et al. 1998). The dots mark the positions of masers labeled by their velocities. Inset: a cartoon of the maser emission from the 0.6 km/s feature which show two sub-components separated by 160 μas. They are aligned with the axis of the outflow from Hd3ii.

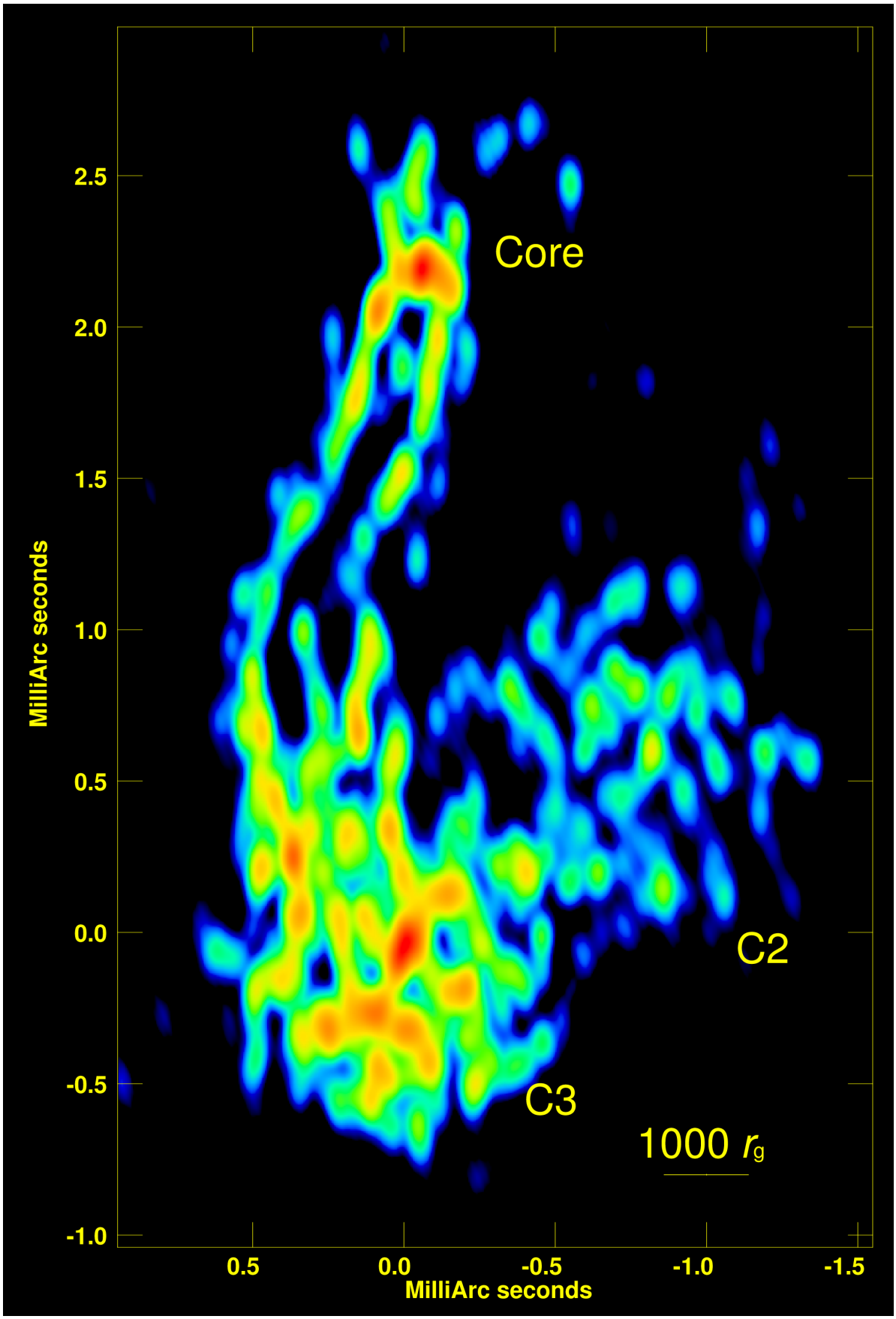

Figure 2: Radio image of the central parsec in 3C84 obtained with RadioAstron at 1.3 cm.