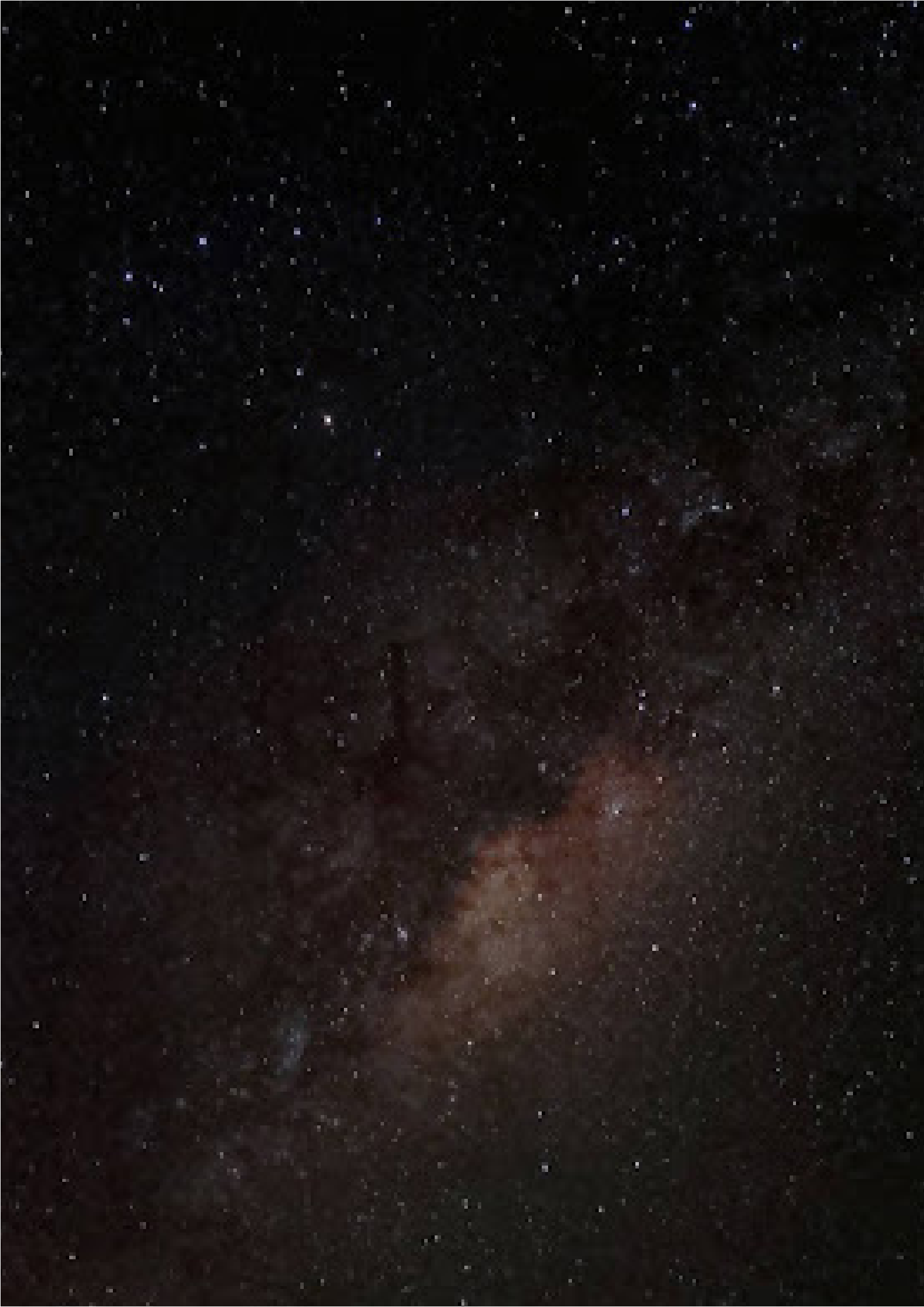
BRICS Astronomy Report

July 2025



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BRICS welcomes new members

The BRICS group currently comprises eleven countries: its five original members **(Brazil, China, India, Russia, and South Africa)** and six new members admitted in 2024-25 **(Egypt, Ethiopia, Indonesia, Iran, Saudi Arabia, and the United Arab Emirates).** The group originally formed with Brazil, Russia, India, and China in 2006, with South Africa joining in 2011. The recent expansion, effective from 2024, stemmed from the Johannesburg Declaration in August 2023.

Following the mandate agreed upon in the Johannesburg Declaration, leaders approved the creation of the BRICS partner country category during the Kazan Summit in 2024. These partner countries include Belarus, Bolivia, Cuba, Kazakhstan, Malaysia, Nigeria, Thailand, Uganda, and Uzbekistan. The BRICS bloc is rapidly expanding its global influence, strategically broadening its membership and deepening collaboration in critical areas like science and technology. This expansion highlights BRICS's growing appeal and its role in reshaping the international landscape.

Beyond its geopolitical expansion, BRICS is making strides in science, technology, and innovation, particularly through the BRICS Intelligent Telescope and Data Network (BITDN). This initiative aims to advance astrophysical research by creating a globally distributed network of wide-field telescopes to rapidly scan the sky, focusing on transient events, survey science, and Big Data. By linking current optical facilities across BRICS nations and incorporating new observatories, the BITDN will provide critical infrastructure for cutting-edge discoveries in astrophysics. As BRICS expands its scientific and technological reach, new member countries' observatories will play vital roles. Indonesia, for example, is set to significantly contribute with its National Observatory of Mount Timau.

This new observatory will feature a 3.8-meter Ritchey–Chrétien telescope, equipped with an ultra-sensitive camera and spectrograph. Situated near the equator, the Tamau Observatory's unique position allows it to observe celestial objects in both the Northern and Southern hemispheres, offering invaluable insights fromtheless-representedsouthernsky.This facility will enable detailed investigations into stellar clusters and stellar physics, bolstering BRICS's collective astrophysical capabilities. In essence, BRICS is not just expanding geographically but is also deeply investing in collaborative scientific and technological advancements that will have a global impact.

BRICS Astronomy Working Group (BAWG)

The BRICS Astronomy Working Group is composed of government officials (or their designated representatives) supported by the focal points on astronomy and experts from BRICS member countries.

Mission of the BAWG

The mission of the BAWG is to promote cooperation between BRICS member countries in the field of astronomy and enabling technologies through joint activities of government, universities, research institutions, and industry, as relevant, to develop astronomical sciences, generate new knowledge, train human capital, develop new technologies and applications, and improve public understanding of science.

Cooperation Activities

The formation and implementation of cooperation activities follow the principles of voluntarism and openness, and each party will participate at their own cost unless alternative sources of funding can be identified.

Secretariat

The Department of Science, Technology and Innovation (DSTI) of South Africa acts as the Secretariat to the Astronomy Working Group, and through the Coordination team, are responsible for:
Dissemination of information to the Astronomy Working Group using various media, including a website.
Organising annual meetings (providing a venue and meeting facilities, meeting agendas and relevant documents, coordinating experts).
Capturing and maintaining the proceedings of the Working Group.

BAWG Workshop

The BRICS Astronomy Workshop provides a platform for BRICS member countries to engage on policy issues and other matters related to research, development and practice in astronomy, and to explore mechanisms for promoting BRICS cooperation in astronomy. The spectrum of scientific issues discussed may include: observational, theoretical and computational studies of the Sun and space weather, exoplanets, stellar astrophysics and asteroseismology, star formation, evolution of stars, the interstellar medium and astro-chemistry, galactic chemical evolution, transient phenomena, pulsars, neutral hydrogen in galaxies, active galactic nuclei and high-redshift galaxies, time-resolved astronomy and galaxy evolution.

BAWG 2024

The 10th BRICS Astronomy Working Group (BAWG) Workshop and Meeting was hosted in hybrid format by Kazan Federal University, supported by the Russian Ministry of Science and Higher Education on 9 - 13 September 2024 This meeting marked a significant milestone as the BRICS Astronomy Working Group (BAWG) celebrated its tenth meeting and, for the first time, welcomed the new BRICS members, who joined in-person and online.

The theme of the meeting was the BRICS Intelligent Telescope and Data Network (BITDN). During the first 3 days of the science meeting, representatives presented talks on a variety of topics in line with the sub-themes which are; Small bodies of the Solar system as transient objects, Transients in astrophysics, Astronomical data, Pipelines for astronomical data in multichannel observations, Science platform for global data network and Astronomical Instrumentation.

The BRICS Astronomy program aims to advance scientific research, technological development, and human capacity development among participating nations. Key activities include workshops on data handling and analysis, student programs offering hands-on experience, software development for telescope control and data processing, and engineering capacity building for telescope construction. These efforts aim to foster collaboration, enhance research capabilities, and cultivate a new generation of astronomers within the BRICS community. The science meeting highlighted the importance of collaboration in science but also emphasised the need for further collaboration in other aspects beyond multi-wavelength astronomy.

During the conference, participants had the opportunity to visit various sites in the beautiful city of Kazan, including a visit to the Astronomical Observatories of Kazan Federal University, which comprises two institutions: the Kazan City Astronomical Observatory and the Engelhardt Astronomical Observatory. The Kazan City Astronomical Observatory was built in 1837 and is located on the University campus. The suburban Engelhardt Astronomical Observatory, which is located 30 km west of Kazan City, includes Astronomical facilities for observations and residential buildings, all located within a park. The Astronomical Observatories of Kazan Federal University is a UNESCO World Heritage site, offering valuable insights into the observatory's rich astronomical history. Participants of the conference had the opportunity to visit both observatories and experience their history.

Meeting. During the meeting, strategic and operational matters were discussed and representatives provided feedback on the progress in the field of Astronomy in their respective countries. One of the key discussion points was on the funding for the BITDN flagship project. The BAWG encouraged member countries to continue engaging their respective funding agencies for funding opportunities and resolved to raise the need for funding at the BRICS Senior Officials Meeting. Another key area discussed was the proposal to establish a BRICS Astronomy Open-access and free-to-publish journal, discussions around this are still ongoing.

It was also recommended that BAWG explore connections with other Working Groups that share common objectives. This approach would improve the effectiveness of BRICS STI, fostering better communication among the groups, strengthening collaboration, and advancing shared goals. The meeting concluded with the drafting of the Resolutions which the partner countries will now focus on for the next year.

The future of the BAWG appears bright and full of promise, especially with the addition of new members who will bring valuable contributions to the partnership. We extend our gratitude to the Russian Federation and Kazan University for their warm hospitality and commitment in organising this year's meeting.
More information about the conference can be found on the meeting website.
To read more about the flagship project and overall BRICS Astronomy, please visit www.bricsastronomy.org

The resolutions to the meeting can be accessed here. https://www.bricsastronomy.org/working-groups/

11th meeting of the BRICS Astronomy Working Group

13 to 15 October 2025

Instituto Nacional de Pesquisas Espaciais (INPE)
São José dos Campos, São Paulo, Brasil

BAWG 2025

11th Annual BRICS Astronomy Working Group (BAWG) Workshop

13 - 17 October 2025
São José dos Campos, State of São Paulo, Brazil

Brazil warmly welcomes all participants to the 11th Meeting of the BRICS Astronomy Working Group and looks forward to efficient and productive cooperation. The 11th Meeting of the BRICS Astronomy Working Group will take place from 13 to 17 October 2025 at the Brazilian National Institute for Space Research (INPE) in São José dos Campos, State of São Paulo, Brazil, in an in-person format. The possibility of participation in an online format will also be considered for those registered participants who cannot attend the event in person.

The first two days will be dedicated to the science meeting, while the remaining three days will focus on the BAWG business meeting and societal benefit programmes, including outreach activities, Heliophysics Capacity Building, and Virtual Observatory Training.
This event is organised by The National Laboratory for Astrophysics (LNA), The Brazilian Center for Research in Physics (CBPF), The Federal Institute of Education, Science and Technology of São Paulo (IFSP), and The National Institute for Space Research (INPE). In 2025, the scientific theme will be "Multi-messenger and Multi-wavelength Transients," bringing together the entire astronomy community, including researchers, outreach professionals, educators, development practitioners, and policymakers, to share the latest results and best practices.

