African Strategy for Fundamental and Applied Physics
Interim Report

Edited by: ASFAP Steering Committee **Version 1: 22 Feb 2023**

Ketevi Assamagan, Simon Connell, Farida Fassi, Shaaban Khalil, Fairouz Malek

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Overview : The Strategy for Physics in Africa.

The African Strategy for Fundamental and Applied Physics was initiated in late 2020.
This is the first interim report on the following Working Group Activities.

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ASFAP TWiki Page …. <here>

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2. Astrophysics & Cosmology
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5. Computing & 4IR
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Submitted to the Proceedings
of the African Conference on Fundamental and Applied Physics
Second Edition, ACP2021, March 7–11, 2022 — Virtual Event

Introduction to the African Strategy for Fundamental and Applied Physics (ASFAP)

Farida Fassi

Mohammed V University in Rabat, Faculty of Science, Morocco

Abstract:
Generating scientific and technological knowledge and converting them into innovations which are of added value to society are key instruments for a society's economic growth and development. As outstanding as these capabilities are for other regions in the world, Africa's science, innovation, education and research infrastructure, particularly in fundamental and applied physics, have over the years been under-valued and under-resourced. To efficiently address the scientific and technological gaps with the rest of the world, Africa's stance needs radical overhaul. With the big ambition to drive a community-wide effort in Africa, the African Strategy for Fundamental and Applied Physics (ASFAP) was founded. The aspiration is to demonstrate the physics potential benefits for African society and how physics can contribute to the technological infrastructure development and to provide trained personnel needed to take advantage of scientific advances. The vision consists in fostering scientific literacy driven by physics-based technologies and their impact for economic growth, including other sciences that draw heavily on advances in physics, in addition to developing and enhancing collaborations and partnerships among Africans in national, regional, and Pan-African organizations. This should assist to tackle the challenges that Africans struggle and prioritize educational and research resources, innovation and development. The ASFAP initiative could present a unique opportunity of overcoming the complexity of the African social and economic challenges, if Africa needs to have and maintain its position as a co-leader in the global scientific process and reap the consequent socio-economic benefits. ASFAP will take a few years with a final report to notify the African policymakers and broader communities concerning the strategic directions that will have greatest impacts on physics education and research in the next decade.

Keywords: ASFAP, Physic Education, Science, Research, Innovation, Human Capital Building

1. Introduction

Science and technology capabilities are fundamental for social and economic growth and development. Yet Africa's science, innovation and education have been chronically under-funded. Transferring knowledge, building research capacity and developing competencies through training and education are major priorities for Africa in the 21st century. Physics combines these priorities by extending the frontiers of knowledge and inspiring young people. It is therefore essential to make basic knowledge of emerging technologies available and accessible to all African citizens to build a steady supply of trained and competent researchers. In this spirit, ASPAF [1] was founded to foster social transformation and economic competitiveness, through science, technology and innovation

Corresponding Author
Email address:farida.fassi@cern.ch (Farida Fassi)

for effective human capital development as a key means of implementation to drive sustainable development in Africa. ASFAP aims to increase African education and research capabilities, build the foundations and frameworks to attract the participation of African physicists, and establish a culture of awareness of grassroots physics activities contrary to the top-down strategies initiated by governments. To address many of the fundamental issues that African society continue to face, ASFAP will complement African top-down strategies and encourage a broad community participation.

2. Africa Major Challenges in the 21th century

Literacy and education are essential for human development in today's knowledge world as Nelson Mandela said "*Education is the most powerful weapon, which we can use to change the world*". Education allows us to better understand the world in which we live. Nevertheless, literacy in the African continent is affected by a number of key factors, which are: colonial legacy includes the linguistic framework that strongly affect the educational environment, as well as shortage of resources (reliable access to electricity), inadequate infrastructure as shown in Graph-1 (middle and right-hand images), lack of digital literacy, lack of trained teachers and better learning material which include Information and Communication Technologies (ICT). These constraints hinder the process of promoting literacy to Africans, and present the biggest challenges of science knowledge creation and technological innovation in Africa. These led to the continent´s failure to create high quality education, stop brain drain, correct for gender equality, as well as they fail to ensure science-led development on a sustainable basis and unlock the minds for brighter economic prospects.

Because of that, the overwhelming majority of the Africans are falling into poverty and lack of decent jobs. Parallel to this, there is a demographic explosion in Africa (see Graph-1, left-hand) based on the United Nations forecasts [2] [3]. Africa's population is expected to grow by an average of 2.2 % (2.5 % by 2040) every year until the 2060s (and by 2050 a quarter of the world's people will be African). In addition, more than half of Africa's population will be under 25 years old [4]. In the next few decades, Africa will become the youngest and most populous continent. In view of these developments, the difficulty of confronting a population explosion and weak economic growth exacerbated the situation. The situation for female youth, who are even worse off than male youth, is particularly serious. Young women suffer from a deeper lack of insufficient levels of literacy and therefore are largely emarginated and work in the informal and precarious sectors.

Graph-1: The world´s population will rise to 10,9 billion by 2100, with most of the growth driven by Africa [3] (Left-hand). Middle and right-hand images show examples of the educational environment issues in Africa.

Corresponding Author
Email address:farida.fassi@cern.ch (Farida Fassi) 2

Although, African countries show commitment to invest in science through investment in research and development (R&D), only four out of five countries still spent less than 1% of global investment in R&D of its Gross Domestic Product, which is the closest to the African Union's suggested of 1% [5]. Furthermore, several countries ranked as 0%, while the R&D expenditures for more than 20 African countries are unknown. This chronic underfunding on Africa's R&D is gravely impacting the Africa´s participation in the creation of scientific knowledge, which is extremely poor in comparison with the rest of the world. The Africa's contribution to the global scientific knowledge is roughly 0.74%. On top of this, African publishing research outputs are under-valued and under-cited in the international indexing systems namely, Scopus and the Web of Science. That said, Africa has also an extremely low number of researchers per million people (it is about 198) [6], and in order to achieve the world average concerning the number of researchers per capita, Africa needs another million new PhDs students. This landscape gets worse and worse when Africa is losing roughly 20,000 professionals to the high-income countries every year due to the lack of opportunity. Hence, one must recognise that the aforementioned limitations leave Africa lagging behind and the continent become a peripheral region in the world. Even, the gap is widening exacerbated by the persist underperformance. It is high time, that Africa narrows and closes the scientific and technological gaps with other regions in the world. That it's been massively underfunded over a long time impacting critically the growth of African economies. Thus, African countries are at a critical juncture socioeconomic, and to achieve the commitment of the leadership a deep African engagement is required. It is therefore, imperative that Policymakers and stakeholders appreciate the return on investment in research, innovation and higher education to reverse the trend towards greater science-led development on a sustainable basis for Africans.

3. ASFAP-African Strategy for Fundamental and Applied Physics

In response to the previously mentioned challenges, ASFAP presents an ambitious initiative that seeks to set up the foundation and framework for enhancing the African science community collaboration in defining education, physics priorities and stressing the powerful of physics for African society. The main goal is to address the interests of a wide range of varying needs from the community with the aim to attract enthusiasms of every physics disciplinary group, which is particularly targeted. These perspectives have arisen from and been driven by the science community with its potential to deliver a long-term strategy that would encourage and engage the continent to align its scientific research policy in physics to support national agendas towards higher education development and improve basic physics research by using more robust means of assessment that focus mainly on values of insight, impact and reliability. All these include a strong desire for investment in African science for economic growth driven by physics-based technologies.

ASFAP founding initiative is designed to be a transparent and democratic process, to be owned by Africans for Africa and it is mandated by the African Physical Society. The co-founders who form the Steering Committee (STC) are: Kétévi Assamagan (Brookhaven National laboratory, USA), Simon Connell (University of Johannesburg, South Africa), Farida Fassi (Mohammed V University in Rabat, Morocco), Shaaban Khalil (Center for Fundamental Physics, Zewail City, Egypt) and Fairouz Malek (CNRS and Grenoble University, France).

Corresponding Author
Email address:farida.fassi@cern.ch (Farida Fassi)

The process development requires a few years and in due course will release the strategy report. STC will first explore manners to better adapt the overall ASFAP strategy generated. In particular, the focus will be suggesting a strategic plan with direction that has a positive and significant impact on physics education and research in the next decade, along with actionable items. The report will be communicated to the African and broader communities. With the aim to make well-informed decisions that would contribute to a sustainable development, a collaborative culture must be instilled as a core principal that can bring together policymakers, managers, scientific communities in national, regional and Pan-African organizations. Moreover, to strengthen this collaboration and ensure the implementation of those decisions one needs to do a close follow up.
Just like a strategic plan, in order to be useful it needs to be periodically reviewed and revised to adjust priorities and re-evaluate goals, so that ASFAP process has to be repeated regularly, every 7-10 years for the following decades with a review of the impact of previous strategies. The overall roadmap process is shown in Fig-1, that illustrates a tentative timeline and deliverables, as well as the activities.

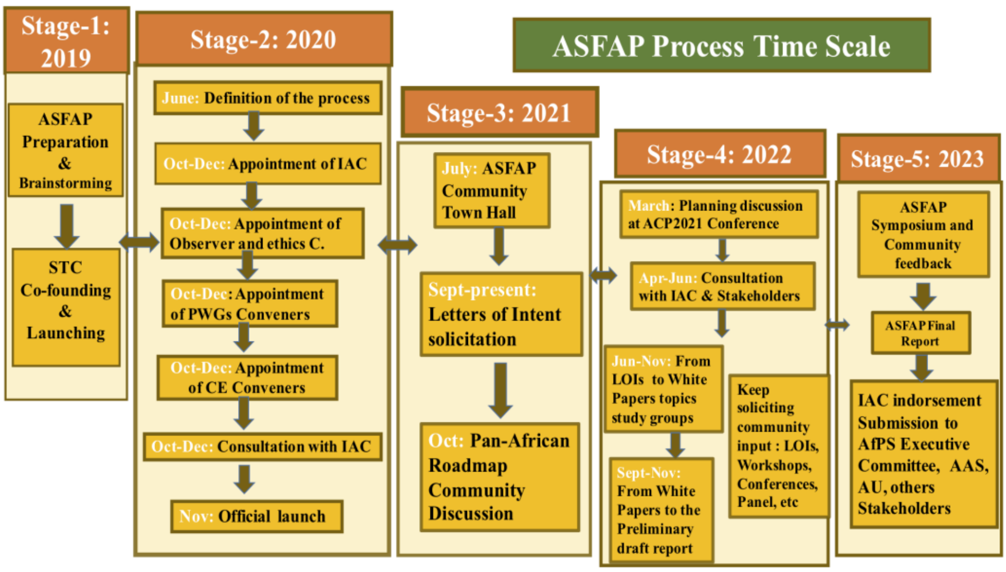

Fig-1: ASFAP roadmap timeline

ASFAP organization structure is shown in Fig-2. The Steering Committee (STC) body manages the process development, ensure the overall coordination and advance the necessary efforts involving all ASFAP bodies. In addition to the final report preparation. The International Advisory Committee (IAC) is formed of international institutes and leading individuals in the field in Africa and beyond. IAC advises on the ASFAP scope, review the progress and engage the international communities and policymakers as well as endorse the final report. ASFAP considers the Observers Committee (OC) who is made up of Seniors and Expects from many research fields in physics. OC is responsible for advising and conveying ideas between STC, Physics Working Groups (PWGs), Fora and Community Engagement groups. OC has also to review the community inputs, in particular Letter Of Intents (LOIs) and White paper, and help PWGs in report editing. ASFAP include also the Ethics

Corresponding Author
Email address:farida.fassi@cern.ch (Farida Fassi) 4

Committee (EC), who is responsible for dissemination and maintain the Guidelines of ASFAP Code of conduct. A subset of EC might serve as an Ombudspersons as well.
ASFAP has a broad footprint by discipline and fields, it has 16 PWGs and are as follows: Accelerators, Astrophysics & Cosmology, Atomic & Molecular Physics, Biophysics, Computing & 4IR, Earth Science, Energy, Fluid and Plasma, Instrumentation & Detectors, Light Sources, Materials Physics, Medical Physics, Nuclear Physics, Particle Physics, Optics and Photonics and Theoretical & Applied Mechanics. PWGs play a pivotal role in the ASFAP process, by encouraging and soliciting the community inputs, engaging the discussion, reviewing and revising the progress in the relevant groups. Furthermore, PWGs are in charge of the group reports preparation. PWGs provide also the liaisons between the different PWGs to enable that cross-cutting topics receive the proper coverage and consideration in all the relevant groups. In what concern the Engagement Groups & Fora, there are Community Engagement, Physics Education, Women in Physics Forum and Young Physicists Forum. These are convened and working closely with STC and the rest of ASFAP bodies to promote science-led development on a sustainable basis, contribute to the scientific literacy of high schools and universities and revitalize higher education. It is clear that the first step should be the gathering of inputs and evidence from the community to draw upon. This kind of inputs give the full picture and help to address the right questions on how to encourage and engage young people in physics, technology and scientific careers. And a special attention must be paid to the women participation. This wide and deep consultation can contribute in raising awareness of the necessity to prepare and form qualified young people about technology and knowledge transfer and can thus stimulate Africa's productivity development.

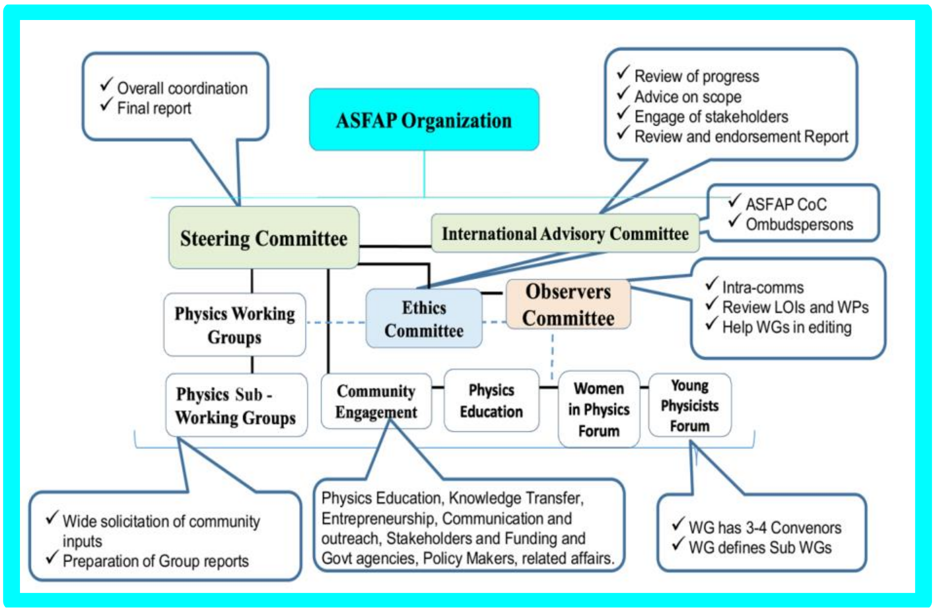

Fig-2: ASFAP Organization structure

Corresponding Author
Email address:farida.fassi@cern.ch (Farida Fassi)

4. African Strategies and ASFAP

Africa has already numerous strategies authored by governments and policymakers, large political bodies and institutions [5] [7] [8]. These include strategies for a green growth model, better education and research, job creation, digital transformation and so on. However, the effective local implementation of these strategies is still missing, and which is evident by the persistent of Africa laggardness. As a result, it is essential for the scientist's community, engineers, technicians, funding agencies and policymakers to come together and create the critical masses needed to address and define a concerted strategy for the continent. Unlike African top-down strategies, ASFAP is based on a large community consultations and large footprints in all the physics and engagement topics of importance to Africa.

Since decades other regions in the world have already been conducting the efforts; this is the case for the European and United States strategies for Particle Physics and other physics fields, and recently Latin America that has been developing its strategy as well. For that, Africa should fight seriously to take its equal place as a co-leader in the global scientific process, along with all the consequent socio-economic benefits. To achieve that, ASFAP is a crucial process, where the central mission would be to help improving higher education in Africa across national borders and in so doing, to contribute in a significant way to the development on the continent. To fulfil this mission several considerations, have to be implemented among them: 1.) the engagement and participation of the African scientist's community, 2.) the establishment of culture awareness for the periodic strategies done by grassroots physicists, 3.) the improvement of the low level of intra-African collaboration in the exchange and sharing of data and in scientific collaboration and 4.) the strength of the African education and research capabilities. Since the international cooperation forms the common denominator of today's culture of scientific activities, it is equally important to increase and sustain networking to extend the existing international scientific ties to Africa, in the development of the strategical visions for fundamental and applied physics. Such as engagement in physics education, communication and outreach, toward developing countries, should be sustained also in targeted programs toward Africa. In order to exploit and overcome a realistic path for development, African countries must adopt a coherent coordinated strategy and implement what it needs to be changed to radically give science and technology their due weight in the development process. This will certainly be a unique opportunity to prosper for a continent of more than a billion people with large unmet needs but vast human potential.

5. Organizations supporting ASFAP

Graph-2 represents the ASFAP support, including the national and international organizations funding agencies and governments organizations, institutions and academies in Africa and beyond. The organizations supporting ASFAP are as follows: African Physical Society, African Union, African Academy of Sciences, Network of African Science Academies (NASAC), South African Department of Science and Innovation, iThemba Labs (South Africa), Hassan II Academy of Science and Technology (Morocco), Ministry of Higher Education and Scientific Research (Tunisia), South African Institute of Physics (SAIP), United Nations Educational, Scientific and Cultural Organization (UNESCO), East African Institute for Fundamental Research (UNESCO-EAIFR), Third world Academy of Sciences (UNESCO-TWAS), International Union of Pure and Applied

Corresponding Author
Email address:farida.fassi@cern.ch (Farida Fassi)

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Physics (IUPAP), CERN (European Organization for Nuclear Research), International Centre for Theoretical Physics (ICTP), International Atomic Energy Agency (IAEA), European Physical Society (EPS), German Physical Society (DPG), Institute of Physics (IOP), French Physical Society, European Astronomical Society (EAS), Spanish Royal Physics Society (RSEF), Spanish Astronomical Society (SEA), Netherlands' Physical Society (NNV), Physical Society of Japan (JPS), Association of Asia Pacific Physical Societies (AAPPS) and Islamic World Educational, Scientific and Cultural Organization (ISESCO).

Graph-2

6. Community Inputs

The worldwide expert community has demonstrated the wish to promote better education and research for Africa. However, they do not consider the African conditions due to their ignorance of the African reality. To translate the diversity and complexity of African realities, Africans themselves must develop their own strategy for science and technology to achieve their greatest impact and benefits. This would also help the international partners interested in capacity development and retention in Africa to integrate the Africans inputs, rather than to default to their own views of how they may want to develop Africa. In this spirit, ASFAP process relies on the African community inputs, as well as Pan-African and international communities. The inputs from the communities are collected in several forms of proposals: LOIs, white papers (that aim to be published in a peer-reviewed Journal), including surveys, Panel discussion, networking with stakeholders, conferences and workshops and then discussed and debated in plenary sessions and topical parallel sessions. The engagement of the community inputs would be also the commitment in PWGs meetings, nominations of the PWGs conveners and liaisons, offering constructive opinions and expertise and encouraging institutional credits for those working on ASFAP for people in leadership roles as conveners and liaisons.

7. Conclusion

ASFAP was founded with a big ambition for change and longer-term reforms that should focus on strengthening institutions, improving infrastructure, accelerating technology adoption and enhancing high education, capacity building, scientific research. In addition, the strategy aims to influencing

Corresponding Author
Email address:farida.fassi@cern.ch (Farida Fassi)

directions of strategic science development taken by policymakers and effective implementation. ASFAP would help donors and funding agency in deciding where best to invest limited resources and support the African Physical Society into an outstanding professional body. The initiative also stresses the pivotal role that physics plays as a key part of the educational system and hence an advanced society governments need to be supportive of the science of physics. It is worth emphasizing, furthermore, that the digital revolution, the so-called 4th Industrial Revolution, presents a great opportunity for Africa to benefit from developed ICT capabilities such as automation and digitalisation if Africa succeeds in implementing the technological transformation locally.

In pursuing this vision, the African scientific communities emphasize the importance of building synergy between fundamental physics and practical applications which is crucial for a solid education in Africa.

8. References

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Corresponding Author
Email address:farida.fassi@cern.ch (Farida Fassi)

Ethics Committee Report

African Strategy on Fundamental and Applied Physics

Nithaya Chetty[1], Samira Hassani[2], Oumar Ka[3], Chilufya Mwewa[4]

University of the Witwatersrand[1], CEA-Centre de Saclay[2], Cheikh Anta Diop University[3], Brookhaven National Laboratory[4]

Introduction

Ethical behavior within the African Strategy on Fundamental and Applied Physics (ASFAP) is governed by a code of conduct (COC) [1], which is a set of core principles and community guidelines to which members of the ASFAP community must adhere. Registration to any working group implies that the member has read and accepted the ASFAP COC. The COC was drafted by the ASFAP steering committee but it subsequently fell under the responsibilities of a four-member ethics committee, which had been established to review and act as custodians of this document. It is the task of the ethics committee to amend this document whenever necessary, while ensuring that ASFAP remains a community where everyone feels welcome and respected. In addition, members of the ethics committee are mandated to serve as ombudspersons if need arises.
We're pleased to report that, so far, we have not received any reports of conflicts within the ASFAP community requiring our intervention. Therefore, this report only outlines amendments we have made to the COC to date.

Amendments to the code of conduct

Since June 2021, we have had several meetings to review contents of the COC and have made adjustments and addendums in addition to some general textual editing. We have also incorporated a few suggestions received from the steering committee. The current version of the COC was implemented in March 2022. Highlighted below are some of the "major'' edits/addendums to the document.

Authorship

Very often there are ethical questions raised around large authorship papers in terms of each author's contribution to the body of work that has been published. In some cases, names are included as authors 'only because it was always done'. Therefore, the ethics committee decided that this matter needed to be covered in the COC. The following text was thus added to section 3(d) of the COC [1].

Authorship offers credit for an individual's contributions to a study. It also holds the author accountable for the content in a published paper.

All individuals who carried out the work are responsible for the decision on who should be listed as an author when that work is published. Any individual who makes a significant contribution to the work (as agreed by everyone contributing to the paper) should be listed as an author. Any other individual or organization should be acknowledged accordingly.
In case of conflict, working group conveners should be contacted in order to help resolve the conflict. If the conveners and the contributors are unable to reach a consensus, the ethics committee should be contacted.

Email Communication

For a community involving hundreds of people, poor use of email communication could be problematic if not addressed. For example, one member could send a personal email to another member (e.g to congratulate them) but adding a larger email group in cc. This may be an issue if several other members reply to this email with everyone in copy. The ethics committee felt that this borders on the "unethical use of email communication''. Hence, the text below was added to the COC as a bullet point in section 3(c).

Ethical use of email communication: If your email concerns an individual person or a closed group of individuals, do not write to or reply to everyone in a general list. In addition, email communication should be done in a respectable manner, respecting the rest of this document's guidelines. Be also conscious of the fact that members of the ASFAP community are in different time zones. Therefore, prompt responses should not always be expected.

Guidelines on virtual meetings

Given that ASFAP meetings are mostly virtual, the steering committee advised to add a section on guidelines for such meetings to the COC. The text below was thus added to section 3(e).

As members of ASFAP are located in various places across the globe, virtual meetings are inevitable. In addition, due to the ongoing pandemic, virtual or hybrid conferences/workshops may also be inevitable. To facilitate the smooth running of such meetings, members of the ASFAP community and invited guests should adhere to the guidelines listed below:

- *Meeting times should accommodate participants from all time zones. Meeting minutes and/or recordings should also be made available on the meeting web page.*
- *Meeting hosts should ensure that only the speaker's microphone is ON at any given time.*
- *Participants should use the raise hand feature found in online meeting solutions (e.g. Zoom), or type their comments/questions in the chat box. Otherwise, participants should wait for an appropriate opportunity to comment or ask questions without interrupting other participants.*
- *Conveners should ensure that each participant receives an equal opportunity to participate in the discussion.*
- *Given that many individuals are currently working remotely, conveners should ensure that the meeting durations are respected. Virtual meetings tend to go overtime, but participants' time zones and personal lives should be respected.*

General edits

- In section 5(b), we replaced "moderator/host/code of conduct committee" by "convener/host/observer/ethics committee" because we believe that members of the observers committee should also be able to speak up in case of violation.
- Throughout the COC document, we removed parts that mention contacting an individual's institution if the individual violates the COC. We believe this is unnecessary as in many cases, members of ASFAP are by no means representing their institutes

Conclusion

We have highlighted the major addendums and edits that we have made to the COC document since our engagement as its custodians. To date, no violations to the COC that needed our intervention have come to our attention.
We believe that we would have done our job very well if there are zero complaints that come to us. Therefore, rather than being passive about these matters, our plan has been to constantly educate the community about these issues in a smart and non-intrusive way. We have not enforced this in the past year and we hope to find a way to keep these ideas alive and discussed in the public domain from time to time. This could, for example, be a five minute slot at every meeting with conveners to remind them of the COC and its importance.

References

[1] ASFAP code of conduct and community guidelines, https://docs.google.com/document/d/1eliKD1LBVtVcKkAaWJ5W4VMy_x7i7JS2pEuTgGpudis/edit - heading=h.ecp3r7c1vr2d

ASFAP Astrophysics and Cosmology Working Group: Current Status and Future Plans

Mirjana Pović[1 2 3], Lerothodi Leeuw[4], Bernard Asabere[5 6], Priscilla Muheki[3], and Sivuyile Manxoyi[7]

[1]Space Science and Geospatial Institute, Entoto Observatory and Reserach Center, Astronomy and Astrophysics Department, Addis Ababa, Ethiopia
[2]Instituto de Astrofísica de Andalucía (CSIC), Granada, Spain
[3]Mbarara University of Science and Technology, Physics Department, Mbarara, Uganda
[4]University of Western Cape, Cape Town, South Africa
[5]Ghana Space Science and Technology Institute, Accra, Ghana
[6]Netherlands Institute for Radio Astronomy (ASTRON), Dwingeloo, The Netherlands
[7]South African Astronomical Observatory, Cape Town, South Africa

Abstract

This report summarises the current status and future plans of the Astrophysics and Cosmology Working Group (WG) under the African Strategy for Fundamental and Applied Physics (ASFAP). It gives a brief introduction to astronomy developments in Africa in the last ten years, showing that astronomy is one of the emerging fields of science on the continent. It describes the structure of the ASFAP Astrophysics and Cosmology WG, its objectives, and the activities carried out. It finally describes the received Letters of Interest and the way forward in the development of the Strategy.

Status of astronomy developments in Africa

Astronomy is currently one of the emerging science fields in Africa. This can be observed through different activities, from institutional and infrastructure developments, human capacity building, research and publications, creation of professional societies and networks, up to the growth in outreach activities and amateur astronomical societies.

Over the last ten years, there has been strong institutional development in astronomy, with many newly established space agencies, research centers, and astronomy departments under the universities (e.g., in Egypt, Ethiopia, Gabon, Ghana, Kenya, Morocco, Nigeria, Rwanda, South Africa, Sudan, etc.; see Pović et al. (2018) for more information). Infrastructure development has also been remarkable, building from small to some of the largest telescopes in the world. Figure 1 (central map) shows some of the existing and forthcoming telescopes and observatories. In radio astronomy, the Square Kilometer Array (SKA)[1] together with the African Very-Long-Baseline Interferometry (VLBI) Network (AVN)[2] are some of the principal initiatives, with the center in South Africa and partnership with Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia, and Zambia. All of these countries signed a memorandum of understanding in 2019 to work jointly on the development of radio astronomy. The MeerKAT[3] radio interferometer, the African SKA precursor, with 64 dishes located in South Africa, already started its operation in 2018 and is producing some of the most detailed radio images of the Universe. In addition, Namibia is building the African Millimeter Telescope (AMT; Backes et al. 2016, 2019), the very first millimeter radio telescope on the African continent, while South Africa is working on the establishment of the Hydrogen Intensity and Real-time Analysis eXperiment (*HIRAX*)[4] radio interferometer. All of the mentioned telescopes form a part of large international collaborations. In optical astronomy, South Africa is hosting the largest 11m South African Large Telescope (SALT)[5],

1 https://www.skatelescope.org/africa/
2 https://www.sarao.ac.za/science/avn/
3 https://www.sarao.ac.za/science/meerkat/
4 https://hirax.ukzn.ac.za/
5 https://www.salt.ac.za/

and a number of different optical telescopes at the South African Astronomical Observatory (SAAO)[6] in partnership with different countries. Morocco also established through different international collaborations several small telescopes at the Oukaïmeden Observatory[7]. Small, 1 - 2m optical telescopes have also been established in several other countries and/or are in the process of being established soon, like in Algeria, Burkina Faso, Egypt, Ethiopia, and Kenya (Pović et al. 2018). In addition, Namibia, in collaboration with Germany, is hosting the High Energy Stereoscopic System (H.E.S.S)[8] Cherenkov telescope for the study of cosmic gamma rays.

New post-graduate programs (MSc and PhD) and summer schools in astronomy and astrophysics increased across the continent, as well as the number of professional astronomers (e.g., in Algeria, Botswana, Burkina Faso, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Mauritius, Morocco, Namibia, Nigeria, Rwanda, Senegal, South Africa, Sudan, Uganda, Zambia, Zimbabwe, etc.). This brought a strong development in astronomy research across the continent (e.g., the number of published research papers tripled from 2011 until 2021; source SRJ-Scimago Journal and Country Rank). Consequently, with the support from the South African Department of Science and Innovation, the African Astronomical Society (AfAS)[9] was re-established in 2019 with an aim to become the voice of astronomy development in Africa. In close collaboration with AfAS, several other initiatives arose such as the African Planetarium Association (APA)[10], the African Network of Women in Astronomy (AfNWA)[11], the African Science Stars (ASSAP)[12], and the Africa-Europe Science Collaboration and Innovation Platform (AERAP)[13]. Africa is also hosting the International Astronomical Union (IAU) Office of Astronomy for Development (OAD)[14], including three Regional OAD Offices in Ethiopia, Nigeria, and Zambia. Finally, public awareness and outreach activities increased exponentially across Africa in the last ten years, including the establishment of more than 70 amateur astronomical societies, as can be seen in Figure 1 (left bottom map).

Despite strong astronomy developments, there are still many challenges and needs to be addressed. For example:

- most of the countries are starting from scratch with astronomy development and therefore need significant support;
- there is a limited number of human resource, plus the limited qualified sector to support all the needs and perform all the activities (this includes a small number of available MSc/PhD scholarships in astronomy and open job positions);
- there is often a lack of supportive infrastructure for scientific (astronomy) developments;
- there is a lack of funding (secured in the long term) and support from local governments;
- many countries suffer day-to-day difficulties with power and internet cuts that may have a significant impact on scientific developments;
- astronomy in Africa is still not accessible to everyone; and
- there is a need for more awareness to be done among the general public, policy- and decision-makers regarding the importance of astronomy and science for Africa's socio-economic and environmental growth and development (see McBride et al. 2018).

The African Strategy for Fundamental and Applied Physics (ASFAP)[15] is therefore timely, to address the enormous developments in astronomy in Africa, but also to highlight the current and future needs.

