BABY TELESCOPE: A TOOL FOR INSPIRING ASTRONOMY RELATED RESEARCH

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ABSTRACT

This paper reports the African Very Long Baseline Interferometry (VLBI) Network Scaled Training Telescope (ASTT), which is nicknamed the 'baby telescope'. It is a 54 cm diameter dish scaled version of a radio telescope, which is designed for training, education and research. It consists of sub-reflector, radiometer, feedhorn, Radio Frequency (RF) cable, Low Noise Amplifier (LNA) fixed on a tripod, which can be moved around. The baby telescope has the capability to point and track astronomical sources like the Sun, Moon and geostationary satellites like Digital Satellite Television (DSTV) satellite, IntelSAT and other satellites within its geographical setting. The telescope is also designed to perform a Hot/Cold load calibration to determine the receiver's temperature and also for optical pointing to determine its pointing model as part of astronomy instrumentation training. It describes its focus in inspiring and training scientists, engineers, technicians, and students in Africa in astronomy in lieu of the Square Kilometre Array (SKA) science project.

Keywords: *baby telescope, astronomy, inspires, AVN, SKA*

INTRODUCTION

It is difficult to teach radio astronomy, which detects invisible radio waves, to students – it is not like optical astronomy where you can point a dish at the sky and stare at a star. The concepts are abstract because you cannot see the spectrum. (Wild, Loots, 2013). But with a miniature handy scaled training telescope this can be much easier and appreciative. The baby telescope is the first miniature version of a radio telescope built for training purposes. It is depicted in figures 1 and 2.

The baby telescope is a nickname of the African VLBI Network Scaled Training Telescope (ASTT). It was built in Cape Town, South Africa by a team of seven Ghanaians under the guidance of the African VLBI Network (AVN) team of SKA- South Africa for use in Ghana for Astronomy outreach activities. The ASTT is however the brainchild of the AVN.

It is a miniature version of a radio telescope, with a 54 cm diameter dish. It is a training-wheel equivalent which is basically a satellite television dish equipped with all the key features of a typical, but much larger, radio telescope. Its budget cost is about GH¢ 4500 – GH¢ 6,000. (Wild, 2013)

The baby telescope is being used to train technicians from African SKA partner countries how to design, build, operate and maintain a radio telescope network on the continent. (Loots, 2013)

It is meant to train technicians, engineers and

Fig. 1: Lateral View of ASTT

Fig. 2: Front View of ASTT

scientists working under the AVN of the SKA project. As they build the entire system, starting with only the components, and will ultimately use it to monitor radio emissions from our own star, the sun. This exercise will help them to familiarise themselves with the principles of radio telescope design and operation and would eventually be able to manage SKA telescope stations. (Loots, 2013).

It is also to educate the African student and general population in lieu of the biggest scientific project ever of the century, that is the SKA. It is housed at the Ghana Space Science and Technology Institute, of the Ghana Atomic Energy Commission in Accra, which is being used for outreach activities.

Focus within the AVN

The AVN is the African wing of the SKA. Nine 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 (Nordling, 2012). The rest are Ghana, Botswana, Kenya, Madagascar, Mauritius, Mozambique, Namibia, and Zambia. (Proven- Adzri et al, 2014). One of the focuses of the AVN is to bring all the other eight African countries up to speed with radio astronomy to be able to participate fully in the SKA project. Many in these Africa countries lack the knowledge or are not appreciative of astronomy that is why the AVN is reaching out to Africa through the building of the Baby telescope. It is be used in outreach activities for schools and also to train technicians, engineers and scientists in radio astronomy instrumentation. It will as well whet the appetite of policy makers for radio astronomy and science in general.

Design and Construction of the ASTT Components

The parts of the baby telescope includes a 54 cm diameter dish, sub-reflector, radiometer, feed-horn, Radio Frequency (RF) cable, Low Noise Amplifier (LNA), tripod stand, etc.

Functionality

The baby telescope has the capacity to point to astronomical sources like the Sun, Moon and geostationary satellites like Digital Satellite Television (DSTV) satellite, IntelSAT and other satellites within its geographical setting. Since the sun is the closest visible astronomical source, it makes its studying, so inspiring to students and learners in Astronomy. The baby telescope tracks the sun for a given amount of time say 2 hours.

It also scans given sources like the Sun or moon and measures the sun's temperature.

The telescope is also designed to perform a Hot/ Cold load calibration to determine the receiver's temperature as a part of astronomy instrumentation training. All these are functions a big radio telescope undertakes and thus a good learning tool for beginners in radio astronomy.

The main function of the baby telescope is to train and enthuse students in science and especially astronomy. It does point to targets in a classroom using a laser pointer fitted on the reflector arm. It also slews simultaneously in both axes to demonstrate how the real radio telescope moves.

Building the baby telescope

It took about six months to build this telescope. Strict systems engineering processes were followed in building it. The components are pre-

sented in figure 3. Figures 4 through to figure 8 are the some of the parts being fixed: cables on the tripod in figure 4, testing the limit switches in figure 5, characterizing the limit switches in figure 6, installing the yoke assembly in figure 7 and 8. The limit switches prevent the telescope from being over-driven so as to destroy the cables. The limit switches are characterized to know its limits. The dish sits on the yoke assembly.