The program will consist of:

- Scientific lectures
- Lectures on education, development, and science outreach
- BRICS Astronomy Working Group meeting
- Virtual Observatory training
- Scientific communication training
- Overview of INPE's space weather program

Attendees can expect keynote talks, hands-on training sessions, working-group discussions, and an overview of INPE's space-weather initiatives. Whether you join us in São José dos Campos or online, your participation will strengthen BRICS collaboration in the study of multi-messenger, multi-wavelength phenomena.
Full information about the conference can be found on the website:

https://www.gov.br/inpe/pt-br/eventos/bawg-workshop

BRICS STI Projects

MALBRICS - Multi-messenger Astronomy League for BRICS 2023-2024

The MALBRICS consortium has facilitated successful cooperation between scientists from BRICS member countries in conducting joint research projects, including organizing observations at research facilities in Russia, China, India, and South Africa, analyzing and publishing the obtained data, and collaboration in analyzing the multiwavelength properties of AGN variability and the optical properties of GRBs. The project participants are leading scientific institutes in the BRICS countries: Sun Yat-sen University in Zhuhai, University of Johannesburg in Johannesburg, Special Astrophysical Observatory of RAS in Nizhny Arkhyz, and Raman Research Institute in Bangalore. MALBRICS set important and ambitious goals: combining the experience of the BRICS countries in the field of astronomy and the advantages of their scientific equipment covering various wavelength and energy ranges. As part of the project, both astronomical observations and the work on creating new astronomical equipment, including software development, were carried out. Observing programs in various ranges of the electromagnetic spectrum were coordinated with each other.

The effective engagement to achieve the scientific goals was determined by the optimal combination of resources, large instruments, and methods within the MALBRICS consortium. Several joint applications for observing time have been submitted to the radio telescopes RATAN-600 and MeerKAT and the 6-m BTA and 1-m Zeiss-1000 optical reflectors, a strategy for observing different classes of objects has been developed, machine learning methods have been agreed upon for blazar classification (Sun Yat-sen University) and clustering (SAO RAS). The studies of blazars - active galactic nuclei distinguished by the presence of a relativistic jet directed close to the observer's line of sight - have been conducted in the member countries before, but thanks to MALBRICS they have acquired new quality and focus due to the close coordination of optical and radio observing programs, the improvement of the methodology for calibrating the observed results, the unification of the results in a single archival standard, and the implementation of modern software tools to all available information on each object under study. Within the course of MALBRICS, the results of several monitoring programs over 25-30 years were shared, namely the data from the SAO RAS optical and radio telescopes as well as from the facilities of other Russian institutes: the Crimean Astrophysical Observatory of RAS, Institute of Applied Astronomy of RAS, and St. Petersburg State University.

Among the most important results are systematic measurements of a large 2000 blazars sample in the radio and optical ranges, obtaining the properties of multiwave variability for a number of them: S4 0954+658, AO 0235+164, Ton 599, PKS 2126-15. As a result, some common properties of the blazars have been suspected: probable quasi-periodicity in wide spectral range, including the low activity state, time delays between flares at different frequencies, the presence of fast variability indicating the existence of compact emission regions inside relativistic jets.

A general correlation between the optical, radio, and X-ray flux variations has also been found, which suggests that we observe the same photon population from different emission regions. The BTA spectroscopy of blazars made it possible to establish the limits on the masses of black holes in their cores. As a result of intensive multiwavelength observations, about 3400 radio and 32000 optical

measurements have been obtained in 2023-2024. A developed method for forming a catalog of blazar radio emission parameters was patented under international copyright in 2023 (Eurasian patent 045154).

A program for gamma-ray burst studies was carried out in tight collaboration between scientists from SAO RAS and University of Johannesburg, where observational facilities of both sides were fruitfully used. A great number of events were observed: GRB 240511A, GRB 241029A, GRB 241030A, GRB 241228B, GRB 250101A, EP250108A, GRB 250114A, GRB 250129A, GRB 250221A, EP250304A, GRB 250309B/AT2025dws. More than a dozen electronic circulars were issued by MALBRICS, and future papers in high-rating peer-reviewed journals are in preparation now. Using measurements from two observatories made it possible to obtain dense GRB data series as well as to cover a wide range of declinations available in the southern and northern hemispheres.

An international online workshop "Multi-messenger astronomy in the BRICS framework" was organized by the representatives from the Special Astrophysical Observatory of the Russian Academy of Sciences with the support of the international scientific organizing committee of the event (5th of December, 2023, https://rat.sao.ru/conferences/brics/index.php). Representatives from all three astronomical consortia created in the framework of BRICS scientific collaboration attended the workshop. The meeting was successful, and we made a decision about the advisability of organizing annual on-line conferences on the scientific investigations jointly conducted by the research groups from the BRICS countries. We drew the attention of the participants to the need for closer integration in conducting research on joint topics. Joint scientific applications for the observing time of the shared-access astronomical instruments of the participating countries was considered as an important contribution to the development of scientific collaboration. In order to coordinate research programs within various astronomical instruments around the globe, a permanent information portal was planned to be created. In order to organize collaborative studies with the largest BRICS telescopes, we agreed to provide alert observations on them using the Director Discrete Time opportunities.

In the MALBRICS framework, an offline meeting between the Chinese and Russian teams was organized in Sun Yat-sen University in December 2023.
For the full-fledged implementation of an international project, it is necessary to integrate observational facilities effectively. Based on the experience gained, a lack of operational coordination for alert observations in the optical and radio ranges was found. To solve this issue, it can be proposed to adapt the existing access policy at large telescopes for flexible and fast response to alert events. Because of the importance of direct scientific contacts, joint efforts to organize in-person scientific interaction should be done.

SAPTARISI

BRICS Nations Unite for Space Science and Discovery

Acronym: In ancient Indian astronomy, the Big Dipper (part of the constellation of Ursa Major) is called SAPTARISI, with the seven stars representing seven Rishis (accomplished and enlightened persons as well as progenitor of the mankind), namely, "Vashistha", "Marichi", "Pulastya", "Pulaha", "Atri", "Angiras" and "Kratu".

The Search and Follow-Up Studies of Time-Domain Astronomical Sources (SAPTARISI) is an ambitious project led by the BRICS nations – Brazil, Russia, India, China, and South Africa. Named after the seven stars, representing seven Rishis, in ancient Indian astronomy, SAPTARISI brings together the latest in Artificial Intelligence (AI), advanced telescopes, and sky surveys to discover more about our universe.

Why SAPTARISI Matters

The ongoing BRICS collaboration creates a unique scientific alliance, allowing the nations to pool their resources and talent in a project that benefits all. The ongoing project has several objectives, including:

- Creating novel machine learning and AI-based methodologies for automated searching, identification, and classification of galactic and extragalactic transients from ongoing and near-term large-scale sky surveys.
- Producing an exhaustive catalogue for indexing and fast retrieval of transients and making it available in public domain via dedicated channels for the astronomical community.
- Follow-up research on a subset of objects using the BRICS collaborators' observing facilities for the high-precision photometry and high-resolution spectroscopy for the determination of basic astrophysical parameters, and improving our understanding on stellar structure and evolution, stellar activities, galactic and extragalactic archaeology
- Modelling the selected sources to comprehend the observed light variations and gain insight into the involved physical processes.
- Pushing the boundaries of knowledge among collaborating institutions and personnel in the BRICS countries and applying the developed techniques to other scientific disciplines and outreach activities.

Here's the objectives and how the SAPTARISI project could make a difference:

1. Strengthen the knowledge in AI and Machine Learning: In doing so, this project will advance skills in processing huge sets of astronomical data.
2. Share Knowledge and Experience: The project encourages collaboration between BRICS scientists, allowing them to share expertise in software development. This will open doors for young talent interested in using technology to explore astronomy.
3. Unite Astronomy and Data Science: As we gather more data from the universe, astronomy and data science are becoming essential partners. The insights from each field make discoveries easier and deepen our understanding of space.
4. Inspire the Next Generation: Educating and involving university students to convert data to knowledge and gaining scientific wisdom means they will be able to help keep scientific activities advancing into the future.

The success of this international programme will be measured by the number of publications in well-known scientific journals, the dissertations of PhD and master's students, the usefulness of the created catalogues,

and the advancements of techniques for database management, signal processing, automated detection, identification, reduction, and statistical inference.

A collaborative foundation

This proposal creates a lasting partnership between all participating institutions in areas like advanced technology, observational methods, data collection, analysis, and data management. It will also enable an important exchange of knowledge and skills among the researchers. The main goal is to create a shared training ground for students at all levels, engaging them actively in every part of the collaboration. Data management, digital signal processing, automated image reduction, and statistical data analysis will serve as leading tools for the astronomy community.

Below is the current project status:

1. Training in AI and Machine Learning for Astronomy

A PhD student, Mr Surath C. Ghosh from India, is being trained in the applications of machine learning and AI for tasks such as the automated classification of variable stars, time-resolved photometry and high-resolution spectroscopy. Presently, we are compiling a catalogue of about a million of A-F type stars for the automated classification of variability.

2. Modelling Chemically Peculiar Star HD118660

The modelling of the chemically peculiar star HD118660 has been completed, with results published by Sarkar et al. (2024) in a paper titled, "Asteroseismology of the mild Am Sct star HD 118660: TESS photometry and modeling" (MNRAS, DOI:10.1093/mnras/stae2258). A major finding is that the presence of high radial modes are not expected for stars with the effective temperature located near the red edge of the instability strip.

3. Discovery of two giant planets

Two giant planets orbiting the red-giant-branch star HD112570 and the red-clump star HD154391 were discovered by Chinese investigators based on the radial-velocity measurements. One of the planets, HD154391b, has one of the longest orbital periods among those ever discovered orbiting evolved stars, which may provide a valuable case in our understanding of planetary formation at wider orbits. The results have been published in The Astronomical Journal (2024, 167, 59).

4. Analysis of Mira Variables

A sample of 335 Mira variables was extracted from LAMOST (the Large Sky Area Multi-Object Fiber Spectroscopic Telescope) DR9 by Chinese investigators. For these variables, oxygen-rich stars are distinguished from carbon-rich stars through the identification of carbon molecular bands present in the optical spectra. Multiple attributes, such as the link between line strength and bolometric luminosity, and the connection between atmospheric parameters and their periods are investigated for the oxygen-rich stars. The correlation between effective temperature and the period is also investigated. This work has been accepted for publication in ApJS.

5. Study of Cataclysmic Variables (CVs)

Chinese investigators found 573 spectra for 368 cataclysmic variables (CVs) from LAMOST DR11. Some of these CVs show interesting properties and are worth follow-up observations. Time-series spectroscopic observations were performed for one of the objects, LAMOST J214242, which is brighter than 12 mag. Fifteen low-resolution spectra with a single exposure time of 350s were obtained using a two-metre telescope by Indian investigators. A detailed data reduction of the spectra is underway, including spectrum extraction, wavelength calibration, and radial velocity

measurement. The orbital properties of the object will be investigated using the obtained radial velocity curve.

6. PhD Completion on Stellar Studies
Mrs Aleksandra S. Avdeeva, from Russia, has defended her PhD thesis. Aleksandra's dissertation is devoted to the use of photometric and spectroscopic data from modern surveys of a significant part of the entire sky.

7. Galactic Extinction Study
Russian researchers estimated the galactic extinction value for 42 areas in the northern celestial hemisphere using Gaia parallaxes and LAMOST data. Their findings align with previous estimates, revealing systematic differences in extinction maps that affect extragalactic object distances by 3-5%. The article is accepted for publication in Galaxies, 2024.

8. Classification by Luminosity
Russian and Chinese investigators explored the possibility of separation of stars of different luminosity classes in the space of atmospheric and photometric parameters, using stellar evolution models, empirical atlases of stellar spectra, the ATLAS9 stellar model library, and published relations between observational and astrophysical characteristics. The article is published in Astrophysical Bulletin, Volume 79, Issue 2, pp. 298-303, 2024.

9. Photometric Classification of Stellar Objects
Russian, Indian and Chinese investigators used photometric data from the WISE, 2MASS, and Pan-STARRS surveys to construct colour-based selection criteria for red dwarfs, brown dwarfs, and Mira variables. On analysing the colour indices, we developed empirical rules that separate these objects with an overall classification accuracy of approximately 91%-92%. While the differentiation between red dwarfs and both Mira variables and brown dwarfs is effective, challenges remain in distinguishing Mira variables from brown dwarfs due to overlapping colour indices. The robustness of our classification technique was validated by a bootstrap analysis, highlighting the significance of colour indices in large photometric surveys for stellar classification. The article is accepted for publication in Variable Stars, 2024.