6 https://www.saao.ac.za/
7 http://moss-observatory.org/
8 https://www.mpi-hd.mpg.de/hfm/HESS/
9 https://www.africanastronomicalsociety.org/
10 https://africanplanetarium.org/
11 https://afnwa.org/
12 https://assap.co.za/
13 https://aerapscience.org/
14 https://www.astro4dev.org/
15 https://africanphysicsstrategy.org

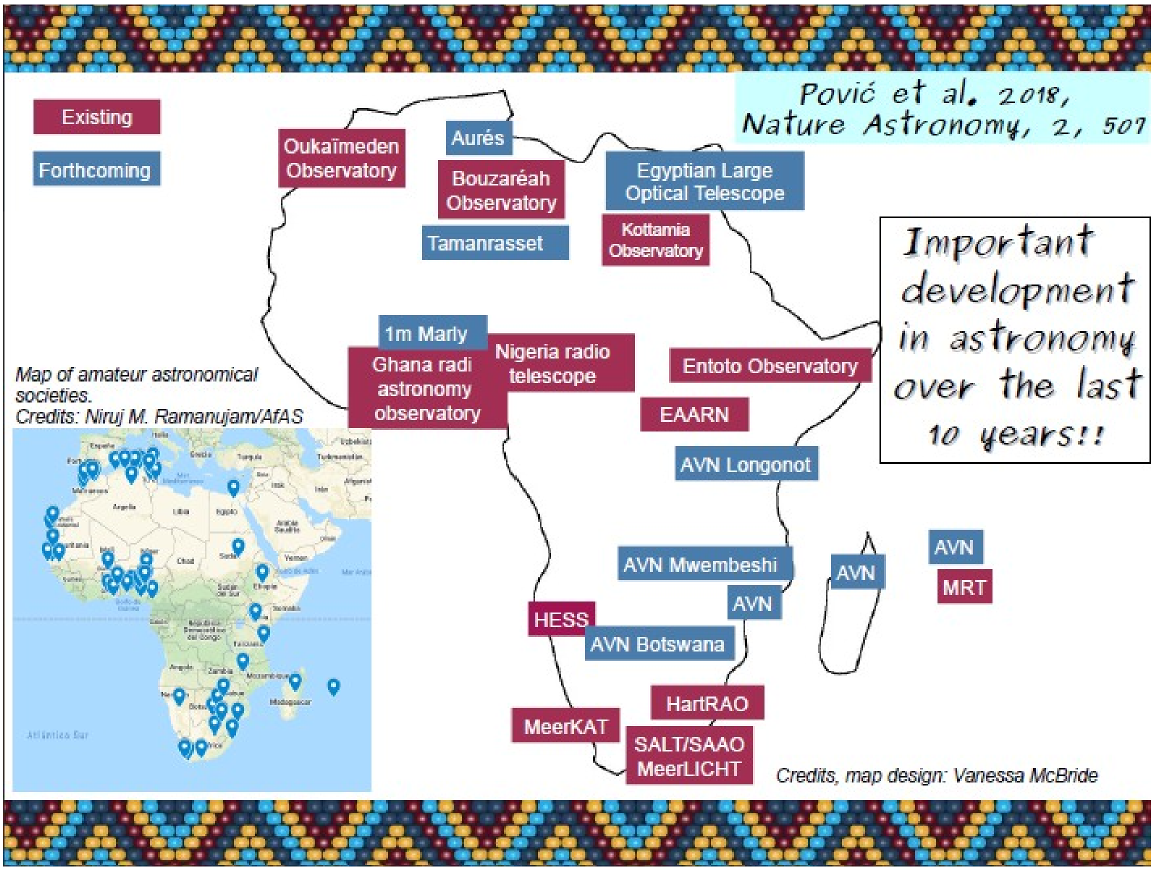

Figure 1. *Central map:* Existing and forthcoming telescopes and observatories in optical, radio, and gamma-rays, produced by Vanessa McBride using the data from Poviće et al. 2018. *Left bottom map:* Amateur astronomical societies in Africa produced by Niruj M. Ramanujam, under the African Astronomical Society (AfAS).

ASFAP Astrophysics and Cosmology Working Group

The Astrophysics and Cosmology Working Group (WG) is one of the 16 created ASFAP physics WGs. It was established with the aim to inform the public and decision-makers about the impact that astronomy may have on African growth and to develop a part of the Strategy that will serve as a Road Map for future astronomy developments. The principal objectives of this WG are:

- to give more visibility to the current astronomy developments in Africa, including some of the long-term initiatives and international partnerships related to institutional/infrastructure developments and human capacity building;
- to bring together all astronomical community for designing the Strategy that will summarise the vision of professional astronomers where astronomy and science in Africa shall be in the future and how they will benefit African social and economical development; and
- to facilitate the decision- and policy-makers to develop their strategies toward sustainable African growth through astronomy/physics, science, technology, and innovation.

The WG is coordinated by five co-conveners, Bernard Asabere (Ghana/The Netherlands), Lerothodi Leeuw (South Africa), Sivuyile Manxoyi (South Africa), Priscilla Muheki (Uganda), and Mirjana Poviće (Ethiopia/Spain). It currently has more than 130 members, from 34 countries (including 20 from Africa, 8 from Europe, and 5/1 from Asia/South America). Members cover all professional stages, from MSc and PhD students, through early-career researchers, up to senior researchers. Regarding gender identity, 64%/34%/2% of members identified as male/female/other, respectively. All members were invited to join one or more of the 11 defined working subgroups.

These subgroups are: solar physics, solar system, planetary sciences, and astrobiology, stellar astronomy, galactic and extragalactic astronomy, cosmology and gravitational astronomy, transients and pulsars, high-energy astrophysics and astro-particle physics, astronomical instrumentation and infrastructure, astronomical methods and data, ethno-archeoastronomy (cultural astronomy), and astronomy for development. Figure 2 shows the number of members per working subgroup. It can be seen that the majority of members (> 60%) are interested in the use of astronomy for the development of our society. Astronomical methods and data is the second most populated subgroup, followed by cosmology and gravitational astronomy, and galactic and extragalactic astronomy. Figure 2 also broadly reflects which fields of astronomy are less developed in Africa and have a smaller number of experts, such as solar physics and transients and pulsars.

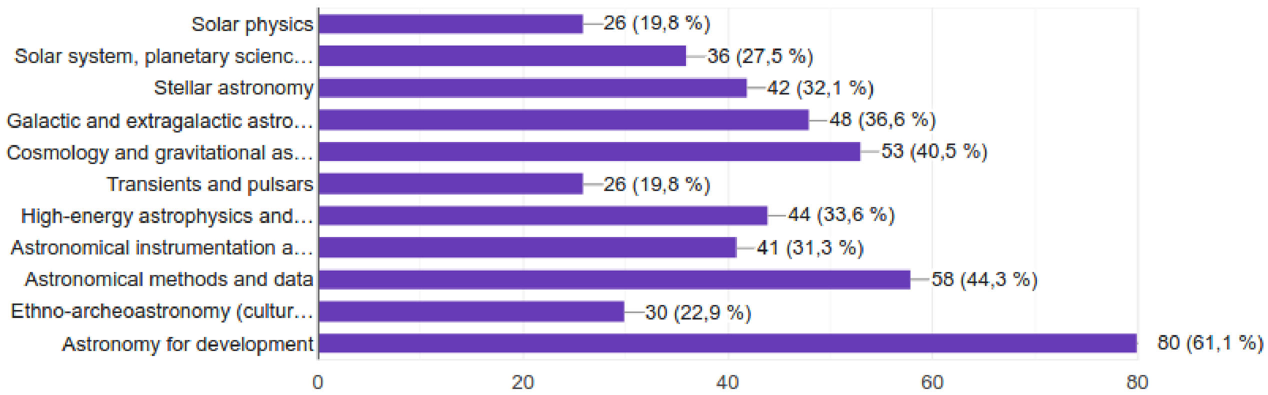

Figure 2. The number of ASFAP Astrophyisics and Cosmology WG members per each defined working subgroup.

Some of the principal activities carried out under the Astrophysics and Cosmology WG include:

- Promotion of ASFAP through different professional networks for inviting the professional community to join the WG.
- Organisation of several meetings for giving information about ASFAP and for creating the proper strategy of Astrophysics and Cosmology WG.
- Participation of the WG in the African Physics Conference in March 2022.
- Promotion of ASFAP and Astrophysics and Cosmology WG through more than 10 invited talks, including the summary given during the AfAS annual conference in March 2022 and during the special session on African-European collaborations in astronomy at the annual meeting of the European Astronomical Society in August 2022.
- Participation of the WG in the discussion led by the ASFAP Youth in Physics Forum about the WG strategy and the importance of astronomy for African development.
- Distribution of the call for ASFAP Letters of Interest (LoI) among the astronomical community.
- Discussion about received LoI, and identification of those that are still missing and that shall be addressed in the coming White Papers.

Status of received Letters of Interest

Until the date of this report, we received 13 LoI (out of 68, ~ 20%) with Astrophysics and Cosmology being indicated as the primary physics WG. The received LoI cover radio astronomy, gamma-rays and optical observational astronomy, cosmology, and astronomy for development. Most of them, describe the initiatives/projects that are already running, but there are also several LoI with new proposed developments. In continuation, we are providing a summary of received LoI and their suggestions:

- **African Radio Astronomy Network** (James Chibueze, NWU/South Africa), suggests building a network of small and cheap radio telescopes, with an aim to provide training in radio astronomy across Africa and to undertake research with the ultimate aim of getting African astronomers to participate in the SKA science.

- **Astro-particle and cosmology potential in the underground of Africa** (Fairouz Malek, CNRS/France, and Yasmine Sara Amhis, IJCLab/France), addresses the opportunity for African countries to contribute to the enhancement of the knowledge and understanding of the fundamental aspects of the Universe by building and leading underground experiments similar to IceCube, ANTARES, Kamioka neutrino observatory, SNOLAB, etc.
- **Continued gamma-ray observations with H.E.S.S** (Michael Backes, UNAM/Namibia), addresses the importance of H.E.S.S telescopes for the current gamma-ray observations, and for the development of the future Cherenkov Telescope Array (CTA).
- **Development in Africa with Radio Astronomy** (Melvin Hoare, University of Leeds/UK), describes the DARA project that has provided basic training in radio astronomy to over 300 young graduates across eight African countries, and scholarships to 26 MSc and 9 PhD African students, with perspectives to continue with the work in future.
- **Furthering the sustainable development goals in Africa by exposing young children to the beauty, excitement and perspective of astrophysics** (George Miley, Leiden University/The Netherlands), suggests that ASFAP incorporates into its strategy the use of astrophysics in the education of very young children (4 - 10 years old), particularly those in underprivileged communities.
- **Gamma-ray astronomy in the context of multi-wavelength astronomy and multi-messenger astrophysics** (Markus Boettcher, NWU/South Africa), summarises opportunities for Africa to take on a driving role in the field of multi-wavelength and multi-messenger astrophysics.
- **Low-frequency (< 1GHz) radio interferometric arrays and radio astronomy/cosmology** (Patrice Okouma, Rhodes University/South Africa), suggests the development in space science and low-frequency (< 1.2 GHz) radio astronomy and cosmology.
- **Observational astronomy in North Africa** (Fairouz Malek, CNRS/France, and Mourad Telmini, University of Tunis El Manar/Tunisia), addresses the opportunity for North African countries to unite in contributing to build and lead a series of local observatories and/or one large facility.
- **The first millimetre-wave radio telescope in Africa: teh Africa Millimetre Telescope** (Michael Backes, UNAM/Namibia), introduces the AMT and its impact on human capacity development in Namibia and Africa.
- **The importance of the financial and technical support for the improvement of cosmology in Cameroon and in Africa** (Ragil Ndongmo, University of Yaoundé I/ Cameroon), addresses the current difficulties in Cameroon regarding the studies in cosmology and brings some suggestions on how to overcome the existing challenges.
- **The Lofar global citizenship radio array "GLORAY"** (George Miley, Leiden University/The Netherlands), summarises a proposal to be submitted to ASTRON and to the International LOFAR Telescope Board to carry out a design study for a project that would transform LOFAR into a multidisciplinary facility that would span 3 continents, including Africa (in particular North Africa).
- **The South African Radio Astronomy Observatory (SARAO)** (Rob Adam, SARAO/South Africa), describes SARAO's vision, mission, objectives, and research infrastructure for radio astronomy developments in South Africa and Africa.
- **Using Astronomy for Development in Africa** (Kevin Govender, OAD-IAU/South Africa), summarises the activities, vision, and strategy behind the OAD, and suggests to ensure the growth of astronomy in Africa and to use the experience of the OAD to ensure that developmental impacts are fully realised.

These received LoI will provide the starting point for the development of White Papers under the ASFAP Astrophysics and Cosmology WG.

Way forward

The final aim of all ASFAP WGs is to produce a series of White Papers that all together will provide input for the final African Strategy and its recommendations regarding the development of fundamental and applied fields of physics. Under the Astrophysics and Cosmology WG, we are planning the following:

- to start discussions under all working subgroups regarding the received LoI and to identify the missing topics and initiatives that are not covered by the LoI;
- to define the White Papers to be developed;
- to define the working groups for each White Paper and to follow their development;
- to share the produced drafts of White Papers with the professional community for receiving feedback and producing the final versions of White Papers to be published;
- to develop the summarised list of recommendations for the Strategy regarding the future astronomy developments in Africa and their impact on our society.

Finally, if you would like to join the ASFAP Astrophysics and Cosmology WG and participate in the coming activities, please fill out the form at:
https://docs.google.com/forms/d/e/1FAIpQLSeGblR09qHUDikGiK0UG-SY1ZFX0pVGV-ChThClrZhLqHJroA/viewform?vc=0&c=0&w=1&flr=0

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Assessment of Atomic and Molecular Physics in Africa

Stéphane Kenmoe[1] and Obinna Abah[2]

[1] *Department of Theoretical Chemistry, University of Duisburg-Essen, Universitätsstr. 2, Essen D-45141, Germany*

[2] *School of Mathematics, Statistics and Physics, Newcastle University, Newcastle upon Tyne NE1 7RU, United Kingdom*

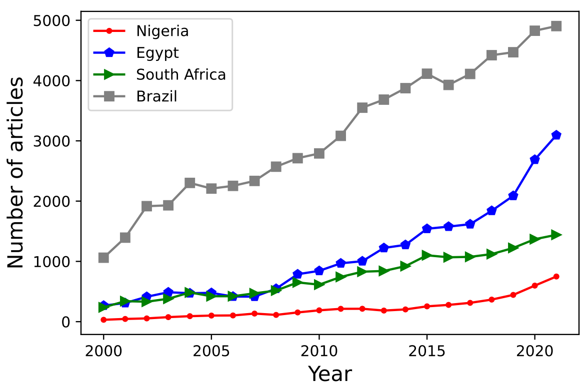
We present the status of the research in the field of atomic and molecular physics in Africa as well as some challenges hindering the efforts being made by the African scientists. We further report the discussions and progress of the African Strategy for Fundamental and Applied Physics (ASFAP) working group on Atomic and Molecular physics with the view of providing the continent research direction for next decade.

Keywords: ASFAP, Atomic and Molecular Physics, Physics and Society

Recent advances in experimental and theoretical scanning probing methods at the atomic scale have led to tremendous applications in biology, medicine, electronics, quantum technologies, spintronics or heterogeneous catalysis. For example, insight into the structure of living cells, the single molecule transistor, the minute working of catalytic reactions allowing the rational design of catalysts and improvement of properties, just to cite a few. However, probing matter at the nanoscale on the African continent is still challenging, both theoretically and experimentally. This stems from the various limitations in research facilities.

Despite the population of about 1.3 billion, which are mainly youth, the research and development output of Africa is quite low in virtually all areas of physics. To quantitatively understand this abysmal performance, we analyse the amount of research articles published by African scientists (based in African institutions) from 2000 – 2021, see Figure 1. Over the last two decades, the total research output from Africa stands shy of 70,000 articles with about 6,000 per year in recent times. It will be interesting to know that these are comparable to the Brazil scientific research output over the same period. However, the dramatic rise of India over the same period clearly shows the need for understanding the problem facing African scientists. This graphical illustration could readily be linked to the poor economic performance of the Africa continent, the world's poorest inhabited continent according to the World Bank. This is basically demonstrated by the difficulty to access energy for community services (health, education and so on) as well as the lack/inadequate information and communication technologies among others [1]. Moreover, only Egypt and South Africa made it in the Top 40 of the world's research and development index in 2021 [2]. However, Africa Union Agenda 2063 has identified Physics – fundamental and applied as a key solution to address the developmental problems facing the continent [3].

(a)



(b)

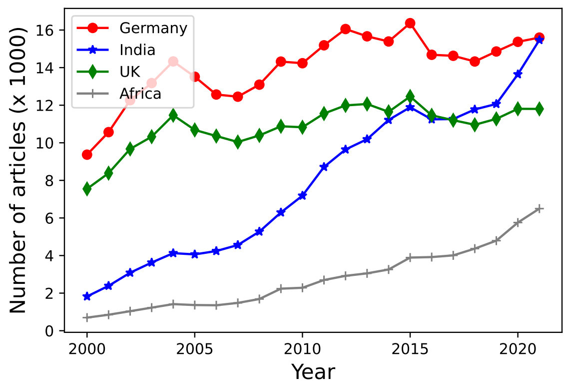


FIG. 1: Research output per year from 2000 – 2021 for search keywords: atoms, atomic, molecular, molecules, or ions. (a) The number of articles published by some African countries (Egypt, Nigeria, South Africa) compared to the Brazil. (b) The total articles published by African scientists (Algeria, Cameroon, Congo, Egypt, Ethiopia, Ghana, Kenya, Morocco, Nigeria, South Africa, Tunisia) compared western countries (Germany and UK) and India. Source: Scopus – accessed October 8, 2022.[6]

Challenges facing African scientists/physicists

On a theoretical point of view, electrical power instability in many countries does not allow sustainable computing and computational facilities are scarce, see Ref.[4] for more discussion. Most sub-saharan countries barely have supercomputers available for research. The few available facilities on the continent are concentrated in Northern Africa and South Africa. Researchers rely on the latter and on external partners such as the Abdus Salam International Centre for Theoretical Physics, Italy. A dependence that limits the productivity but also the size of the system to study simple molecules. Experimentally, resources are also scarce. For example, it is only recently that central Africa got its first operational AFM apparatus in what is likely the first nanotechnology laboratory in the Republic of Congo. Besides, the light source community is still to build the first synchrotron on the continent and relies on external sources and networks like the Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME) and the free and open-source software such as Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS). Unfortunately, for Africa, international organizations often support research of their interest and are compounded by the government's ill-advised policies towards education.

Current support towards enhance research output

During the last decades, various research groups and networks have been active on the continent, thanks to some foreign collaborations/donors. These include Physics Department, Marien Ngouabi University (Brazzaville, Congo), CEPAMOQ (Douala, Cameroon), Lasers Atoms Laboratory, Cheikh Anta Diop University (Dakar, Senegal), Atomic Molecular Spectroscopy and Applications Laboratory, University of Tunis El Manar (Tunisia), Medical University of Southern Africa (South Africa), African Laser Atomic Molecular and Optical Science Network. In addition, there is growth in the study of materials sciences in Africa through the African School for Electronic Structure Methods and Applications (ASESMA).

As an extension of these efforts, African physicists from a variety of specializations are developing an African strategy for basic and applied physics, see https://africanphysicsstrategy.org/ [5]. Organized into several working groups, committees, and forums, they are working to produce a report to inform the African and broader community of strategic directions that can positively impact physics education and research over the next decade [7, 8].The report is intended to help African policy makers, educators, researchers, communities, and international partners prioritize resources and activities for physics education and research at the national, regional, and pan-African levels. As part of this group of African physicists, we have the task of coordinating the activities of the Atomic and Molecular Physics working group.

Atomic and molecular physics working group – journey so far and way forward

In the spirit of the ASFAP, the Atomic and Molecular Physics (AMP) working group aims at reporting on the state of research and knowledge transfer of these groups and their derivatives on the continental level but also on the various research carried by African scientists in AMP performed all over the world and that align to sustainable development goals. From the above-mentioned research groups and networks, we have identified and have traced the various African scientists still active in the field, their research interests and compiled their various achievements.

As part of this, we have successfully organised meetings and had an online workshop on Atomic and Molecular Physics in January 2022 during which the discussion is cantered on identifying challenges facing different research groups across the continent among others. These efforts, in conjunction with other ASFAP working group, have resulted in some letter of intents (LOIs) submitted for the strategies. In addition, after deliberation with the ASFAP Steering committee members and the Photonics and Optics working group during the second African Conference of Fundamental and Applied Physics ACP2021, there is a unilateral decision to merge the two working groups – *Atomic, Molecular and Optical Physics*. We believe that this will synergise interdisciplinary activities towards industrial and technological advancements.

To conclude, we advocate for physics-based policies in the various country, region and the continent at large. These will be geared towards development of human capital as well as engaging the private sectors for support. Finally, with the support of international collaborations, qualitative increase in the research output of Atomic, Molecular and Optical Physics in Africa will become a fruition.

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The African Biophysics Landscape: A Provisional Status Report

Tjaart P.J. Krüger[a], B. Trevor Sewell[b], Lawrence Norris[c,d]

[a]*Department of Physics, University of Pretoria, South Africa*

[b]*Department of Integrative Biomedical Sciences, University of Cape Town, South Africa*

[c]*African Physical Society*

[d]*African Light Source Foundation*

Abstract

This is a provisional status report of biophysics activities in Africa. We start by highlighting the importance of biophysics research and development for every country's economy in the 21st century. Yet, the amount of biophysics activity in African countries varies between woefully little to nothing at all. We present a scope of biophysics research on the continent based on a pilot scientometrics study. We discuss a number of existing multinational programmes and infrastructure initiatives and propose a Pan African Professional Society for Biophysics. We emphasize the need for education, infrastructure and career development, and conclude with a list of suggested recommendations for expedited development of biophysics research on the continent.

Introduction

Biophysics is an interdisciplinary field that applies the principles and methods of physics to understand how biological systems work. This research field brings the disciplines and concepts of physics and biology together in a unique manner and can be applied to all scales of biological organization, from the molecular level where quantum biology plays an important role to the level of organisms and populations of organisms. One can gain an understanding of how energy flows through vast complex systems to obtaining information and manipulating entities on the molecular and atomic levels. As such Biophysics is an extremely powerful scientific platform that can address many of the critical challenges that face humanity today and in the future. To undertake this work requires highly skilled individuals collaborating across the globe. These individuals, skills and collaborations need to be identified and fostered. Africa is a fundamental player in this endeavour with a vast, as yet relatively untapped resource of human capital that needs to be mobilized. This initiative is a critical element in this process and Africa is on the brink of a renaissance which must be encouraged and allowed to grow.

The importance of Biophysics in Africa

Biophysics can have a tremendous impact on any country's economy. For example, by understanding crop yields and animal physiology at the molecular level, harnessing energy production and pollution remediation capabilities of plants and bacteria, and of course meeting all the human health challenges that cripple our lives. In fact, biophysics is a fundamental enabling science in medicine, agribusiness, and industrial biotechnology. [1] It is a wellspring of innovation and instrumentation for any country interested in developing a high-tech economy.

Biophysics has already revolutionised medical research and continues to do so, as evidenced by many Nobel Prizes. The previous century has evidenced great progress in treating diseases. In fact, biophysics helped to create powerful vaccines against infectious diseases. It described and controlled diseases of metabolism, such as diabetes. Biophysics provided both the tools and the understanding for treating the diseases of growth known as cancers. With the help of biophysics we are witnessing in the 21st century a rapid progress in the understanding of diseases at a fundamental level. [2] At the Biophysics Winter School of the 66th Annual Conference of the South African Institute of Physics on 1

July 2022, Martin Friede (the scientific officer responsible for vaccine delivery systems within the Initiative for Vaccine Research (IVR) at the World Health Organization in Geneva, Switzerland) stated that it is impossible to develop the next generation of vaccines without biophysics.

Biophysics underpins very large sections of the bio-economy and therefore a strong and diverse biophysics research and commercial sector is vital for the success of the African economy. There is a global emphasis on developing the bio-economy. The UK [3], EU [4], USA [5], and South Africa [6] have all formulated strategies to move away from the traditional industrial base and develop a strong bio-economy.

Biophysics is not limited to the bio-economy. Besides medical sciences and food security, other Grand Challenges that biophysics can address include environmental management (for example to combat pollution and climate change), energy security (to develop renewable energy sources), computing, and even security and telecommunications. Clearly, Biophysics drives numerous critical innovative developments.

The 21st century has been referred to as the *century of biology* [7], with the expectation that biotechnology will lead to some of the most significant innovations. One example is Quantum Biology, which is expected to play an important future role. In fact, many of the European Union's Key Enabling Technologies are based on quantum-mechanical phenomena and find examples in nature. Specifically, in the areas of photonics, nanotechnology, nanoelectronics, advanced materials, and photovoltaics there are examples of biological systems that can do what we would like to accomplish in man-made technologies.

Scope of biophysics research in Africa

For an initial assessment of the scope of biophysics research in Africa, we conducted a pilot scientometric study. On the Web of Science database we selected all publications co-authored by at least one African researcher in journals that contain the keyword **Biophys**, **Biomolecular**, or *Biomaterials*. The first keyword represented mainly the journals Biophysical Journal, Biophysical Chemistry, European Biophysics Journal with Biophysics Letters, Biochemistry and Biophysics*, and Biochimica et Biophysica Acta*. The Journal of Biomolecular Structure and Dynamics was represented by the second keyword, while the journal Biomaterials was the main hit for the third keyword. The results are displayed in Figure 1, where the keyword *Biomaterials* was considered separately.

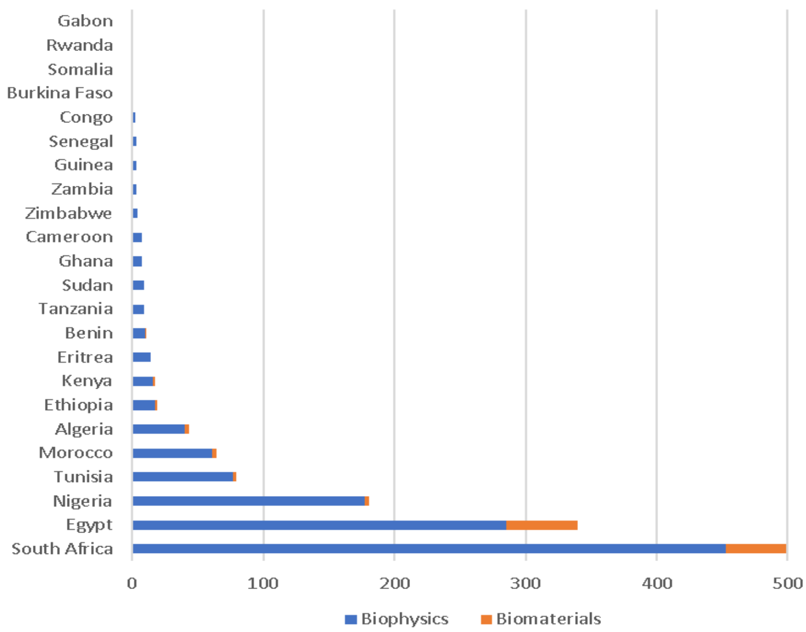

Figure 1: Representative WoS Biophysics Publications from Africa

Although this is by far not an exhaustive list of biophysics publications, we considered it representative for an initial assessment because these are well-known biophysics journals that publish predominantly biophysics research. We recognize that the relative output between countries may somewhat change in a more comprehensive study.

Our findings in Figure 1 indicate that South Africa is leading biophysics research on the continent. This is not surprising considering that this country, in general, produces most ISI scientific publications. By extension, the top few countries in Figure 1 are recognized as the most research-intensive countries on the continent. This study made us aware of a large number of active biophysics researchers at various institutions across the continent. At the other hand, we also recognize that the output of some countries such as Ethiopia, Kenya and Tanzania is possibly underestimated in Figure 1 because we are aware of a few institutions in these countries that are active in biophysics research.

We are eager to extend this pilot study because a comprehensive biophysics database would enable inclusive development of biophysics research on the continent. A comprehensive scientometrics study will also provide a significant amount of valuable information such as a breakdown of institutions and departments active in biophysics research, research topics within the broad domain of biophysics that are studied on the continent, better differentiation between research driven by African authors and those in which African researchers play a secondary role. An extended study may also include various other disciplines that have a strong overlap with biophysics, for example, biomathematics and bioinformatics. Our database of biomaterials research in Africa must also be extended. There is a comparatively large interest in biomaterials research in Africa, which is not reflected adequately in Figure 1.

The following are some of the challenges that must be recognized in a more comprehensive study. Biophysics is vast and interdisciplinary, with biophysics papers often published in different types of discipline-specific journals (such as physics, chemistry, biology, and engineering) and in various interdisciplinary journals (like physical chemistry, and chemical biology). The fraction of biophysics papers in those journals is often relatively small, indicating that it may be difficult to filter out biophysics-specific papers from databases without a significant amount of labour-intensive work.

We may also consider including non-ISI journals. Two examples are the *Egyptian Journal of Biophysics and Biomedical Engineering* and the *Nigerian Journal of Biophysics*, which we consider to be good initiatives for developing biophysics research in Egypt and Nigeria, even though the former journal publishes only about five papers per annum. We do, however, express caution about the Nigerian Journal of Biophysics, which shows characteristics of a possible predatory journal.

Through the Association of African Universities (AAU), the African Research Universities Alliance (ARUA), and the Network of African Science Academies (NASAC), we intend to field a survey of institutions to determine the extent of biophysics research at their institution as measured by publications in biophysics journals co-authored by faculty members, Honours, MSc, and PhD theses in the field, and graduate courses in biophysics, which may be definedbroadly.

Multinational research programmes and meetings

To put Africa on the global Biophysics maps, it is essential to establish multinational research programmes, consortia, and training events. Examples of existing successful research and training centres are the African Centre for Advanced Studies based at the University of Yaoundé I (ACAS, having computational biophysics as one of their research focus areas), the African Institute for Mathematical Sciences (AIMS, with mathematical biology as a research thread), the African Laser Centre (ALC, which funds many research projects on biophotonics), and the National Institute for Theoretical and Computational Sciences (NITheCS, with research programmes on bioinformatics and quantum biology).

Research in structural biology has seen notable development in recent years, in particular in South Africa, as a result of international collaborations. In general, these collaborations occurred between individuals and were stimulated by grants from international funding organizations including the Wellcome Trust and the Carnegie Corporation of New York. The Carnegie Corporation grant to the University of Cape Town and the University of the Western Cape was awarded for the establishment of a Master's programme in Structural Biology that was taught by internationally renowned experts. It also enabled the creation of rudimentary local infrastructure, gave rise to substantial research, and led to the continuing use of the EMBL beamline (BM14) at ESRF by South African scientists. More recently, the START (Synchrotron Techniques for African Research and Technology) programme funded by the UK Science and Technology Research Council funded research using the facilities at Diamond Light Source and eBIC (electron Bio-Imaging Centre) by nine PIs and thirteen bioscience postdoctoral research assistants over a period of three years [8].

The START programme led to the formation of a community of some 50 people with the common interest of using the facilities of the Diamond Light Source for protein structure determination. This, in turn, led to collaboration and cooperation. The challenge, following the end of the funding period, is to hold this community together. To this end, a meeting called "Legacy of START" was held in October 2022 to discuss the achievements of the START programme.

A further important development from the Legacy of START meeting is that a discussion with the South African National Research Foundation (NRF) on the development of a sustainable national programme in Structural Biology had been initiated. The NRF want to focus the discussion on the acquisition of a modern cryo-electron microscope and the supporting infrastructure required to make this viable.

Biostruct-Africa is another Structural Biology initiative. It was recently established as an independent organization to promote knowledge transfer and mentoring of Africa-based researchers using cutting-edge techniques in Structural Biology.

