

Low Frequency (< 1GHz) Radio Interferometric Arrays and Radio-Astronomy/Cosmology

As an Additional Pathway to the Scientific & Technological Renaissance of Africa

Nigeria hosts the IAU West African Regional Office of Astronomy for development (WAROAD: <http://www.westafrica.astro4dev.org/>). It is bound to become a hub for astronomy (and space science) research and education activities in the region. WAROAD coordinates astronomy research and activities in the region. Among the activities being coordinated by WAROAD include helping Universities to develop astronomy curricula, introduction of astronomy courses in higher institutions, exchange programmes among institutions in West Africa. A flagship program was the introduction, in 2013, of a bi-annual Astronomy Summer School. It has now matured into the Pan African School for Emerging Astronomers (PASEA: www.paseafrica.org). PASEA has encouraged a good number of students taking to astronomy studies for their postgraduate studies and exchange programmes. Many of them have joined Graduate programmes all over the world.

The diffusion of these initiatives and opportunities into Central Africa (CA) is a priority. We foresee CA as key geographical area where research niches of continental and universal importance abound and will give Africa a comparative advantage. Towards this Vision for CA and therefore Africa as a whole, we have identified Gabon as a local player that could play a leading role in the CA region.

In Gabon, the currently dominant foray into the Space Arena is being rolled out through the Gabonese Agency for Earth Observations (AGEOS: www.ageos.ga/). AGEOS is gradually maturing into a full-fledged Space Agency. The Republic of Gabon, under an initiative led by AGEOS, and supported by the Gabon Sovereign Funds, has embarked on a plan to develop a platform of services

dedicated to: (1) RainForest monitoring, (2) Land use monitoring, (3) Sea Pollution monitoring and (4) Maritime traffic monitoring.

The three main components of the AGEOS platform are:

- A Ground Station made of a 7.3 m , X-band (8-8.4 GHz), S-band upgradable; A second station for radar-type signal
- A Competency Centre made of an Administrative hub; Technical Departments (signal reception and processing);
- Training, research & development and Data distribution infrastructure Geoportal (Catalog): www.ageos.ga

The platform above has a ~ 2500 km radius of coverage centred on Gabon and covering ~ 23 African countries, dominantly on the West Coast.

The growth of activity linked to the increase in these monitoring campaigns as well as international collaborations is triggering a larger inflow of data that will require dedicated HPC platforms to perform automated tasks of data processing. Since both Earth observations and astronomy share many common grounds on the data processing end, we foresee this national venture into Earth Observations as the lead gateway into providing a greater visibility for both astronomy/cosmology and HPC in the area. This thrust needs to be actively supported, at the continental scale by all organisations bound to the scientific and technological Renaissance of Africa.

The expected surge in use of HPC within the AGEOS in Gabon will have as collateral to densify the local pool of expertise. This is directly congruent with our strong vision to see Gabon being actively/aggressively assisted in becoming a regional leader. With AGEOS, and on national funds, the country has already gained significant momentum in that direction and continue to do so, with vision.

Congruent to the above and towards taking full advantage of these fast developments in the Space arena and particularly in Space Science, we have identified low-frequency ($< 1\text{GHz}$) radio-astronomy/cosmology as a niche area where an investment both in Human Capital Development and infrastructure support (HPC capability and arrays) deserves full attention from ALL. The reason for this boils down to one research theme that is a niche at the interface between Space Science and Low Frequency ($<1.2\text{ GHz}$) Radio-Astronomy/Cosmology: Understanding better the Ionosphere at equatorial latitudes. One can look at the Ionosphere as

- a) an object of interest for Space Sciences.
- b) a contaminant that needs to be corrected for in any Low Frequency ($<1.2\text{ GHz}$) Radio-Astronomy/Cosmology observation using radio-interferometry;
- c) a topic whose, clearly interdisciplinary exploration for the purposes of Space Science or Low Frequency ($<1.2\text{ GHz}$) Radio-Astronomy/Cosmology requires a computational infrastructure.

Therefore, by aggressively pursuing the expansion of Low Frequency ($<1.2\text{ GHz}$) Radio-Astronomy/Cosmology, we literally can “kill three birds and their offsprings in one shot”: This summarises our Vision.

To clarify further, let us recap that the Ionosphere is a complex medium that exhibits continuous changes mostly related to diurnal and seasonal variations as well as solar and magnetic activities. The variability directly translates to fluctuations in electron density. The electron density in the ionosphere dictates the lowest frequency observable from the ground (approximately 10 MHz).

Above ~ 10 MHz, the Ionosphere affects any incoming signals in three main ways:

1. Faraday rotation.
2. differential phase delays.
3. absorption in the High Frequency band (HF; 3-30 MHz) and the low-end of the Very High Frequency band (VHF; 30-300 MHz) due to the presence of the so-called “D-region” in daytime

(1) and (2) above constitute major contaminants in low frequency (< 1 GHz) radio-astronomy/cosmology with low frequency (< 1 GHz) radio interferometers. In clear, strengthening low frequency (< 1 GHz) radio-astronomy/cosmology with low frequency (< 1 GHz) radio interferometers in Africa is congruent with any continental activity in space science. An aggressive implementation would have two legs:

- Strengthening existing facilities for Space Science oriented activities such as the ones in Gabon so that they become regional hubs;
- Intensifying the adoption and mastery of the science and technology of low frequency (< 1 GHz) radio interferometric arrays (LFRIA).

Fortunately, Africa, TODAY, has the privilege, in South Africa, to host an increasing number of LFRIA (www.sarao.ac.za ; HERA: reionization.org ; HIRAX: [Homepage - HIRAX \(ukzn.ac.za\)](http://Homepage - HIRAX (ukzn.ac.za))). All that is left to carefully craft is an increased mobility of this expertise into the continent, towards already leading hubs such the one emerging around AGEOS in Gabon. The HPC skills attached to this thrust are an evident collateral as we continue the Scientific and Technological Renaissance of Africa.