10. Astrosat Follow-Up Observations
An observing proposal titled, "Follow-up observations of objects with significant UV excess" has been accepted for the observing time from Astrosat. The main objective of this proposal is follow-up observations of 13 sources exhibiting significant UV excess, identified by cross-matching the GALEX all-sky catalogue with optical surveys. The sample for this was selected from Karpov et al. (2021) who discovered these transient UV sources.

11. Chemical Analysis of HD 180347
An analysis of high-precision space-based photometric and high-resolution spectroscopic observations of HD 180347 was performed. The spectral type of this star and obtained atmospheric parameters such as the effective temperature, surface gravity, and projected rotational, micro turbulent, and radial velocities were determined. A detailed chemical abundance analysis derived for 25 chemical elements was conducted.

Principal Investigators:

India: Santosh Joshi (ARIES, Nainital) (Coordinator)
https://old.aries.res.in/~santosh/santosh_wp/

Russia: Oleg Malkov (INASAN, Moscow)
http://www.inasan.ru/~malkov

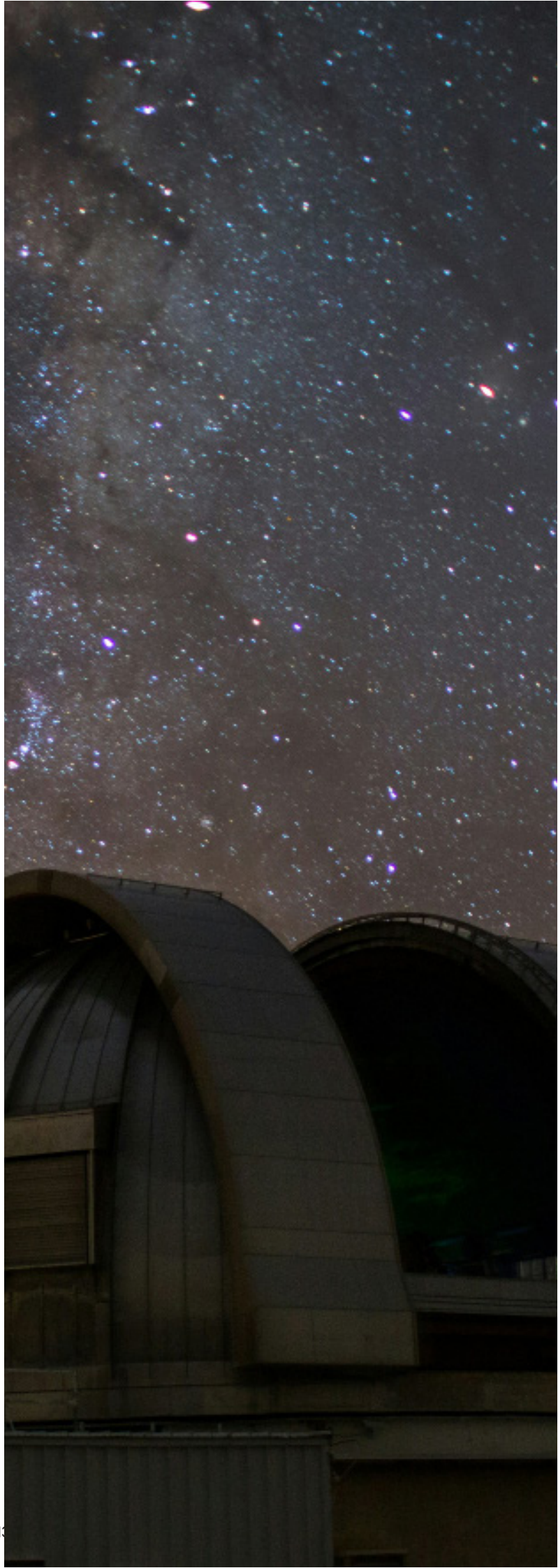
China: Kefeng Tan (NAOC, Beijing) (http://groups.bao.ac.cn/sage/tzcysage/member_scientist/202105/t20210520_640353.html)

Effectiveness of the program:

The outcome of this multilateral program would be measured by the number of publications in reputed scientific journals, dissertations of PhD and master students, utility of the generated catalogues, advancement of techniques related to database management, signal processing, automated detection, identification, reduction and statistical inference.

Summary:

The present proposal forges a long-lasting synergy between all partner institutions in the areas of advanced technology, observational methodology, data acquisition, analysis and data management. It will also lead to a vibrant transfer of knowledge and skills among the investigators. The main objective is to develop a joint training ground for students at all levels through their active involvement in all aspects of the collaboration. The data management, digital signal processing, automated image reduction, and statistical analysis of data would act as a forefront tool for the astronomical community.



CoNMuTraMO

Constraining the Nature of Multi-messenger Transients with Coordinated Multi-wavelength Observations

The goal of this project is to harness existing optical, radio and X-ray facilities available to the five BRICS countries to perform coordinated follow-up and monitoring of multi-messenger (MM) transients. The science case for the project will focus on (but will not be limited to) the observation of high-energy short-lived transient such as Fast Radio Bursts (FRBs), Gamma-ray Bursts (GRBs) and the follow-up of neutrino and gravitational wave (GW) MM events. In particular, the project aims to utilize a global multi-wavelength (MWL) observational network to support the upcoming O4 run of LIGO-VIRGO- KAGRA (LVK) GW observatories.

The science goals of the project will be achieved by the planning and conducting of coordinated MWL campaigns involving the participating facilities and scientists in the five BRICS countries, through the establishment of a network of cooperation for joint observational programs. This BRICS-wide network will be unique in the sense that it will cover the entire electromagnetic (EM) spectrum, from radio to gamma-rays, as well as a global range of latitudes and longitudes, thus providing complete sky and temporal coverage for follow-up and monitoring.

Our teams are directly associated with various observatories in the five BRICS countries, which will be integrated as needed for MWL observations and include the following:

- Brazil: OPD, ROPK, LLAMA
- Russia: IKI, Zeiss-100/INASAN, AZT-33IK/ ISTP, BSA/PRAO
- ACS LPI, INTEGRAL
- India: HCT, DOT, GIT, VBO, AstroSat, uGMRT
- China: Xinglong, Yunnan, FAST, INSIGHT
- South Africa: SAAO, SALT, MeerKAT, H.E.S.S.

The network's coordinated operation and big data integration will be made at software level using virtual observatory protocols and artificial intelligence tools for optimization. By involving teams from various facilities, and with a wide range of expertise in observational astronomy, the project will have a large impact in the training of students and the development of human capacity. It will also generate opportunities for early career scientists to pursue impactful and collaborative international research.

1. Scientific/Intellectual Merit

The study of transient events is crucial because it offers the key ingredients to test the fundamental physical laws and the behaviour of matter and energy in the most extreme physical conditions. Transient phenomena are seen across a wide range of object classes, from the nearest to the farthest producing energies up to 1051-1052 erg in only a few seconds, which is manifested across the electromagnetic (EM) spectrum.

The BRICS consortium proves to be exemplary in terms of available resources, coupled with global coverage, to conduct coordinated multi-wavelength (MWL) observations, covering the full range of the EM spectrum ranging from radio (uGMRT, MeerKAT, Kunming) to gamma-rays (H.E.S.S., MACE). Such prompt responses of these facilities have already contributed to some of the ground-breaking discoveries that have revolutionized the study of transients. The large datasets obtained for these events aid in coupling traditional astrophysics and Big Data.

Beyond MWL explorations of the EM spectrum, the field of multi-messenger astronomy (MMA) has made a quantum

leap with the development of facilities to detect cosmic rays, neutrinos and gravitational waves (GWs). The study of exotic transient phenomena sits at the heart of this MMA revolution and the future prospects for the detection and study of some of these energetic transients heralds a new era in time domain astronomy. Although transients have been studied within the BRICS framework over the last few years, this focused proposal will be timely for monitoring transient alerts from MMA facilities which detect GWs and neutrinos.

The LIGO-VIRGO-KAGRA (LVK) GW observatories are presently undergoing upgrades, with the fourth observing run (O4; due to start Aug 2022) keenly anticipated by astronomers. Exploiting the MWL follow-up opportunities following from the O4 run will benefit from better coordination between the existing BRICS facilities. The advancement of computing resources with high performance, increased speed and bandwidth, coupled with Machine Learning (ML), enables us to take an ambitious step in integrating the facilities in a more efficient manner for coordinated follow-up observations.

The transient events we aim to study as part of this project come from a variety of astrophysical objects and are briefly outlined below:

GWs were first directly detected on 14 Sep 2015. The true era of MMA began on 17 Aug 2017, when observations from LIGO and VIRGO led to the first discovery of GWs and EM radiation from a binary neutron star (BNS) merger, GW170817 and its coincident association with a short Gamma Ray Burst (SGRB) 170817A. This event yielded a scientific bonanza in the fields of gravitational physics, nucleosynthesis, extreme states of nuclear matter, relativistic explosions and jets, and cosmology, all thanks to coordinated observations by several dozen facilities across the globe, including some within BRICS. At the same time, it revealed several surprises, including energetics and structure of the jets emanating from the remnant of the merger. Neutron star-black hole (NS-BH) mergers are another intriguing GW and MM source that could help us solve several puzzles in the field.

Some of the questions which will be answered with the detection of O4 events and their MWL follow up are: How much energy do mergers release? How many mergers have relativistic jets? What is the underlying relation between BNS mergers and SGRBs? What will a NS-BH merger look like? NS-BH mergers may lack the bright optical emission and will require an optimized radio search strategy for discovery. In such a case, is there a way to find NS mergers where searches for kilonovae are inhibited?

Stellar collapses or mergers of compact objects give rise to sudden and violent explosions accompanied by the formation of a powerful jet, appearing as a GRB if the jet is pointed towards the line of sight of the observer. Despite many studies it remains unclear which types of stars produce such jets and which ones do not. Observational evidence has shown that some GRBs are associated with the supernova explosion of massive stars but not all exploding stars produce GRBs.

Polarization measurements are meaningful to provide constraints on jet orientation which has recently been possible due to the exceptional capability of the CZTI detector onboard the Indian AstroSat satellite. Recent detections of GRB emission at TeV energies with MAGIC and H.E.S.S has also opened an unexplored window in the very high energy domain. More MWL studies would be required to answer some of these open questions.

Since 2013, the IceCube neutrino detector at the South Pole has established a flux of astrophysical VHE neutrinos. The sources of these neutrinos are not firmly

established, but blazars appear as likely sources of at least some of those neutrinos. Several blazars are now tentatively associated with astrophysical VHE neutrinos, in particular TXS 0506+056, identified as the source of the VHE neutrino event IceCube-170922A as well as a neutrino flare in 2014 – 2015. With planned upgrades to IceCube and the construction of the next-generation KM3NeT neutrino observatory in the Mediterranean Sea, a golden age of neutrino MMA is on the horizon, and the proposed coordinated follow-up observations of IceCube (and, in the future KM3NeT) neutrino alerts will play a key role in advancing this field.

Fast Radio Bursts (FRBs) are luminous millisecond radio transients studied over the past decade. Despite a large increase in discoveries in recent years, we still have little understanding about the origin of these bursts. Most FRBs are seemingly single flashes. However, some FRBs emit multiple bursts, sometimes as frequently as 20 bursts in half an hour. Recent observations of FRB 20121102 suggest that the source can emit two kinds of bursts at different luminosity scales that mimic different morphologies. Thus the question of what causes FRBs, whether all FRBs can repeat, and whether repeating and non-repeating FRBs arise from different astrophysical channels remain unanswered.

Deep surveys with radio telescopes conducted by BRICS facilities are potentially the most powerful approaches for radio detection of planetary companions of M and K dwarfs and is another prospective area to be explored in detail. This project will bridge the field of deep surveys, big data and transient science by collaboration in developing algorithms and software systems to mine deep survey data sets for transient signals. Exploring the current research topics in transient astronomy within the fruitful collaboration of the BRICS will help in answering some of the open questions and yield high impact results along with training of human resources and several other societal benefits.

2. Fit to call objectives

The expected broader impacts of this work will be:

- The BRICS-wide coordinated ground and space-based MWL observations of astronomical transients will probe the underlying physical mechanisms giving rise to such transients.
- The analysis of big and diverse datasets collected through MWL observing facilities within the BRICS consortium will leverage high performance computing resources and help in developing robust and efficient data analysis pipelines and software.
- We will use ML and artificial intelligence algorithms to explore the transient space/surveys in a larger perspective of interdisciplinary research and collaborations.
- Training of human resources (young researchers and technical staff) in this program can in future be utilized for upcoming BRICS and international facilities. Workshops and conferences will serve as essential tools for knowledge exchange within the consortium.
- The proposal aims at addressing the wider socioeconomic benefits by bridging the industry and academic disciplines, engaging society and raising awareness in the society by public outreach engagements and capacity building.