It is undeniable that meetings of international societies play an important role in bringing biophysicists together and thus enabling people to identify others with similar interests that may ultimately lead to collaborations and joint publications. In 2021, the African Light Source Foundation and the African Physical Society collaborated to put on the *Biophysics in Africa* online conference during Biophysical Society's Biophysics Week. There were ~40 presentations. The two organizations plan to reprise the effort in 2023, during the week of 20-24 March, again the Biophysical Society's Biophysics Week.

Three prominent international societies represent the interests of biophysicists, viz. the International Union for Pure and Applied Biophysics (IUPAB), the International Union of Pure and Applied Physics (IUPAP) through Commission C6: Biological Physics, and the Biophysical Society (BPS). While the first two require national membership, the BPS is an individual membership society. BPS have sponsored a thematic meeting on "Biophysics in the Understanding, Diagnosis, and Treatment of Infectious Diseases" in South Africa and IUPAB have sponsored a meeting on "Biophysics and Structural Biology at Synchrotrons" that was documented in a special issue of Biophysical Reviews [9].

IUPAB is keen to promote biophysics in Africa. They have recently held capacity building events in Kenya and Uganda and is currently constituting a Kenyan Society with currently 5 distinct and active Chapters established in 2022 around the country. Similarly, a Ugandan Biophysical Society (with one chapter to date) is being constituted. The National Committee for Physics in Egypt has a Biophysics subgroup, and recently approached IUPAB for active participation.

There are many other societies in which biophysicists participate and which assist in promoting overlapping interests. Notable among these is the International Union of Crystallography (IUCr) that assists in coordinating a substantial international network of Structural Biologists. Notably, after several years of development following the International Year of Crystallography in 2014, the African Crystallographic Association (AfCA) was founded at the annual conference of the African Light Source and African Physical Society (*vide infra*). AfCA will be convening its first stand-alone conference in Kenya in January 2023.

Towards a Pan-African Professional Society for Biophysics

Professional societies generally set the parameters in which people practice the profession. In some cases, professional societies control certification and accreditation processes, thus establishing who has the right to practice in the profession. Professional societies generally are the stewards of communication channels and archives of the profession. Thus, they are the mechanisms where people gain recognition in the profession. They set the standards for ethical professional practice. They are advocates for the profession in government and with various other venues. Professional societies are generally the mechanisms by which change is instituted in the profession. They provide forums for marketing, intellectual pollination, and career networking. They provide personal and professional services.

These functions are vital for biophysics in Africa. But with there being limited sustainable resources and given the multi-disciplinary nature of biophysics, it will be highly beneficial to cooperate with already existing disciplinary societies to establish a full-on, Pan-African biophysics professional society. We suggest forming an advisory council consisting of members of the following organizations: African Bioimaging Consortium, African Crystallographic Association, African Laser Centre, African Light Source Foundation, African Materials Research Society, African Mathematical Union, African Optics and Photonics Society, African Physical Society, Biostruct Africa, Federation of African Engineering Organizations, Federation of African Medical Physics Organizations, Federation of African Societies of Biochemistry and Molecular Biology, Federation of African Societies of Chemistry, IEEE Africa, and Society of Neuroscience in Africa.

With input and support from this advisory council, the activities of the Pan-African biophysics could include the following: (a) Convening meetings, schools, and workshops; (b) Operating a preprint server for African biophysics researchers to post the pre-published work; (c) Operating a repository of MSc and PhD theses in biophysics; (d) Operating a virtual journal that collects the published work of Africans in biophysics; (e) Publishing a newsletter about and for African biophysicists; and (f) Operating an online community of practice for African biophysicists, both on and off the continent. Inside this online community can be subgroup structure according to particular interests, e.g., biocomputing, biomaterials, biomechanics, biophotonics, cell physiology, clinical medical physics, genomics, industrial biophysics, mathematical biology, molecular biochemistry and pharmacology, physical biochemistry, plant and agricultural biophysics, quantum biology, and structural biology.

This council could immediately develop an implementation plan for the South African Bioeconomy Strategy in a Pan-African context as well as a Pan-African Structural Biology Initiative, and a strategy for exploiting Africa’s biodiversity. The biophysics society can take on developing or being a continental adhering body of IUPAB as well as a Pan-African representative for IUPAP C6. Through an effort analogous to the ASFAP, the council can develop a 'Shaping' report specifically for biophysics and medical physics, so that the African governments can understand the intellectual and economic role of these two related but distinct fields [13].

Infrastructure in Africa for Biophysics research

Infrastructure is an indirect source of information about the quality and quantity of research activity. Although numerous state-of-the-art research facilities on other continents are accessible to African researchers, here we are focussing exclusively on research infrastructure on the African continent. A representative scientometric analysis of biomolecular research equipment at sub-Saharan universities for plants-based drug development found that there is a severe shortage of essential research equipment and that many of the existing research instruments are in a dysfunctional state [10]. The study focussed only on a sample of 25 universities where the research environment is relatively good. The situation at most other universities on the continent is even worse. The study concludes that “the cost of establishing comprehensive biomolecular research infrastructure in at least one university per sub-Saharan nation is negligible relative to their gross domestic products (GDPs). Thus, even with the current economic resources, sub-Saharan African countries would upgrade biomolecular research capabilities in their leading universities without disrupting other economic priorities.” In other words, sub-Saharan countries should see no financial barrier against buying essential research equipment. What is needed is political impetus, which may start by influencing policymakers and making them aware of the essential need for basic biophysics infrastructure.

The African Laser Centre (ALC) is an example of an infrastructure programme of benefit to the whole continent. The programme provides funding for accessing and maintaining laser research equipment, for laser-based research collaborations on the continent, and for postgraduate student bursaries. the

The programme's purpose is to support laser-based research and technological development in the whole of Africa provided that access to infrastructure, support, and funding proceeds via a South-African based researcher. Noteworthy is that Biophotonics is a growing research domain of this programme.

The Centre for High-Performance Computing (CHPC) based in Cape Town is an example of a South African-based infrastructure programme that makes its facilities available to various other African countries without the condition of an active research collaboration with a South-African researcher. Researchers of the 16 SADC Members States and the 8 African SKA Partner Countries may use the CHPC for any research domain. Researchers from remaining African countries have access to the CHPC through collaboration with South African researchers. Currently, only a small number of projects for which the CHPC is used have a biophysics nature. In the near future, we would like to see a significant growth in computational biophysics enabled by the CHPC. Computational biophysics is also undoubtedly enabled by the African Supercomputing Center (ASCC) in Morocco, and the Laboratory of Modelling and Simulation in Engineering, Biomimetics and Prototypes at the University of Yaoundé I in Cameroon.

In South Africa, the NRF provides for the National Equipment Programme (NEP) that co-funds equipment at academic institutions. This has resulted in widespread placement of equipment that is of interest to biophysicists including X-ray diffractometers, electron microscopes, mass spectrometers, confocal microscopes, a single-molecule spectroscopy facility, and a variety of other important pieces of support equipment.

Recently, the Chan Zuckerberg Initiative has established the Africa Microscopy Initiative that houses a fleet of advanced, commercial optical microscopes [11]. These instruments are tailored for use in the life sciences and provide high spatial and temporal resolution to study a variety of biology. Equipped with ancillary infrastructure that includes cell culture and molecular biology equipment, the Imaging Centre offers advanced microscopy instruments on an open-access basis to scientists working in Africa. Coupled to the centre is a training programme that will support African Scientists in the achievement of their research goals without any cost to the researcher and the African Bioimaging Consortium (ABIC), a network of life science researchers throughout Africa with an interest in and use for microscopy. This community-driven initiative aims to unite the African microscopy community and support the development of bioimaging across the continent.

The Benin government established the X-TechLab in Seme City research park in collaboration with IUCr. X-TechLab is an experimental platform dedicated to the use of X-ray techniques for scientific and technological research on development issues specific to the African continent. It has held training courses in X-ray crystallography, and supported research in small-molecule crystallography, and structural enzymology [15,16].

In spite of these encouraging developments there are gaping holes in the infrastructure available to biophysicists – the most notable being the complete absence of modern NMR instruments and cryo-electron microscopes on the continent. The fragility of the situation in cryo-electron microscopy compromises the ability of African scientists to use this technique at international infrastructures as the research samples cannot be validated and thus access will not be granted.

Less well known is the desperate shortage of modern equipment for the preparation of proteins. As a consequence, many researchers resort to leaving the preparation of material to international collaborators, thus weakening the position of the African scientists. This situation results in generations of students that are unable to reliably produce the basic material required for further research.

It is clearly impossible for the continent to house all the equipment necessary for modern biophysics and provide the expertise necessary to exploit and maintain it. This is also true for most European countries. The European solution is to form consortia called ERICs (European Research Infrastructure Consortium), which facilitate the establishment and operation of research infrastructures with European interest on a not-for-profit basis. The ERIC of interest to Structural Biologists is Instruct, which provides access to 11 centres and 27 facilities in 14 countries for scientists from member countries. The resources can also be accessed by scientists from non-member countries. South African scientists have exploited the resources through an MoU with the University of Cape Town.

Career Development

The world has seen a substantial growth in biophysics and structural biology over the last half century. An evident example for this is the growth in the number of deposits in the protein data bank, which has now reached nearly 200,000. Macromolecular structures are the enablers of studies in molecular biophysics and the numbers are thus a good indicator of activity. Furthermore, the structures are widely used by industries concerned with drug and agrochemical development. The African contribution to this huge international effort is negligible and has come from only two countries: South Africa and Egypt [12]. Indeed, very few African biophysicists and structural biologists have found work on the continent and most have built their careers abroad. It is self-evident that the growth of these disciplines in Africa depends on the retention and development of qualified people.

Recommendations

We offer the following list of suggestions for accelerated development of biophysics research on the continent:

1. **Establishment of a Pan-African Professional Society for Biophysics**, as discussed above.
2. **Establishment of sustainable academic infrastructure**: Considerable investment is required to extend biophysics infrastructure on the continent to promote state-of-the-art home-based research. Additional funding is required to maintain existing infrastructure and to replace initial appointees following their resignation or retirement.
3. **Scientometrics/bibliometrics study**: Extension of the pilot scientometrics study to create a comprehensive database of biophysicists in Africa and a catalogue of biophysics research, training, and education happening on the continent.
4. **Tapping into support from international societies**: IUPAB has expressed their desire to establish more biophysics activity on the African continent, for example by supporting and co-organizing workshops or even congresses in the future. At present only South Africa maintains its membership of the IUPAB through the South African Institute of Physics (SAIP). IUPAB supplies up to EUR 10,000 start-up grants for workshops and conferences. They have 61 affiliated societies and over 20,000 members.
5. **Biophysics schools, workshops and conferences**: Besides the activities already taking place, for example an annual Biophysics School in Tanzania, Biophysics Schools organized through SAIP, and several Schools and Workshops in Structural Biophysics, we will encourage more activities. One of them is an annual Biophysics in Africa online conference during Biophysics Week, which was started in 2021.
6. **African research libraries**: We want to encourage African research libraries to have a full complement of biophysics titles in their serial subscriptions.
7. **Biophysics careers**: We would like to create a document listing potential jobs when studying biophysics, emphasizing that biophysics not only contributes to the knowledge industry but also to important economic development of every country.
8. **Virtual department**: Accessibility of biophysics education can be greatly enhanced by creating a virtual African biophysics department where a network of people can give online courses and engage with students online.
9. **Requests for political incentives**: African governments should develop multi-departmental initiatives to support the work of African biophysicists. They should incentivize our universities to build infrastructure in all the fields that support biophysics, including chemistry and biochemistry labs, computing, as well as equipment in spectroscopy, electron microscopy and crystallography. They should implement policies that encourage our industries to invest in the bioeconomy strategy.
10. **Encouragement**: The development of biophysics research on the African continent has been slow over the past few decades. A major reason is that most African people interested in biophysics study abroad and remain abroad. Most of those who returned to their home countries have remained in biophysics for short periods of time. There is therefore a great need of nurturing and encouraging existing and aspiring biophysicists.

Acknowledgments

The authors would like to thank Raymond Sparrow for fruitful discussions and feedback.

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Status of the Computing for Research in Africa

Ghita Rahal

CC-IN2P3, CNRS, France

May 20st, 2022

Introduction

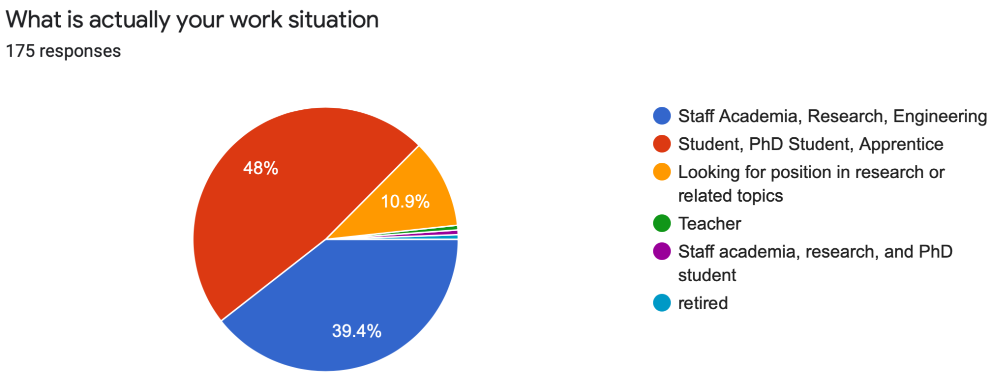
Research in any Science needs nowadays strong computing services to extract results and make discoveries.
What we define as computing service might rank from the underlying structure, namely networks, computers, storage, to applications and software but, as well, new techniques such as Artificial Intelligence to extract the expected results.

In order to estimate the overall needs in this field, we have launched a survey including all the people that we could reach, participants in ASFAP[1] as well as the attendants to the 2nd African Conference of Fundamental and Applied Physics ACP2021 that was held in mars 2022. Results of the survey can be found here[2].
In this paper we summarize the answers that were provided to the different questions of the survey and extract some general observations. Possible guidelines and recommendations to improve the situation are drawn in the conclusion.

1. Panel distribution

175 people filled in the survey out of which 167 were African citizens. 26 countries of the African continent were represented.
82% of the African citizens are based in Africa, the rest is what is defined as the diaspora, i.e., people that are based in other continents.
For the Non-African citizens, the motivation for participation was mainly an already established collaboration with African colleagues or students.
Figure 1 highlights the job situation of the participants: 48% are students and 39.4% hold a position in academia, research, engineering. More than 88% work in Africa, whether it is in their own country or in another African country. 10.9% reside out of Africa.

[1] ASFAP is the African Strategy for Fundamental and Applied physics: https://africanphysicsstrategy.org
[2] The result of the survey as of June 2022 is here:
https://twiki.cern.ch/twiki/pub/AfricanStrategy/AfComputing4IR/ASFAP:_Comp4IR_Survey.pdf



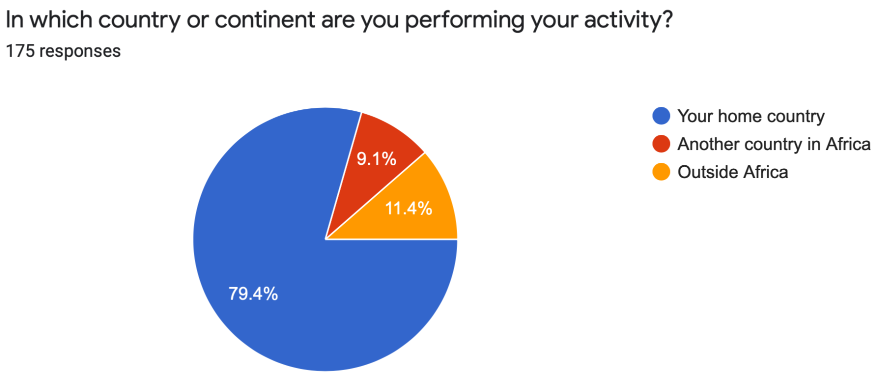


Figure 1: shows the work situation of the participants (top) and the location of the activity (bottom)

2. Field of Research

The field of research in which the participants are working is spread among many disciplines as shown in the figure below. The name of the fields is the name of the various working groups that are represented in the ASFAP. A large number of fields are concerned by the computing, fundamental physics such as Astrophysics and cosmology as well as physics domains such as the energy (biomass, fossil, nuclear and solar, etc.).

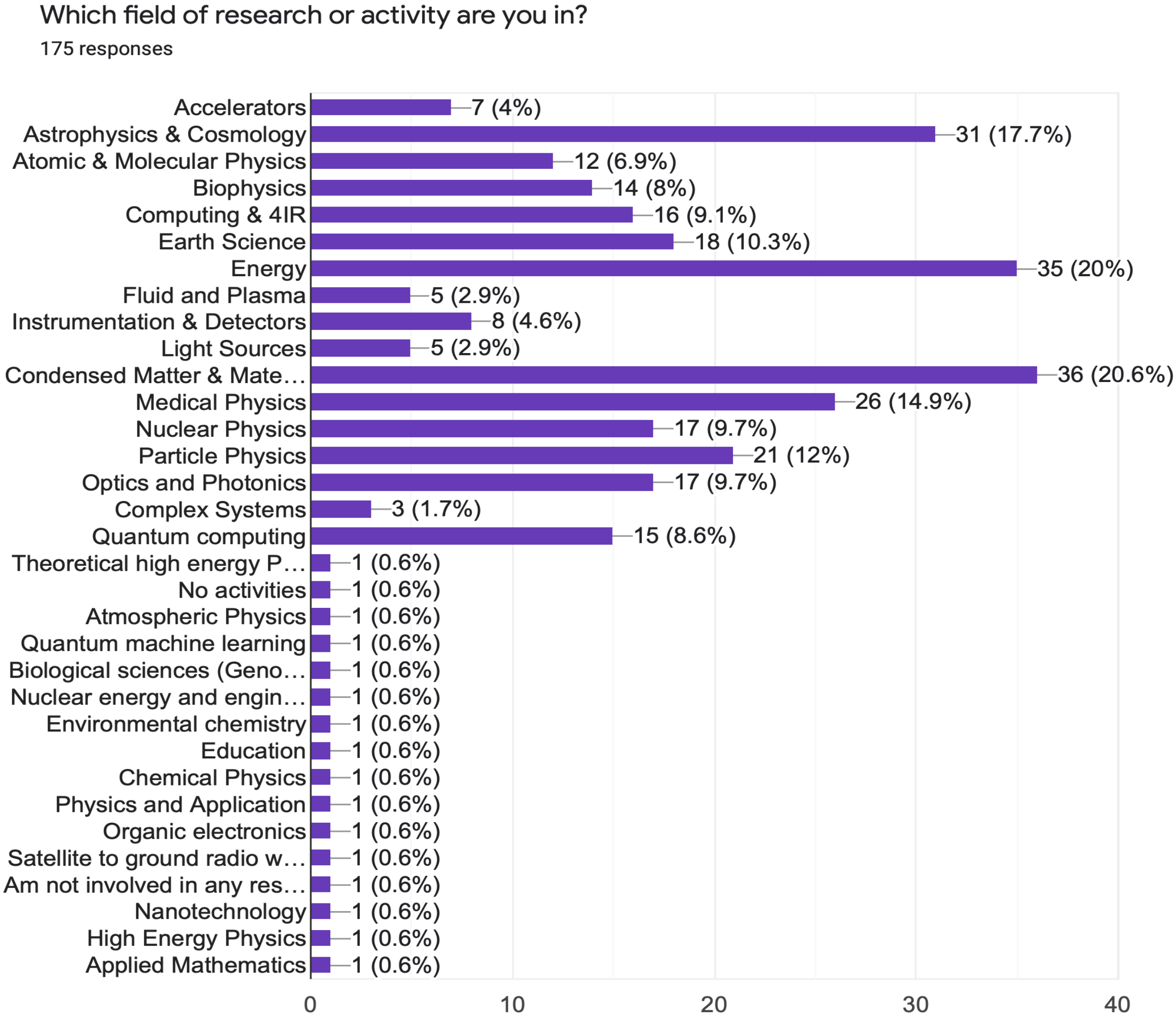


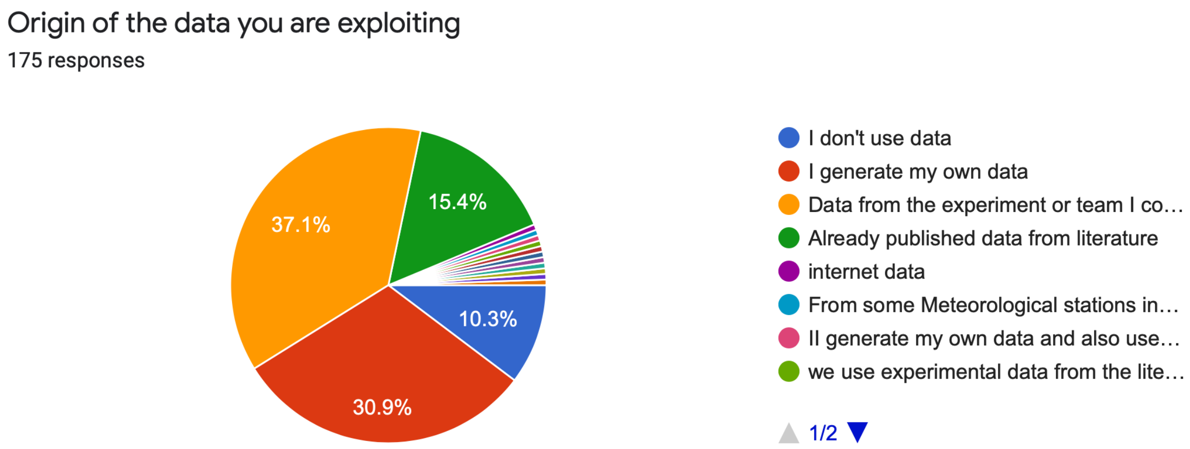
Figure 2: Field of Research covered by the participants

3. Properties of the exploited data sample

Depending on whether the scientist is part of a collaboration or working alone, the storage location and the volume of the data that he is analysing in order to extract results varies a lot. Figure 3 below shows the distribution and the magnitude of the sample.

- About 40% of the participants use data coming from an experiment or a collaboration they belong to, 15% use some open data from literature and about 35% use personal data. The numbers quoted here have been obtained summing up the numbers in the pie of fig 3 that fall in the same category.
- Considering the magnitude of the data samples, the majority of the samples are at the Gigabyte and Megabyte level. It is to be noted that the samples of Terabytes- and Petabytes-level are most of the time stored internationally.

- As to understand where the users are running their job to exploit the data, another graph not shown here shows that 57% of the scientists do it in their own laboratory or in their own country, while 20% do it internationally.



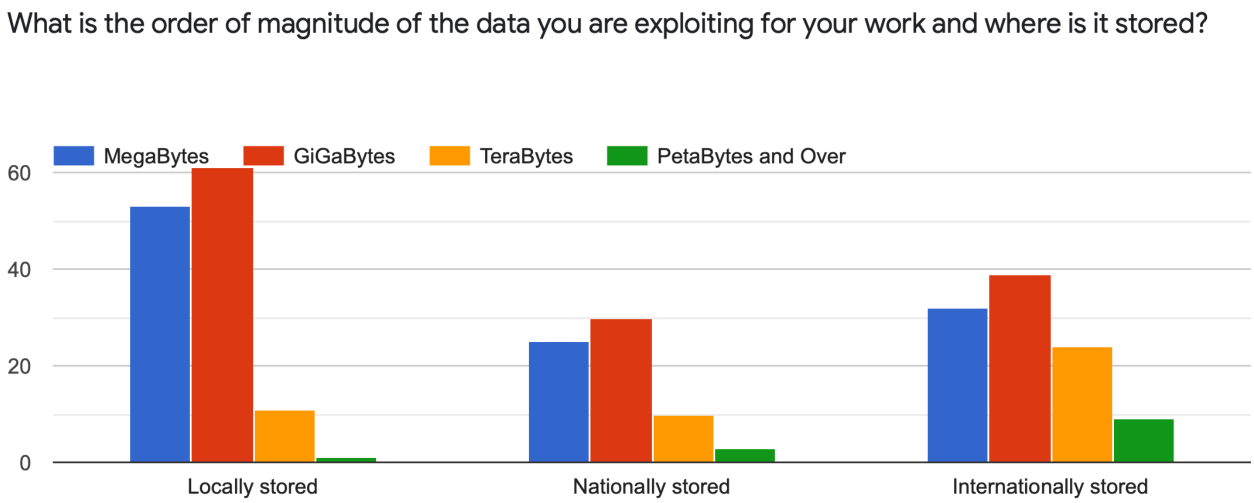


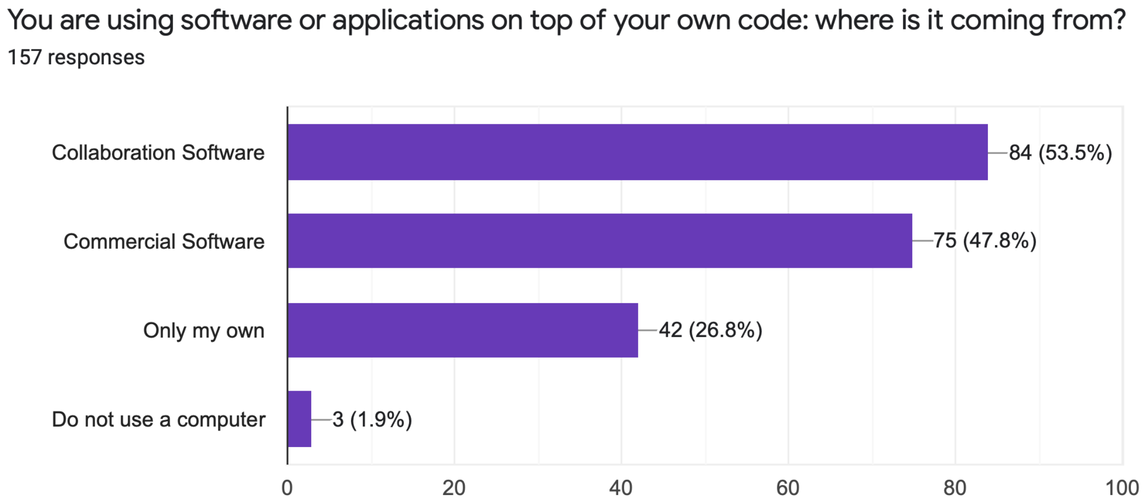
Figure 3: upper graph shows the origin of the data that is exploited. The lower graph the magnitude of the sample as a function of the storage location

4. Software and Tools to exploit data

Figure 4 below illustrate the type of software scientists are using:

- In the top graph of fig 4, we observe that 52.9% of the scientists use collaboration software and 48.4% use commercial software to exploit their data. Only 24.6% of them use exclusively their own software. It is important to note that 11.6% cannot use software because of lack of computing resources. Some comments collected below in this survey point out the fact that sometimes, the need is very modest (1 laptop for example) but even that is not available. Even if it has not been studied in this survey it might be worth investigating why even the modest requests are not satisfied.

- In the pie of the bottom graph of fig 4, usage of Artificial Intelligence (AI) or Deep Learning (DL) is represented. Already 20.9% of the scientists have introduced it in their toolbox. What is striking is that more than 73% of the scientists would like to use it but are prevented to do so either because they cannot find the information and/or training they need, or because they lack computing resources to execute it. This is important to keep in mind because of the growing importance of AI in many fields of sciences.



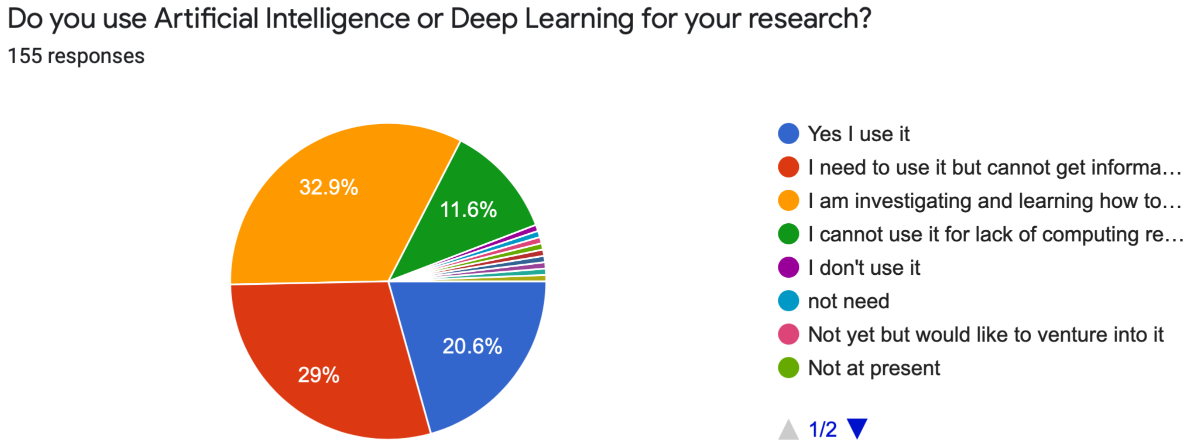


Figure 4: Top is distribution of the type of software that is used by the researchers. Bottom shows the usage of Artificial Intelligence or Deep Learning by the scientists.

5. Status of the infrastructure and tools

We have questioned the participants about the resources or knowledge that need to be provided in order to be able to use the magnifying effect of the computing to extract research results. They rated the different points in the figure 5:

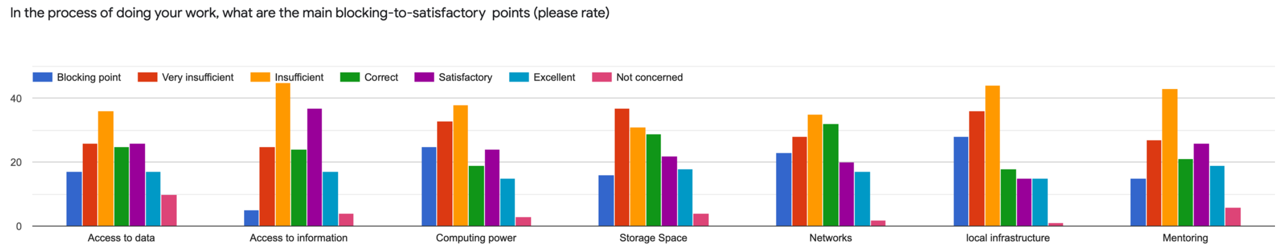


Figure 5: Main blocking or satisfactory points to be able to exploit data:

If we summarize the results they are as follows:

- **Access to data and access to information**: about half of the people experience blocking points leading to insufficient access to the data they need. This could be due to different reasons some of which could be equipment, networks or the fact that scientists feel isolated from the rest of their community.

- **Hardware resources, Computing power, Storage space and Networks**: 55 to 60% of the participant find it insufficient. When it comes specifically to local infrastructure, 66% of the people find it insufficient. The reason of the difference between the 2 percentage above is certainly that some people use international infrastructures that are more efficient: 20% of the people are based outside their home country and about 40% claim that they use resources abroad (see fig.1).
- **Mentoring:** training, guidance, lectures, etc..: 54% of the participants don't find it sufficient. This point will be detailed later.