Operating the baby telescope

The baby telescope is operated using a laptop computer. The telescope has a built in GPS (Global Positioning System). The positioning provided is in Geocentric Cartesian Coordinates that can be transformed into Geographic Coordinates and other coordinate systems around the globe. It then communicates through an FPGA (Field Programmable Gate Array) to the laptop. The operator gives the telescope instructions through a Linux command line. The program installed on the laptop is called Field System, which is developed using python programming. It can also be remotely operated using a smart phone. It has an in-built telnet that can allow communication through a smart phone. Below are pictures of the baby telescope in use.

Fig. 3: Pictures of components (AVN, 2013)

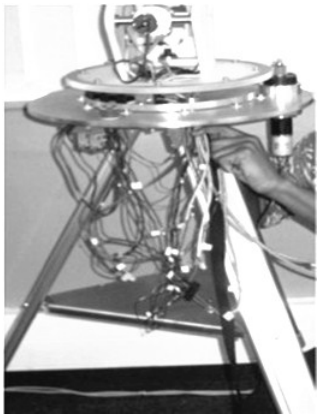

Fig. 4: Cable Assembly on ASTT

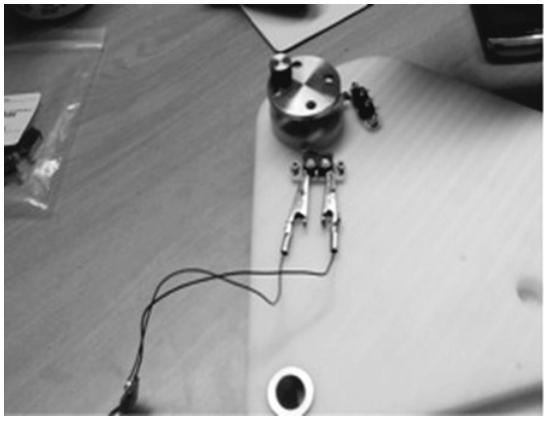

Fig. 5: Testing of Limit Switches

Fig. 6: Characterization of Limit Switches

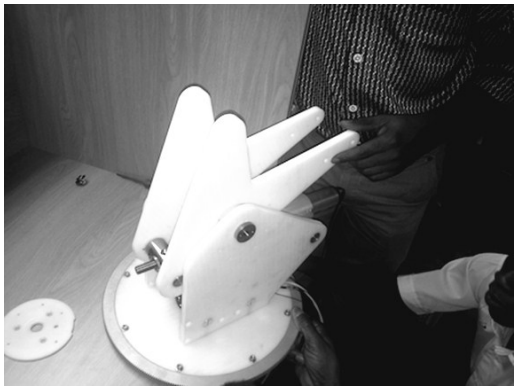

Fig. 7: Elevation-Azimuth Yoke Assembly

Fig. 8: Fixing of Yoke Assembly on the Pedestal Assembly

Fig. 9: Illustrating Some Functions of the Baby Telescope to Scientist, Students and Teachers

RESULTS AND DISCUSSION

Inspiring the Populace in Astronomy and Science

The baby telescope is a great inspirer to astronomy for many students and teachers who had the chance to play with it. The baby telescope has all the functional parts of a working telescope with all the parts scaled down. This design did impact the knowledge of the team by hands–on experience in areas of mechanical, software, electronics, radio frequency engineering and project management.

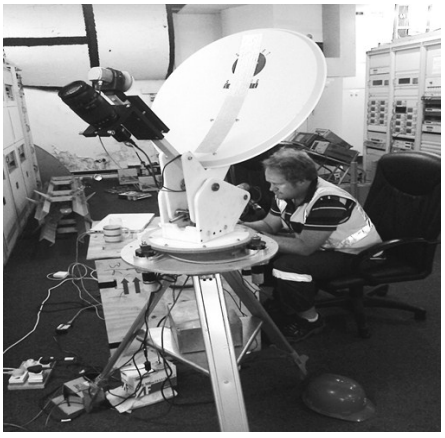

Fig. 10: Optical pointing: Night viewing of stars

It has been used by technicians to learn how to troubleshoot telescope systems.

Optical pointing

An optical camera is fixed on the baby telescope's arm as in figure 10 to take snaps of stars in the night sky. This is learning curve to generate a pointing model for the baby telescope and to transfer this skill to the bigger 32- metre radio telescope at Kuntunse, near Accra. (manuscript in preparation).

Stakeholder Involvement in SKA Project

The Ghana Space Science Technology Institute is the forerunner of space program in Ghana. It is thus a key responsibility of the institute to popularize space activities among our stakeholders mainly: students, scientist, policy makers, industry and collaborators. The ASTT has been a significant tool in achieving this task. The ASTT has been used to give a clearer picture and better understanding of the principles and functions of radio telescopes to our stakeholders during outreach in schools, conferences, seminars/ workshops, presentations, and ministerial meetings. It is also become a tool used to train students of the Royal Society program, collaboration between GSSTI and University of Leeds. This has greatly increased the involvement of our stakeholders in activities of the institute, especially the conversion of the 32-m antenna.

CONCLUSION

The baby telescope has achieved and is achieving its purpose by inspiring many minds in Ghana on the subject of astronomy and science in general. It is a real engineering masterpiece designed by SKA South Africa and built by Ghanaians under the supervision of SKA South-Africa. It is also of immense benefit to the scientists, engineers and technicians under the AVN. It's a low cost tool that can be replicated to be distributed to schools in Africa and a curriculum developed to attach to it.

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