3. Personnel/Expertise of the Consortium

In the era of big data and MMA, collaborations among BRICS countries have become even more relevant. The diverse expertise (i.e. observations, theory, simulations, computations, handling big data) available among different partner countries will be utilized to build on existing research activities within BRICS countries over recent years, covering the various

themes of this proposal in a coordinated MWL approach. Deep survey programs using large databases have potential to be applicable for societal benefits, such as utilizing the resources and experiences earned to identify potential areas and work toward some of the post-COVID19 related challenges.

Most of the proposed researchers of this proposal are globally connected and many have achieved scientific results of high impact in transient astronomy. For this program, a wide geographical longitudinal coverage coming from state of the art facilities already established and managed by the BRICS countries make this one of the most compelling international collaborations to conduct research related to upcoming LVK O4 run or other time critical MWL Observations.

The consortium includes both senior and early-career researchers from universities and institutes and is open to establish collaboration with all types of institutions within and outside the BRICS countries. All participating countries will be able to utilize a significant number of trained researchers and observational facilities in their respective countries to pursue the goals of the proposal.

Based on our previous successful experiences of bilateral and multilateral collaborations, we expect that this project will catalyse and develop vibrant networks of collaborators around its varied themes. In particular, the support of early careers researchers will have a large capacity development benefit. This will be supported by research visits between different BRICS groups and through workshops and meetings, both virtual and physical.

Flagship Project:

BRICS Intelligent Telescope and Data Network BITDN

As emerging economies, the BRICS countries face a specific set of challenges but are also uniquely placed to act on the opportunities that the fourth industrial revolution presents. This proposed flagship astronomy programme is a collaborative scientific enterprise, drawing on the strengths of all five BRICS partners, while at the same time seeking to address in-country socioeconomic development challenges. Framing development imperatives in the context of the United Nations Sustainable Development Agenda, this programme will clearly impact Goals 4 (Quality Education), 9 (Industry, Innovation & Infrastructure) and 17 (Partnerships) and has the potential to advance others. It will also have a strong component of Capacity Development, particularly building for the 4th Industrial Revolution, through the training of students and young researchers.

The flagship scientific programme will develop a network of astronomical telescopes, some already existing, and an associated intelligent data network which is the enabler for the science programme. This will leverage existing and planned new telescope and cyber facilities within the BRICS countries and will also draw on the opportunities presented by other multi-wavelength space- and ground-based facilities within, or accessed by, the BRICS group.

The programme focuses on two key areas: 1) the scientific advance, within the BRICS partners, of the rapidly expanding domain of wide-field multi-wavelength imaging sky surveys and the detection and study of transient and time-variable phenomena in the Universe, one of the pillars of modern astrophysics, and 2) technical solutions to the associated enormous Big Data and Big Compute challenges arising from such worldwide networks of transient detectors and imaging surveys, including the Square Kilometre Array (SKA) and the Rubin Observatory's Legacy Survey of Space and Time (LSST), leading global projects in which many BRICS countries are actively involved.

Thanks to their unique, worldwide geographical distribution, BRICS countries are well placed to take the global lead in this quickly evolving and compelling research area, utilizing both existing and future telescopes within BRICS. The latter includes an ambitious plan for a global network of optical telescopes with the unprecedented ability to observe the entire sky continuously on a timescale of less than an hour, greatly increasing our ability to monitor the changing cosmos. New science would not happen without innovation in both instruments and big data science methods and systems, and this project will therefore bring together teams within BRICS to lead programmes in data innovation in each partner country.

The collaboration will include academia and industry from partner countries and will focus on developing technologies of the 4th industrial revolution. An essential human capital development programme is designed to create a new generation of data-savvy scientists and engineers within BRICS, strengthening the scientific community in the global South. Cross disciplinary and links with industry will be a key focus of this project, accelerating technological spinoffs and working actively to promote science for development. The depth and breadth of this network, embedded through this project, will benefit the BRICS participants beyond what we could achieve as individual countries. The nature of this proposed flagship programme is such that it creates the potential to stimulate conversations across disciplines to tackle current global challenges such as COVID-19, using data skills, training and infrastructure.

Country reports

Brazil

Ulisses Barres de Almeida, CBPF
BRICS-STI Brazil Principal Investigator

The Brazilian activities in the the BRICS STI & BITDN Flagship programmes during the year 2024 included the following main topics, centered around the subject of extreme astrophysical transient detection and follow-up.

1. Monthly virtual meetings of the Brazil BRICS-STI team, attended by representatives of all the main participating national institutions (CBPF, INPE and LNA)
2. Astrophysics Seminar at the National Space Sciences Institute (INPE), “The BRICS Intelligent Telescope and Data Network (BITDN) Project”, March 2024, São José dos Campos, Brazil.
3. Hybrid meeting for coordinating Einstein Probe (EP) transients follow-ups, which took place at LNA on 10 May 2024, during a visit of Dr. David Buckley from SAAO (South Africa), with remote participation of the Chinese EP team lead by Ningchen Sun, from UCAS.
4. In-person meeting of the BRICS Astronomy Working Group (BAWG), organized at the margins of the IAU General Assembly, which took place in Cape Town, South Africa, on 13 August 2024 (attended in person)
5. BRICS Astronomy Working Group (BAWG) meeting, between 9-12 Sep 2024. Brazil represented in-person by the delegate Alex Wuensche, from INPE.

Visit of BRICS PI from South Africa to Brazil (David Buckley, SAAO)
In addition to the meetings above, Brazil

welcomed Dr. David Buckley, the BRICS PI from the South African Astronomical Observatory (SAAO), for a visit to the Brazilian Centre for Physics Research (CBPF) and the National Laboratory of Astrophysics (LNA), in May 20024.

The purpose of the visit was to further engage the Brazilian BRICS Astronomy team with our International BRICS counterparts, in particular in the context of the 3-year BRICS STI framework programme, "Constraining the Nature of Multi-messenger Transients with Coordinated Multi- wavelength".
In addition to attending the FINK-Brazil workshop entitled "Enabling Astronomical Transient discoveries in the Rubin era: the Fink-Brazil Workshop", from 6-10 May, which was hosted at CBPF, in Rio de Janeiro, Dr. David Buckley also visited LNA, in Minas Gerais.

The visit to LNA took place between 9 – 12 May. On 10 May a Videoconference with our Chinese collaborators within the BRICS STI programme was organised, which included Dr Ningchen Sun, the Chinese PI, to discuss followup observations of Einstein Probe X-ray sources. This X-ray telescope was launched by China in February. It was agreed that the Chinese EP team would pro-actively communicate alerts using the WeChat platform for prompt optical followup, for which time at the SOAR telescope was allocated. A visit to the Observatório Pico dos Dias took place on 11 May 2024.

Research

The SPARC4 multi-band fast polarimetric camera, ideal for transient follow-up observations in the context of the BRICs-STI programme was installed in the LNA 1.6 m telescope art Pico dos Dias Observatory, and started scientific commissioning in March. As part of the BRICS-STI activities we submitted a proposal and observed 3 VHE-active blazar sources over 34 observational epochs. Over the year 2024, we have concluded the automated pipelines for data reduction and started the analysis of the observations which should then be published as part of a work to characterize the new instrumentation.

Once fully operational, SPARC4 will be used as a regular follow-up instrument for the BRICS-STI observational programme. Following the meeting with Dr. Ninghchen Sun to CBPF and LNA in May 2024, we are now more actively involved in the follow-up of Einstein Probe transient X-ray sources, which include both compact accreting binaries and GRBs. We anticipate this to ramp up in 2025, utilizing the appropriate facilities accessible to the BRCS collaboration.

India

Kuntal Misra
ARIES
BRICS Project Co-Investigator

1. Financial report - From October 2022 to the present, we have received one instalment of the grant for the first year, INR 15,96,920.

2. Scientific report - Two Junior Research Fellows (JRFs) were hired in the BRICS project. After completing their graduate school coursework, they will work on the multi-messenger aspects of GRBs. Observing proposals were submitted to the 3.6m Devasthal Optical Telescope (DOT), 1.3m Devasthal Fast Optical Telescope (DFOT) and the 1.04m Sampurnanand Telescope.

The fields of GRBs accessible with these telescopes were observed to detect an optical counterpart. Some detections and upper limits were reported. Further, an analysis of the prompt emission of peculiar GRBs was initiated. A systematic study of prompt and afterglow properties of peculiar GRBs with an ambiguous classification is planned.

China

Ningchen Sun
UCAS/NAOC
BRICS Project Co-Investigator

Meetings

1. Einstein Probe Scientific Symposium, 25-28 May, 2024, Suzhou
2. The 3rd Symposium on the Frontiers of Supernovae and Time-Domain Astronomy, 21-23 Jun, 2024, Beijing
3. The 5th Gravitational Wave Astrophysics Conference, 29 Jun-5 Jul, 2024, Jingzhou
4. "The Progenitors of Supernovae and their Explosions", 25-31 August 2024, Dali
5. BRICS Astronomy Working Group (BAWG) meeting, 9-12 Sep 2024, Kazan
6. 6. SiTian project annual meeting, 10 Oct - 1 Nov 2024, Hangzhou
7. Einstein Probe Scientific Symposium, 16 Dec, 2024, Xiamen

Visits

1. I visited Thailand on 7-10 Jan 2024. The purpose of this visit was to explore the opportunities of using Thai facilities to carry out follow-up observations of multi-messenger transients. I built a collaboration in time-domain astronomy with Dr. Samaporn Tinyanont, Dr. Krittapas Chanchaiworawit, and Dr. Kanthanakorn Noysena. We discussed how to apply for telescope time and perform observations in a following ZOOM meeting.
2. I hosted Prof. David Buckley from SAAO at NAOC on 23-28 July 2024. We, together with Prof. Weimin Yuan and Prof. Jifeng Liu, discussed the observations of Einstein Probe and SiTian alerts. I also showed him around the Xinglong Observing Station, where the SiTian Prototype Telescope is located. 3. I hosted

Dr. Samaporn Tinyanont, Dr. Krittapas Chanchaiworawit, and Dr. Kanthanakorn Noysena at NAOC on 2-4 Sep 2024. We further discussed the follow-up observations of Einstein Probe alerts with the Thai Robotic Telescope network.

Proposals

1. 2025C1 - Search for optical counterparts of the Einstein Probe detected X-ray transients DOT/ Imager+ADFOSC 40 hours
2. PI: Misra K. – Submitted
3. 2025a - Pursuing the first lights from core-collapse supernovae: rapid follow-up observations of Einstein Probe alerts GTC/OSIRIS+ 15 hours; NOT/ALFOSC 10 hours; LT/IO:O+SPRAT 45 hours
4. PI: Aguado D. – Accepted
5. 2025a - Pursuing the first lights of core-collapse supernovae with EP and LT LT/IO:O+SPRAT 30 hours
6. PI: Maund J. R. – Accepted
7. 2025a - Solving the missing energy problem in TDEs LT/LIRIC 10 hours
8. PI: Maund J. R. – Accepted
9. p115 - Persuing the first lights of core-collapse supernovae with EP and VLT VLT/FORS2 15.76 hours
10. PI: Wang L. – Accepted
11. 2024c2 - Search for optical counterparts of the Einstein Probe detected X-ray transients DOT/ ADFOSC 40 hours
12. PI: Misra K. – Accepted
13. 2024b - Pursuing the first lights of core-collapse supernovae with EP and LT LT/IO:O+SPRAT 26 hours
14. PI: Maund J. R. – Accepted
15. 2024b - Solving the missing energy problem in TDEs LT/LIRIC 10 hours
16. Maund J. R. – Accepted
17. 2024b - Pursuing the first lights from core-collapse supernovae: rapid follow-up observations of Einstein Probe alerts
18. GTC/OSIRIS+ 15 hours; NOT/ALFOSC 10 hours; LT/IO:O+SPRAT 32 hours
19. PI: Aguado D. – Accepted

Research

In 2024, I have submitted/published 6 papers with myself as the corresponding author, which focuses on the progenitors of astronomical transients. We have been actively searching for and following the optical counterparts of Einstein Probe alerts. Examples include EP241021a, EP250108a, EP250111a, SN2024aecx, and so on.