6. Education and knowledge

Figure 6 below highlights one of the major problems of the education in sciences:

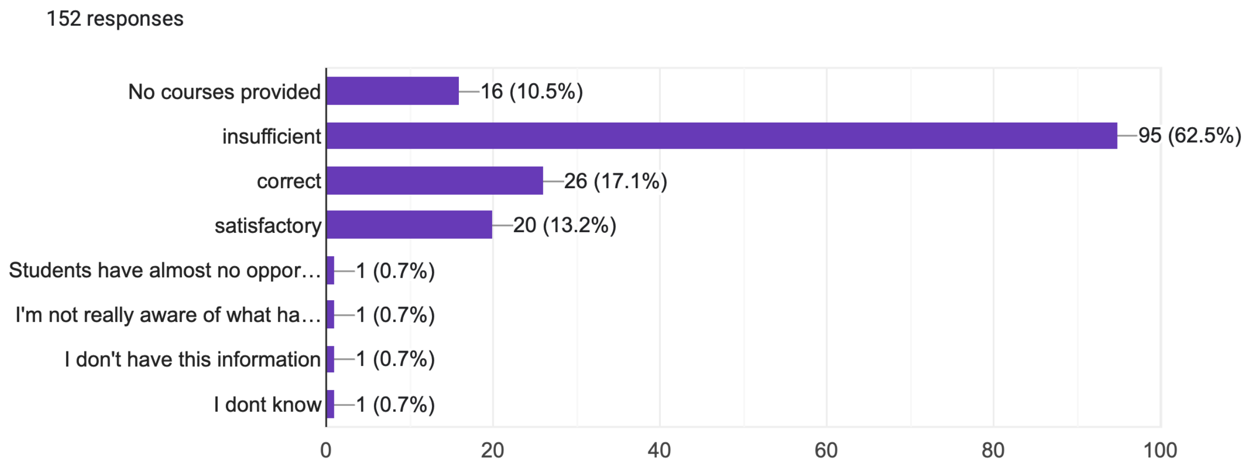


Figure 6: Rating of teaching and training provided to students during their cursus

75% of the participants claim they are provided no or insufficient level of courses or trainings during their cursus. This impacts not only the students themselves but it creates a generation of managers and scientists that are not made aware of the huge potential that computing can provide to their science field.

7. Bottlenecks

In Figure 7, we specifically question the users about the main bottlenecks there are facing when they want to use computing.

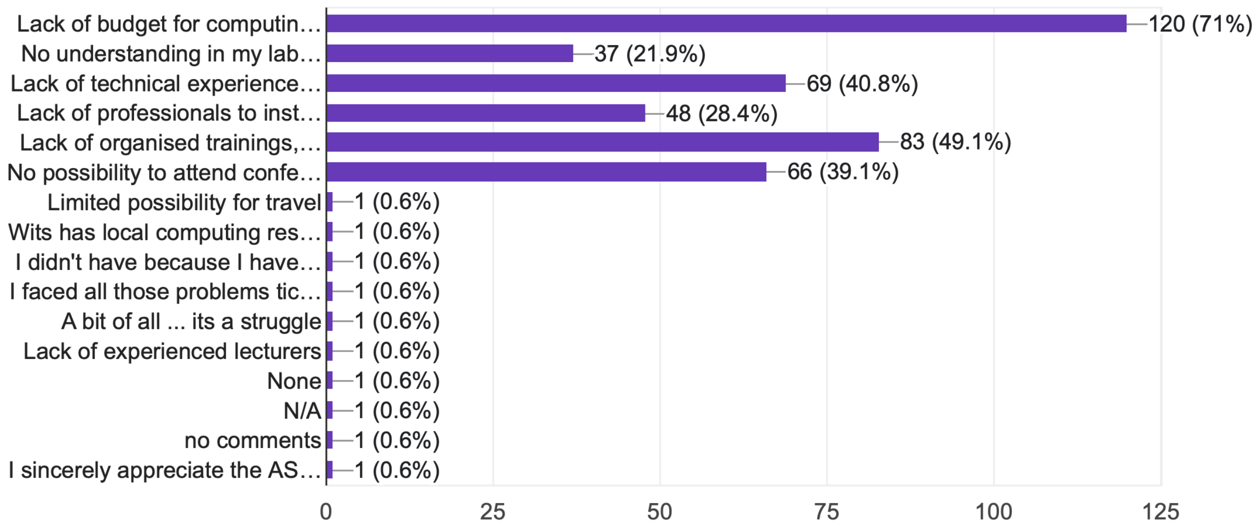


Figure 7: Problems faced by the scientists to perform their job

Two main group of answers:

- **Computing resources**: the largest number of responses stress the lack of budget for computing, the lack of technical support and the fact that the hierarchy and the stakeholders do not understand the need of computing for research: what would a scientist do with a computer when doing crystallography for example?
- **Education, knowledge**: the participants point out the lack of organised trainings and workshops and the difficulty to attend those organised abroad. More detailed information is found in the previous paragraph and fig 6 about the teaching and education in computing: 75% of the scientists are not provided courses and lectures, or at an insufficient level.

8. General comments from the survey

In the free comments asked for after some questions, the participants highlight and give precisions on the points raised above in particular about the resources: sometimes it is one computer that is

needed and not being provided. HPC resources are also cited, certainly due to the needs related to AI and DL.
Many others raise the problematic linked to lack of budget, lack of professionals to install and run data centres and difficulty to find collaborators or join collaborations to work in team.

Being asked what they would consider to improve research productivity in their country, the participants elaborated on isolation: scientists and engineers would gain a lot by working together and by having collaborations within African countries as well as with foreign countries.

9. Conclusion and recommendations

This survey was launched to evaluate the status of computing resources in the field of African physics research. The panel was mainly composed from participants from Africa and residing in Africa. Considering the answers, we draw the following guidelines to improve the situation and boost the scientific research in Africa:

- **Build and improve and the infrastructure**: the infrastructure should be made available and, if already existing, improved at a significant level.
    - **Network**: One essential part of the Computing situation is the access, availability and performance of the **Network**, i.e., Academic and Research Network, in Africa. Networks are vital for the access to data and information. This is not only true at the level of the universities and research centres, but even more at national and international level with connection to other countries. We need to have a global picture of the Network status in order to know the possible problems for the research groups and draw the strategy for improvement. Without filling this gap, there is no possibility of collaboration or share of knowledge. An African coordinated initiative would be a real asset.
    - **Storage and computing power** are necessary to store and process the data, which is the only way to produce results and science. The computing needed is more and more sophisticated now that Artificial Intelligence and Deep Learning have entered the game in all sciences. As suggested by some of the participants, large data centres shared within a country or with other countries within Africa would certainly be a solution that would federate the resources, decrease the costs and the disparities between universities and countries.
    - **Qualified technical staff** are necessary to deploy and run these computing resources and make them available to the physics research scientists that would not be able to deal with Cloud deployment or computer access to storage. Here a collaboration between different African countries and foreign countries could be a fruitful initiative to share IT technicians, setup few test sites, and start having an infrastructure on site.

- **Build Knowledge and include computing in Education**: The poll has highlighted the insufficient level of education in computing. Many solutions should be envisaged simultaneously:
    - Increasing the level of **computing courses** in the cursus of the physics (and other sciences) students.
    - Training **IT professionals** to prepare and operate the infrastructure.
    - Organising regular **workshops and training**. This would be highly beneficial for knowledge sharing and knowledge update to stay in the forefront in computing where evolution is very fast. But this would have an important positive side effect: Researchers have highlighted the fact that they quite often work isolated. These workshops are the best place to meet their peers and initiate collaborations that would only be beneficial to raise the research productivity.
    - Last but not least, **national and international collaboration** with others more advanced in these fields throughout the world would speed up the knowledge transfer and build collaborations that would be mutually beneficial.

The top priority is raising the awareness of the governing bodies and stakeholders at each level: state, university, research centres, about the importance of the computing in physics research. This is absolutely necessary as this evolution needs strategic planning over years.
Budget should be expressly dedicated to computing whether it is at the personal computer level as well as to the level of building and running large infrastructure.
None of the main discoveries of the last decade would have been made possible without the collaborative work and the distributed use of powerful data centres all over the world.

10. Acknowledgments

I would like to thank all the participants that have taken some time to respond to the survey. My thanks go also to the organizers of 2021 ACP conference, to the ASFAP steering committee and to José Salt and Uli Raich for their comments and advice on this paper.
3

Status and Impact of Fluid and Plasma Physics for Education and Capacity Development in Africa

Fluid & Plasma WG
O. D. Makinde (Stellenbosch University, RSA)
J. Foster (The University of Michigan, USA)

Report on Presentation: ASFAP 2022 by O.D. Makinde

Abstract: In physics, a fluid is a liquid, gas, or other material that continuously deforms under an applied shear stress, or external force. They are substances which cannot resist any shear force applied to them. Meanwhile, plasma refers to an electrically conducting medium in which there are roughly equal numbers of positively and negatively charged particles produced when the atoms in a gas become ionized. In this report, the concept of fluid and plasma physics is briefly outlined, followed by an overview of the status and impact of fluids and plasma physics education and capacity development in Africa.

Keywords: Fluids and plasma physics; Magnetohydrodynamics; Education and capacity development in Africa

1. Introduction

Adequate knowledge in fluid and plasma physics is a necessary prerequisite for development of technology and innovation, and thereby constitutes a key input into the transition to a knowledge-based economy [1]. Applications of fluids and Plasma physics range from energy production by thermonuclear fusion to laboratory astrophysics, creation of intense sources of high-energy particle and radiation beams, and fundamental studies involving high-field quantum electrodynamics [2]. Plasma is being used in many high tech industries. It is used in making many microelectronic or electronic devices such as semiconductors. It can help make features on chips for computers. Plasma is also used in making transmitters for microwaves or high temperature films. Fluids and Plasma research are leading to profound new insights on the inner workings of the sun and other stars, and fascinating astrophysical objects such as black holes and neutron stars. The study of fluids and plasma enable prediction of space weather, medical treatments, and even water purification [3]. Majority of plasma phenomena observed in real experiments can be explained by a fluid model, in which the identity of the individual particle is neglected, and only the motion of fluid elements is taken into account [4]. The theoretical study of plasma as fluids are governed by the concept of magnetohydrodynamics which involved a combination of conservation of conducting fluid mass, charges and momentum equations coupled with state equation and Maxwell equations of electromagnetism [5]. Plasma may involve the dynamics positively charged ion fluid and negatively charged electron fluid. In a partially ionized gas, for the dynamics of fluid of neutral atoms may also be involved. The neutral fluid will interact with the ions and electrons only through collisions. The ion and electron fluids will interact with each other even in the absence of collisions, due to the generation of the electric and magnetic fields [6]. The magnetohydrodynamic approach treats the plasma as a single fluid with mass density $\rho_m = n_e m_e + n_i m_i$, charge density $\sigma = q_e n_e + q_i n_i$, mass velocity $V = (n_e m_e v_e + n_i m_i v_e) / \rho_m$, current density $j = q_e n_e v_e + q_i n_i v_i = q_e n_e (v_e - v_i)$ and total pressure $p = p_e + p_i$ as outlined in the equations below [7-9];

i) $\frac{\partial \rho_m}{\partial t} + \nabla \cdot (nV) = 0,$ (Mass conservation equation)

ii) $\frac{\partial \sigma}{\partial t} + \nabla \cdot (nj) = 0,$ (Charge conservation equation)

iii) $\rho\left(\frac{\partial V}{\partial t} + \mathrm{V} \cdot \nabla V\right) = \sigma E + j \times B - \nabla P,$ (Momentum equation)

iv) $P = Cn^{\gamma}$ for an ideal gas $P = nkT$ (Equation of state)

v)
$$\nabla \times B = \mu_0 j + \frac{1}{c^2}\frac{\partial E}{\partial t}, \quad \nabla \times E = -\frac{\partial B}{\partial t},$$
$$\nabla \cdot B = 0, \ \nabla \cdot (\in_0 E) = \sigma, \quad E + V \times B = \eta j + \frac{j \times B - \nabla p_e}{ne},$$
(Maxwell equations)

where the subscripts i and e represent the ions and electrons, respectively, C is a constant, γ is the ratio of specific heat C_p/C_v, t is the time, B is the magnetic field strength, E is the electric field, T is the temperature, n is the particle density, η is the resistivity.

2. Status of Fluids and Plasma Physics in Africa

Due to lacks of necessary research laboratories infrastructure, technical support, and so forth in many academic and research institutions in Africa, relatively few scientists in the field of fluids and plasma physics have managed to perform at a level competitive with the best in the world. The figure 1 below depicts the level of research output in the fluids and plasma physics in Africa [10].

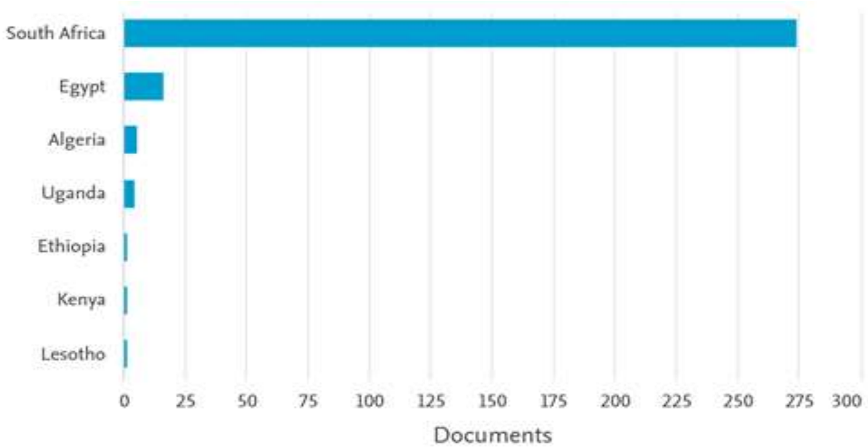


Figure 1: Fluids and plasma physics research output in Africa (source- SCOPUS database[10])

From figure 1, it is obvious that very few countries and scientists within Africa are engaging in productive research in the field of fluids and plasma physics. The largest visible research output on fluids and plasma physics comes from the institutions in South Africa, followed by the institutions in Egypt, Algeria, Uganda, Ethiopia, Kenya and Lesotho. Although research and academic institutions in other African countries may be engaging in some research activities in fluids and plasma physics, however, most of the output are not visible on the SCOPUS database.

3. Fluid & Plasma Physics Education and Capacity Development in Africa

The challenges of education and capacity development in the field of fluids and plasma physics in Africa include inadequate funding of science education at secondary and tertiary levels, lack of infrastructure, absent of physics-based industries, poverty, etc [11]. To excel in physics & science education and training in Africa is to conquer Mount Everest without the aid of additional oxygen. Meanwhile, scientific advancement cannot occur without quality education; to achieve that quality, African countries will require significant investment at all educational levels. African scientists have to convince their governments, businesses, and the public that investment in physics education is beneficial and will lead to economic development and an enhanced quality of life [12]. Physics curricula should emphasize project work and problem solving, with a complement of activities in entrepreneurship. Figure 2 below depicts a strategy that African countries' may adopt for education and capacity development in fluid and plasma physics.

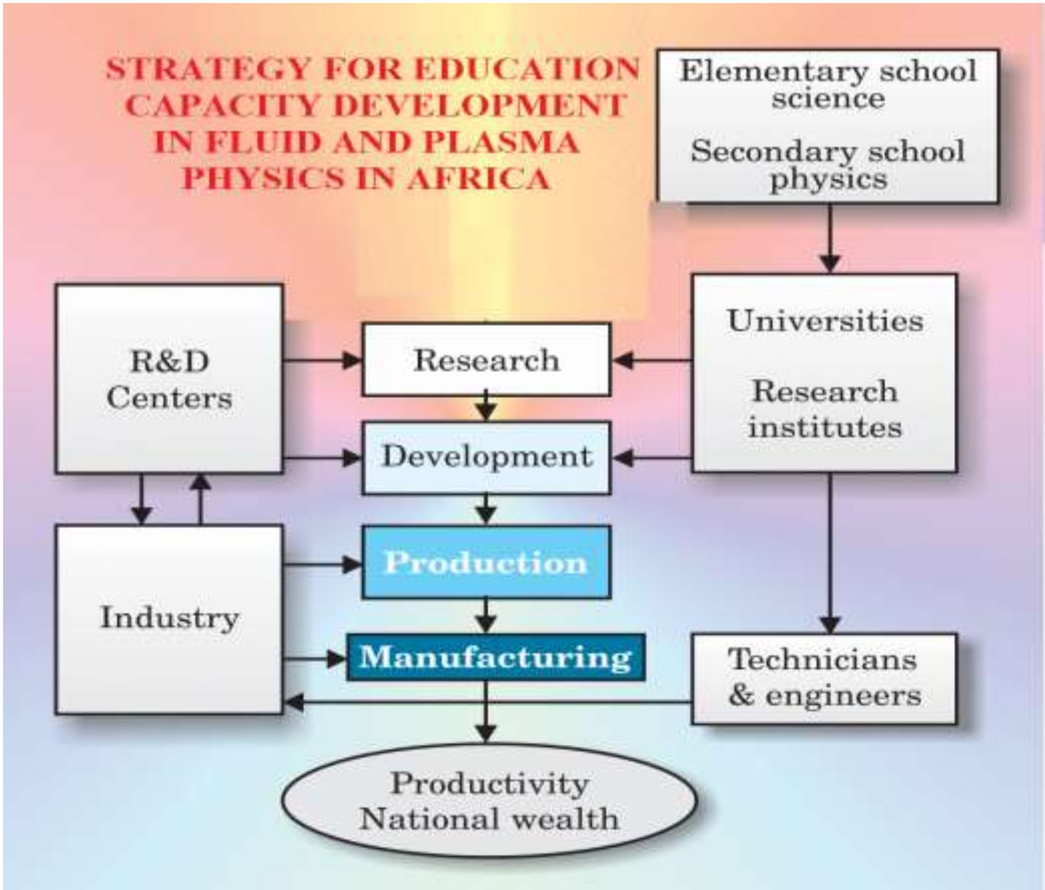


Figure 2: Strategy for education capacity development in fluid and plasma physics in Africa

The proposed capacity development strategy envisages a close and mutual interaction between the African educational institutions, research institution and industries. Moreover, post-doctoral research activities should be encouraged in the field of fluid and plasma physics in Africa tertiary and research institutions, scientists in Africa should be encouraged to publish their research outputs in the main stream peer-review academic journals for global visibility.

4. Conclusion

The status and impact of impact of fluid and plasma physics in the scientific and technological advancement of Africa can be enhanced through adequate educational training, research and mutual interaction of African scientists with the related industries. This can only be achieved through national, regional and international collaboration coupled with sufficient investment from their governments, businesses and private sectors into capacity development in the field.

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Instrumentation and Detector Physics Working Group

Ulrich Goerlach, Paul Gueye, Nieldane Stodart, 4/12/2022

By construction this working group is transversal and multi-disciplinary and its activities are related to all other physics groups. The Instrumentation and Detectors Physics Group aims to identify existing or new initiatives and projects within a wide range of instrumentation, which should be further developed in order to become valid proposals to create new facilities in Africa. The role of the WG is to coordinate and to encourage these initiatives and to help in the process of writing the so-called "White papers".

In the early phase of the WG a small and probably insufficient attempt was made to obtain an approximate overview over existing facilities in Africa by going through web pages, conference proceedings and other miscellaneous sources of information. This turned out to be fairly difficult, especially in the physics domains outside of the competences of the WG conveners. Nevertheless the prejudice that most of the instrumental centres are concentrated in South Africa, Namibia and in the Northern part of Africa seemed to be confirmed: Examples are the Nuclear facilities with accelerators at iThemba Labs and several astrophysics observatories (SAAO, HESS, SKA). In the North are centres like the Centre National de l'Énergie, des Sciences et des Techniques Nucléaires (CNESTEN, Morocco) or the Center for Development of Advanced Technologies (CDAT, Algeria). Some instrumentational centres exist also in other countries, for example the Lasers Atoms Laboratory at Cheikh Anta Diop University (Dakar, Senegal), the Atomic Molecular Spectroscopy and Applications Laboratory, University of Tunis El Manar (Tunisia), the Radiocarbon laboratory of the Institut Fondamentale d'Afrique Noire (IFAN), Senegal, the Centre for Energy Research and Development (CERD), Nigeria and several more; but only very few are located in the sub-Saharan countries of central Africa.

A first meeting of the WG took place in November 2021, with the principal goal to help the submission of LoIs by structuring the collected information on existing facilities.

From the collected approximate survey and listening to talks at ACP2021 and other meetings, it was confirmed that the main problems researchers are facing is the need for experimental Facilities. The second essential need is educational training centres in instrumentation for basic and advanced experimental physics.

After the first bunch of submitted LoIs, those were identified, which were possibly related to instrumentation; three categories were defined:

1. Extensions of existing facilities:
   - (Radio)-Astronomy: (51, 54, 56, 67),
   - Accelerator centres: (17, 24),
2. New facilities
   - Astronomy: local observatories for North Africa (14),
   - Astroparticle underground (15),
   - African millimetre telescope (33),
   - Am-Be neutron source (39),
   - AfLS (not a special LoI),
   - Instrumentation for AfLS (58, 59, 61,66).
3. Centres of Excellence (the instrumentation part is not always explicit or clear)
   - Graphen Flagship (4),
   - Energy centre of excellence (5),
   - NANOAFNET(10),
   - Quantum physics and biology (19, 23, 27, 49)
   - Education, ICEPA (68)

In spring 2022 the conveners of the WG started to approach the authors of the existing LoIs directly in order to require more details and to encourage the concretisation of the plans:

Two meetings were held in spring 2022, one on May 5th and one on June 9th with 21 and 14 participants, respectively. Further meetings were planned but cancelled due to problems identifying dates confirm to the convenience of speakers and conveners; the beginning of the summer break put an end to that round of meetings.

On May 5th three LoIs were discussed: #39: Am-Be neutron source, #54 Low Frequency (< 1GHz) RadioInterferometric Arrays and #33: The first millimetre-wave radio telescope.

Followed by a meeting on June 9th, where three further LOIs were presented, two on existing facilities at iThemba Labs (#17, #24) and one on the UNESCO-UNISA and the NANOAFNET (#10).

All these projects are built on some existing experience and activities with the potential for the future to create African wide collaborations. The existing facilities at iThemba labs do already attract scientists from other countries like Algeria, Senegal, Burkina Faso, Nigeria, however there is quite some room to increase such collaborations.

In the discussions following the presentations it became evident that one of the most important short comings were in fact the problem to find enough person power to widen the scope of these projects beyond the country where these activities are located at present.

Especially for the astrophysical related projects this is a bit surprising because Africa has a fairly large astronomy community, particular in East Africa.

Unfortunately this start of the LoI-review could not be continued after the summer break, for various reasons. One has to review the reasons and restart this process in 2023.

Within the Instrumentation and Detector working group we discussed a proposal for a “International Centre for Experimental Physics in Africa (ICEPA)” in order to address the lack of experimental training facilities in Africa. Some ideas were sketched and then submitted as LoI (#68). The LoI was also presented at a meeting of the Physics Education working group. The idea for such a school was born from the apparent lack but need for experimental education and know-how in most African countries and the concept is very much inspired by the African Institute for Mathematical Sciences (AIMS) and other educational centres like Southern African Institute for Nuclear Technology and Sciences (SAINT) or the Sèmè City in Benin.

The proposed centre will consist of a master-like curriculum of typically one and a half year, including a 6-month research project and will include high-level lectures combined with hands-on experiences. A final examination and a recognised diploma (the association to a university will be required in such case) should conclude the cursus.

Apparently the proposed training centre is very similar to AIMS, but it is aimed at experimental physics and strongly oriented towards instrumentation. For the latter, the idea is to build experimental installations and facilities, which partially could be contributed and/or donated by international collaborators or universities, who ideally, would also take the responsibility to maintain the equipment, at least for the first years until local staff has been trained and educated.

Conclusions and outlook:

After an enthusiastic start in 2021/2022 in the context of the ASFAP townhall meeting in spring 2022 the activity came to an apparent hold during summer 2022 and needs to be revived to pursue the review of LoIs and guide their proponents to White Papers. The activity also suffered from a lack of interaction with the other working groups, whose input is urgently required because instrumentation can only be developed in the physics context. The other short coming of the working group is the still insufficient mobilisation of the African community itself for ASFAP in order to construct and to develop the proposed projects and to find African leaders as spokes persons for them.

ASFAP impact towards the 1st African Light Source

Gihan Kamel (1 and 2)

(1)SESAME Synchrotron (Synchrotron-light for Experimental Science and Applications in the Middle East), 19252 Allan, Jordan.
(2)Department of Physics, Faculty of Science, Helwan University, Cairo, Egypt.

The concrete vision of having Africa as a leader sharing equivalent responsibilities and deliverables towards the global scientific societies turn out to be more obvious by time. Africa is not an exception when it comes to advanced science and technological grounds. Many challenges do exist and many others are still accumulating such as establishing cutting-edge large scale research infrastructures and institutions, reversing the brain-drain dramatic challenge, addressing local and/or regional concerns (health, environment, water, human heritage), as well as being a vehicle for industrial development and growing economy. In addition to bringing forward the African educational systems, employment status, besides the human capacity building which is alleged to be the backbone of any advanced society. Into the discussion, and besides their strong influence on education and advancing science and technology, as well as, capacity building development, are synchrotron light sources demonstrating the extensive capabilities with numerous techniques supporting a wide range of applications of basic science for instance physics, chemistry and biology, along with applied science aspects including life sciences such as biomedicine, pharmaceuticals and drug design, in addition to agriculture, environment, and air and water pollution, besides materials science and industrial applications, and energy and climate change. Furthermore, comprehensive insights can be identified and documented for cultural heritage and archaeology domains.

Keywords *ASFAP, Light Sources, African synchrotron, Capacity building, economic development*

To address the above multiple challenges and more, a huge demand in the implementation of such infrastructures is evidently viewed. For instance, based on several statistical figures, one of the most important aspects to be also tackled is the gender balance concern. Light sources have also shown to be effective in reducing such a gap as much as possible being an open and flexible environment that is based only on scientific merit and skills. In addition, synchrotron light sources proved to convey a valuable segment of diplomacy — that is based on scientific cooperation ceasing complications across borders. Through them, collaborations were made possible only using the neutral language of science. This in line, can encourage new partnerships on the national and international levels to address mutual demands of scientific and societal challenges, and education and economic development as well. One activity of the African School of Physics (ASP) is the African Conference on Fundamental and Applied Physics (ACP) with its first edition in 2018 at the University of Namibia in Windhoek. In this manuscript, a contribution on the light sources for capacity development and research in Africa that was presented during the second edition of ACP [1], organized on March 7-11, 2022, is reported here.

In an attempt to catch the fast evolving scientific and technical race of light sources around the world, African scientists – through collaborations, agreements and training fellowships – are also in a race with time to set up the first facility ever in the continent. In this contribution, the significant need of such facilities to the African continent – the only continent that is left exclusively without a single synchrotron light source is emphasized (Figure 1). Occasionally, establishing a synchrotron light source goes beyond the financial capacity or even a dedicated initial budget of a single country. Therefore, it represents a real bottleneck for the low economic standing position countries – which is the current case of most African countries. On the other hand, the condition can be also deteriorating as a direct influence by the human capacity deficiency, that yet again, signifies the necessity to reverse the brain-drain issue. Overall, synchrotron light facilities do operate in what can be considered as a democratic mode; that is by facilitating efficacious scientific cooperation to promote peace and understanding between people from different cultures, religions, races, and political systems (Herman Winick).

Figure 1: Distribution of synchrotron light sources around the world.

As a general reflection, diverse motivations do embody the aforementioned case, such as the next:

- establishing a world-class and applied research interdisciplinary research laboratories.
- Addressing the many local and regional concerns (for instance; human health, environment, materials and energy, cultural and human heritage, etc.).
- providing a vigorous environment for successful collaborations and allowing the essential space needed for individual career development.
- attracting African diasporas thus drawing back the brain-drain alarm and in the same time resolving the internal brain-drain to other sectors as well, this is the case as the majority may tend to target other fields rather than natural sciences or engineering where the remuneration for jobs in economy for example are much higher than for scientists and with many excellent young scientists choosing such more profitable careers.
- training and preparing graduate students who will no longer need to go abroad to industrialized countries, which implies a minimum of infrastructure and some interesting projects to take place and to be constantly developed in the home country and/or region.
- promoting development of high-tech industry (capacity building).
- decreasing the gender gap on every occasion proves possible.

The ASFAP (African Strategy for Fundamental and Applied Physics [2] basic objective is to develop capacity building in physics education and research. With no exception and as noteworthy as achievements are growing up for other regions, similar scientific and economic challenges persist to be addressed in African continent with the dream that Africa, too, should take its matching identity as a co-leader in the global scientific arena. With this, the requisite of having the ASFAP has turned out to be indispensable for Africa. One of the ASFAP working groups is dedicated to light sources establishment and development. A recent assessment survey launched by the ASFAP Light Sources Working group was released in February. The survey expected to gather a further considerate input from the African scientific community among others on the case of founding an African light source. The subsequent purpose of this questionnaire is to well prepare and establish collaborative research themes and angles. It also aims at preparing Letter of Intents for the Light Sources Working Group within the ASFAP. Herein, some assembled inspirations out of the survey are listed in the following sections.

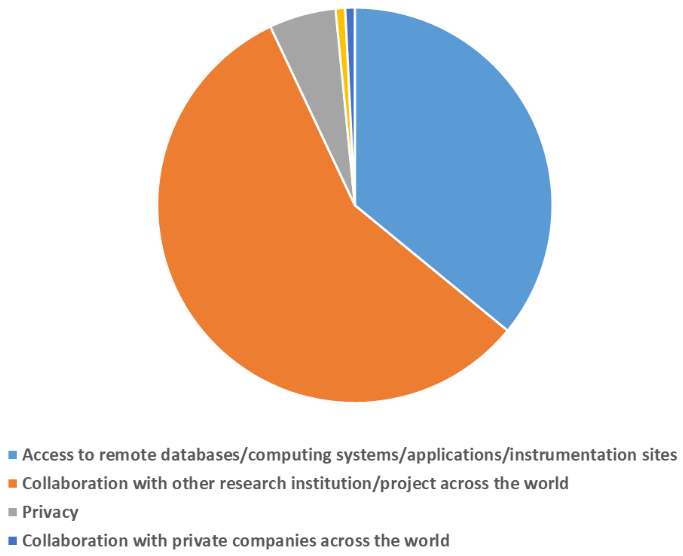

Figure 2: Chief research assisting requirements reported through the ASFAP survey on light sources.

77% of the survey's participants are resident citizens in African countries, while 26% are African diasporas. Participants from nineteen African countries (Nigeria, Morocco, Kenya, Cameron, Senegal, South Africa, Ethiopia, Tunisia, Uganda, Algeria, Ghana, Sudan, Egypt, Ivory Coast, Zambia, Mozambique, Togo, Congo, and Sierra Leon. Participants from 13 non-African countries have also contributed to the survey. Specifically, from USA, India, Pakistan, Italy, Germany, Jordan, UK, France, Malaysia, Peru, Canada, Japan, and Portugal.

Amongst the research interests and scientific activities those were favored by the respondents of the survey came on top the basic and/or applied science, followed by life sciences, materials sciences, cultural heritage and archaeology, accelerators' physics and technology, optical instrumentations, beamlines development, as well as experimental instrumentation and data analysis approaches. A thought-provoking input was also attained by the fact that 76% of the researchers and students opted for current and/or future synchrotron-related interests. Figure 3 shows the required synchrotron techniques, which again, confirms the necessity of establishing such a facility. Moreover, geographical distribution, collaborations with other research institutions, access to remote databases and software, as well as advanced instrumentation, were assigned as higher priorities for research chief requirements. 70% of those who participated showed a previous experience in light sources facilities, while 61% opted for a looked-for employment given the opportunity and depending on qualifications. Besides, 88% opted for their willingness to initiate interactions on different axes of collaboration and assistance with other African groups. 81% marked their need for advanced training regarding the general use of such available infrastructures, with a descending order of financial, technical, and scientific support.

