The first millimetre-wave radio telescope in Africa: the Africa Millimetre Telescope – Letter of Interest

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Abstract

The Event Horizon Telescope (EHT) is an earth-size virtual telescope that comprises of several telescopes that observe together at mm to sub-mm wavelengths in the mode of very long baseline interferometry (VLBI). The EHT is used to image supermassive black holes (SMBH) such as Sagittarius A* and was recently used to image M87, the famous "first image of a black hole" in 2017 which was subsequently unveiled in 2019. Whilst EHT's antennas are distributed around the globe, none of these antennas are located on the African continent. The Africa Millimetre Telescope (AMT) will be Africa's first mm-wave radio telescope and is planned to be built on the Gamsberg Mountain in Namibia. The AMT will have aims to have significant impact on human capacity development in Namibia and Africa.

Introduction

The Event Horizon Telescope (EHT) is a very long baseline interferometry (VLBI) network of mm-wave radio telescopes around the globe. Its main scientific goal is to observe supermassive black holes at their event horizon scale the EHT is capable of achieving 12–20 µas angular resolution. After observations with 7 EHT telescopes at 5 geographical locations, spanning several days in April 2017, the first image of a black hole 'shadow' (M87 at 1.3 mm /230 GHz) was released in April 2019 [1]. It showed a prominent ring with a diameter of ≈ 40 µas, consistent with the size and shape of the lensed photon orbit encircling the shadow of a supermassive black hole. Later, the magnetic field configuration was inferred by polarization information of the same data [2], and also the innermost region and limb brightening of the jet of Cen A was revealed by EHT observations [3]. Key to obtaining further information about the innermost region around the supermassive black hole in M87 as well as the one in the centre of the Milky Way galaxy, Sagittarius A*, will be through dynamical imaging [4] and many single images and will require consistent and reliable telescope availability throughout the EHT network. For securing robustness of the EHT against telescope dropouts and to increase the time available for dynamical imaging, the Africa Millimetre Telescope (AMT) will be built on the second-highest mountain in Southwestern Africa, Mt. Gamsberg in Namibia [5].

Technical Specifications

The AMT will utilize the refurbished 15 m diameter Swedish-ESO Submillimetre Telescope (SEST) [6] that will be located on Mt. Gamsberg. The AMT will host 3.5 mm (86 GHz), 1.3 mm (230 GHz) and possibly 0.8 mm (345 GHz) band receivers. Possibilities for the AMT to host receivers to observe in the centimetre-wave regime to link up with the African VLBI Network (AVN) [7] are also investigated. Preliminary site studies regarding the precipitable

water vapour already yielded very promising results [8, 9] and more detailed in-situ measurements with purpose-built equipment are underway [10].

Science Scope

The AMT will be strategically located in such a way that Sagittarius A* will be directly overhead and thus will triple the observing time for dynamical imaging of Sagittarius A* for the EHT. Moreover, the AMT will increase the east-west baseline coverage, as well as the EHT's sensitivity to southern hemisphere targets, particularly important for the short variability timescale of Sagittarius A* [11]. Initial simulations show improved image quality by adding the AMT to the EHT [12] as well as vastly improved robustness against telescope dropouts [13].

Besides VLBI observations with the EHT at 1.3 mm and 0.8 mm, the AMT shall also be used for VLBI observations at 3.5 mm within the Global mm-VLBI Array (GMVA), increasing the sensitivity and imaging fidelity for a range of scientific targets, including binary supermassive black hole candidates and the innermost jets of blazars associated with neutrino events.

Radio continuum flux monitoring of blazars [14] is one of the major single-dish science cases of the AMT. The apparent connection between mm-wave radio emission and very-high-energy gamma rays might lead to breaking the degeneracy in emission models regarding the emission region of gamma-rays in these enigmatic sources. High-cadence monitoring observations with the AMT together with the co-located H.E.S.S. and/or CTA, and regular mm-VLBI imaging will be key. Recently, first results from simultaneous multi-wavelength observations, investigate the broadband properties of M87 during the EHT imaging campaign were published [15].

Social Impact

The AMT project from its onset incorporates a social impact plan. Besides regional human capacity development in radio astronomy as well as engineering and atmospheric studies through a local scholarship scheme, also an active outreach program is planned: scientists and students will visit local schools throughout Namibia with a mobile planetarium to show of the wonders of the Universe to the learners and to promote STEM education among the locals [16].

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