South Africa

David A.H. Buckley | SAAO
Principal Investigator

Activities with respect to the CoNMuTraMO BRICS STI & BITDN programmes during 2024 included the following relevant meetings, with overlapping themes regarding transient detection and followup.

1. "Rubin ToO 2024: Envisioning the Vera C. Rubin LSST Target of Opportunity Program", 18-20 March 2024 (attended virtually)
2. FINK-Brazil workshop entitled "Enabling Astronomical Transient discoveries in the Rubin era: the Fink-Brazil Workshop", from 6-10 May 2024, Rio de Janeiro (in person)
3. BRICS Astronomy Working Group (BAWG) meeting, 9-12 Sep 2024 (attended virtually; talk presented on BITDN status)
4. "LSST@Europe V", from 16-20 Sep 2024, La Palma (in person; talk presented on SALT/SAAO in-kind access for Rubin LSST)
5. 15th Gaia Science Alerts Workshop, from 30 Sep-2 Oct 2024, Heraklion (in person; talk presented on SALT transient programme)

Visits

In addition to the above science meetings attended, several other visits were made to observatories/facilities involved in aspect of both the BRICS astronomy programmes, including BRICS STI framework programme "Constraining the Nature of Multi-messenger Transients with Coordinated Multi-wavelength". These included the following:

Brazil (4-12 May 2024)
The purpose of this visit was to advance the BRICS astronomy collaborations within Brazil. In addition, aspects within the 3-year BRICS STI framework programme ("Constraining the Nature of Multi-

messenger Transients with Coordinated Multi-wavelength") were also relevant to the visit.

The major reason for the timing of the visit to attend the FINK-Brazil workshop entitled "Enabling Astronomical Transient discoveries in the Rubin era: the Fink-Brazil Workshop", from 6-10 May, hosted at the Centro Brasileiro de Pesquisas Fisicas (CBPF) in Rio de Janeiro. Its relevance relates to the triggering of transient and variable object followup, through the alert broker, FINK, being developed mostly in France and Brazil. This is one of the brokers which is currently used for ZTF alerts and will also be one of the Rubin LSST alert brokers, which is relevant to the goals of the SAAO's Intelligent Observatory project. Both myself and an SAAO software engineer attended. The Brazil connection, through BRICS, will mean the potential to support this work through the BRICS astronomy programmes.

From 9 – 12 May I visited the Brazilian National Laboratory for Astrophysics (LNA) in Itujubá, about 5 hours by road from Rio. On 10 May we held Zoom call with our Chinese collaborators within the BRICS STI programme, including Dr Ningchen Sun, the Chinese PI, to discuss followup observations of Einstein Probe X-ray sources. This X-ray telescope was launched by China in Feb. They agreed to pro-actively communicate alerts using the WeChat platform for prompt optical followup.

ROTSE facility Namibia (23-28 May & 17-24 Oct 2024)

ROTSE (Robotic Optical Transient Search Experiment) is a wide-field (2.6 degree diameter) 0.45 m diameter telescope, which operated at the HESS site in Namibia until 2013, doing fast optical follow-up observations of GRBs (gamma-ray bursts). It was subsequently de-commissioned when operational support became a challenge. It is now being refurbished with a new observatory control system and a CMOS camera for observing fast optical transients, particularly high energy and multi-messenger events (e.g. GRBs, supernovae, Gravitational Waves), some of the themes of the BRICS programmes.
Two visits were made in 2024, resulting in the telescope's partial recommissioning and is expected to be fully functional during 2025.

National Astronomical Observatory of China (23-28 July 2024)

From 23-28 July I visited the National Astronomy Observatory of the Chinese Academy of Sciences (NAOC). I met the Einstein Probe (new Chinese X-ray telescope launched in Feb 2024) team and Principal Investigator, Prof Weimin Yuan. I also met with Dr Ningcheng Sun, Chinese PI for our BRICS STI programme, plus other collaborators involved in the SALT Transient programme, for which I presented a colloquium talk.

I also met with the NAOC Director General, Prof Jifeng Liu, co-PI of the BRICS Intelligent Telescope and Data Network (BITDN) and discussed the future plans for the programme. I also visited the Xinglong station to see the recently completed Sitian prototype transient detection telescope, which will form the basis of the Sitian network in China and also possibly for the extended BITDN global transient detection network.

Research

The SALT Large Science Programme (2021-2-LSP-001) on transient followup, led by David Buckley (SAAO/UCT/UFS), continues to be very productive, with 34 refereed papers published in 2024, of which 3 were related to the themes of the BITDN multi-messenger progamme, namely:

- Potter, S. B., Buckley, D. A. H., Scaringi, S., Monageng, I. M., Egbo, O. D., Charles, P. A., Erasmus, N., van Gendmn, C., Loubser, E.,

Titus, K., Rosie, K., Gajjar, H., Worters, H. L., Chandra, S., Julie, R. P. M., & Hlakola, M. (2024), MNRAS, 532, , L21. Optical spectroscopic and photometric classification of the X-ray transient EP240309a (EP J115415.8-501810) as an intermediate polar.

- Driessen, L. N., Barr, E. D., Buckley, D. A. H., Caleb, M., Chen, H., Chen, W., Gromadzki, M., Jankowski, F., Kraan-Korteweg, R. C., Palmerio, J., Rajwade, K. M., Tremou, E., Kramer, M., Stappers, B. W., Vergani, S. D., Woudt, P. A., Bezuidenhout, M. C., Malenta, M., Morello, V., Sanidas, S., Surnis, M. P., & Fender, R. P. (2024), MNRAS, 527, 3659. FRB 20210405I: a nearby Fast Radio Burst localized to sub-arcsecond precision with MeerKAT.
- Zhu, Y.-M., Wang, Y., Zhou, H., Lipunov, V., Buckley, D. A. H., Balanutsa, P., Jin, Z.-P., & Wei, D.-M. (2024), MNRAS, 527, 1638. A two-component jet model for the optical plateau in the afterglow of GRB 191221B.

Following the visit to NAOC in July 2024, we are now more actively involved in the followup of Einstein Probe transient X-ray sources, which have included both compact accreting binaries (see paper i. above) and GRBs. We anticipate this to ramp up in 2025, utilizing the appropriate facilities accessible to the BRCS collaboration.

Appointment

On 1 Nov 2024, Dr Nikita Rawat (ARIES, India) joined the research group as a BRICS STI Postdoctoral Fellow, funded by the BRICS STI ("Constraining the Nature of Multi-messenger Transients with Coordinated Multi-wavelength").

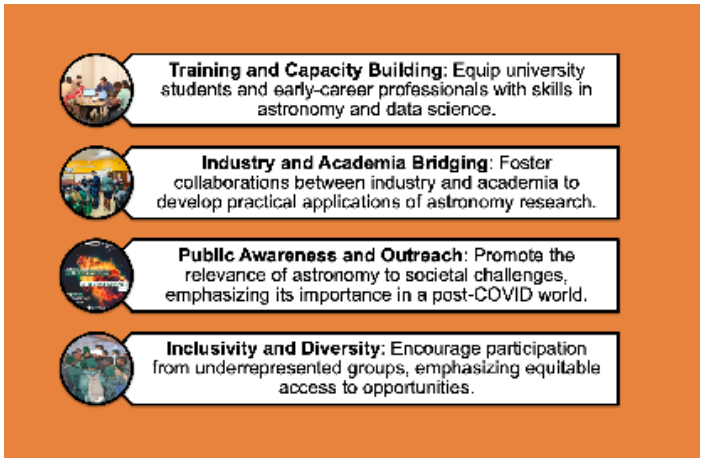
Societal Benefit Activities

Overview of outreach, education, and development programs within the BITDN and STI projects

Strategic to the scientific and technical activities of the BITDN Project are:

- the joint support and mentoring of students and young researchers by the collaborating BRICS scientists,
- the development of community relationships between different astronomy groups within the BRICS family,
- the sharing of data and working together on the scientific returns, as well as
- facilitating the establishment of community-developed and maintained software systems.

Key objectives of the societal benefit activities:



Socioeconomic benefits

Human capital development (HCD) is a key aspect of the project. An integral part of the new approach to science driven by big data, big compute and large international collaborations is to create and embed the science platforms within the research communities so that researchers may work collaboratively on these large, diverse multi-wavelength data sets. Such platforms are best developed through extensive, international programmes such as the one proposed here. It promotes sustained collaboration between partners from the BRICS countries, and prevents duplication of efforts in developing such platforms in individual countries, while concurrently cultivating the expertise that forms a core component of knowledge-based economies. There are also wider socioeconomic benefit implications, and these include building bridges with industry and across academic disciplines, engaging society and working towards preserving life on Earth.

1. Training young scientists & technicians

The project aims to support the training of both scientists and technicians (impacting on SDG 4 - quality education) through postgraduate scholarships, research schools, data workshops and hackathons, as well as conference participation. While exchange visits and workshops are essential tools for knowledge transfer, this project will provide innovative alternatives to residential workshops through **training hubs, virtual and in-person.**

Working with the industry and building on existing and forthcoming tools for international scientific collaboration on large datasets, the project will explore

and develop a training hub that is able to operate across multiple languages, time zones and learning modes to provide state-of the-art training and collaboration opportunities to students in the network, while minimizing travel. Such a training hub, addresses also SDGs 13 (climate action) for the virtual training, and 9 (industry, innovation and infrastructure), and can be a tool to encourage and retain women in the programme, addressing SDG 5 (gender equality). Benefits of this hub have the potential to be much broader, impacting the BRICS consortium as a whole, and potentially also the education sector (SDG 4). The HCD programme focuses on developing leadership opportunities for early career researchers. This is essential to drive both scientific excellence and transformation (SDG 10) and to strengthen the independence of the scientific community in the global South.

Bridges with industry

The data and compute requirements that drive this project lend themselves to joint industry-academic programmes, internships and cross-disciplinary interventions. Tools and skills will be developed that have potential impacts broader than astronomy. For example, accurate analysis of large quantities of real-time (streamed) data is necessary to meet the science goals of this project. But the computing infrastructure and software required to build such systems can likely be applied in medicine (SDG 3), sentiment analysis and a myriad of other fields. Part of this project will include actively seeking out such opportunities to contribute tools and skills to industry and other disciplines, thereby contributing to SDG 17 (partnerships) and SDG 9 (industry, innovation), as well as exchange and internship programmes attached to projects carried out in partnership with industries (SDG 4 - education).

This project aims to create a bridge between industry and astronomy by leveraging big data, AI, and advanced computing to solve real-world challenges. Astronomy, as a field that requires processing vast amounts of real-time data, offers transferrable skills and tools applicable to various industries, including finance, logistics, healthcare, and artificial intelligence. Through joint industry-academic programs, internships, and cross-disciplinary interventions, this initiative will ensure that knowledge and technological advancements from astronomy contribute to broader societal and economic growth.

Public science awareness & development of communities

Specific initiatives are planned to develop outreach resources showcasing the facilities, science collaborations and technology developments in the project. These are based on the expertise developed in this arena in the BRICS countries. **The Cascade Outreach model,** as developed in South Africa, works to promote young scientists as role models while reducing the load on established minority scientists who are disproportionately asked to represent their science as efforts are made to diversify the field.

It serves to offer a sustainable solution to practical outreach and communication training for students and researchers and can be very simply translated to different contexts. This project is committed to the principles of open science and aims to strengthen the impact of the scientific programme in the training of young scientists and community outreach through a citizen science approach. Tools such as the Open Universe Initiative (under the coordination of the United Nations Office for Outer Space Affairs) aim to improve the accessibility and sharing of astronomical data from many

different facilities. As such it supports engagement through citizen science projects, as well as supporting scientific partnerships across the BRICS countries. India has developed models for science engagement that can be scaled up to accommodate large numbers of visitors. This is part of a campaign to engender a "scientific temper" and ease the tensions between science and superstition. Lessons from these efforts can be translated across the BRICS network.

The Office of Astronomy for Development, together with a number of international partners, has identified a model for the development of local communities around an astronomical facility, such as an observatory. Benefits could include job creation through astronomy-related tourism, education programmes, the development or training of specific skills within a community, and stimulation of local innovation and activities that may draw youth away from negative or harmful pursuits. The specific implementation is context-specific, but close collaboration between the astronomy facility, local community and the government is key to sustainability.