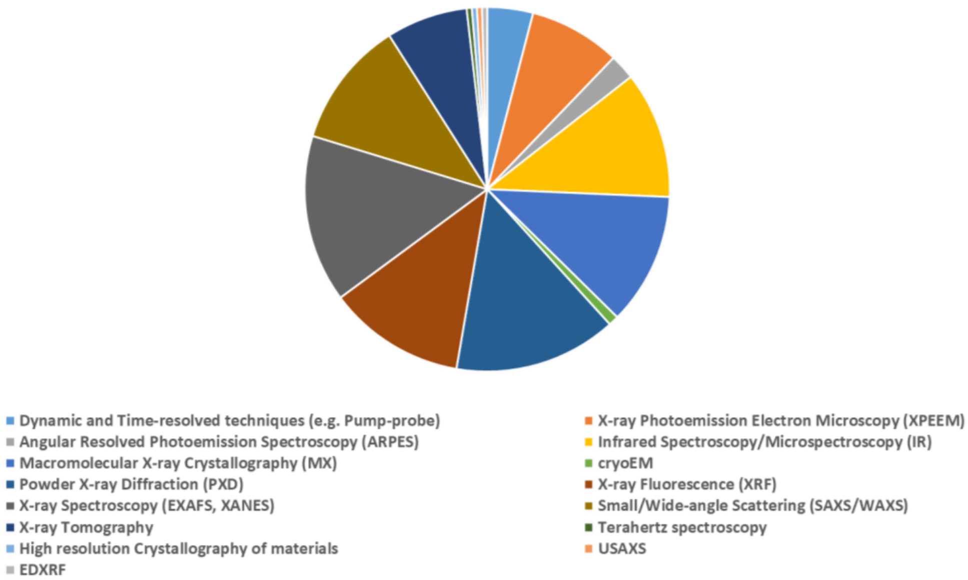

Figure 3: Favorable techniques reported through the ASFAP survey on light sources.

Tackling the expected scientific impacts of light sources have been also brought to the attention of the participants. Some detailed responses are provided subsequently:

- Human health and energy-related materials discovery and development.
- Transfer the know-how among the related counties, and bridging communities through collaborations.
- Profile for African Science, capacity building, local technology, local infrastructure, enhanced networks and participation in international collaborations, more innovation, African wealth.
- A light source facility will support many other research field, providing a framework for research and education centered in Africa. It will also draw the international community and boost the regional economy in providing jobs.
- To make sure that specific problems get attention and not have to depend on exogenous market and policy forces.
- Solving local problems with greater economic output, by means of light sources one can develop solutions and products to raise the balance of trade for Africa.
- Improving major scientific, educational and socio-economic and industrial advances.
- Diversification of the types of research questions posed, particularly in medicine, energy and materials. Escape from European fixation on batteries and fusion.
- With the abundance of mineral resources on the continent of Africa and the huge interest in crystallography, this is a great opportunity to explore our raw materials to create wealth for our people and also education on the interaction of matter with light which will help build the science base of our people.
- To foster scientific and technological excellence; prevent or reverse the brain drain by enabling world-class scientific research; build cultural bridges between diverse societies, as well as education and capacity building.
- Supporting the Pan-African initiative of Africa having its own scientific light source.
- Discovery of novel molecules capable of curing diseases and infections that affect the population.
- Increase number of publications in African countries
- Significant if one would like to keep pace with the global community.

- Light sources technology must be more available and cheaper for all geographical areas in Africa and the world as it provides cutting-edge tools for advancing almost any branch of science.
- Mastering our raw materials and transforming them to get out of poverty.
- Addressing of brain drain and societal issues; Promotion of knowledge base economies

For instance, the status of the human health in Africa represents a huge pillar of scientific research by African scientists and others. Many diseases are there to be investigated and treated. Figure 4 sheds some light on some of the targets to be explored.

There is no doubt that such global research infrastructures do have a strong impact on economy, food security, and disaster management. Moreover, 73% of the participants expected societal impact of light sources in the form of establishing a common culture of knowledge, competitive local industry, entrepreneurship, and capacity building.

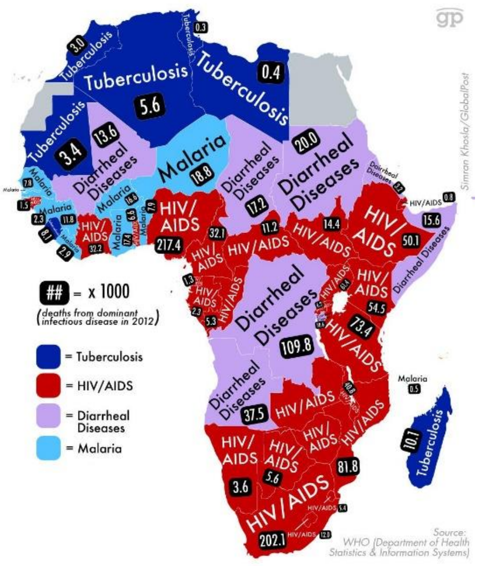

Figure 4: Human health examples of persistent diseases in the African continent.

The participants were also invited to provide their insights on what sort of changes are essential to allow better use of networking facilities. Some collected opinions were as following:

- Prepare short videos highlighting the scientific impact of using synchrotron facilities and addressing what kind of research could be conducted in such facilities. Also, it is important to outreach activities to undergraduate students.
- Scientists everywhere have challenges with stable funding, it is likely more acute in Africa than in the US, EU and Asia.
- Establishment of more local facilities with clustered partnerships (Intra-continental and extra-continental), and sharing equipment available in Africa cross the country and/or within the same through its different institutions.

- Dynamic collaborations to expose the underprivileged institutions.
- Bilateral agreements with African nations by major US and European agencies.

At the same level of importance, and as there is a clear need to have a research infrastructure in Africa specifically and African light source to cope with challenges that Africa is facing, it was also vital to gain some insights from the scientific community on how can African countries join forces to overcome the major challenges to establish its own light source. Below are some of them:

- To start with common infrastructures that can be shared among all communities.
- Cooperation in benchmarking degrees, visas, mobility and exchange funds.
- Involve local industry.
- Develop a concrete strategic vision for a light source facility - Engaging policymakers and the international community to support such a vision.
- In Africa, this might have to be done on region basis via the RECs. Each country, then each REC should develop a major science facility policy in general (as part of STI policies, respectively), and a light source policy in particular. Which can be then developing joint policies given other realities, e.g. transportation routes.
- With the African Union podium and other African institutions in promoting the light source in all African countries and regions.
- By instituting centers of excellence, sharing experiences, equipment and good team work.
- Invest in the science that drives light sources in the rest of the world, e.g. the study of proteins. Plus, showing the necessity of using the light source for research in Africa to solve our local problems such as malaria, famine and technological advancement.
- There must be intense educational system on the research capabilities of light sources and their importance to scientific revolution in Africa.
- Through scientific discoveries and common research activities to tackle preexisting problems and those raised by the side effects of technologies.
- Reach the Critical Mass. Ensure mobility, training, and enrollment of large multi-skilled young scientists through workshops and conferences and funding.
- Collaboration and joint funding to meet the expense of such a huge infrastructure to establish the first African Light Source. African governments can also provide joint funding that involves the private sector. Revenues from minerals and exports should be invested in a light source.
- Establishing better scientific masses within Africa than are groups/projects, much like the commercial and trade blocks that are already existing.
- Top-down and bottom-up organization. Grass roots support is very important. It would be hard to justify "from the top" without strong evidence of current or near-future demand. The multinational aspect of such a project should not be forgotten - it would be a great way for African nations to work closer together. Coming under the umbrella of a Pan-African society such as the AU or perhaps a regional one like SADC, ECOWAS, etc. is another depending on the eventual decisions made. Use the experience gained from SESAME light source on how they are reaching out to new Members to convince them to join.
- Establishment of a regional project, and networking with other light sources.
- Raising awareness among African Heads of State and the African Union on the need to implement their light source for controlled and therefore sustainable development.

Another inquiry of the survey targeted the major obstacles faced when attempting to pursue scientific research in a worldwide light source? Answers were given with the following order.

- Bureaucracy in the facility of destination.
- Lack of funding schemes (travel and mobility, project expenses, etc.).
- Lack of basic and/or preliminary research equipment in own country.
- Lack of mentoring.
- Lack of training opportunities to develop professional skills.
- Scientific merit-related needs.
- Bureaucracy in own country.
- Lack of dedicated manpower.

Based on the above-mentioned information provided within this simple statistical survey, it was also significant to retrieve some informative data on the prospect of the potential cross-disciplinary collaborations and links to light sources user-communities which may be achieved by create multi-folds' links with academia and industrial sectors, as well as, the basic interdisciplinary collaborations. Results showed the following crucial aspects:

- A light source facility can serve communities in various disciplines: materials physics, atomic and molecular physics, biophysics, optics and photonics, Pharmacognosy, etc.
- Materials and Energy systems, biomedical engineering, and plant molecules exploitation.
- Major advances in drug discovery and materials development - crystallographers work with chemists in the extraction and crystallization of potential drug molecules including different vaccine development.
- Agriculture where chemists will synthesize and crystallize fertilizers for crop production, and new techniques to be applied to new fields such as imaging for paleontology, archaeology etc.
- Development of new materials or characterization of newly discovered materials from mines.
- Advancement of society based on communication because it explores wanted field as per the situation.

Light sources are the best example of an open and multidisciplinary research infrastructure. They provide strong opportunities for integration through networking and cost-sharing, and promote multi-disciplinary collaboration with the wider global community, while promoting science diplomacy and peace at large. Moreover, environmental problems, advanced materials, cultural heritage valorization are all complex issue intrinsically involving cross-disciplinary collaboration.

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Submitted to the Proceedings
of the African Conference on Fundamental and Applied
Physics

Second Edition, ACP2021, March 7–11, 2022 — Virtual Event

ASFAP Working Groups Activity Summary: Biophysics, Light Sources, Atomic and Molecular Physics, Condensed Matter and Materials Physics, and Earth Sciences

Sonia Haddad[a], Gihan Kamel[b*], Lalla Btissam Drissi[c], Samuel Chigome[d,]

[a]*Laboratoire de Physique de la Mati`ere Condens´ee, Facult´e des Sciences de Tunis, Universit´e Tunis El Manar, Campus Universitaire 1060 Tunis, Tunisia*
[b]*Department of Physics, Faculty of Science, Helwan University, Egypt, and SESAME Synchrotron Light Source, Jordan*
[c]*Faculty of Sciences, Mohammed V University, Rabat, Morocco*
[d]*Botswana Institute for Technology Research and Innovation, Gaborone, Botswana*

Abstract

Various panel sessions were organized to highlight the activities of the African Strategy for Fundamental and Applied Physics (ASFAP) Working Groups during the second African Conference of Fundamental and Applied Physics (ACP2021) that was held in March 7–11, 2022. A joint session was devoted to highlight the activities assigned to the Light Sources, Accelerators, Biophysics, Earth Sciences, Atomic and Molecular Physics, and Condensed Matter and Materials Physics Working Groups. Major outcomes and recommendations are demonstrated and deliberated in this contribution.

Keywords: The African School of Physics, ASP, the African Conference on Fundamental and Applied Physics, ACP, Light sources, Condensed Matter and Materials Physics, Biophysics, Earth Science, Atomic & Molecular, ASFAP.

Introduction

The African Strategy for Fundamental and Applied Physics (ASFAP) aims at implementing state- of-the-art scientific and technological knowledge and development in Africa based on a concrete and tangible strategic vision in a multi-fold approach. In an attempt to create a focal point for capacity building, retention and advanced research, various specialized working groups were established to raise the awareness about the ASFAP objectives, activities, as well as, the envisaged deliverables. In this regard, six Working Groups representing Light Sources, Accelerators, Biophysics, Earth Sciences, Atomic and Molecular Physics, and Condensed Matter and Materials Physics did contribute to the ACP2021. The groups' objectives and activities were presented. In addition, several outcomes of mutual discussions highlighting the received Letters of Intent (LoIs) and the published surveys were provided.

* Corresponding Author (Gihan Kamel)

1. Biophysics WG

The ASFAP Biophysics working group tackles one of the most demanded disciplines in Physics. The Working Group aims at assessing the scope of the biophysics education in Africa, extending the biophysics research database, as well as, development of biophysics curricula. The group has received seven LoIs and is expecting to receive more letters of support as a result of the subsequent planned on-line conference titled "Biophysics in Africa" which was also organized by this group in March 21-25, 2022 [3]. This conference shed the light on the different topics of biophysics, in particular; molecular biophysics, structural biology, maternal biophysics, computational biology, quantum biology, radiology, and biophotonics.

Among the various activities, the Biophysics Working Group has launched a call for Letters of Intent during the organized Biophysics Winter School (4 July 2022) [5], and also at the Structural Biology Workshop (April 25-28, 2022). The group proposed to extend the biophysics research databases and to work in liaison with other ASFAP WGs, as well as with other related international organizations such as the International Union of Pure and Applied Physics, IUPAP, and with the Biophysical Society [6]. In order to have more synergy with other groups, the Biophysics WG did propose to be merged with other ASFAP Working Groups as well namely the Light Sources and the Nuclear Physics ones.

2. Light Sources WG

The ASAFP Light Sources WG is mandated to highlight the demands of the wide scientific community in different disciplines, and to bring the important role that light sources including synchrotron radiation facilities to the front-lines. Such large-scale infrastructures are playing a key role in scientific and technological advancement of any society. Many challenges do exist in Africa such as establishing cutting-edge research infrastructures and institutions, reversing the brain-drain dramatic challenge, addressing concerns such as health, environment, water, energy, and climate change, etc. In addition, the WG is also aiming at boosting the visibility of the fundamental significance of such a competent light source facility in Africa.

In an attempt to implement such goals, the Light Sources WG launched a comprehensive survey in which physicists from different African countries and diaspora have also participated (Fig.1). According to this survey [9], there is an essential need to establish a light source in Africa, which is the only continent that is left behind without such a large-scale infrastructure thus far.

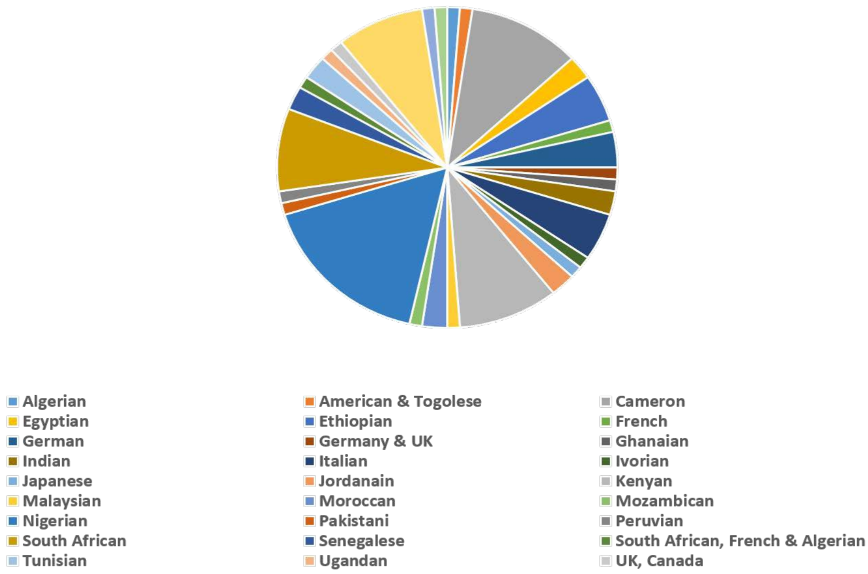


Figure 1: Origin of the participants to the survey launched by the Light sources working group [7, 9].

Furthermore, the survey conveyed a practical vision that the African countries should share existing infrastructures while preparing for a common platform which can then be guided by a scientific council involving African Physicists and third parties like UNESCO for instance. It is worth to note that only 13% of the participants to this questionnaire were female students and experienced researchers, which brings into the surface the necessity of minimizing the gender gap in Africa.

The survey has also underlined the challenging difficulties pausing so many African Physicists in pursuing an advanced scientific career in worldwide light sources (Fig.2). The participants have also provided some recommendations about the current educational systems in African countries. For that, they proposed to include Light sources training sessions and lectures in the African curricula of graduate students. They also suggested to involve local industry and
engage policymakers and the international community in order to support the strategic vision for African targeted infrastructures and light sources facilities.

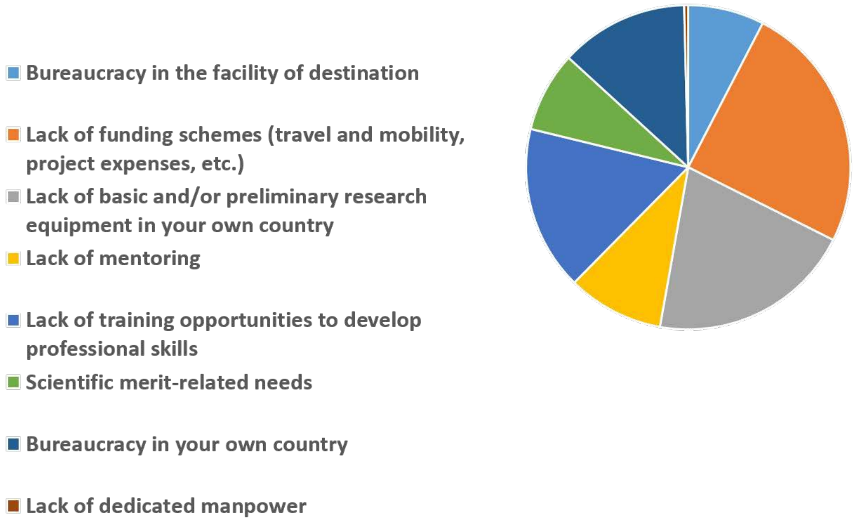


Figure 2: Difficulties facing scientists in Africa as has been raised by participants to the Light sources survey [7, 9].

In addition to the survey, several LoIs were submitted in favor of the establishment of the first light source in Africa. The WG is currently analyzing these received letters, and intends to advocate for more through complementary activities.

3. Atomic & Molecular Physics WG

The ASFAP Atomic and Molecular Physics (AMP) working group's strategy is to identify and approach similar working groups in Africa, and African diaspora in the field, focusing on quantum physics/technologies researchers, electronic structure communities like ASESMA, CASESMA, as well as, the optics groups in Cameroon. Out of the main disciplines is that the AMP WG is tasked to monitor the activities of various scopes such as Atomic structure, properties, and dynamics, Molecular, Chemical and Cluster Physics, Cold Matter; Quantum Technologies; and Astrophysics and Plasma Physics. The working group [8] has also organized an online mini-workshop on 10th January 2022 where a hundred of participants had registered. However, due to some connectivity issues, only 30% to 40% of the participants managed to attend. Concerning the LoIs, the WG on Atomic and Molecular Physics (AMP) has received only seven LoIs among others where the AMP disciplines are not the primary field. The best strategy to overcome this drawback is to merge the AMP WG with other ASFAP working groups to boost the foreseen goals. The outcomes of the discussion session on AMP brought out the necessity to get Africa involved in the rising worldwide quantum initiatives and quantum technologies, as Africa is left behind in the nationwide investments in such technology (Fig.3).

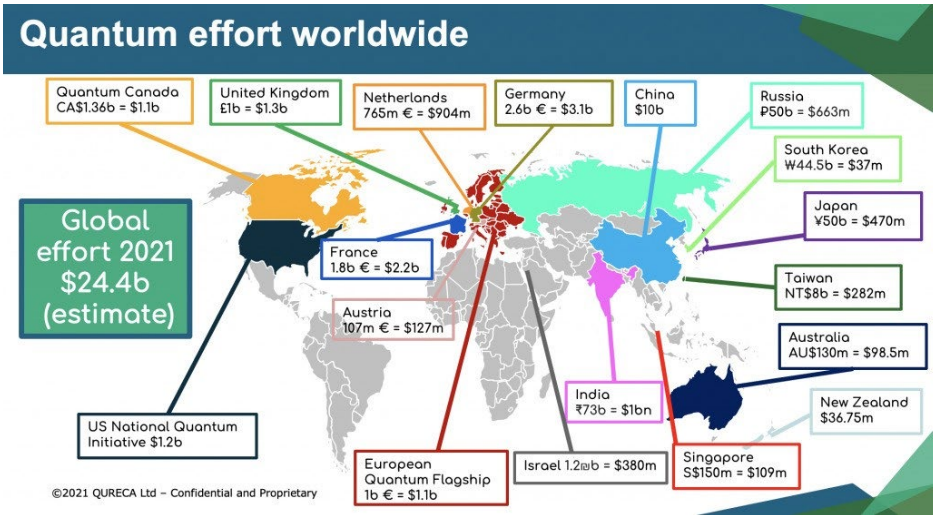


Figure 3: Quantum initiatives worldwide [8].

4. Condensed Matter & Materials Physics WG

The Condensed Matter & Materials Physics (CM) WG [10] has organized an online mini-Workshop on 15th December 2021 [11] where more than 200 participants attended with a rate of 38% of full workshop attendance. However, only 28% of female participation was observed (Fig.4). This workshop included an introduction to ASFAP, presented by members of the steering committee, as well as, some plenary talks aimed to raise the awareness about the importance of the Condensed Matter and Materials Physics in Africa developmental path [11].

The CM WG has also launched a survey to collect recommendations which can then be structured within the LoIs [12]. The survey has received, till June 28$^{\text{th},}$ 2022, a total number of 209 responses. During the ACP 2021, a percentage of more than 55% responses has been reached with a total of 198 responses were collected. It was emphasized that the survey should be advertised during all the events held in Africa to attract more participants. The survey's participants comprise different areas in Condensed Matter Physics. Figure 5 shows the different relevant areas to the condensed matter physics as the respondents of the survey have indicated. The survey has given a clear evidence that there is a huge lack in equipment for African experimentalists and theorists as shown in Figure 6. On the other hand, the survey also indicated that there is an urgent need to improve the standing of the curricula in Master and Doctorate levels, and to establish joint inter- Africa post-graduate degrees. Another recommendation highlighted the importance that the educational courses should be extended to hands-on sessions in research laboratories and engagement of industrial sectors (Fig. 7).

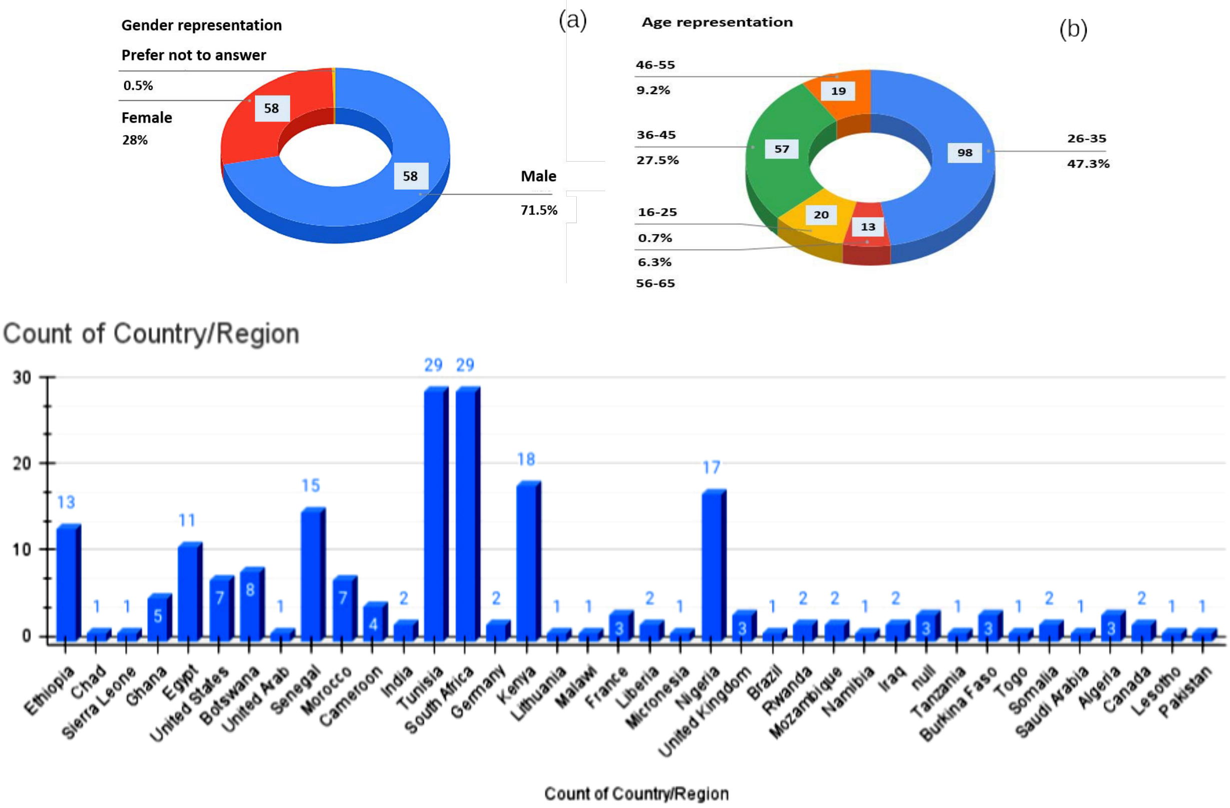


Figure 4: Statistics of the on-line mini-workshop organized by the Condensed Matter and Materials Physics WG: (a) The gender participation ratios. (b) The age distribution of the attendees [10] and (c) the number of participants per country.

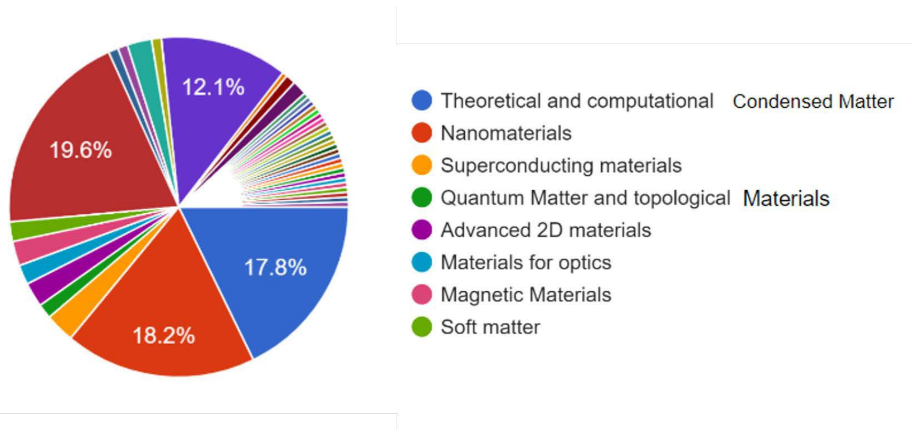
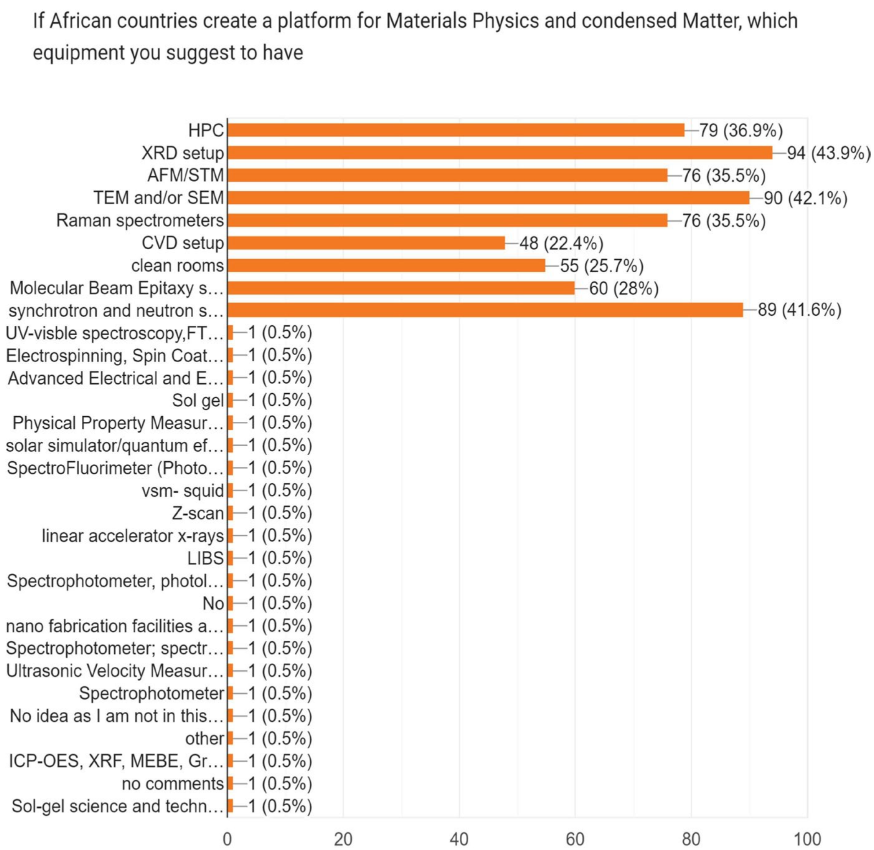


Figure 5: Some favorable research areas of the participants to the survey launched by the Condensed Matter and Materials Physics WG [10].



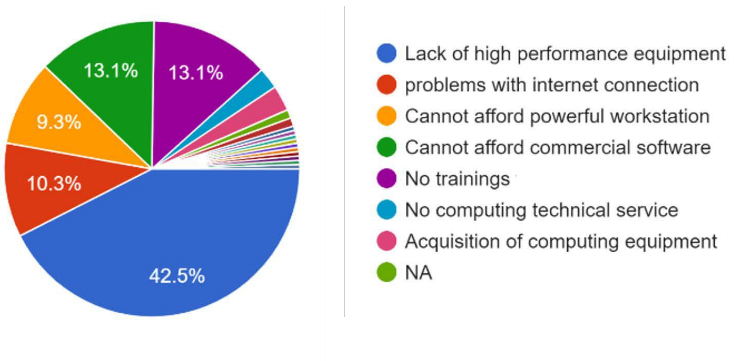


Figure 6: Selected responses to the survey launched by the Condensed Matter and Materials Physics WG on the requirements of numerical calculations. Data are updated on June 28$^{\text{th}}$ 2022 [12].

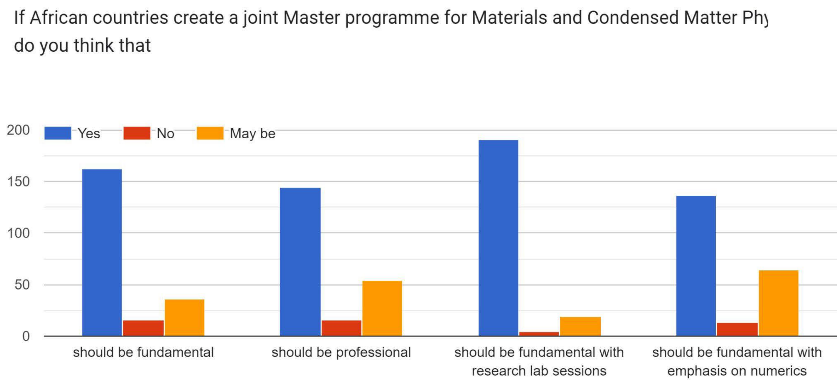


Figure 7: Items from the responses to the survey launched by the Condensed Matter and Materials Physics WG. Data are updated on June 28$^{\text{th}}$ 2022 [12].

Concerning the LoIs submitted to the ASFAP WGs, 13 out of 64 were addressed to the CM & MP WG. Several ideas were proposed to promote the CM Physics in Africa, and in particular:

- to prioritize research and development of new materials by establishing more centers of excellence - with financial support from the African Union (AU);
- to build a road map to promote teaching and training in CM and MP and to create an inductive environment aiming to engage interested young researchers;
- to minimize the gap between academic and industrial sectors;
- to initiate exchange mutual programmes of collaboration between African universities and to advocate for more female researchers in the field.

