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A space VLBI mission at sub-mm wavelengths

Zsolt Paragi*(1) and the THEZA team
(1) Joint Institute for VLBI ERIC (JIVE), Dwingeloo, The Netherlands; e-mail: zsolt.paragi@gmail.com

One of the major challenges for radio astronomy in the coming decades is a realization of a space VLBI mission operating at high frequencies, mostly beyond the reach for ground-based telescopes. The TeraHertz Exploration and Zooming-in for Astrophysics (THEZA) is a proposed mission to realize ultra-sharp imaging of celestial radio sources at the level of angular resolution down to (sub-) microarcseconds [1]. It focuses on millimetre and sub-millimetre wavelengths (frequencies above ~300 GHz), but allows for science operations at longer wavelengths, too. The leading science driver is probing physics of spacetime in the vicinity of supermassive black holes (SMBH), but it allows for studying a range of phenomena at ultra-high spatial resolutions [1]. THEZA will open up a sizeable range of hitherto unreachable parameters of observational astrophysics.

The various concepts and technical challenges, along with the leading science themes are outlined in [2]. Besides imaging a sample of SMBH on event horizon scales, perhaps the most intriguing goal is to be able to separate the direct images from the photon ring structure. Photon rings is a fine structure embedded in the main image that is less sensitive to the accretion flow properties, therefore allowing for measurements of the black hole spin, or even spacetime deviation from the Kerr solution. The best way to achieve this is extending the observing frequencies beyond that of the Event Horizon Telescope (EHT) and with baseline lengths extending to space. This would guarantee the required resolution and would also alleviate the issue with opacity due to synchrotron self-absorption in radio cores.

Active Galactic Nuclei (AGN) will also be very relevant in the multi-messenger era, they will be prime targets for future very-high-energy and gravitational wave instruments (e.g., CTA, LISA). The prospects for observing the aftermath of LISA-detected SMBH mergers at the highest spatial resolution is particularly appealing. Launching detailed design studies of space VLBI missions is therefore very timely. The presentation will focus on the topics defining the engineering requirement to the mission consistent with the top science tasks of prospective Space VLBI systems at sub-mm wavelengths.

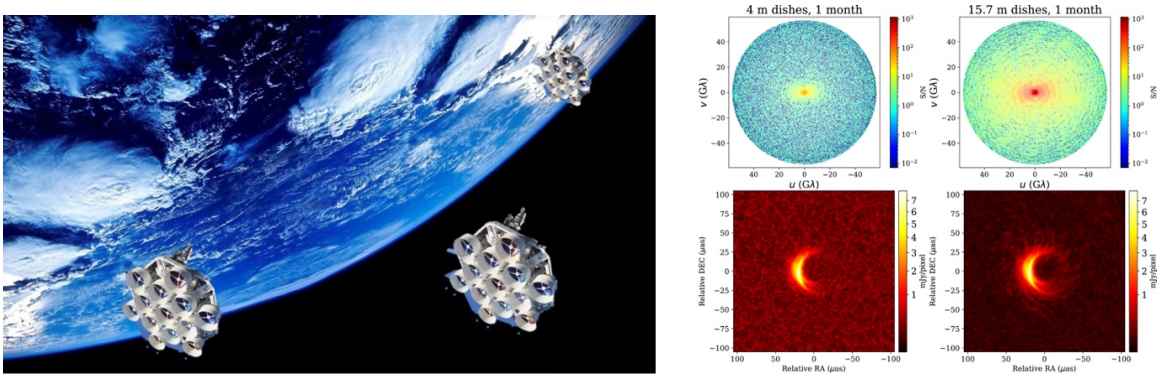

Figure 1. Left: artist's impression of a three-element version of the THEZA concept. Right: simulated visibility SNR (upper half) and reconstructed images (lower half) using a three-element concept with 4m and 15.7m dishes, based on a GRMHD model of Sgr A* [2, and references therein].

References

[1] L. I. Gurvits, Z. Paragi, V. Casasola et al., "THEZA: TeraHertz Exploration and Zooming-in for Astrophysics", Experimental Astronomy, **51**, 3, June 2021, pp. 559-594, doi:10.1007/s10686-021-09714-y
[2] L. I. Gurvits, Z. Paragi, R.I. Amils et al., "The science case and challenges of space-borne sub-millimeter interferometry", Acta Astronautica, **196**, July 2022, pp. 314-333, doi:10.1016/j.actaastro.2022.04.020