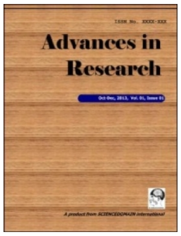

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Ghana in the Square Kilometre Array

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Authors' contributions

This work was carried out in collaboration between all authors. Author PAE designed the study, wrote the protocol and wrote the first draft of the manuscript. Author NABK wrote the introduction. Author EA worked on the speciality and the project timeline. Authors PAE, DA and PKA worked on the Ghana Antenna. All authors read and approved the final manuscript.

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ABSTRACT

Ghana Space Science and Technology Institute, in collaboration with Square Kilometre Array (SKA) -South Africa, is currently converting a redundant 32-metre telecommunications antenna at Kutunse, Ghana into a radio telescope. The aim is to add this antenna to the Africa Very Long Baseline Interferometry (VLBI) Network (AVN), which South Africa's Hartebeesthoek Radio Astronomy Observatory is currently the only one. This paper gives an introduction about the Square Kilometer Array, and how a redundant 32-metre telecommunication antenna at Kutunse, Ghana will be converted into a radio telescope and Ghana will be put on the spotlight in radio astronomy science and greatly impact science education in Ghana. The SKA telescopes will be used to study Very Long Baseline Interferometry, radiometry, maser studies, pulsar timing, and supernova. It will also be capable of studying quasars, gamma- ray flares, transient radio source behavior,

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interacting binary stars, and development of celestial and terrestrial reference frames. Singularly, the dishes are also capable of single dish experiments like spectroscopy, pulsars and radiometry and gain insight into the evolution of the universe.

Keywords: SKA; radio telescope; VLBI; kutunse; African VLBI network; Ghana.

1. INTRODUCTION

The Kutunse antenna was originally built in early 1980s for telecommunication; but with the inception of high-speed fibre-optic cables the antenna is no longer good for today's high demand of communication. Consequently the antenna was last used as telecommunications antenna in 2002 [1,2]. Nevertheless, the antenna have been assessed and found to be capable of performing Very Long Baseline Interferometry (VLBI) and other radio astronomy science. However, the old-age antenna requires a lot of makeover to be able to perform science experiments like VLBI, radiometry, interferometry, maser studies, pulsar timing and many more under the Square Kilometer Array (SKA).

Eight African countries are serving as outstations for the SKA in Africa, jointly referred to as the African VLBI Network (AVN). South Africa's Hartebeesthoek Radio Astronomy Observatory is currently the only member of the AVN [3]. The rest are Ghana, Botswana, Kenya, Madagascar, Mauritius, Mozambique, Namibia, and Zambia.

South Africa has over the years gained experience in radio astronomy, but the rest of the continent has only a few researchers to work on the SKA. Ghana currently lacked expertise in astronomy; to address this need of astronomers, SKA- South Africa and the Royal Society, UK are therefore training a generation of radio astronomers and engineers with the conversion of the satellite dishes [3,4]. This will prepare Africa for the SKA.

2. SPECIALTY OF THE SKA

The SKA, will be the world's biggest telescope and one of the biggest scientific projects ever. It will be made up of many large radio wave receivers that will be linked together. A total of 3000 telescopes will be built across Australia and Africa. The total surface area of all the antennas together will add up to approximately one square kilometre. The SKA is special because it will be so big and so strong. It will be at least 50 times more powerful and 10 000 times faster than any other radio telescope currently in operation.

Since radio astronomy is a collective effort of all scientists in the world to understand the evolution of the universe, many different countries are working together to build and pay for the SKA. At least 13 countries and close to 100 organisations are already involved, and more are joining the project [5].

3. MAKE-UP OF THE SKA

The SKA will be made up of three different kinds of receiving technologies: (1) the mid-frequency dishes will be about 15 m in diameter. The dish array of the SKA is the most well known of the three receiver types, and makes up a significant part of the SKA. (2) Large flat disk-shaped receivers, each about 60 m wide, will operate at mid frequencies. (3) Small upright radio receivers, about 1.5 m high, will operate at low frequencies. South Africa's

MeerKAT telescope is an SKA precursor or 'pathfinder' telescope. It will consist of 64 dish-shaped antennas and will be the most powerful radio telescope in the southern hemisphere. MeerKAT will become part of SKA Phase one [5].