5. Earth Sciences WG

The Earth Science (ES) WG [13] did not receive yet LoIs. To overcome this issue, this WG will call for LoIs under the umbrella of organizations which will be asked to disseminate the call through their existing networks and mailing lists. The ES WG will organize a mini-symposium planned for direct engagement with the African Earth Sciences community. The event will include an introduction to ASFAP and a keynote conference. During the event, the participants will discuss the content of the questionnaire which will be addressed to involved African researchers in Earth Sciences.

Outcomes and remarks:

The essential conclusions of the presentations and the discussion sessions of the above-mentioned WGs can be summarized as follows into two categories.

- The first one concerns a modified approach that is essentially related to the working groups:
- reconsidering a new structuring of the WGs possibly through merging some of them, and to assist creating a constructive synergy by sharing surveys' results, common events, meetings, as well as, data;
- nominating some active focal points in different African countries in order to facilitate targeting various official channels aiming at attracting science and education Ministries, scientific organizations and institutes, in addition to the potential national and international science societies;
- boosting gender balance since women are still underrepresented in the participant communities of ASFAP activities.

- The second category of the concluding remarks deals with the recommendations, which can be summarized as follows:
- Africa needs to define the priorities for regional centers;
- ASFAP needs to keep interaction with different scientific institutions and organization such as ICTP (Italy) and EAIFR (Rwanda) and other regional centers;
- there is a large consensus of the necessity to join forces to build a virtual university (and for other disciplines), and to set-up regional Centers for example for instrumentation and detectors (from small to big equipment).

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- https://forms.gle/nau9mdKC8WJMwVxTA
- https://indico.cern.ch/event/1060503/contributions/4772157/

Submitted to the Proceedings
of the African Conference on Fundamental and Applied Physics
Second Edition, ACP2021, March 7–11, 2022 — Virtual Event

High Energy Physics activities in Africa: An overview

Yasmine Amhis[a], Mohamed Chabab[b,*], Zinhle Buthelzi[c]

[a]*IJCLab, Orsay, France*
[b] *LPHEA, Cadi Ayyad University, Marrakech-Morocco*
[c]*iThemba LABS, Soth Africa*

Abstract

This document summarises our best knowledge of the ongoing High Energy Physics activities in Africa. The information was primarily extracted from the first ASFAP Particle Physics day organised on November 2021 and on our working group talk presented at ACP 2021 conference on March 2022.

Keywords: High Energy Physics, ASFAP.

1. Introduction

High Energy Physics (HEP) reveals the profound connections underlying all observed phenomena, ranging from the smallest to the largest structures in our Universe. Everything in our universe is found to be made from elementary particles, as a few basic matter blocks, governed by four fundamental interactions. Our best knowledge of how these particles interact is encoded in the Standard Model of particle physics (SM). The SM developed in the seventies has become an established and well tested theory. This document is divided in two section, the first one focuses on theoretical HEP physics while the second one is dedicated to experimental particle physics in Africa. For each field, the activities are reported per country by alphabetical order. If an important activity had been forgotten please contact the authors. To contribute in a significant way to the development of HEP in Africa, we believe that we should focus on maintaining leadership of the organization of HEP education programs in some targeted institutes, with involvement of African governments and policy makers. To this end, ASFAP has dedicated a working group to Particle Physics with the aim to build an African network, support and expand the activities in this field, and ultimately prepare a road map based on collected letter of intents proposed by particle physics community. The list provided in Table 1 is a tentative summary of the current (as of 2022) involvements of African countries in particle physics experiments.

2. Overview on Theoretical physics in Africa

In July 2012, ATLAS and CMS experiments at LHC have announced the discovery of a scalar particle, later identified as a Higgs boson, the last missing piece of the Standard

*Corresponding Author
Email addresses: yasmine.amhis@ijclab.in2p3.fr (Yasmine Amhis), mchabab@uca.ac.ma (Mohamed Chabab)

Model [1, 2]. However, despite its success, there are still many fundamental questions awaiting a clear answer, which require the construction of new theoretical models, beyond the SM, which is then treated as effective theory of a more fundamental description. Among unsolved problems and experimental data that cannot be explained by the SM , we can cite: the neutrino mass generation, pattern of fermions hierarchy, and dark matter/energy. possible extensions of the SM This means that we have to look at alternatives beyond Standard Model (BSM) that could solve those issues and could be tested at the LHC and future colliders. So far, many theoretical proposals are on the shelves: The most attractive one are BSM Models involving Higgs fields with higher representation: more doublet, more singlet, doublet and triplet,..

Several African groups have strong expertise in phenomenology of the beyond the Standard Model Physics. Theses groups have gained footholds in dealing with multi-Higgs models with an emphasis on the symmetries of the scalar sector and Dark Matter candidates arising from these models.

The Egyptian team, from the Center for Fundamental Physics (CFP) at Zewail City Research areas, is specialist in many high energy theory topics including: Susy phenomenology, early Universe and astro-Particle Physics (selected references [3]).

The Moroccan groups, from Cadi Ayyad and Abdelmalek Saadi Universities, have relevant expertise in phenomenological studies in BSM physics including non-minimal Higgs models and supersymmetric scenarios with a particular focus on Higgs phyics , theoretical and EW precision constraints on scalar sectors in various extensions of the SM, including their implementation in high energy physics tools (selected references [4]).

The East African Institute for Fundamental Research (EAIFR), at the University of Rwanda has research interest in fundamental physics with a focus on collider physics, physics beyond the Standard Model, cosmic inflation, Dark Matter and Dark Energy. EAIFR has produced significant papers on the impact of additional Higgs bosons on signal rates and study of possible deviations from the SM (selected references [5]).

The South African HEP groups are strongly involved in development of BSM phenomenology and analysis of the data collected by the ATLAS experiment at the LHC. They are mainly affiliated to U. Witwaters, Johansburg U. and iThemba LABS (selected references [6]).

At last, a team from Madagascar is specialist of non perturbative methods in strong interactions. More precisely, they use QCD sum rules to predict hadron properties, such as masses and coupling constants(selected references [7]).

3. Experimental physics

The Large Hadron Collider is the largest and most powerful collider in the world. It is located at CERN between Switzerland and France. The first proton beams started to circulate in 2008. Four major experiments, ATLAS, CMS, LHCb and ALICE are located across the ring. A sketch of ATLAS and CMS can be found in Figure 1. Their purpose is complementary and aims at understanding the behaviour of fundamental particles and their interactions. An upgrade of the LHC, HL-LHC, is foreseen in 2025. After a successful period of data taking (Run1/2) the detectors are being upgraded in many phases. A detailed list of the associated institutes can be found in Table 1. The information collected in this

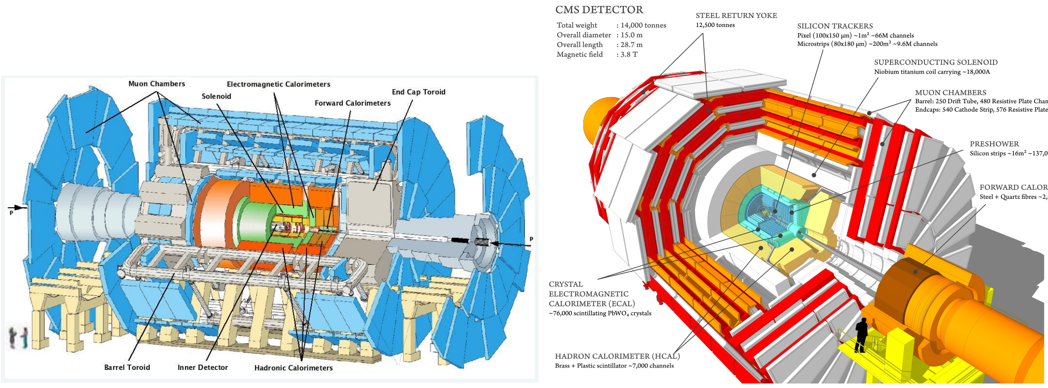

Figure 1: ATLAS (left) and CMS(right) detectors.

document is based on the material that was presented at the First ASFAP Particle Physics Day.

3.1. Algeria

A computing group contributes to ATLAS to face future computing challenges during the HL-LHC upgrade. This body of work consists of two projects porting of ATLAS software to parallel architectures and monitoring of conditions database access.

3.2. Egypt

The cluster of groups contributes to the CMS experiment. On the physics analyses side, Beyond Standard Model searches have been or are being conducted. For instance a Z' search, Kaluza Klien excitation from Extra-dimensions, and also Dark matter searches signatures combined with mono-Z mono-Higgs or mono-Z' topologies. On the detector side the groups are involved in developments of the Resistive Plate Chamber (RPC) as well as Gas Electron Multiplier (GEM).

3.3. Madagascar

DUNE is an international flagship experiment to unlock the mysteries of neutrinos. The group contributed to the Near Detector Conceptual design report and to the SAND-System for on-Axis Neutrino Detection.

3.4. Morocco

ATLAS:. In 1996, Morocco signed an agreement with CERN and became the first African member of the ATLAS collaboration. The RUPHE, a Moroccan cluster of several HEP groups, works currently on HL-LHC, High Granularity Timing Detector (HGTD). Two axes are pursued on the b-tagging and performance optimisation. For the first axis, there are ongoing studies are based on the Generic Boosted Decision Tree and self-tagging. For the latter the aim is improvement the jet energy resolution in the forward region and use of particle-flow reconstruction and HGTD impact. The assembly of HGTD modedules locally coordinated by MAScIR. The groups contributed team beam campaigns to finalise the choice of Low Gain Avalanche Detector (LGAD). On the analyses side the following topics have been investigated: Search for a BSM resonance in the top quark sector, search for Invisible Higgs, Search for Hidden Higgs or dark Sector, search for charged Higgs in $H^+ \to tb$ channel, diboson resonances in semi-leptonic final states Z', Kaluza Klein and Dihiggs HH resonant and non-resonant production : $bb\ell\ell$ and $bbVV$ channels

ANTARES/KM3Net. KM3NeT, the legitimate successor of ANTARES, is a new research nfrastructure consisting of a network of deep-sea neutrino telescopes in the Mediterranean Sea. The main objectives of the KM3NeT1 Collaboration are: i) the discovery and subsequent observation of high- energy neutrino sources in the Universe and ii) the determination of the mass hierarchy of neutrinos (MHN). These objectives are strongly motivated by two recent important discoveries, namely: The high- energy astrophysical neutrino signal reported by IceCube, and the sizeable contribution of electron neutrinos to the third neutrino mass eigenstate as reported by Daya Bay, Reno and others. To meet these objectives, KM3NeT is building two detectors ORCA and ARCA. Morocco has signed an agreement to join KM3NeT collaboration in 2017. So far three universities (Mohammed V U., Cadi Ayyad U., and Mohammed 1 U.), currently full members of the collaboration, are actively participating in the production line of optical modules in a national site located in Rabat. Besides, the Moroccan team is also involved in the physics analysis of many topics, essentially related to search for magnetic monopoles, search for nuclearites, and study of the neutrino mass hierarchy [8].

3.5. South Africa

There are multiple South African experimental HEP research groups active in both the ALICE and ATLAS experiments.

ALICE. The group contributes to upgrade projects towards a common read out unit for the muon identifier, the Low-Voltage System for muon tracking, and online data processing for the Transition Radiation Detector. Given the travel restrictions, the possibility to work operate the systems remotely has been utilised. The ALICE experiment explores the outcomes of heavy ion collision, the group worked on W and Z boson tests of the Standard Model via the study of the cross-sections in lead-lead and proton-lead collisions.

ATLAS. On the hardware side the following activities are ongoing:

- Silicon detector developments on both the SCT and ITk system including, data acquisition electronics development, evaporative cooling systems, material description in simulation, firmware and test QC for EoS redout cards, polymoderator design, procurement, and fabrication.
- Muon New Small Wheel work including, material description in simulation, manufacturing and assembly of components and installation tools as well as commissioning.
- ATLAS Local Trigger Interface boards were installed in the TTC crates of LBA, LBC, EBA, EBC and the Laser crate.
- Assembly, quality checks and installation of the gap scintillator counters on the ATLAS detector

- Phase-II upgrade of the Tile Calorimeter, 50% of the production of the Low Voltage Power Supplies (LVPS), 24% of the production of the Tile Preprocessor (PPr).
- Participation to ATLAS TileCal November 2021 Test-beam.
- CFD simulations for temperature and humidity distributions inside the detector ITk volume.
- Operation of the TDAQ SysAdmin and Network, Muon ConfigDB in the Control Room
- Detector Lab – Micro-Megas NSW.

On the physics analyses side, the following analyses are or have been pursued:

- Top quark mass measurement utilising leptonic J/ψ decays.
- Higgs boson production in association with a W/Z boson, with the Higgs decaying to two bottom quarks.
- New Physics searches via the study of top electro-weak couplings in rare processes (ttW, tWZ)
- Boosted Heavy Neutrino Search.
- Dark and semi-visible jets: unusual signatures emanating from strongly interacting dark sector.
- Anatomy of the multi-lepton anomalies.
- The Higgs Portal to the Dark and or Hidden sector for example $H \to Z_d Z_d \to 4e, 4\mu, 2e2\mu$, $H \to \gamma\gamma_d$

Acknowledgments

The authors would like to thank Abdeslam Hoummada, Peter Jenni and James Keaveney for the fruitful discussions and feedback.

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Experiment	Institution	Country
ANTARES	Faculté des Sciences, Université Mohammed 1, Oujda	Morocco
ANTARES	Faculté des Sciences, Université Mohammed V, Rabat	Morocco
ANTARES	Faculté des Sciences Semlalia, Université Cadi Ayyad, Marrakech	Morocco
KM3Net	Faculté des Sciences Semlalia, Université Cadi Ayyad, Marrakech	Morocco
KM3NeT	Faculté des Sciences, Université Mohammed 1, Oujda	Morocco
KM3Net	Faculté des Sciences, Université Mohammed V, Rabat	Morocco
KM3Net	Universities of Johannesburg/Witwatersrand/North-West	South Africa
DUNE	The University of Antananarivo	Madagascar
ATLAS Morocco Cluster	Faculté des Sciences Ain Chock, Université Hassan II, Casablanca	Morocco
	Faculté des Sciences, Université Ibn-Tofail, Kénitra	Morocco
	LPHEA, Faculté des Sciences Semlalia, Université Cadi Ayyad, Marrakech	Morocco
	LPMR, Faculté des Sciences, Université Mohamed Premier, Oujda	Morocco
	Faculté des sciences, Université Mohammed V, Rabat	Morocco
	Mohammed VI Polytechnic University, Ben Guerir	Morocco
ATLAS South Africa Cluster	Department of Physics, University of Cape Town, Cape Town	South Africa
	Department of Mechanical Engineering Science, University of Johannesburg	South Africa
	University of South Africa, Department of Physics, Pretoria	South Africa
	iThemba Labs, Western Cape	South Africa
	University of South Africa, Department of Physics, Pretoria	South Africa
	University of Zululand, KwaDlangezwa	South Africa
	School of Physics, University of the Witwatersrand, Johannesburg	South Africa
ATLAS Technical Associate Institute	Ecole Nationale Supérieure d'Informatique (ESI)	Algeria
CMS	Academy of Scientific Research and Technology, Cairo	Egypt
CMS	Center for High Energy Physics (CHEP-FU), Fayoum University, El-Fayoum	Egypt
ALICE	iThemba LABS, Universities of Cape Town/Witwatersrand	South Africa

Table 1: Overview of ongoing High Energy Physics activities and institutions in Africa.

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Submitted to the Proceedings
of the African Conference on Fundamental and Applied Physics
Second Edition, ACP2021, March 7–11, 2022 — Virtual Event

ASFAP summary report: Particles and their Applications

María Moreno Llácer[a,*]

[a] *Instituto de Física Corpuscular (IFIC), Centro Mixto Universidad de Valencia - CSIC, Valencia, Spain*

Abstract

The Second Biennal African Conference on Fundamental and Applied Physics (ACP) took place in March 2022. The scientific program included three summary reports on the African Strategy for Fundamental and Applied Physics (ASFAP). Here, the summary report of "Particle Physics and related applications" groups (Particle Physics, Nuclear Physics, Medical Physics, Astrophysics and Cosmology, Fluid and Plasma, and Complex Systems; and the cross-cutting fields: Accelerators, Instrumentation and Detectors, Computing, and Nuclear Energy) is presented. The scope of each of the groups, the events organised so far and their upcoming activities are summarised.

Keywords: The African Conference on Fundamental and Applied Physics, ACP, the African Strategy for Fundamental and Applied Physics, ASFAP, Particle Physics, Nuclear Physics, Medical Physics, Astrophysics and Cosmology, Fluid and Plasma, Complex Systems, Accelerators, Instrumentation and Detectors, Computing, and Nuclear Energy

1. Introduction

The scientific program of the Second Biennal African Conference on Fundamental and Applied Physics (ACP2021), that took place online in March 2022 [1, 2], included three working sessions with three summary reports on the African Strategy for Fundamental and Applied Physics (ASFAP) [3]. ASFAP effort started in 2019, with the objetive to develop a strategy to increase African education and research capabilities; improve collaborations; and inform policymakers, stakeholders and international partners on the strategic directions likely to impact African advancement. For the development of such strategy, input was requested to the whole community (from all career stages and nationalities) as letters of interest (LOI). ASFAP has 16 Physics Working Groups and 6 Engagement Groups. Here, the summary of the report of the "Particle Physics and related applications" groups is presented. At the time of ACP2021, around 25-30 LOIs were submitted by these groups.

2. Particle Physics

The scope of the Particle Physics group is to:

- Contribute to build a network of Particle Physicists in Africa.

*Corresponding Author
Email address: maria.moreno.llacer@cern.ch (María Moreno Llácer)

- Push forward the ongoing activities and foster cooperations between African researchers for both Experimental and Theoretical physics.
- Address the possibilities of evolution and expansion of these involvements and drive future endeavors.
- Collect scientific inputs from the African Particle Physics community (in form of written LOIs) from subgroups, to provide a shared roadmap for the field (white paper).

The research experience of the groups in Africa involved in Particle Physics is very broad. On theoretical physics, there are groups working on radiative corrections in the Standard Model and beyond, perturbative unitarity and boundedness from below for scalar potentials and electroweak precision tests, Naturalness and Veltman conditions, Charged Higgs phenomenology and Vector like quarks. On the experimental physics side, there is expertise on physics analysis, beam tests, electronics development and remote operations.

Given the vast amount of topics covered by the group, four subgroups have been proposed (with two conveners for each, an experimentalist and a theorist):

1. "Fundamental constituents and forces" (Higgs physics; electroweak and beyond Standard Model physics; direct searches)
2. "Symmetries and composite structures" (flavour physics, charge-parity violation; strong interaction, hadron physics, heavy ions; indirect searches; neutron electric dipole moment)
3. "Light messengers" (neutrino physics: neutrino parameters, charge-parity violation, beyond Standard Model)
4. "Infrastructures"

The Particle Physics group organised the "First ASFAP Particle Physics Day" in November 2021 with more than ten contributions from different groups around the whole African continent. It was an online event and it included reports from institutes working on the different experiments (ATLAS [4], CMS [5], ALICE [6] and LHCb [7]) of the Large Hadron Collider [8] at CERN, as well as reports from DUNE experiment on neutrino physics and theory groups, as shown in Figure 1. The next event is planned for Spring 2022: "the ASFAP Particle Physics PhD and postdocs day". So far, 7 LOIs have been received.

Figure 1: Covers of some of the presentations of XXX

The presence at CERN of the Particle Physics group is quite relevant, with involvement in experiments either as full members or associate (ATLAS, CMS and ALICE); also training opportunities in LHCb and computing WLCG. During the conference, it was pointed out several times that collaborations at CERN are very open, and the international laboratory is welcoming further participation of African physicists and groups. CERN can offer exciting science and training opportunities in an international context. Such networking also within Africa would also be highly beneficial.

3. Nuclear Physics

The first mini-workshop organised by the Nuclear Physics group took place in March 2022 with four contributions: i) "ASFAP introduction"; ii) "Nuclear Physics Activities at BIUST"; iii) "The Pan African Virtual Nuclear University"; and, iv) report from a student "Tanzania: challenges facing nuclear physics research (lack of suitable and qualified personnel, laboratory equipment for nuclear research, etc.)". It followed with a discussion session in which few relevant aspects were brought-up, such as the need for a training session on Geant4 program (a nuclear and particle physics simulation software). So far, 4 LOIs have been received: three on experimental facilities and one about education and training.

4. Nuclear Energy

The energy situation, which is very worrying in Africa, is evidenced by the absence, in most countries, of energy policies based on energy development master plans in the short, medium and long term. The "Energy" working group includes energy for a broad range of needs in Africa. It covered nine topics, "Nuclear Energy" is one of them. Such subgroup includes nuclear reactors, micro reactors, civil nuclear, synchrotron and fusion physics.
The objectives of the Energy working group are to:

- Strengthen cooperation/relations between African researchers and other actors in energy.
- Identify scientific communities working in the field of energy, energy efficiency and sustainable development.
- Create a dynamic of exchange and sharing of knowledge and know-how between academics and experts.
- Have an overview and mapping on the research and innovation in energy area around Africa.
- Facilitate the collaboration between researchers working in same topics.
- Facilitate and encourage researchers to participate in the ASFAP project in an active manner and submit LOIs.

The first meeting of this working group took place in February 2022 with contributions on the different kind of energies and regions in Africa. A second event is planned and, so far, 16 LOIs have been received.

The concrete scope of the "Nuclear Energy" subgroup is:

- *Nuclear reactors*: Define and locate the African position on research and future of nuclear energy
- *Micro-reactors*: Research on the application of nuclear energy in health and civil fields
- *Civil nuclear*: Training and development in nuclear energy
- *Synchrotron*: Training and development in synchrotron techniques
- *Fusion physics*: Sharing information+results with actors and researchers in the field

5. Medical Physics

The Medical Physics group organised its first mini-workshop in December 2021 with an overview of ASFAP mission and contributions from the International Atomic Energy Agency (IAEA), the Federation of African Medical Physics Organizations (FAMPO), and the platfrom Global Health Catalysts (GHT). Now, the focus is on bringing all Medical Physics Organisations together through FAMPO. One of the next meetings will be devoted for a joint sesion of the Medical Physics, Nuclear Physics, Energy and Instrumentation groups.

6. Astrophysics and Cosmology

The first mini-workshop of the Astrophysics and Cosmology group took place in November 2021, with more than 110 people involved (people from 21 countries in Africa and from 14 countries in Europe, South America and Asia). This working group is subdivided into different subgroups: solar physics; solar system, planetary sciences, astrobiology; stellar astronomy; galactic and extragalactic astronomy; cosmology and gravitational astronomy; transients and pulsars; high-energy astrophysics and astro-particle physics; astronomical instrumentation and infrastructure; astronomical methods and data; ethno-archeoastronomy (cultural astronomy); and astronomy for development. Close to 65% of the participants are men and 35% women.

The conveners of the working group have presented ASFAP initiative at more than 20 international conferences, and also distributed information about it among different networks and e-mail lists such as the African Astronomical Society, the African Network of Women in Astronomy, and Astronomy in Africa.

The plans for the upcoming months are: i) to start with regular meetings under each subgroup; ii) discuss about received LoIs and promote submission of new ones so that all topics are covered; iii) start shaping the White Papers; iv) discuss connections with other ASFAP working groups.

During the ACP2021, the second call for applications (schoolarships) of the Pan African Planetary and Space Science Network (PAPSSN) was advertised.

7. Fluid and Plasma

The Fluid and Plasma Physics group presented its strategy and initiatives in the ASFAP Town Hall meeting from July 2021. The focus on the group is on: i) non-thermal plasma generation (affordable low-cost methods); ii) environmental applications; iii) water purification; iv) disinfection; v) plasma agriculture (plasma-activated water); vi) plasma medicine; and, vii) aerospace applications. The role of plasma science and technology in enabling/augmenting new processes and applications is really broad, but it also faces grand challenges (infrastructure development, local technologies, education, etc.). Additional person power in this working group would be very benefitial.

8. Complex Systems

The Complex Systems includes theoretical groups working on applied mechanics such as biomechanics, solid mechanics, micro- and nano-structures dynamics, dynamical systems, and computer modeling. The work strategy includes these work-packages: WP1) identify the working groups in Africa and African scientists in the field all over the world; WP2) send out invitations and keep advertising to embark more people; WP3) form workgroups, assign tasks and come out with an activity timetable. Person power in the group is quite limited, so additional contributions would be very benefitial.

9. Instrumentation and Detectors

The Instrumentation and Detectors Physics Group aims at promoting physics, development, design, implementation and evolution for a broad range of instrumentation and detectors applications in Africa. It is a transversal and multi-disciplinary group related to all physics groups. The goals of the group are: i) provide a coherent/flexible framework for efforts in instrumentation and detectors across Africa; ii) target groups: laboratories/centers, universities, pre-college; ii) bottom-up approach: individual and/or group collaborations; iv) encourage and help to submit LOIs; v) identify projects in instrumentation across countries, like shared facilities; vi) useful and meaningful efforts with tangible results; vii) cost effective implementation.

The first meeting of this working group took place in November 2021, with the goal to help the submission of LOIs by collecting and structuring information on existing facilities and projects in instrumentation. The main purpose of the meeting was to identify the most important future needs with respect to instrumentation in all fields of physics in Africa.

From a survey and listening to talks at ACP2021 and other meetings, it was concluded that the main problem that experimental researchers are facing is the need for experimental facilities and educational training centres in instrumentation for basic and applied experimental physics.

Starting from existing LOIs and discussions at ACP2021, the conveners of the group have approached the LOI's authors directly and encouraged concretisation on the plans. They also discussed a very interesting proposal for a "International Centre for Experimental Physics in Africa (ICEPA)", common LOI of Instrumental and Physics Education working group. The idea is inspired by African Institute for Mathematical Sciences (AIMS) and other educational centres like Southern African Institute for Nuclear Technology and Sciences (SAINT). It will consist on a master-like curriculum typically one and a half year, including 6-month research project. It will include high-level lectures ($\leq$50%) and hands-on experiences ($\geq$50%), with a final examination and recognised diploma (association to university required in such case). The proposed educational training centre is similar to AIMS, but for experimental physics, strongly oriented towards instrumentation. Experimental installations and/or facilities will be installed at such a centre.

10. Computing and 4$^{\text{th}}$ Industrial Revolution

The Computing and 4$^{\text{th}}$ Industrial Revolution group is also a transversal one. In order to identify the needs for computing in the science community a survey was opened. The group covers a abroad range of topics: data science, (deep) machine learning, artificial intelligence, quantum science and technology, distributed computing, distributed analysis, computational physics, African infrastructure for networks and cloud services, e-learning, high performance computing, open source software, internet and bandwidth capacities, data centers, governance and policy, etc. This working group is co-organizing "International Conference on Data Science, Machine Learning and Artificial Intelligence" conference, in collaboration with Namibia University of Science and Technology (NUST). The current status of this working group is described in Ref. [9].

11. Accelerators

Accelerators is also a transversal working group, in connection with other groups such as Particle Physics, Nuclear Physics, Medical Physics and Radiation Biophysics, Material Science, Astrophysics and Cosmology, and Instrumentation and Detectors. The conveners started collecting a list of all existing facilities in Africa. This was not that trivial, as some of them cannot be found online, and there is also lack of information about the research that is being done in those facilities. Another challenge is the fact that the Accelerator community in the African continent is very small due to lack of facilities where young people can be trained. Thus, before thinking of building more facilities on the African continent, the African youth needs to be trained with necessary skills. iThemba Laboratory for Accelerator Based Science (LABS) in South Africa has recently been appointed as a collaborating center for IAEA. They are planning to host a training based on Electrostatic Accelerators which will take place in December 2022 at iThemba LABS. The training will target the audience from facilities in Africa to address the lack of skills in operation and maintenance. This initiative is a crucial starting point on this collaboration which will have a huge impact on the field of particle accelerator in African continent.

12. Conclusions

The summary of the report of the Particle Physics group and related applications of ASFAP at ACP2021 is presented here. It would be great to profit from the momentum of the conference and carry on with the planned activities and submit more LOIs. It is essential to establish connections among the different African groups, and also synergies among the different working groups are also very important. Joint meetings/workshops and even liasions among the different groups are encouraged. In case there is no national-level Physics Society, the idea of appointing national contact points could be considered. If any institute or university wants to get involved in the experiments at CERN, please get in touch with the ASFAP Steering Commitee. CERN makes cooperation agreements with governments once there is a solid basis of scientific cooperation.

Acknowledgments

The author would like to thank the ACP2021 Organizing Committee and the ASFAP Steering Committee for their initiative.

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Submitted to the Proceedings
of the African Conference on Fundamental and Applied Physics
Second Edition, ACP2021, March 7–11, 2022 — Virtual Event

Physics Education for Capacity Development and Research in Africa

Sam Ramaila

University of Johannesburg, South Africa

Abstract

The acceleration of socio-economic development is intrinsically linked to the level of scientific development. While the existing scientific interventions within Africa played a transformative role in the enhancement of human capital development, adequate investment in research and development is required to make further significant strides going forward. Unlocking Africa's potential requires sustained investment in research and development. However, inadequate expenditure in research and development as a percentage of gross domestic product by African countries does not augur well for the progressive realization of sustainable scientific development. This contribution highlights challenges afflicting physics education in Africa and provides a reflection on key areas for intervention to strengthen capacity building. Critical interrogation of enablers and constraints is required in order to harness the efficacy of capacity building efforts with a view to engender fundamental transformative change in relation to meaningful enhancement of human capital development in Africa. Reconfiguration of the existing scientific interventions some of which yielded remarkable results remains a key strategic imperative in the long to medium term. Progressive realization of this key strategic imperative hinges to a large degree on the establishment of collaborative partnerships involving African key stakeholders. Contextually appropriate recommendations for coherent acceleration of scientific development within the broader African context are advanced.

Keywords: Physics Education, capacity building, scientific development, scientific interventions, transformative change

1. Introduction

Capacity development and sustainable scientific development in Africa are plagued by existing pervasive fundamental challenges. These challenges include lack of requisite facilities to conduct research at many African institutions and universities, inadequate engagement by physicists in research and academia, low doctoral enrolment and graduates, low research publications as well as paucity of research institutes and industry which limits job opportunities for physicists to teaching in secondary schools and universities [1, 2]. There is a critical need to put appropriate scientific interventions in place which are essentially geared towards the improvement of the quality of physics education in Africa. In response to this key strategic imperative, the Association of Commonwealth Universities (ACU) and the Institute of Physics (IOP) created an evidence base for a potential multi-year programme to improve physics training, research, infrastructure and collaboration in nine countries in Sub Saharan Africa [3]. These countries are Ethiopia, Ghana, Kenya, Malawi, Nigeria, Rwanda, South Africa, Tanzania and Uganda. This enormous undertaking represents a significant step towards strengthening physics education for capacity development and research in Africa.

* Corresponding Author
Email address:ramailasam8@gmail.com (Sam Ramaila)

2. Capacity development and research

Physics education provides a solid basis for progressive realization of capacity development and robust pursuit of scientific research in Africa. However, a range of interventions are required to strengthen human capacity development. Strengthening human capacity development should be predicated on clearly identified key areas for intervention. Key areas for intervention identified by the Association of Commonwealth Universities and Institute of Physics include gender inclusivity, training and education, academic and staff capacity, innovation and commercialization as well as collaboration and networks [3]. The under-representation of women in physics remains a major structural problem in Africa. Physics training and education ought to foster the inclusion of women as an integral part of capacity development. In addition, African universities need to create opportunities for establishing vibrant partnerships that promote collaborative construction of scientific knowledge. The advent of the Fourth Industrial Revolution provides enormous opportunities for African universities to embrace digital transformation with a view to foster innovation and commercialization.