Data Analytics Training

Introduction

The BRICS Astronomy & Inter-University Institute for Data Intensive Astronomy (IDIA) has successfully launched a Data Analytics training course as part of our Societal Benefits Program. This initiative is crucial for human capital development (HCD), a core component of the BRICS Intelligent Telescope and Data Network project. A fundamental aspect of the evolving, data-driven scientific landscape, characterised by extensive data, significant computational demands, and large-scale international collaborations, is the integration of science platforms within research communities. This integration enables researchers to collaborate effectively on diverse, multi-wavelength datasets.

The Data Analytics training course commenced on the 5th of April 2025. This innovative 8-week virtual training program focuses on data science and machine learning with practical applications in Astronomy. Its primary objective is to enhance participants' comprehension of data science concepts and improve their research capabilities, with a strong emphasis on real-world astronomical applications.

Program overview

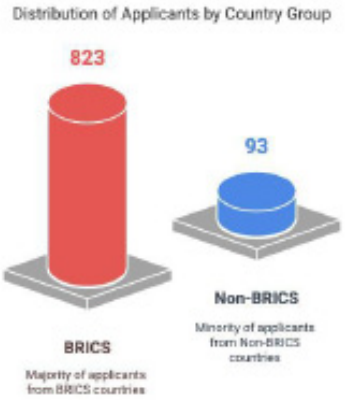
This virtual program was meticulously designed to accommodate individuals across all skill levels, from novices to advanced users. It delivers hands-on learning experiences in critical areas of data science and machine learning, with a specific focus on the management, analysis, and interpretation of large astronomical datasets. The program also explores new research avenues within BRICS countries and IDIA.

Key objectives

The program is designed to equip participants with the essential knowledge and practical tools necessary for effectively managing and analysing scientific data. It aims to foster innovation by supporting the development of machine-learning applications for use in astronomy and related scientific fields. Furthermore, a key objective is to build a collaborative community, providing a space for participants to exchange ideas, address challenges, and develop solutions, thereby strengthening the broader research network.

Applicant demographics

The program received a substantial number of applications, underscoring significant global interest in the convergence of data science, machine learning, and astronomy. A total of 916 applications were received, representing a diverse array of countries.



Geographic distribution: The majority of applicants are from India (66.9%), followed by South Africa (8.6%), and Brazil (1.5%). Other BRICS and partner countries also demonstrated significant representation, highlighting the strong engagement from these regions and potentially indicating a greater demand for astronomy data science and AI training within them. The distribution by country group further illustrates this, with 823 applicants from BRICS countries and 93 from non-BRICS countries

Figure 1.: Distribution of Applicants by Country Figure 1.2: Distribution of Applicants by Country

Educational Qualifications: A significant portion of applicants hold university degrees, with 43.1% possessing a Bachelor's degree and 39.5% holding a Master's degree. A smaller percentage of applicants hold PhDs (8.6%) or other qualifications.

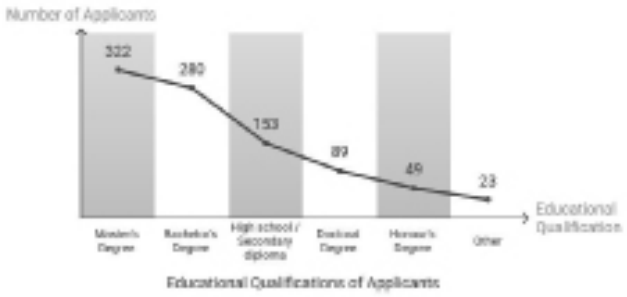


Figure 2: Educational background of the applicants

Programming experience: The applicant pool demonstrates a high level of programming experience, with 838 applicants indicating prior programming knowledge, while 78 applicants reported no prior programming experience.

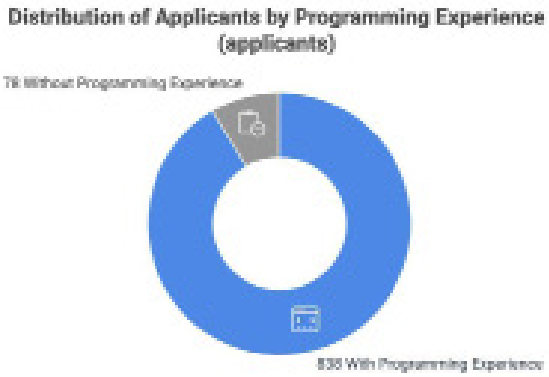


Figure 3: Distribution of Applicants by Programming Experience

Data Science Hackathons

Scaling Innovation: The BRICS Hackathon Journey
From Inception to the Future of Data-Driven Astronomy and Socioeconomic Impact

Executive Summary

Since 2022, the BRICS Intelligent Telescope and Data Network (BITDN), in collaboration with key partners such as the Inter-University Institute for Data Intensive Astronomy (IDIA), has been at the forefront of organizing impactful hackathons. These events have provided platforms for participants from BRICS nations to engage in solving challenging problems in data science and related fields. Through a combination of innovative programming, strategic partnerships, and a strong focus on capacity building, the BITDN hackathon series has established a sustainable pipeline for scientific discovery and socioeconomic development across the Global South. This report provides a comprehensive overview of the journey so far, highlights key milestones, and outlines the vision for the future, culminating in the ambitious BITDN Hackathon 2025 and beyond.

Introduction

The rapid advancement of data-intensive science has opened unprecedented opportunities for global collaboration, particularly in astronomy, where the scale and complexity of data demand innovative, cross-disciplinary solutions. The BRICS Intelligent Telescope and Data Network (BITDN) was conceived as a strategic response to these challenges, aiming to leverage the collective strengths of BRICS nations, Brazil, Russia, India, China, South Africa, Saudi Arabia, Egypt, United Arab Emirates, Ethiopia, Indonesia, and Iran to drive scientific and technological innovation.

Hackathons have emerged as a cornerstone of BITDN's capacity-building and innovation agenda. These events provide a dynamic platform for participants to engage with real-world scientific problems, develop technical and soft skills, and build lasting international networks. By aligning with the United Nations Sustainable Development Goals (SDGs), particularly Quality Education, Industry, Innovation & Infrastructure, and Partnerships, BITDN hackathons are not only advancing science but also contributing to broader socioeconomic goals.

The BITDN Hackathon Series: 2022–2024
Early Foundations and Strategic Partnerships

The BITDN hackathon journey began in 2022, with the first event organised in partnership with the Inter-University Institute for Data Intensive Astronomy (IDIA) and other key stakeholders. The objective was clear: to create a collaborative environment where postgraduate students and early-career researchers could tackle challenging problems in data science, with a focus on astronomy.

Over the next two years, the hackathon series expanded in scale and scope, incorporating new partners such as the Office of Astronomy for Development (OAD), the African Astronomical Society (AfAS), and the BRICS Astronomy Working Group (BAWG). These collaborations enabled BITDN to reach a wider audience, diversify the range of challenges, and enhance the overall impact of the programme.

Key Events and Participation

Major hackathons conducted between 2022 and 2024 include:

- BITDN Hackathon 2022: The inaugural event, setting the standard for future

hackathons.

- UKZN Hackathon 2023: Hosted by the University of KwaZulu-Natal, focusing on advanced data science challenges.
- AfAS Data Science Hackathon 2023: A pan-African event emphasising open science and collaboration.
- BAWG Hackathon 2023: A landmark event uniting all BRICS nations for the first time.
- AfAS Hackathon 2024: Further expanding regional participation and technical scope.

Over these five events, more than 700 applications were received, with around 120 participants selected based on their skills in Python programming and motivation to engage in data science challenges. Each hackathon typically hosted 25–30 participants, fostering a collaborative and innovative environment.

A Groundbreaking Milestone: The BAWG Hackathon 2023

The **BRICS Astronomy Working Group (BAWG) Hackathon,** conducted in 2023, was a landmark event. It united postgraduate astronomy students from all BRICS nations for the first time, bringing together 27 participants. The hackathon focused on clustering astronomical data using machine learning, with a specific goal of distinguishing active galactic nuclei (AGNs) from star-forming galaxies (SFGs) using MeerKAT MIGHTEE survey data. Hosted on the ilifu cloud platform, this event highlighted the power of international collaboration and innovation in astronomy and data science.

Figure 4: BAWG Hackathon 2023, Cape Town South Africa

Cloud Computing and Collaborative Infrastructure

Cloud computing has emerged as a foundational pillar for the success and future growth of the BRICS Intelligent Telescope and Data Network (BITDN) hackathon series and broader collaborative astronomy research across BRICS and partner nations. The ability to access, process, and analyse vast astronomical datasets in a distributed, scalable, and collaborative environment is essential to meet the demands of data-intensive science in the era of next-generation observatories.

Existing Cloud Infrastructure and Partnerships

The Inter-University Institute for Data Intensive Astronomy (IDIA) research cloud, initially developed through a partnership of South African universities and research institutions, has proven the immense value of shared, high-performance computing resources. This infrastructure supports researchers across countries, enabling them to handle large datasets from MeerKAT and other radio astronomy facilities. The success of this model has inspired the expansion of cloud platforms such as the ilifu cloud, which is designed to accommodate exponentially increasing data volumes expected from major international projects.

BITDN is establishing a cloud network that connects data centres and computing facilities across all BRICS countries. This distributed infrastructure will enable seamless sharing of data, software, and computational resources, empowering scientists and students to collaborate effectively regardless of their physical location. Each BRICS partner with cloud computing facilities will host a cloud node with dedicated technical support, coordinated centrally to ensure interoperability and optimal resource

utilisation.

Enabling Seamless Collaboration and Innovation

Cloud computing enables diverse teams from multiple countries to collaborate in real time, regardless of geographic location. For BITDN hackathons, this capability is critical: participants require access to large-scale datasets, the ability to run computationally intensive machine learning models, and the means to develop, test, and share code collaboratively. By hosting hackathon environments on cloud platforms, BITDN ensures that all participants have equitable access to the necessary computational power and data storage, fostering inclusivity and levelling the playing field.

Moreover, cloud platforms enhance reproducibility and transparency in research by allowing scientists to share not only their results but also the exact data processing workflows, software environments, and codebases. This openness accelerates scientific progress and builds trust within the community.

Future Directions: Expanding Cloud Access Across BRICS

Looking ahead, expanding and harmonising cloud infrastructure access across all BRICS countries will be pivotal to the BITDN hackathon programme's continued growth and impact. Providing equitable, reliable, and scalable cloud resources will empower a broader and more diverse pool of participants to engage meaningfully with data-intensive challenges.

BITDN plans to integrate cloud computing deeply into future projects and hackathon designs, including the upcoming 2025 flagship event. This integration will support hybrid virtual/in-person formats, phased challenges requiring scalable computation, and post-event pathways for deploying successful solutions into production environments. By leveraging cloud computing as the technological backbone, BITDN will enable participants to tackle increasingly complex scientific problems, collaborate across borders seamlessly, and contribute to transformative discoveries in astronomy and data science.

Hack4dev: Shaping the Future of Hackathons

Building on a collaborative foundation established by several partners, including the BRICS Intelligent Telescope and Data Network (BITDN), the **Hack4dev initiative** emerged as a transformative effort to enhance the impact and effectiveness of hackathons. The initiative unites efforts from key organisations, such as the Inter-University Institute for Data Intensive Astronomy (IDIA) and the Office of Astronomy for Development (OAD), to achieve greater outcomes in hackathon design and implementation.

In 2023, Eslam Hussein, a data scientist from the BITDN project, took the lead in advancing Hack4dev by analysing past hackathons and research to develop a new framework for impactful hackathons. By March 2024, Hack4dev had established this framework, beginning with the recruitment of skilled teams in data science and event organisation.

A major milestone for Hack4dev was the Call for Trainers, launched in June 2024. The call attracted over 60 applicants, including 20 from BRICS+ nations. Fourteen trainers were selected to lead regional hackathons, representing countries such as Ethiopia, South Africa, India, and Brazil.

On October 23, 2024, Hack4dev hosted its first Data Science Trainers' Hackathon at WITS University in Johannesburg, South Africa. This event marked the official launch of the Data Science Hackathon Program. The program will conduct 14

regional hackathons from February to April 2025, exceeding the total number of hackathons conducted over the last few years.

Figure 5: Hack4dev was initiated at the Office of Astronomy for Development (OAD) on May 4, 2022. The photo features Eslam Hussein (far left) and Duduzile Kubheka (third from right).