4. OPERATION OF THE RADIO TELESCOPES

Radio telescopes work in much the same way as the ordinary radio. As radios are tuned to different frequencies, the receivers in radios pick up different stations. Radio telescopes collect radio waves from objects millions or billions of light years away from Earth. These radio signals will be amplified and processed by computers to interpret the signals to form images that give us snapshots of the Universe [5].

5. SCIENCE OF THE SKA

Radio astronomers will use the SKA to understand how stars and galaxies are formed, and how they evolved over time, and perhaps to detect life elsewhere in the Universe. Scientific studies like Very Long Baseline Interferometry, radiometry, interferometry, maser studies, pulsar timing, and supernova will be studied with the SKA. It will also be capable of studying quasars, gamma- ray flares, transient radio source behavior, interacting binary stars, development of celestial and terrestrial reference frames. Singularly, the dishes are also capable of single dish experiments like spectroscopy, pulsars and radiometry [6].

6. PROJECT TIMELINE

Over the next three years (up to 2016) teams of radio astronomy scientists and engineers from around the world will work together to finalize the design of the SKA. They will decide on the design of each receiver type, the antennas, and the design of all the other elements. First elements for SKA: (1) Phase 1 is expected to be deployed at the SKA sites in 2016 and start of the construction is scheduled to commence in 2018 and complete in 2023. (2) Detailed design for SKA Phase 2 is expected to happen between 2018 and 2021 [5].

7. THE GHANA ANTENNA

The Kutunse antenna in Ghana, when converted will operate between 5.0 GHz to 6.67 GHz capable of studying masers, which are pathfinders to star formation regions. Other scientists from all over the world will use the antenna to study the universe. A photograph of the antenna is shown in Fig. 1. The Kutunse antenna as part of the AVN is to train scientists and engineers to be able manage the second phase of the SKA project.

The technologies and systems required for the AVN will require engineers to work at the cutting edge of design and innovation, such as better high-performance computing to manage the astronomical data, new manufacturing and construction techniques. The Kutunse radio astronomy station would be equipped with a hydrogen maser frequency standard providing frequency standard and reference frequencies for the receiver / signal chain, GPS receiver providing time standard for recording systems, wideband internet connection, etc.

The most important spin-off, however, will be the generation of new knowledge and knowledge workers - young scientists and engineers with cutting edge skills and expertise in a wide range of scarce and innovative field.

Fig. 1. The Kutunse antenna in Ghana

With the inclusion of the Ghana radio telescope at Kutunse, in Accra, a big gap will be filled in the network as shown in Fig. 2. More baselines will be created for the VLBI network and European VLBI Network (EVN). Ghana filling the gap removes a lot of ambiguity in getting the fine source structure in the north-south direction with the EVN. Above +40 degrees declination with the EVN, Hartebeesthoek Radio Astronomy Observatory cannot observe the sources, so Ghana will be the southernmost telescope and will give the maximum resolution in the north-south direction.

Since Ghana is 5.75 degrees above the equator, the Kutunse antenna would see the sky more than any similar telescope. A map of the entire plane of the Milky Way galaxy can be made [7].

Fig. 2. Network for astronomical VLBI [8]

Singularly to Ghana, through the conversion of the Kutunse antenna, the expertise developed would be used to help in the conversion of other 26 more antennas to be converted in Africa. Infrastructure like roads, hotels, fast fiber optic Internet would be developed around the radio telescope sites. Science and technology training in astronomy, physics, optics, chemistry, electronics, computing, medicine, defense, mechanics, software, etc, would be developed. Starting in 2017, Over 120 telescopes would be built in Ghana, with dozens of remote stations accompanying them creating over 1000 jobs- in construction, operation and maintenance over the next 10 years.

8. CONCLUSION

Ghana stands to gain from the AVN project and the bigger SKA project. The AVN will prepare Ghanaian scientist, engineers and technologist in radio astronomy to participate in the biggest science infrastructure ever built in the world. This will bring about other science infrastructure like ground stations to monitor the environment. It will also improve science education and perception in Ghana. How about making great discoveries about the early universe with the help of a radio telescope in Ghana.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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