3. Unlocking Africa's potential through physics education

Physics education has the potential to play a pivotal role in unlocking Africa's potential. Sustainable pursuit of scientific research in fundamental and applied physics requires highly skilled physicists. By its very nature, effective physics education can be harnessed as a vital means to train the next generation of physicists required to unlock Africa's potential. Other creative mechanisms identified to unlock Africa's potential include addressing Africa's inability to fill positions in physics fields, critical reflection on future aspirations and the role of physics education, and rethinking the role of teachers and other stakeholders in physics education [4]. Filling positions in physics fields in Africa remains a perennial challenge which stems from existing limited critical mass of available physicists. This perennial challenge stifles Africa's global scientific competitiveness.

4. Existing interventions promoting scientific development in Africa

There is a number of existing interventions promoting scientific development in Africa. The South African Institute of Physics (SAIP) coordinates a Teacher Development Project which is primarily aimed at teacher professional development in South Africa [5]. The project program is accredited by the South African Council for Educators (SACE). SACE is the professional council for educators that aims to enhance the status of the teaching profession through appropriate registration, management of professional development and inculcation of a Code of Ethics for all educators [6]. Teachers' participation in the SAIP Teacher Development Project enables them to accumulate Continuous Professional Development (CPD) Points which are essential for career enhancement. The National Astrophysics and Space Science Programme (NASSP) is another existing intervention that promotes scientific development in Africa. NASSP is a multi-institutional initiative funded by the Department of Science and Innovation through the National Research Foundation to train South African students in

Astrophysics and Space Science at Honours and Master's levels and to provide a pipeline to PhD studies in these and related research areas [7]. At another pragmatic level, the African Union (AU) established Innovating Education in Africa Initiative in 2018. The initiative is aimed at identifying, promoting and supporting the systemic adoption and replication of education innovations in all aspects of education and training in Africa, fostering policy dialogues with policy makers and development stakeholders to make the case for embedding innovation in education systems in Africa and endorsing the implementation of the continental programme [8]. As a dynamic and vibrant scientific intervention, the African School of Fundamental Physics and Applications made significant strides in human capacity development in Africa since its inception [9]. This monumental achievement is evidenced by a substantial number of students from various African countries who benefited immensely through active participation in this scientific intervention. The success achieved through the implementation of the aforementioned scientific interventions underscores the need for more interventions to be put in place across the African continent with a view to unlock Africa's potential.

5. Attraction and retention of students in Physics

Concerted efforts are required to attract and retain students in Physics. Attraction and retention of students in Physics can be realized through adoption of appropriate and sustainable mechanisms. These mechanisms may include:

- Assessing the quality of students entering African universities.
- Rethinking student under-preparedness for higher education.
- Assessing the state of undergraduate physics teaching and learning in African universities.
- Developing a set of standards for Physics training in Africa.
- Assessing levels of commonality and diversity of the physics programmes in Africa.
- Assessing range, scope and effectiveness of current teaching and learning practices in Physics at African universities.
- Developing a set of contextually appropriate recommendations aimed at improving the effectiveness of Physics teaching at African universities.

6. Recommendations

Scientific development remains a key strategic imperative in Africa. Coherent realization of this imperative ought to be informed by contextually appropriate recommendations. The following proposed recommendations are advanced to inform scientific development within the broader African context:

- There is a need for enhanced coordination of existing scientific interventions.
- Regular assessment of the impact and efficacy of existing scientific interventions is imperative.
- There is a need to go beyond capacity building to track and monitor the progress made through coherent implementation of existing scientific interventions.

- Active involvement of African key stakeholders in scientific development is imperative.
- Enhanced coordination of African efforts aimed at acceleration of meaningful scientific development is absolutely essential.
- It is imperative for African universities to embrace evidenced-based physics education research that fosters adequate exposure to plurality of knowledge epistemologies.
- Increased investment in scientific development is crucial for unlocking Africa's potential.
- Better funding of African universities is a timely and necessary strategic intervention.
- There is a need to establish African scientific evaluation and monitoring committee.

7. Conclusion

Physics education is crucial for the acceleration of socio-economic development in Africa. Strengthening physics education remains a key requirement for capacity development and sustainable pursuit of scientific research within the broader African context. Existing scientific interventions ought to be sustained and augmented to ensure skills development through active involvement in physics education activities. African countries face the key imperative to address inadequate expenditure in research and development as a percentage of gross domestic product with a view to facilitate sustainable scientific development in its broadest sense.

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Projects

1. Review of Physics Education System in Africa

Jesutofunmi Fajemisin
PhD Student,
Department of Physics,
University of South Florida, Tampa, Florida, USA.
&
University of Ibadan, Ibadan
Nigeria

Toivo Samuel
MSc Student
Department of Physics
University of Pretoria, Pretoria, South Africa.
&
Eduardo Mondlane University,
Mozambique

2. Peer Assisted Physics Learning, PAPL

Jesutofunmi Fajemisin
PhD Student,
Department of Physics,
University of South Florida, Tampa, Florida, USA.

Review of Physics Education System

Introduction

The education system of a country is defined by the teaching methods, learning environment, government policies, assessment technique adopted in the country. It is of great importance to know how the education system differs from country to country in Africa. If the mode of teaching physics in Togo is different from Nigeria even though they are both West African countries, then we should be curious to know the possible factors responsible for this and how does this difference affect the quality of the result achieved. A perfect understanding of the education system of a university will affect our expectations from students from the university. This review will be of greater importance to the development of research in Africa. We proposed that we have a database of information about all the available research areas and resources in every university in Africa and a centralized grading evaluation system that accounts for the uniformity in the grading system.

A short survey was conducted. Here is a list of the questions that were asked:

1. Country
2. Official Language of Communication in schools
3. Area of specializations that are available in your institution.
4. Undergraduate & Postgraduate
    a. Grading scale
    b. What grading scale is adopted in your institution (letter grade, point grade, …)
    c. What percent grade does each letter/point grade represent.

71 responses were received from 19 countries – Benin, Burkina Faso, Cameroon, Democratic Republic of Congo, Egypt, Ethiopia, Germany, Ghana, Italy, Kenya, Rwanda, Madagascar, Mozambique, Morocco, Nigeria, Senegal, South Africa, Tanzania and Tunisia. We deduced the following points:

- Every field in physics is significantly represented in Africa universities.
- Official languages in the education system in Africa are English, Swahili, French, Portuguese, Spanish (Equatorial Guinea) and Arabic.
- Grading scale ranges from a scale of 4.0 to 20.0

As an illustration, we compared in detail the differences in the education system of Nigeria and Mozambique. Note that Nigeria and Mozambique were colonized by Britain and Portugal and that the language of communication in schools were English and Portuguese respectively.

- **Question - What is the name of your department?**

  Nigeria – Department of Physics, University of Ibadan, Nigeria

  Mozambique – Department of Physics, Eduardo Mondlane University, Mozambique

- **Question** – **What is the official language?**

  Nigeria – English

  Mozambique – Portuguese

- **Question - What is your grading system?**

  Nigeria – 4.0

  A=70-100
  B=60-69
  C=50-59
  D= 45-49
  F=0-44

  Mozambique – 20.0

  A = 15-20

  B = 12-14.99

  C = 10-11.99

  F = 0-9.99

- **Question - Do you have to write exams every semester?**

  Nigeria – Yes. It is compulsory for every student to write exams every semester on the theory courses. Practical courses are graded using the report submitted for each lab session. The exam duration is between 2-3 hours.

  Mozambique – Students must write exams every semester and the exams are theoretical and practical depending on the subject. Duration for written exams is 90 min.

  Also,

  i. Students with cumulative point of 0-9 are excluded from the exams and have failed automatically.

ii. Students with 10-13 points before exam are allowed to write the exam and the final point is the average between the point before and the grade in the exam.

iii. Students with an average of 14-20 are excused from the exam and pass to the next level.

- **Question - Tell us about the undergraduate research program?**

  Nigeria – After completion of coursework, students are assigned supervisors by the department. The supervisor guides the student either in his research interest or a suggestion from the student. The result of the research is defended to the academic committee. Duration is 2-3 months.

  Mozambique – After completion of course work, students must choose one of the forms of assessment:

  1) State exam
  2) Degree thesis

  In the state exam, Students are divided into groups and each student is to present a literature review of a particular topic assigned by the group. The student is graded by his ability to understand the concepts and answer questions. Duration is one month.

  In the degree thesis, A student is assigned a supervisor and a complete research work is defended to the committee. Duration is 6 months.

Recommendations

1. **A Book/Database that contains information about the education system of each university in Africa.**
   We propose a collection of information from all the departments of physics in all the universities in Africa. This collection can be in a book form or online database or both. The information includes the following:
   - Syllabus
   - Areas of Specialization
   - Experimental and Computational Resources
   - List of Lecturers and their research interests
   - Grading system
   - Contact information – Email, website link, etc.

A one stop information of all the universities in Africa will strengthen collaboration among African scientists as well as exchange programs within African universities. The awareness of the location of certain experimental and computational resources will be achieved without the informal networking we are used to. Also, universities outside Africa will build more trust in African student's foundation since they can easily access information about the background.

2. **Certified Africa Uniform Evaluation System**

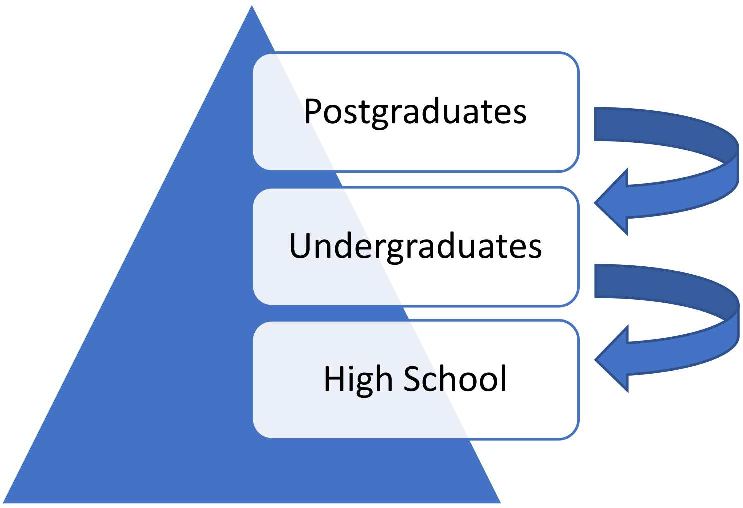
   Due to the diversity in the grading system across universities in Africa, we propose we have a certified evaluation system designed by Africans for Africans. Any transcript regardless of the grading scale can be converted to a standard scale that is accepted worldwide. There are a lot of commercial websites that African students are subjected to use by American and Canadian universities to convert their grading scale to their standard. It is unfortunate that these website creators have no detailed information about our education system and there is a high possibility of bias in their computation.

Peer Assisted Physics Learning PAPL

Peer Assisted Physics Learning, PAPL, is a learning loop that connects physics students at all levels (from high school to postgraduate levels). It's a structure that helps students learn without pressure under the supervision of a higher-level student leader. Undergraduate students at several African colleges are taught to teach in high schools in their unique surroundings. Similarly, African postgraduate students in Africa and the diaspora will support undergraduate students in their studies virtually and in-person. Our goal is to bridge the gap between these levels of education and to encourage students to pursue STEM courses. Peer Assisted Learning is an approach that has been used successfully by several colleges across the world. The "Supplemental Instruction" (SI) concept was developed in the 1970s at the University of Kansas City, Missouri. The Peer Assisted Study Support (PASS), Peer Assisted Learning (PAL), and Peer Assisted Study Sessions are some of the variations of Supplemental Instruction (SI)[1,2]

Peer Assisted Physics Learning, PAPL is divided into two phases:

1. High School Phase
2. Undergraduate Phase



High School Phase

Undergraduate volunteers at different levels are trained to teach for two hours each week in high schools (with a focus on public schools). For each topic, a (canvas, Moodle) module is created, and each volunteer is required to follow the module in order to ensure consistency of understanding across schools. An agreement will be reached with the high school administration to incorporate PAPL into their program. When every school has access, volunteers will be allocated to schools based on their proximity to their university or residential location. The lecture modules span from theoretical to practical and simulations, depending on the situation.

For efficiency and encouragement, it is recommended that volunteers be paid monthly a sum sufficient to cover their transportation and lunch for each session. This will enable some of them to take care of themselves and remain committed to the vision's goals.

Students will be split into groups for problem solving and lab sessions, making PAPL class sessions more interesting and dynamic. We will allow them to teach one another in order to encourage teamwork as a life skill.

Undergraduate Phase

The rate at which Africans are leaving the continent is concerning, and we must consider how to transform brain drain into gain. PAPL allows postgraduate students in the diaspora to contribute back to the continent. The undergraduates and postgraduates will form a mentor-mentee connection (home and abroad). This will help to solve the issue of students leaving STEM fields. The mentor's responsibility is to support the mentee in their academics, give required resources and guidance on difficult courses, and teach them virtually or in-person if necessary. They will also be dedicated to bringing out the best in them without passing judgment. If necessary, they can recommend them to a therapist.

Evaluation

Students will be assessed once a year. We will hold a centralized test that will be required of all PAPL students. The best pupils will be recognized, while the average and others will be given extra attention and supported to grow. They will not be ignored because the goal of this program is to help them rather than to blame them.

Committees

Different committees will be set up to help with the structure of the program.

- Counselling
- Academic
- ICT
- Logistics

Conclusion

In summary, we propose a pan-African Peer Assisted Physics Learning system to mentor and guide students in STEM as well as to promote the involvement of the African diaspora in the academic development of young people in the continent.

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Submitted to the Proceedings
of the African Conference on Fundamental and Applied Physics
Second Edition, ACP2021, March 7–11, 2022 — Virtual Event

Physics Masterclasses in Africa and the World

Uta Bilow[a], Kenneth Cecire[b]

[a] *Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, 01062, Germany*
[b] *Department of Physics and Astronomy, University of Notre Dame, Notre Dame, 46556, Indiana, USA*

Abstract

International Masterclasses (IMC) enable high school students and teachers to work with particle physicists to analyze authentic data from contemporary experiments and experience being "physicists for a day". The IMC program has a worldwide reach, including several universities and research institutes in Egypt, Algeria, Morocco, Sao Tomé and Principe, and South Africa. As technical infrastructure in Africa improves, there is a great opportunity for many more African institutes to offer IMC on their premises. The authors will discuss the advantages of IMC to Africa, how institutes may join, and ways to overcome obstacles.

Keywords: The African School of Physics, ASP, The African Conference on Fundamental and Applied Physics, ACP, International Particle Physics Outreach Group, IPPOG, International Masterclasses, IMC, education, outreach, particle physics

1. Introduction

International Masterclasses (IMC) are experimental particle physics education and outreach events for high school students aged 15 to 19 years. In the IMC concept, students become "scientists for a day". They are invited to a research institute or a university, where they attend introductory talks on topics such as the Standard Model, detectors, and accelerators to help them prepare them to make their own measurements. Students analyze authentic data from an actual experiment to be able to answer a research question or to draw conclusions from the measurement. Currently, students at different masterclasses are engaged in measurements from the Large Hadron Collider (LHC) at Conseil Européen pour la Recherche Nucléaire (CERN), Belle II at Kō Energī Kasokuki Kenkyū (KEK), neutrino experiments at Fermilab, and particle therapy from Gesellschaft für Schwerionenforschung (GSI). The capstone of the masterclass is an international videoconference with 3-5 other masterclass institutes that have made measurements from the same experiment. [1] [2]

What makes this event a *masterclass* is the interaction of high school students and their teachers with the particle physicists who host and tutor the event. Most important, as students analyze data for their measurements, they interact with physicists to ask questions and clarify the meaning of the data. It is in this interaction that the physicists impart not only specific information but also their approach to understanding both the experiments and the results. One way to express the goal of a masterclass is to help students see data as scientists see data.

Email addresses: `Uta.Bilow@tu-dresden.de` (Uta Bilow), `kcecire@nd.edu` (Kenneth Cecire)

This paper is organized as follows. In Sections 2, we explain details of the masterclass day. In Section 3, we discuss goals, motivations, and requirements. In Section 4, we flesh out the opportunities from different "flavors" of masterclass. We conclude in Section 5 with an invitation to participate.

2. The Moving Parts

The masterclass day varies depending on the institute and time zone but generally follows a plan similar to this Sample Agenda:

Local Time	Activity
(prep)	(classroom)
09:00-09:30	registration and welcome
09:30-10:30	introduction to particle physics
10:30-11:30	second talk or tour
11:30-12:00	introduction to measurement
12:00-13:00	lunch (with physicists)
13:00-15:00	data analysis
15:00-16:00	local combination of results and discussion
16:00-17:00	international videoconference

The international videoconference has the following key features:

- 45-60 minute duration
- 3-5 institutes, reflecting international collaboration (where possible)
- Same measurement, different data
- 2-3 moderators (physicists, graduate students)
- moderation centers: CERN, Fermilab, KEK, GSI, TriIniversity Meson Facility (TRIUMF)
- Agenda of videoconference:
  - welcome
  - combination and discussion of results
  - general Q&A
  - quiz (CERN).

[1] [3]

3. Why and What

Why do we facilitate and promote International Masterclasses? Why do physicists invest their time and efforts in them? IMC is a way to help start development of the next generation of scientists and engineers by giving young learners a real experience with cutting-edge science. In the same way, IMC promotes interest in science among all students. Visiting a university or laboratory where they work side-by-side with physicists near their homes as well as international collaborators, high school students have the chance to participate in the excitement of contemporary physics research. Teachers who bring students to masterclasses year after year often develop their own expertise and interest that can enhance their instruction in the classroom.

To host a masterclass, local organizers need to secure space to work with students and computers with high-speed internet (unless the masterclass is local only). All masterclass packages are web browser-based (although some need installation of Java and software, e.g. event display). All masterclass packages are available for educational purposes without cost. The physicist leadership of the masterclass should consist of an organizer, at least one tutor for each ten students, coordination with IMC, some flexibility to deal with local conditions and unforeseen problems, and a welcoming attitude.

4. Opportunities

The masterclasses described so far have been from the IMC "regular season". These are the mostly standard full masterclasses that occur each year from February to April and are coordinated by IMC central. However, there are additional opportunities that arise each year.

World Wide Data Day (W2D2) is a one-day simplified masterclass event held in November or December each year. W2D2 measurements are from the ATLAS and CMS detectors in the LHC and can be completed in about two hours, from introduction to videoconference end. High school teachers organize W2D2 measurements at their own schools and connect their students to physicists in the videoconferences, which occur in a day-long "shift". [4]

IMC also holds special masterclasses for the International Day of Women and Girls in Science on 11th February each year. These are much like standard masterclasses but are designed to especially benefit young women with female scientists as role models and discussions of women in physics. [1]

In addition, any organizers can host masterclasses anytime of the year, in or out of the IMC schedule. IMC gives these initiatives support upon request and many institutions, from universities and laboratories to high schools, have successfully created meaningful particle physics masterclasses opportunities for students.

IMC is open to alternative designs of masterclasses as needed by local organizers. There have been masterclasses for university physics students, masterclasses as outreach activities in conferences, and many more examples.

5. Conclusion and Invitation

International Masterclasses have spread to countries all around the world. Africa is part of IMC but there is great room for mutual growth and enrichment for high school students and teachers between IMC and physicists in Africa. Some of these opportunities include masterclasses already described, adaptations to make the masterclasses more appropriate in the local context, and masterclasses redesigned for African physics experiments, such as HESS or the African Light Source.

The authors invite physicists and graduate students in Africa and the world to think about organizing a masterclass, tutoring in a masterclass, becoming a videoconference moderator, or even creating a new masterclass measurement. The authors, as co-Coordinators of International Masterclasses, are eager to help.

References

[1] International Masterclasses, https://www.physicsmasterclasses.org/.

[2] Uta Bilow, Kenneth Cecire., Current Status of International Particle Physics Masterclasses, https://doi.org/10.22323/1.390.0937 (2020).

[3] LHC Masterclasses Project Map 2022, https://quarknet.org/content/lhc-masterclass-library-project-map (2022).

[4] World Wide Data Day, https://quarknet.org/content/world-wide-data-day (2022).

Status of ASFAP Women in Physics working Group Activities

Introduction

Women in Physics forum is a working group of ASFAP which involves women and men from different corners of the world having the spirit to help out with the gender inclusivity in the field of Physics as women are still few in this field when you compare this to men's involvement. There is a need to put together strategies to fill this gap.

It is acknowledged that there is a low number of women in the field of Physics and there are challenging working conditions that women face. Women spend more time performing unpaid work, such as childcare and housework, than men. This is a serious problem for the global scientific community in general.

Women are also clearly underrepresented in fields related to science, engineering, manufacturing and construction. Coming to more advanced degree programmes, especially in science-related fields, women are fewer than men, which is the case in research as well. Recently, women account for 30 % of all researchers, a remarkable increase compared to previous decades, but still far from parity. An estimated 781 million people aged 15 and over remain illiterate, worldwide. Nearly two thirds of them are women, a proportion that has remained unchanged for two decades. Illiteracy rates are highest among older people and are higher among women than men. In Oceania, Sub-Saharan Africa and Southern Asia, between 30 and 55 per cent of employed women are contributing as family workers, about 20 percentage points higher than men in the same regions. This situation is not different to what we have in most African countries.

Why Women in Physics Forum?

The objective of Women in Physics Forum (WPF)[1] is to alleviate the lack of the African women participating in Physics. WPF has plans to collect ideas, opinions, career paths, working experiences and scientific research of women in physics in Africa continent in order to have a reach database that we can refer ourselves to. Furthermore, the forum is mandated to clearly identify and raise awareness on challenges and science career opportunities for women in Physicists in Africa and advocate for change by informing policymakers for action.

The aim of this report is to summarize the discussion of the ASFAP Women in Physic Forum working group. The recommendations for future activities in WPF are summarised in the report as well. Please

[1] https://twiki.cern.ch/twiki/bin/view/AfricanStrategy/AfWomenInPhysics

note that WPF working group of the ASFAP has not made great progress over the duration of the year, but a few has been done.

Women in Physics Forum Past activities

The group has so far held one successful workshop on 11th February, when the group joined the whole world to celebrate the international day for women and girls in science. The theme of this virtual workshop was W***omen in different fields of Physics in Africa: challenges/needs, opportunities, current status and future perspectives***[2]. WPF also actively participated in the second edition of the African Conference on Fundamental and Applied Physics tagged ACP2021[3] and contributed by presenting on the status of Women in physics in Africa.

This working group is led by 3 co-convenors; after WPF was created in 2021, members met twice to plan for different activities including worships sessions to discuss among others insights into the challenges that the Women in physics in Africa encounter and the tools to overcome them. They also stressed on the strategies to adopt women to actively participate in the already existing programmes to enhance their visibility in physics and science at large.

On December 9, 2021, WPF got a chance to participate in Then AERAP Africa-Europe Science Collaboration Platform[4] in a session dedicated for Women's Movements in African Science, Technology, and Innovation: what are the right policy support instruments". This session aimed to give more visibility to different women's movements in the fields of science, technology, and innovation, and to get their recommendations regarding the needed policy support instruments.

WFR gave also a presentation on the Strategies to retain Women in Physics during a workshop organized by ASFAP: Young African Physicists' Challenges and opportunities on 24th January 2022.

Feedback from Workshop and working group discussions

It was noted that the **poor participation of women in science fields like physics** is one of the reasons the women in physics forum was initiated and this was the initiative of ASFAP steering committee.

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2 https://indico.cern.ch/event/1106203/

3 https://indico.cern.ch/event/1060503/

4 https://aerapeuafricasummit.sched.com/

Lack of female role models in the field of physics in Africa is one of the reason why we have few young females to pursue physics as their career. By organizing seminars where sharing successful stories of individual experiences and inspirational talks is part of the strategies to help the younger generation in building their confidences in these fields.

During WPF workshop, one of the speakers; Prof Diale the Professor at Pretoria University[5] shared her personal experience and extended her good will messages to the audience which included the target group – the young girls.

Another topic laid emphasis on how the Women in Physics forum can put into action the activities of ASFAP and the call for letter of interest, unfortunately, there was no LOI specific for this working group due to **lack of commitment**; something to change.

The visibility of women in Physics, especially Africans to inspire the future scientists in our continent still a problem, therefore one needs strategy to boost this and put women in Physics in Africa on the world map[6].

Lack of information has been one of the challenges hindering women to further their career in science. The solution to this is to share all the opportunities for Women in Physics as well as in STEM and links will be compiled and shared to all network.

Plan of WPF Working Group to mitigate the shortage of participation of African Women in Physics

- Inspiration of the young Women to consider Scientific Careers, potential progress, prospects, through outreaches programs where parents are also involved
- Mentorship program; women need mentors who are truly in their corner and networking initiatives within Africa and the international community
- Strengthening this working group and engage women in Physics in this forum to sensitize others to be part of it and be committed (to sit and discuss how to bring everyone to gather on the consensus of inclusivity in – Physics during breakfast meeting, workshops, seminars, etc.)
- To promote the recognition of the scientific achievements of senior women physicists (role models[7])
- Data Collection, regular survey to have a database of women in physics on the continents; **who is who**!

[5] https://www.up.ac.za/physics/article/2086799/mmantsae-diale

[6] https://mcusercontent.com/63e42c583930d9f7a8b637982/files/cb0d6039-0948-26d7-be00-0b5fea6492d1/2_African_Women_in_Physics.docx.pdf

[7] https://mailchi.mp/89398bfb8661/african-physics-newsletter_091521?e=e9b6fb4d4b

- Organize a seminar on the gender balance in the working place and the role played by men in this and on how to balance family and career in science for women to keep up momentum in her career
- To strengthen research efforts and training opportunities of young women physicists via information sharing of different opportunities
- To encourage women in Physics to be part of the decision-making positions
- To have new leadership to make the group active

Submitted to the Proceedings
of the African Conference on Fundamental and Applied Physics
Second Edition, ACP2021, March 7–11, 2022 — Virtual Event

Young Physicists Forum and the Importance for Education and Capacity Development for Africa

Benard Mulilo[a,*], Mounia Laassiri[b], Diallo Boye[c]

[a] *University of Zambia, Zambia*
[b] *Mohammed V University, Morocco*
[c] *Brookhaven National Laboratory, US*

Abstract

Higher education and advanced scientific research lead to social, economic, and political development of any country. All developed societies like the current 2022 G7 countries: Canada, France, Germany, Italy, Japan, the UK, and the US have all not only heavily invested in higher education but also in advanced scientific research in their respective countries. Similarly, for African countries to develop socially, economically, and politically, they must follow suit by massively investing in higher education and local scientific research.

Keywords: Young Physicists Forum, YPF, African Strategy for Fundamental and Applied Physics, ASFAP, Second Edition of the African Conference on Fundamental and Applied Physics, ACP2021, African School of Physics, ASP, Physics Working Groups, YPF-Survey

1. Introduction

In 2009, the United Nations Population Fund announced that the population of Africa had reached the one-billion mark and doubled in size in 27 years [1]. Regardless of the size and large pool of the human resource that the continent is endowed with, most African countries still continue struggling economically. Based on World Bank estimates [2], the proportion of Africans living on less than US$ 1.90 per day fell from 56% in 1990 to 43% in 2012. This indicates a positive improvement of 13% in the living standards of people in Africa though according to the World Bank Report [2], there were still more poor people in Africa in 2012 than in 1990 estimated to be more than 330 million up from about 280 million due to rapid population growth [1] that the continent has been undergoing over the years. Furthermore, despite poverty being a major problem in Africa [2], the continent also experiences deadly diseases such as the Acquired Immune Deficiency Syndrome (AIDS) caused by the Human Immunodeficiency Virus (HIV) believed to have originated from Africa [3, 4]; Ebola virus disease [5] whose fatality rate is around 50% with case fatality rates ranging from 25% to 90% in past outbreaks [5], and the recent outbreak of the COVID-19 pandemic [6], which has impacted negatively on Africa and the rest of the world. The continent also faces challenges of science and technology [7] with many African countries technologically

*Corresponding Author
Email address: `benard.mulilo@unza.zm` (Benard Mulilo)

depending on other continents for engineering, educational, agricultural, and health services, among others. African countries also face inadequate research-output capability or interest with Africa noted to generate only less than 1% of the world's research output [8] despite its increasing population [1]. Due to all these challenges and other factors, the continent has seen young, talented, skilled, and educated Africans leaving African countries in search for better opportunities overseas, a trend referred to as brain drain [9]. To overcome all these challenges and others, African countries should emulate the scientific, education, health, social, political, and economic policies of developed societies such as the Group of Seven (G7) 2022 countries: Canada, France, Germany, Italy, Japan, the UK, and the US [10], which have all massively invested in higher education, science, and technological advancements. The Young Physicists Forum (YPF) [11] was founded in 2021 by the African Strategy for Fundamental and Applied Physics (ASFAP) [12], amid the COVID-19 pandemic [6], to identify the major challenges that young physicists face and solutions thereof in order to positively contribute to the educational and local-scientific research on the continent, and thus, build capacity for Africa.

2. Young Physicists Forum

The Young Physicists Forum [11] is one of the engagement and physics working groups (PWG) under the African Strategy for Fundamental and Applied Physics (ASFAP) [12]. The forum is driven by three, young, and vibrant physicists who are co-conveners of the group all in possession of a doctor of philosophy in physics [11]. The co-conveners' mandate is, among other things, to ensure that the group remains sharply focused on its aims and objectives. The forum has a total of 65 active and registered members [11], most of whom are in possession of either a master of science degree or doctor of philosophy in physics. There is, however, no discrimination regarding the highest level of education YPF members [11] must meet and, therefore, all interested individuals within and outside the African continent are eligible to join the forum [11] as long as they sign up [11] and get approved by the steering committee of ASFAP [12]. The group also encourages bachelors students in various science disciplines, particularly physics, from various African universities to join the YPF [11] and enjoy the mentoring/scholarship benefits that YPF members share within the group, and thus increase their chance of embarking on postgraduate studies either within Africa or overseas. The Young Physicists Forum [11] reports to the steering committee of ASFAP [12] in a well organized structure as shown in Figure 1.