Impact and Outcomes

Scientific and Technical Achievements

BITDN hackathons have consistently delivered high-impact scientific and technical outcomes, including:

- Development of Innovative Tools: Participants have designed and prototyped novel algorithms and software solutions, with the hackathon materials and challenges made publicly available to the global astronomy and data science communities via github.
- Advancements in Machine Learning: Hackathons have driven the development of new approaches for clustering, classification, and anomaly detection in large astronomical datasets.
- Potential Integration with Major Facilities: There are ongoing efforts and future plans to adapt and integrate promising solutions developed during the hackathons with major international projects such as the Square Kilometre Array (SKA) and the Rubin Observatory's Legacy Survey of Space and Time (LSST).

Capacity Building and Human Capital Development

A core objective of the BITDN hackathon series is to build capacity for the Fourth Industrial Revolution within the BRICS community. Key achievements include:

- Skills Development: Participants have gained hands-on experience in programming, machine learning, cloud computing, and data analytics.
- Diversity and Inclusion: Hackathons have actively engaged underrepresented communities, promoting gender balance and geographic diversity.
- Professional Growth: Many participants have leveraged their hackathon experience to advance their academic and professional careers, including publishing research, securing scholarships, and joining leading research institutions.

Socioeconomic and Global South Leadership

BITDN hackathons have positioned the Global South as a leader in scientific innovation and problem solving. By leveraging local talent and fostering international partnerships, these events have contributed to:

- **Socioeconomic Development:** Empowering participants with skills relevant to high growth industries, thereby enhancing employability and entrepreneurship.
- **Global Recognition:** Showcasing the capabilities of BRICS nations on the international stage, attracting collaboration opportunities.

The BITDN Hackathon 2025: Vision and Plan

The 2025 hackathon builds on the

success of previous BITDN events, which have attracted many participants from across the BRICS nations. These events feature hands on problem solving sessions, mentorship from leading scientists and experts, and opportunities for participants to work on real-world challenges using actual astronomical datasets. Past hackathons have demonstrated high engagement, with significant representation from underrepresented communities, and have resulted in the development of open source tools, innovative algorithms, and new approaches to big data challenges in astronomy. The hackathon also serves as a platform for networking, skills development, and exposure to cutting edge research, further strengthening the scientific community within the BRICS countries.

Expanding the Network

The BITDN Hackathon 2025 marks a new chapter, expanding participation to include all BRICS nations, Saudi Arabia, Egypt, United Arab Emirates, Ethiopia, Indonesia, and Iran. This broader network reflects BITDN's commitment to inclusivity and global collaboration.

Project Overview

The BRICS 2025 Hackathon will focus on advancing the BITDN's core scientific and technical goals through intensive, collaborative problem-solving. Participants from Brazil, Russia, India, China, South Africa, Saudi Arabia, Egypt, United Arab Emirates, Ethiopia, Indonesia, and Iran will tackle challenges centred on **galaxy morphology classification** and **anomaly detection,** leveraging datasets from surveys like SDSS and Galaxy Zoo. Teams will develop machine learning models, comparing architectures against state of the art frameworks like Zoobot, while innovating in uncertainty quantification (e.g., Bayesian neural networks) and scalability for next generation facilities such as LSST and SKA. The event will include pre-hackathon training workshops for facilitators, mentorship from BRICS astronomy experts (throughout the hackathon the facilitators and experts will be available on slack for participants to ask questions), and collaboration (virtual) sessions to ensure solutions align with real-world scientific and computational demands.

The hackathon will emphasise capacity building and socioeconomic impact, integrating the BITDN's commitment to human capital development and United Nations Sustainable Development Goals. Structured as a hybrid virtual event.

Alignment with Sustainable Development Goals

The hackathon will explicitly align with the United Nations Sustainable Development Goals, focusing on:

- Quality Education: Providing high-quality, hands-on learning experiences.
- Industry, Innovation & Infrastructure: Driving technological innovation and infrastructure development.
- Partnerships: Strengthening international and cross-sector collaborations.

Skills Development and Participant Experience

Technical Skills

Participants will develop and refine a range of technical skills, including:

- **Programming & Software Development:** Mastering tools and frameworks relevant to astronomical data science.
- **Debugging & Integration:** Working on real-world problems sharpens your

as you combine machine learning, coding and astronomy knowledge to create a functional solution.
- **Exposure to New Technologies:** Hackathons often focus on cutting edge fields such as artificial intelligence, cloud computing, giving you hands on experience with the latest tech. In this hackathon, you will be exposed to the latest astronomy datasets and cloud computing infrastructures.
- **Design & User Experience:** You'll learn to design user friendly solutions (codes) and consider the end-user experience, making your solutions practical and adaptable.

Soft Skills

Hackathons provide a unique environment for developing essential soft skills:

- Critical & Creative Thinking: You'll be challenged to analyse the problem, think outside the box, and develop innovative solutions under time pressure.
- Teamwork & Collaboration: Hackathons are team based, so you'll practice dividing tasks, communicating clearly and effectively, and leveraging each member's strengths.
- Time Management: With strict deadlines, you'll learn to prioritise tasks, set achievable goals, and deliver results efficiently.
- Adaptability: The fast-paced environment requires you to quickly adjust to new challenges, tools, and team dynamic.
- Communication & Presentation: Presenting your project to judges hones your ability to explain complex ideas clearly and persuasively.

Professional Growth

Participation in the BITDN hackathon series offers significant professional benefits:

- **Networking**: You'll connect with peers, mentors, and professionals, expanding your professional network and opening doors for future collaboration across the BRICS network.
- **Industry Recognition**: Successful participation can boost your coding portfolio and make you more visible to future employers.
- **Confidence & Motivation**: You will build self-assurance and confidence through the successful completion of challenging projects.

Monitoring, Evaluation, and Sustainability

Monitoring and Evaluation

To ensure continued success and impact, BITDN implements robust monitoring and evaluation mechanisms, including:

- **Participation Metrics:** Tracking diversity, engagement, and retention.
- **Skills Assessment:** Evaluating technical and soft skills development.
- **Impact Measurement:** Assessing scientific, educational, and socioeconomic outcomes.

Sustainability and Future Directions

BITDN is committed to sustaining and scaling its hackathon programme by:

- Expanding Partnerships: Bringing all countries and organisations into the network.
- Continuous Improvement: Incorporating feedback and lessons learned to enhance future events.

Conclusion

The BRICS Hackathon series, underpinned by the BITDN and Hack4dev initiatives,

has established a vibrant ecosystem for innovation, capacity building, and international collaboration. As the programme evolves, it continues to empower the next generation of scientists and engineers, advancing both scientific discovery and socioeconomic development across the Global South.

The journey from the first BITDN hackathon in 2022 to the ambitious plans for 2025 and beyond demonstrates the power of strategic collaboration, visionary leadership, and sustained investment in human capital. By harnessing the collective strengths of BRICS and partner nations, the BITDN hackathon series is paving the way for a brighter, more inclusive future for science and society.

Earth and Beyond Science Fair

Introduction

BRICS Astronomy, along with the Johannesburg City Parks and Zoo and the South African Astronomical Observatory (SAAO), partnered with the Eskom Expo for Young Scientists. This collaboration came in the form of the Earth and Beyond Science Fair.

Project overview

The Earth and Beyond Science Fair invited grade 8 to grade 12 learners from both public and private schools in Gauteng to showcase their scientific capabilities. Learners were tasked with creating projects that highlighted topics within the fields of "Earth" (environmental, Earth, plant and animal sciences) and "Beyond" (physics, astronomy & space sciences, and science & innovation).

The learners submitted their own presentation proposals within these themes, prompting them from the very start to embrace critical thinking, team cooperation and independent exploration. It was encouraged that they tackle topics of not only passion, intrigue and eminence, but that they also consider the world around us beyond pure academia by looking at the intersection of science and society, to either find challenges we face and posit intelligent and impactful solutions to them, or to delve into scientific subject matters that hold societal consequence and importance. Once finalising their choice of project, learners conducted their own research, produced a written scientific report, and put together a presentation that was showcased to the judges at the Earth and Beyond Science Fair.

The learners were teamed up with mentors, who were associated with the field of study to which their project pertained, to guide and advise them through the process. Despite the assistance of these mentors, the learners were the driving force of their own projects, taking control and ownership of their experiences.

Figures 5: Students presenting their projects to the judges

Astronomy has a history of typically being seen as a field dominated by the global North and the "Western world", monopolised by Europe and North America,

despite the records of groundbreaking research and discoveries in numerous other parts of the world that go largely unrecognised by many - eclipsed by those such as the ancient Greco-Romans or Renaissance Era Western Europeans. In recent times, there has been a great shift. Astronomy has experienced dramatic, if not explosive, growth in the global South, and South Africa in particular.

With projects such as the Southern African Large Telescope (SALT) and the Square Kilometer Array (SKA), the feasibility of careers in the astronomical sciences is higher than ever and only growing. Similarly, despite a lack of astronomy based projects in learner-focused science fairs in the past, an interest in astronomy amongst South African youths is evident by the presence of several such projects in the Earth and Beyond Science Fair. With these types of initiatives, learners are able to gain exposure to this career path as a reality, rather than an intangible dream, thus promoting astronomy in South Africa.

Figures 6: Students presenting their projects to the judges

The experience of participating in an event like this that promotes science in a practical approach allows for the fostering of interest, awe, scientific thinking and critical skills, all while shaping the future of science through the next generation of astronomers.

Event overview

Upon the day of presentation, there were a total of 39 participants working on 28 projects. The participants included male and female secondary school learners from across 5 government schools of varying quintile designations. The presentations were reviewed by a panel of 15 judges from various scientific backgrounds.

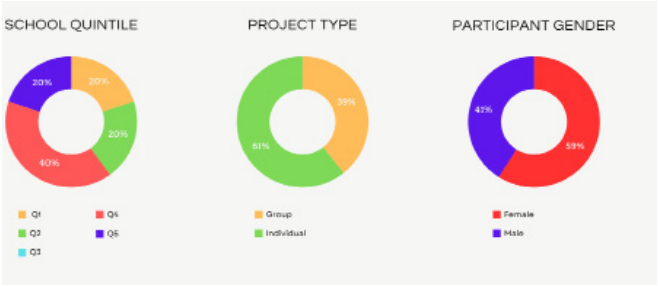


Figure 7: Pie charts showing the percentage distribution of schools based on their quintile, projects based on their types, and the participating learners based on their gender

Of all the projects, 5 focused on astronomy and space science topics. There were 2 astronomy and astrophysics graduates who acted as meteors for the learners involved in these projects. The overall second place winner was a female student presenting in the physics, astronomy and space sciences categories with the topic of "Luxions: A New Light". She and the other winners will progress to the regional competition.

Figure 8: Second place winner Ms Akerele (second from

the right) and BRICS Astronomy Project Coordinator Duduzile Kubheka (right) at the prize giving ceremony

Beyond providing a platform for learners to present their projects, the Fair was opened up to educators and members of the public. It also included activities designed to enrich the scientific knowledge and awareness of the learners, through talks and workshops by professionals and experts on themes including broader presentations on the Earth and space sciences featured in the presentations as well as hands-on interactions dealing with telescope observation skills and the application of artificial intelligence.

Figure 9: Presentation on biodiversity for the learners, by Johannesburg City Parks and Zoo

Plans moving forward

Progression:

- The Earth and Beyond Science Fair is only the first step in a larger initiative. It acts as the preliminary round and those who qualify will be able to progress to the Expo for Young Scientists Johannesburg Regional Science Fair, and subsequently have the opportunity to progress to the annual Expo for Young Scientists International Science Fair.

- Extending into further plans, the goal is to implement more science fairs in South Africa and even astronomy-centric fairs reaching a broader range of age and backgrounds.

Expansion:

- This fair and its succeeding rounds act as a pilot programme in a larger initiative.

- Using this scheme of learner-centric science fairs, the programme can be expanded to include a larger pool of participants. This could focus on specific groups, such as women in STEM, underserved communities, learners with disabilities and so forth. It could also be expanded to broaden the reach, rather than to target particular demographics. This could be on a national level as planned in the progression details. Ideally, it would be taken to an international level as a collaborative effort between the BRICS countries for an opportunity for academic and cultural exchange, benefitting not only the learners but also the organisers, educators, participating staff and guests.

- Though the current scheme encompasses fairs spanning all science fields, its expansion would focus on astronomy and astronomy-related sciences, to reflect and spotlight their rapid rise in presence, inter-disciplinary collaboration, societal relevance and career feasibility.

