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OBSERVING SUPERMASSIVE BLACK HOLES: TOWARD OPTIMISATION OF A SPACEBORNE VLBI MISSION

Abstract

Very long Baseline Interferometry (VLBI) provides the finest angular resolution of all astronomical observation techniques. The Earth-based Event Horizon Telescope (EHT) has demonstrated this in recent years with the landmark achievement of resolving the shadows of the supermassive black holes M87* and Sgr A*. However, these observations also showed that the science case for further sharpening the resolution of astrophysical studies is far from being exhausted. The only way to overcome fundamental limits on angular resolution of Earth-based arrays is to place part of or the entire interferometer in space. In this paper, several concepts of spaceborne VLBI systems are discussed including, TeraHertz Exploration and Zooming-in for Astrophysics (THEZA) and the Black Hole Explorer (BHEX).

Spaceborne VLBI telescopes have some of the most demanding requirements of any scientific spacecraft. The VLBI system as a whole includes globally distributed elements, each with their own functional constraints, limiting when observations can be performed. This necessitates optimisation of the system parameters in order to maximise the scientific return of the mission. End-to-end mission simulations are an indispensable tool in conducting such an optimisation.

Presented is an investigation into how the impact of the functional constraints of a spaceborne VLBI telescope affect the overall system performance. A preliminary analysis of how these constraints can be minimised through optimisation of the orbit and spacecraft configuration is also provided. Various scientific objectives such as, photon ring detection, black hole demographic studies and image reconstruction are taken into account during the concept design activity. A space-based VLBI simulation tool has been developed to model such missions and its capabilities are demonstrated throughout the paper. It is imperative that the functional constraints are considered early in the design of the future space-based VLBI systems in order to generate feasible mission concepts and to identify the key technology developments required to mitigate these limitations.