The aims and objectives of the ASFAP-YPF [11] are, among others, to collect ideas, opinions, and experiences on education, physics outlook, careers, workplace environment, and scientific research in Africa. Furthermore, the forum is mandated to clearly identify and raise awareness of the educational challenges and science career opportunities for young physicists in Africa and advocate for change by informing policymakers for action. Last, but not the least, the forum also aims at collecting preliminary data for future research. Since the group's inception in 2021, the Young Physicists Forum [11] has made tremendous progress in meeting its mandate (i.e., its aims and objectives) with the main modes of information dissemination being through scheduled meetings within the group and regular co-conveners' meetings, which are usually held on a weekly basis on Wednesday at 5:00 PM, Coordinated Universal Time (UTC). The forum has also formulated a survey [13] to

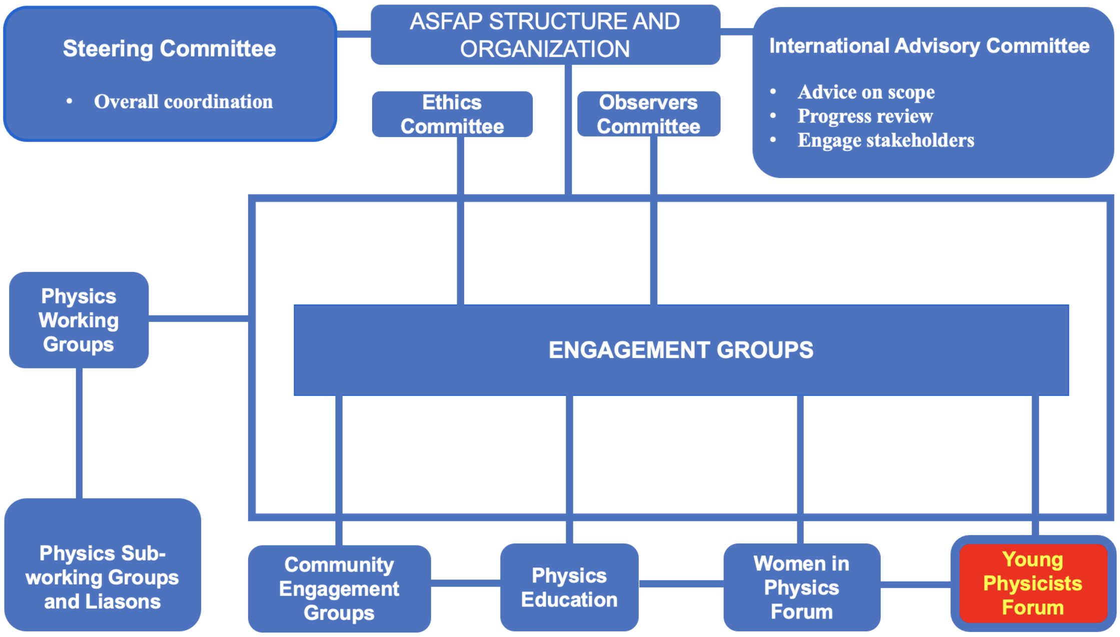


Figure 1: Structure and organization of the African Strategy for Fundamental and Applied Physics.

solicit for a wider community input of ideas. In addition, the group has so far held one successful workshop with stakeholders within and outside ASFAP [12] that was virtually conducted on 26th January, 2022 tagged *ASFAP: YPF-Challenges and Opportunities* [14]. The YPF [11] also actively participated in the second edition of the African Conference on Fundamental and Applied Physics tagged *ACP2021* [15] and contributed three talks under different themes mainly focused on the status and progress the forum has so far made in line with the aims and objectives of the group.

3. Challenges and Opportunities Survey

To solicit for a wider community input, the Young Physicists Forum [11] has opened a survey [13] to sample African respondents within and overseas, main of whom are alumni of the African School of Physics (ASP) [16]. The survey [13] is aimed at gathering information on the education background, research performance, collaboration opportunities, career development, and workplace environment of the respondents. Survey results [13] show that 79.56%, of the respondents pursued their highest level of education within Africa while 20.44% of the respondents attained their highest level of education outside the continent of Africa. The survey [13] has further revealed that of the respondents who attained their highest level of education within Africa normalized to 100%, only 39.42% were satisfied. Factors leading to the educational dissatisfaction rate by respondents are plotted in Figure 2 and outlined in Table 1. From Figure 2 and Table 1, it is evident that good quality education and research in Africa still remain a huge challenge. Other major obstacles of an African educational system include the lack of mentors, skills training, libraries, job insecurity, and to a lesser extent political instability such as wars, among others. Since education, science, and technology are ingredients that contribute massively to good life and development of the global economy, there is need to solicit for remedies that counter the education and research challenges that many African countries have been grappling with for years.

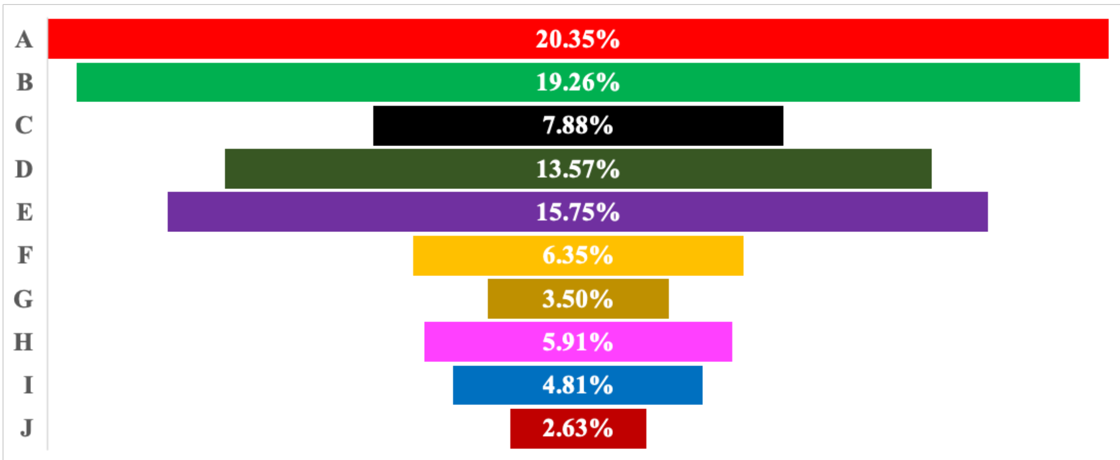


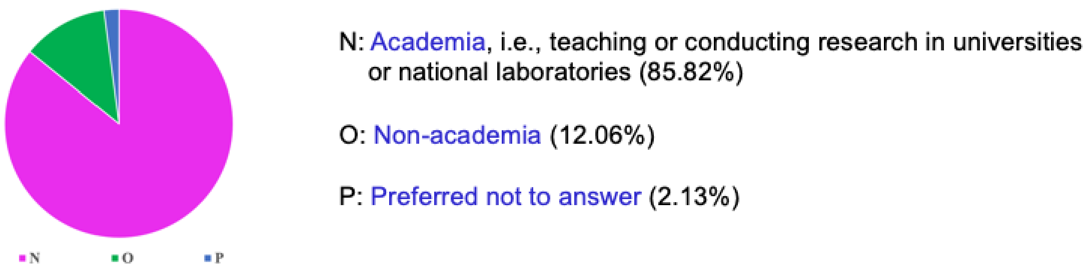
Figure 2: Challenges faced by respondents pursuing their highest level of education in African universities.

Table 1: Educational challenges faced by respondents pursuing higher education in African institutions

Responses	Challenges	Rate (%)
A	Lack of research funding	20.35
B	Lack of research equipment	19.26
C	Lack of mentoring support	7.88
D	Lack of mobility opportunities	13.57
E	Lack of proper skills training	15.75
F	Lack of access to libraries	6.35
G	Limitation of academic freedom	3.50
H	Imbalance between work and family demands	5.91
I	Job insecurity	4.81
J	Political instability and wars	2.63

According to the survey [13] being conducted by the Young Physicists Forum [11], prominent solutions to educational challenges include raising awareness to African policymakers and private enterprises on the need to fund research through provision of grants, which universities in Africa should accountably utilize to buy experimental equipment and conduct meaningful research. African governments should also invest in building higher learning institutions that are well equipped with research facilities such as modern laboratories where academic staff and their students could establish the link between theory and experimental work. This would then help reduce over-dependence on foreign research facilities and contribute to meaningful and solid collaboration relationships with other institutions and research facilities overseas. Public and private universities should work together and help improve the internet network in universities and research facilities across Africa as a good and stable internet connectivity undoubtedly enhances scientific research output and helps improve the quality of learning.

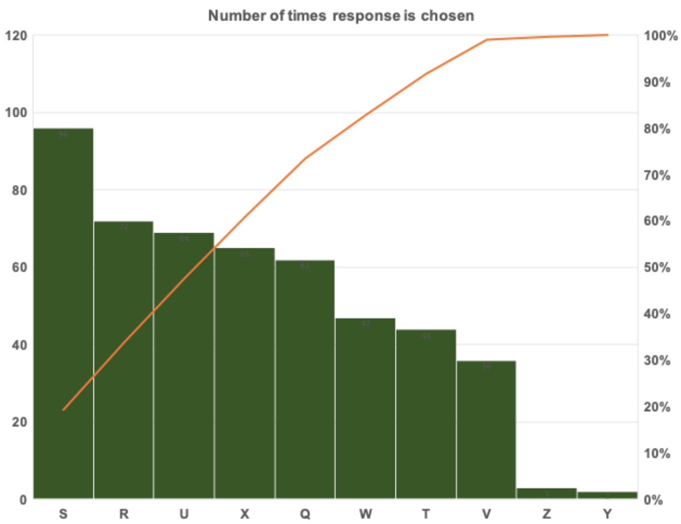
Other measures that may help counter educational challenges in Africa include revision of the school and university curricula by reducing over-dependence on theoretical work [13], building scientific research facilities, and securing laboratory equipment to encourage research skills and knowledge acquisition through experimental work among African students. Furthermore, the lack of mentors in science disciplines like physics in African universities could be resolved by motivating professors to embark on scientific-research projects and closely working with their students [13] once research grants are available to them from governments and private enterprises. Academic staff should also spend more advisory time with their students and try and establish the link between theoretical and experimental work together [13]. Additionally, academic staff members should offer more structured feedback to students and also establish research collaborations within and outside the continent so as to expose their students scientifically [13]. Occupational and career guidance should also be provided to students by their advisors in order to motivate them regarding their future endeavours in academia within Africa [13]. Career with occupational development is another huge challenge being faced by young physicists in Africa [13]. According to the population sampled in the survey [13], it is found that roughly 85.82% of the respondents are in the field of academia where they are teaching and conducting research in national universities and laboratories while those in non-academia fields accounted to about 12.06%, and approximately 2.13% preferred not to reveal there occupation as shown in the pie chart in Figure 3 by N, O, and P, respectively. Those in academia identified themselves as bachelors, masters, and doctoral students, postdocs, engineers, technicians, physicists as well as faculty members.



Occupation and precent representation of sample									
Current position	Bachelors students	Masters students	PhD students	Postdocs	Engineers	Technicians	Faculty	Physicists	other
Percent (%)	3.55	10.64	44.68	8.51	0.71	0.71	14.18	9.93	7.09

Figure 3: Occupation and percent representation of respondents according to the survey conducted by YPF.

Results of the survey [13] have further revealed that securing an academia position in universities and national research facilities within Africa poses a major challenge and is, at the same time, a huge sacrifice owing to the fact that the workplace environment is mostly not conducive due to lack of experimental equipment, among other challenges, more so in the last two years with the breakout of the COVID-19 pandemic [6]. Based on the results of the survey [13], the Young Physicists Forum [11] have learnt that the effects of the nature of an academia-workplace environment in Africa and the impact of the COVID-19 [6] have led to a reduction of academic interactions between academic staff and students, experimental activities, and research funding as highlighted in Figure 4. Other negative effects include less advisor-student interactions, physical and mental-health problems as well as financial hardships, among other challenges, as described in Figure 4. The poor currency-exchange rate of African currencies against major world currencies such as the United States Dollars ($) and British Pound (£), among others, is another major challenge [13] not explicitly stated in Figure 4, but being faced in the academia field in Africa as this significantly and negatively impacts scientific-collaboration work between Africa and other continents as far as international research visits and conferences by students and academic staff are concerned.



	Nature of workplace and COVID-19 impact (Responses)
S	Reduction of academic interactions
R	Reduction of experimental activities
U	Less advisor-student interactions
X	Financial hardship
Q	Reduction of research funding
W	Mental health problems
T	Less productivity of online classes
V	Physical health problems
Z	Not applicable
Y	None

Figure 4: Impact of the nature of the workplace and COVID-19 pandemic on research institutions in Africa.

The lack of good will and minimal interest in education, science, and technology in Africa [7] have led to a huge challenge over the years where the world has witnessed a large number of skilled manpower leaving Africa for other continents in search of a more conducive workplace environment and an attractive income to support their families, a trend known as brain drain [9]. The survey [13] being conducted by the YPF [11] has so far revealed some instances of brain drain [13, 9] that have been taking place in Africa over the years. These include young and skilled African students studying abroad on scholarships opting to stay and work overseas after completion of their studies [13]. Researchers and postdocs also feel more comfortable working overseas than in African universities where they are either not welcomed or because of the nature of an African academia workplace environment and meagre salaries [13]. The lack of academic freedom (i.e., students having no choice of what to study due to financial reasons), inadequate funding, and absence of research equipment disfavor Africa as a good destination for good quality education and research work [13]. Political instability such as wars in some countries in Africa drive away academically qualified personnel to other countries outside the continent where they settle down peacefully and continue to contribute to science and technology there than in their African countries of origin [13]. In spite of all these brain drain challenges [13, 9], the hope for Africa in education, science, and technology [7] is still alive. Through the survey [13], the YPF [11] have come up with measures to counter the effects of brain drain [9] and hence help keep alive the hope of African countries to develop their education and build capacity for Africa. Some of these interventions are summarized and listed in Table 2.

Table 2: Measures that may help counter brain drain according to the survey conducted by the YPF

	Interventions that may help counter brain drain in most African countries
1	Create a school of excellence within Africa for Africans who have obtained their baccalaureate with honors in order to encourage African academic excellence and experience.
2	Policymakers on the continent should partner with private enterprises and work together to improve the research-workplace environment and conditions of service such as salaries to match foreign-based counterparts in academia.
3	Create national research laboratories and more academic positions in African universities and provide research grants to enable academic staff members to embark on a meaningful scientific research experience within the continent.
4	Policymakers should stabilize African currencies to compete favorably with other major world currencies such that the salaries skilled academic staff are earning in Africa are favourably comparable to salaries fellow counterparts earn abroad.
5	Enhance and connect African academic infrastructures with the rest of the world; promote scientific collaborations with international universities, research institutions, and laboratories and allow creative young Africans to present new scientific research projects.
6	Massive investment in African university education is required that will result in an increase in well paying jobs. A marketing campaign should be setup to encourage the youth to stay and work in their respective countries in Africa.

4. Conclusions

The African continent is endowed with abundant natural resources ranging from huge arable land through oil, natural gas, and minerals to floras and faunas. It is amazingly puzzling to note that the continent holds a large proportion of the world's natural resources, both renewable and non-renewable and yet, to a large extent, Africa still remains undeveloped with higher poverty levels [2] than other continents. To restrain or minimize these challenges, Africa should heavily invest in higher education and promote local scientific research [13, 7]. Advanced scientific research carried out within Africa would, for example, help find solutions to diseases such as HIV/AIDS [4, 3] that have been ravaging the continent over the years; produce vaccines of its own to cure pandemics such as COVID-19 [6] without having to entirely depend or solely wait for developed societies [10] to share portions of their vaccines; process its abundant natural resources from raw materials to finished products, and reduce over-dependence on developed countries for finished goods and services [7]. This would, in turn, build an even better relationship between Africa and the rest of the world as far as business is concerned. Since higher education and research are key to social, political, and economic independence of any country, it goes without saying that, education and research should be prioritized across Africa and ensure that educated human resource is enticed to stay and work within the continent by offering an attractive workplace environment and competitive conditions of service and thus, help minimize the brain-drain [13, 9] phenomenon. The YPF [11] is entirely open and solely devoted to identifying the challenges that young physicists face in developing their careers in Africa and finding solutions as well as career opportunities available for young physicists on the continent so as to revamp education and build capacity for Africa. The YPF is also entirely committed to mentor young physicists in Africa and to help promote research collaborations with other young physicists globally [13]. All in all, the YPF [11] is willing to partner with policymakers across the continent and beyond, the private sector, and business enterprises as far as promotion of higher education and advanced, local scientific-research projects in Africa are concerned.

Acknowledgments

Young Physicists Forum co-conveners are thankful to all YPF members, ASFAP's Engagement and Physics Working Groups for their positive contributions. Gratitude also goes to ASFAP's steering committee and stakeholders who have made this work possible.

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Submitted to the Proceedings
of the African Conference on Fundamental and Applied Physics
Second Edition, ACP2021, March 7–11, 2022 — Virtual Event

ASFAP Working Group Summary of Societal Engagements

Mounia Laassiri[a,*], Marie Clémentine Nibamureke[b], Bertrand Tchanche Fankam[c], Sam Ramaila[b], Ndeye Arame Boye-Faye[b], Diallo Boye[d], Marie Chantal Cyulinyana[e], Uli Raich[f], Jamal Mimouni[g], Benard Mulilo[h], Iroka Chidinma Joy[i]

[a] *Mohamed V University, Morocco*
[b] *University of Johannesburg, South Africa*
[c] *Université Alioune Diop, Senegal*
[d] *Brookhaven National Laboratory, USA*
[e] *University of Rwanda, Rwanda*
[f] *CERN, Switzerland*
[g] *University of Constantine-1 & CERIST, Algeria*
[h] *University of Zambia, Zambia*
[i] *NASRDA, Nigeria*

Abstract

The second African Conference of Fundamental and Applied Physics (ACP2021) took place in the week of March 7–11, 2022. During this conference, all the African Strategy for Fundamental and Applied Physics (ASFAP) working groups had been reserved specials sessions to discuss their scope, activities (past & current) and topics of common interests. The aim of this report is to summarize the discussion of the ASFAP working groups in societal engagements, namely Physics Education, Community Engagement, Young Physicists and Women in Physics. The recommendations for future activities in societal engagements are summarised in the report as well.

Keywords: The African Strategy for Fundamental and Applied Physics, ASFAP, Physics Education, Community Engagement, Young Physicists, Women in Physics

1. Introduction

The ACP2021 [1, 2] was held virtually, with over six hundred and fifty registered participants, five hundred and sixty-three of whom came from thirty-three African countries. The overall program, presentations and recordings are available at [2].

The compilation of the ASFAP working group summary of societal engagements is based on discussions and working meetings from the societal engagements community. All major societal engagement projects in ASFAP have been included in this report and have been categorized as follows:

- Societal Engagements: Status & Plan;

*Corresponding Author
Email address: mounia.laassiri@gmail.com (Mounia Laassiri)

- Discussion on Societal Engagements.

2. Societal Engagements: Status & Plan

ASFAP contains four working groups devoted to societal engagements. Our task was twofold: to discuss the focus and scope of the working groups in societal engagements; and either identify topics of common interest or topics that are cross-cutting among various societal engagement working groups.

2.1. Physics Education

Research in fundamental and applied physics needs to be supported by a strong and effective physics education to train the next generation of physicists. The objective of the Physics Education (Phys Ed) [3] working group is to identify where improvements are needed and propose improved methods to prepare and deliver physics instructions or lessons.

As part of the ASFAP process, the Phys Ed working group held workshops, carried out discussions regarding participation and attitudes toward physics education and outreach. Targeted workshops include physics education discussion: at the university level [4, 5], with the Francophone countries [6] and with the engagement working groups [7]. The Phys Ed working group received a number of letter of interests (LOIs) [8] that will be used to form white-paper study groups for the ASFAP strategy.

The Phys Ed working group developed its goals, strategies and recommendations from physicists and education input and outreach professionals obtained prior to and during the ACP2021 meeting. The recommendations support a proactive, coordinated Phys Ed working group effort from the entire ASFAP community. The following are recommendations from previous meetings, conferences and workshops:

Recommendation 1: Increase investment in infrastructure and equipment.
For Africa to adequately leverage its potential for developing physics education and outreach, a coordinated effort between African countries is needed to ensure that a sustained stream of investment is directed.

Recommendation 2: Improve the quality of teachings through the training of teachers and a strong focus on applications and technologies.
Less theory oriented curricula and more practicals and experimental physics are needed if we want to train good skilled physicists and engineers in African countries.

Recommendation 3: Pan-African association of physics teachers and lecturers
We propose to establish a Pan-African association of physics teachers and lecturers. Science societies in Africa should be strongly encouraged to commemorate continental scientific events.

2.2. Community Engagement

Community Engagement (CE) [9] working group consists of several sub-groups, namely physics communication and outreach; technology transfer; Internet connectivity/ start-up resources, applications and industry; e-lab & e-learning; business development and entrepreneurism; public education and outreach, diversity, inclusion and equity; government engagement and public policy; and career pipelines & development, retention and capacity development. The objective of CE working group is to draw a broader engagement and participation in the development of the African strategy, address issues of physics education and intra-African—national, regional and pan-African—collaborations on education and research.

The CE working group held five pre-meetings in order to discuss the scope and different topics proposed by the group. February 2021, CE held a workshop with other societal engagement working groups [10]. At this workshop, discussions led to ideas for future collaborations between CE and other societal engagement working groups. The CE working group has proposed a series of topics in conjunction with other societal engagement working groups. Among them:

- Physics and Environmental Pollution:
  How can we use physics to resolve the problem of environmental pollution and raise awareness of the local community on environmental pollution? This would include: recycling methods for plastics, waste burning, special collection programs for pharmaceutical waste, education & awareness campaigns.

- Public Outreach & Education:
  This will create awareness and broaden the community's understanding of physics. It would include a survey on the views of physics teachers in Africa, periodic training of physics teachers, annual fairs to introduce the public and in particular the children to the fun of physics. It would also include virtual physics laboratories sessions and campus visits for high school children. Virtual Physics laboratories: for those schools where there is no access to laboratories (+ internet access): classroom demonstrations for teachers and students and physics Olympiads.

- Astronomy in the service of physics:
  Astronomy is that discipline which can fire up people's imagination, and hook them to science. It may at the same time play the role of an appetizer for the other sciences in addition to being a fundamental science by itself. Indeed, the Cosmos being after all the largest laboratory in the World. Astronomy could be seen as generalized physics, unless physics (the study of the matter) wishes to reclaim it to itself and considers it as part of it! In this case, physicists will have to get their act together as far as their connection to astronomy.

2.3. Young Physicists Forum

Young Physicists Forum (YPF) [11] was established to engage rising-star physicists to gather, study and debate the major issues in their research careers. As a guideline, YPF roughly defines young physicist as students, postdocs, engineers, technicians, faculty, etc., up to ∼10 years post-highest degree. The main objectives of the YPF are among others, to create a diverse continent of next-generation physicists to play an active role in collaborations pertaining to scientific research and educational issues in Africa.

Since launching YPF in 2021, the forum has played an active role in identifying the challenges and remedies for young physicists to flourish in various physics fields. To this effect, the forum has so far conducted several virtual meetings to share the knowledge. January 2022 [12], the forum invited stakeholders to discuss some of the challenges and opportunities for young African physicists. The workshop brought together young physicist researchers and feature panelists, drawing more than one hundred and forty registered participants from all over Africa. During presentations and panel discussion, physicists detailed the challenges facing young African physicists; highlighted existing solutions; and brainstormed new strategies for research and policy.

Physicists Data Collection: ASFAP— Young Physicists Forum Survey

The ASFAP— Young Physicists Forum survey [13] was originally intended to run for five and a half months (from July 15 until December 31, 2021), however, the deadline was extended to December 31, 2022 to allow further feedback from the community. Results from two of the questions are presented below.

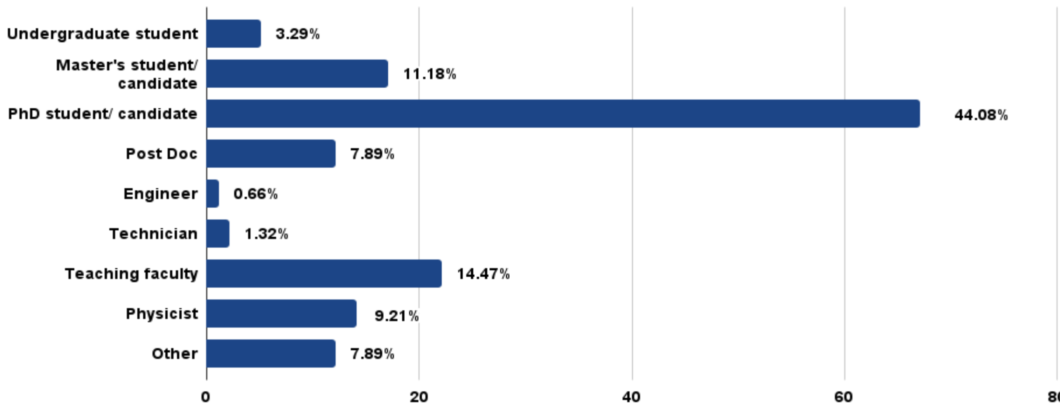

Figure 1: Current position of the respondents.

Figure 1 shows that majority of the survey respondents are PhD students or candidates (44.08%), followed by teaching faculty members (14.47%) and Master's students or candidates (11.18%).

The results in Figure 2 show that general lack of research funding and funding for equipment identified by two-thirds of our respondents as the biggest challenges. Challenges related to human capacity building and professional development (lack of training opportunities; lack of mobility and lack of mentoring and support) were subsequently

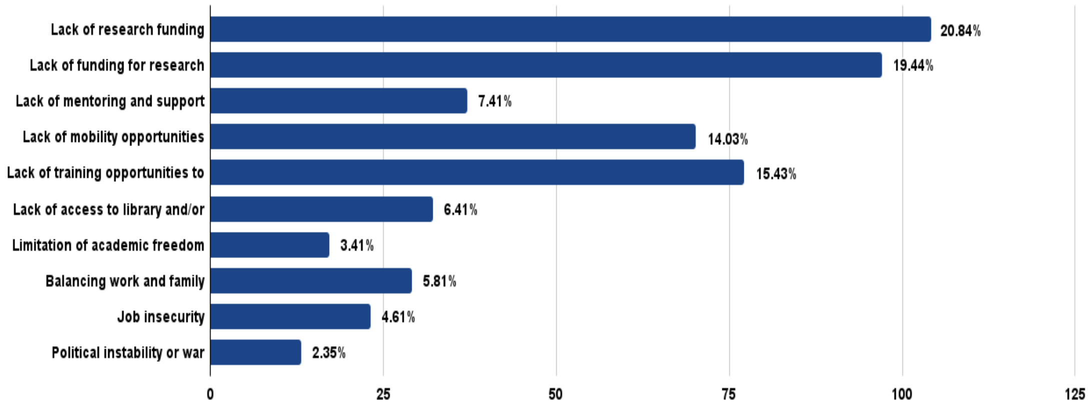

Figure 2: Respondents' perceptions of the impact of 10 challenges on their careers.

listed as the third largest challenges by most of our respondents and, importantly, especially by the young physicists. Therefore the need to develop digit libraries supported by efficient Internet connectivity at low costs to African researchers. The fifth largest challenge (balancing work and family demands) speaks to time demands. Interestingly, 'job insecurity' received the lowest rating. Political and social factors (lack of academic freedom and political instability) was also not listed as a major challenge– probably because most of our respondents are already in permanent academic or research positions.

The YPF has received a number of LOIs so far and are related to the challenges facing young African physicists [8]. In addition to the LOIs, many YPF topics and issues were collected through workshops and the survey results.

2.4. Women in Physics Forum

Despite so many efforts over the past decades to close the gender gap in physics in Africa, women are still largely unrepresented in the physics workforce and even fewer women reach leadership positions. The objective of Women in Physics Forum (WiPF) [14] is to mitigate the lack of the African women participating in Physics.

In the short time since WiPF was launched in 2021, WiPF has started important discussions with ASFAP community regarding women's participation in and attitudes toward physics and raised awareness of the systemic structural barriers that silently push women away from their career track.

WiPF organized their first workshop in February 2022 [15] which was the international Day for Women and Girls in Science. On December 9, 2021, WiPF get a chance to participate in The AERAP Africa-Europe Science Collaboration Platform in a session dedicated for women's movements in the fields of science, technology, and innovation. As a result of these many meetings and discussion sessions, WiPF developed the following strategies and implementation plans to help women community achieve the overarching WiPF goals:

- Initiate mentorship and networking initiatives.
- Establish a system to encourage more girls to study physics.
- Links to external databases or community-generated databases that track important statistics on women participation in physics.
- Emphasize on the gender balance in working place.
- Funding of physics projects for women and removing age limit for women in physics.

3. Discussion on Societal Engagements

Following Societal Engagements: Status & Plan at ACP2021, we had a discussion of a mix of community engagement, physics education, young physicists, and women in physics colleagues. Ideas for future interactions between all societal engagement working groups have been identified.

Implementation ideas

1. Organise join meetings to disseminate new ideas and work to identify common issues.
2. Work to identify and improve the the grassroots level related-issues.
3. Create and foster new opportunities for interaction with fields beyond physics.
4. Develop and increase access to resources, training activities, and opportunities that engage physicists with policy makers, opinion leaders, the general public, educators and students.

The societal engagements will be engaged in a variety of efforts to inform the public and policy makers about fundamental and applied physics research, and to encourage support for that research. The societal engagements should augment and enhance ongoing efforts by providing continental coordination and support, and by developing needed resources to make a compelling case for support of fundamental and applied physics research.

4. Conclusions

We summarized past and current activities of the societal engagements community. These include: (1) conferences, workshops, meetings and panel discussions, (2) survey, and (3) letter of interests. These activities have been useful in terms of interest and participation, and should be encouraged and continued. However, we conclude that more direct engagement from all societal engagement working groups is needed.

Acknowledgments

Special thanks to the ASFAP— societal engagement co-conveners & session organizers for their contributions.

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ASFAP - Interim Report - Conclusions

By the ASFAP Steering Committee
Ketevi Assamagan, Simon Connell, Farida Fassi, Shaaban Khalil, Fairouz Malek

In this paper, we have presented an interim report on ASFAP. The report presents the progress that has been made since the launch of ASFSP in November 2020. Prior to the launch, a digital infrastructure was developed to facilitate communication and organise the ASFAP activities, emphasizing the provision of and access to information, the transparency of the process and its inclusivity. This was achieved with a website centralizing the activities, communicating the process and its status and holding all slowly changing documentation. A Wiki page was developed to handle the working group level activities, which need a more dynamic platform, where the fast-changing information can be recorded by the community collaboratively itself. The CERN email list was used in a self-subscribe mode in nested levels from the growing full ASFAP community down to its smallest groups, to allow all ASFAP components to operate and interact efficiently. The Indico Agenda System handled the meetings for all and archived their results, and it was also the tool used to collect Letters of Interest. Once this comprehensive machinery was in place, the ASFAP process as a community driven project was launched. Following the launch, the community participation developed as reflected in group meetings, panel discussions, workshops, surveys, reviews, and submission of letters of interest. Many of these activities occurred during the COVID period, so remote participation and online digital tools were very important. The activities are rendered transparent and archived in the various online tools described above. The report is a preliminary review of the collected sum of all the inputs collected to date; it also offers an understanding of the efforts still needed to achieve a comprehensive final summary of ASFAP. In this report we also take stock of the process in order to assess the trajectory towards the final document.

The current ASFAP process is the first such community driven process for Africa. It has had so far the participation of more than 600 scientists from all over Africa [1]. Overview or estimate of the number of workshops, meetings, surveys, LOI and participation. Indeed the community has engaged and has responded. It's important to pause and consider that this is the first community-driven continent-wide review process for Africa. Many aspects are new, for at least many of the participants: The Pan African consciousness to generate a continent wide response: The fact that the emerging researchers should exercise their voice too, as its their future that is discussed: The fact that the scientific community can appreciate that they can be agents of change and development on this scale: The fact that African nations can have a vision for science at the frontiers and in a global context: All these novel elements are realized in this first effort towards the ASFAP. As such, we must be conscious that the ASFAP process is a progression. Growing on from the first one will be increased community participation, increased responsiveness, deeper studies within the responses. The ASFAP process will grow. Our aim is therefore not to achieve perfection in this first process, but to distill out the common vision and wisdom, and present that. Subsequent processes will build on this. As Africa becomes accustomed to exercising its unified community driven voice, there will be improved participation. At this stage we note a large range in the types of Letters of Intent. These vary from detailed studies to extended observations and commentaries. Some are submitted by groups and some by individuals. The standing and experience of the authors also covers a wide range, from students and emerging researchers to senior established researchers. As such the task of various committees contributing to the final synthesis is important, as it must process and present in a common unified way this range of material

The STC will continue engaging the community targeting a more advanced summary report by the end of this year. It is noteworthy to mention the complexity in committing the community- not only because the culture and awareness of such a report is not installed yet- but reaching the community across Africa is still challenging. Therefore the momentum needs to be kept to not lose the primary ASFAP goal.

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