- The endpoint execution would be centered around combining the aforementioned expansion proposal by having regular inter-BRICS (or fully internationally inclusive) fairs at levels for primary, secondary and tertiary education participants. These fairs would focus on astronomy and space science to proliferate the current trends in astronomy-related growth within the BRICS countries.

Key objectives
Short term goals:

- Expose high school learners to scientific content in a more real-world-accurate context than their classroom content and popular media

- Provide this exposure with an importance placed on previously underexposed communities and societal groups.

Long term goals:

- Encourage scientific minded skills and thought processes, such as critical thinking, creativity, innovation and independent growth beyond the expectations which are held for the minimum requirements at secondary education level
- Increase visibility of and active interest in astronomy and astronomy-related sciences and amongst learners and students
- Promote astronomy studies in a climate of phenomenal growth and potential in the global South, moulding the future of astronomy

Conclusion

A school science fair, though perhaps seen as something unremarkable at first glance, is something that holds great weight when treated with the appropriate importance and care. By integrating science into the experience of learners in ways that extend beyond the classroom and syllabus expectations, they are encouraged to explore their full potential in a controlled and guided environment - learning new information and invaluable skills. The inclusion and promotion of astronomy and space science themes in the learners' projects mirror the same growth of these sciences in the global South. It, on a small scale, is able to increase the visibility and interest in astronomy amongst learners and promote further study.

Despite these being seemingly small effects in each fair, by hosting more of them and on larger scales, the potential effects are considerable, on both local and international levels. By promoting and nurturing an interest in astronomy from primary and secondary school - and possibly into tertiary education too - these efforts hold the capability to inspire and shape future generations of astronomers.

Access Initiative:

Driving change through collaboration

Figure 10: Participants of the Access initiative at the South African Astronomical Observatory

BRICS Astronomy, in collaboration with Transport SETA, Phephani Learnerships, Benathi Driving School, Ukhanyo Foundation, and iThemba Youth Choir, launched The Access Initiative. This societal benefit program directly tackles youth unemployment in South Africa by providing vital access to education, employment, and mobility.

In early 2025, the program selected 50 young, unemployed, and out-of-school individuals to participate. The primary beneficiaries are disadvantaged youth from South African townships, with a specific focus on those currently unemployed or not enrolled in formal education. Interns at the observatory are also included, as gaining these

essential skills will significantly enhance their current roles and broaden their future career prospects. By providing these crucial driving skills, the Access initiative seeks to empower these young individuals and substantially improve their employability.

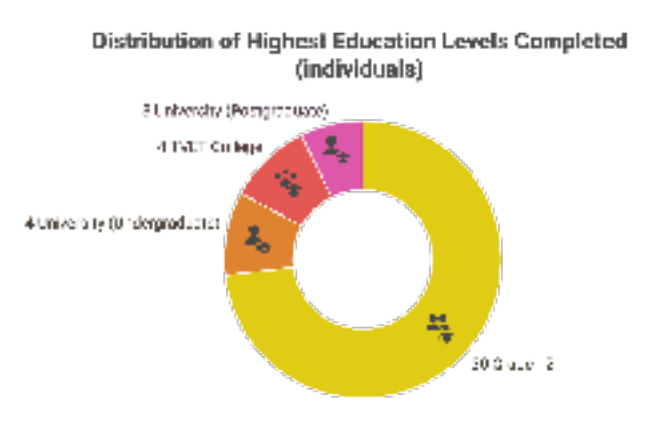


Figure 11: Distribution of Highest Education Levels Completed

Established through a partnership with a Social Development organisation and Sector Education and Training Authorities (SETAs), the initiative aims to enroll unemployed South African youth in a Skills Development Programme to help them obtain learner's and driver's licenses. While not directly related to astronomy, the primary output of BITDN, this program tackles a significant societal need. For unemployed youth, especially those with limited education beyond matric, acquiring a driver's license dramatically improves their chances of securing employment across various sectors. Such opportunities are life-changing, bridging the gap between unemployment and employment, and fostering financial stability. BITDN's commitment to societal benefits is evident in its willingness to utilize its human resources, administrative capabilities, and coordination expertise to contribute meaningfully to societal advancement.

Figure 12: Participants of the Access initiative at the Amazon Web Services Skills Centre, Cape Town.

Beyond merely assisting participants in obtaining their driver's licenses, we hosted a workshop with the primary goal of empowering them to confidently navigate the various opportunities available in higher education, the job market, and entrepreneurship. The workshop featured a session led by the University of the Western Cape's Student Enrolment Department, offering practical guidance on how to apply for university. This was followed by a hands-on session where participants began their actual university applications. The four-day programme wrapped up with an inspiring site visit to the Amazon Web Services (AWS) Skills Centre in Cape Town, where learners were introduced to exciting opportunities in cloud computing and digital skills development.

Figure 13: Areas that the participants showed interest in getting help with

Youtube Video Series

The Youtube Video series aims to establish a centralized platform to enhance research communication and foster collaboration among researchers across BRICS nations, particularly since BRICS Astronomy has only one annual event. The platform will serve a dual purpose, facilitating academic exchange and translating complex research into accessible content for the general public. The secondary aim of the project is to develop public-friendly versions of research talks, specifically designed to simplify complex scientific concepts for a general audience. This includes optimizing content for platforms like TikTok to maximize reach and engagement.

Progress to Date:

We have conducted initial interviews with Dr. Eder Martioli from Brazil and Dr. Seblu, Humne from Ethiopia so far. We encourage BRICS researchers to participate in this initiative. Please select your preferred slot for a research presentation: https://wkf.ms/3GcAypn

See the interviews here: https://www.youtube.com/playlist?list=PLPm8wu0PjzR_g1Bo4SE2GKdjPO2xlSTXD

Science Communication Training

This program is designed to equip young astronomers across BRICS and African countries with essential science communication skills. The initiative aims to enhance participants' ability to effectively share scientific knowledge, foster public engagement, and inspire interest in astronomy and science as a whole.

Key Features of the Program

- Engaging experienced science communicators as trainers.
- Ensuring representation from each BRICS nation to promote diverse perspectives and collaboration.
- Implementing a cascade outreach model, providing participants with practical, hands-on experience in science communication.

Core Topics to be Covered (list to be expanded)

1. Overview of science engagement: Its importance and impact.
2. Effective science communication skills: Key techniques for connecting with diverse audiences.
3. Science communication planning: Crafting strategies for impactful outreach.
4. Storytelling and writing: Communicating complex ideas in an

accessible and engaging way.
5. Presentation and media skills: Public speaking and interacting with traditional and digital media.
6. Social media for science: Leveraging online platforms to share knowledge.
7. Public engagement with science: Approaches to inspire curiosity and participation.
8. Building networks in science communication: Connecting with peers and professionals.

This program is a crucial step toward empowering young astronomers to become ambassadors of science within their communities and beyond.

Structure:

The plan is to host a series of online workshops, followed by an in-person session during the BAWG meeting. After the in-person workshop, participants will have the chance to take part in outreach and public engagement activities in local schools and communities near the BAWG meeting location. The workshops will feature presentations that incorporate interactive elements, ensuring active participant engagement and opportunities for practical application of the concepts discussed.

Guest speakers from BRICS and African countries, including experienced science communicators and outreach professionals.
Assignments and practical activities to apply skills learned during the sessions.
Have at least 2 presenters per session

Progress so far:

Session 1: The importance of Science Communication and Media Relations
The team successfully arranged and hosted the first session with representation from 29 countries. The session was held on 3 April 2024, focusing on the themes:
Overview of Science Engagement – Its Importance and Impact

This opening session explored the role and significance of science engagement, highlighting perspectives from various countries and regions. Participants gained insights into the importance of science communication, its different applications, and its broader societal impact.

Science Communication and Media Engagement

The session also addressed the critical role of media in democratizing science, sharing innovations, facilitating technology transfer, and applying research to tackle societal challenges such as poverty and unemployment. It provided practical guidance on engaging the public through traditional and digital media platforms.

The session was chaired by Ms Duduzile Kubheka, with Ms Thembela Mantungwa from South Africa and Dr A.P. Jayaraman from India serving as the main speakers for the respective themes. Following the success of this session, the team is now working on clearer project planning to enable more focused engagements with various stakeholder groups. Plans are also underway to continue hosting these sessions on a quarterly basis.

Magazine

1. Background & Strategic Context

The BRICS Astronomy Magazine was established in 2022 as a communication and collaboration tool within the framework of the BRICS Astronomy Working Group (BAWG). This initiative forms part of the broader BRICS Science, Technology, and Innovation Cooperation Plan, endorsed by the BRICS governments to promote science diplomacy, joint research, and capacity building across member states, including Brazil, Russia, India, China, South Africa, and increasingly, BRICS countries.

The purpose of the magazine is to:

- Showcase joint astronomy efforts and advances across BRICS nations.
- Promote the sharing of scientific knowledge and resources.
- Raise awareness of the societal benefits of astronomy.
- Support international partnerships and emerging researchers.
- Build bridges between institutions, governments, and citizens through accessible science communication.

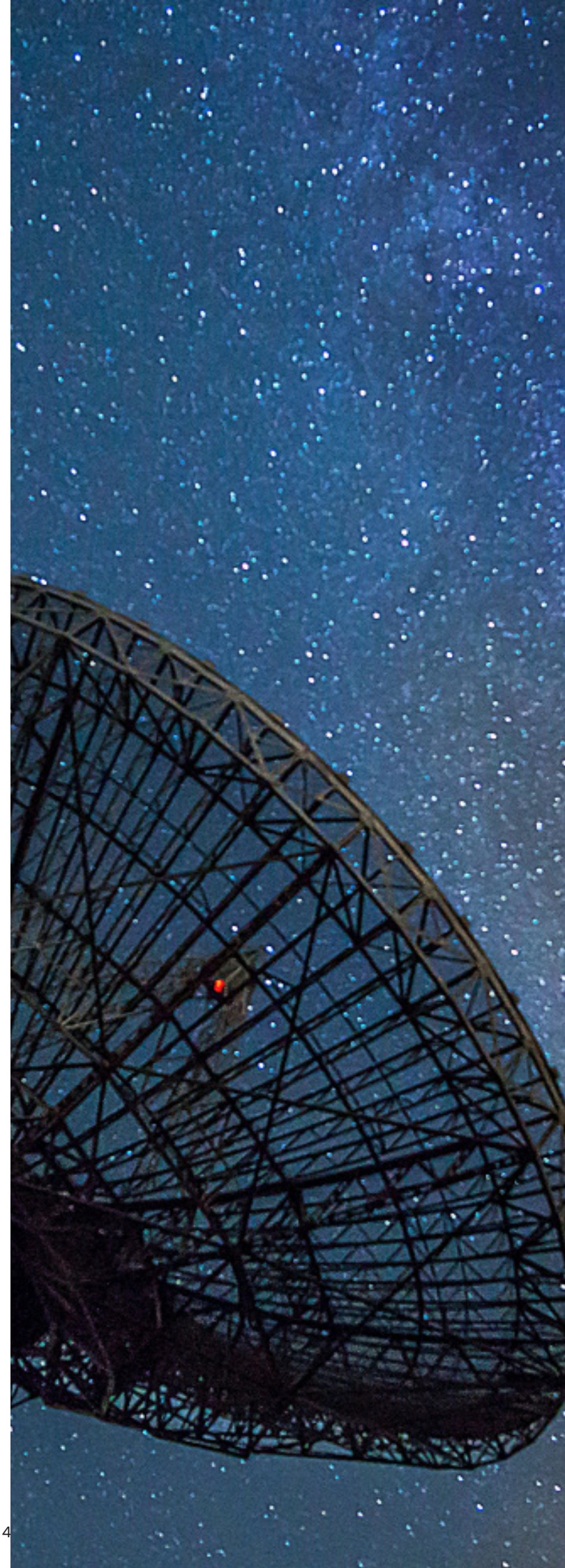
This publication is produced by African Science Stars and guided by contributions from BRICS astronomy stakeholders.

2. Overview of Editions and Their Focus Areas

Edition 1 – 2022

The inaugural edition set the tone by introducing BRICS astronomy cooperation to a broad audience. It included:

- An overview of the BAWG's goals and member institutions.
- National astronomy infrastructure and capacity.
- South Africa's SKA leadership and outreach models.




IDIA

- Profiles on emerging astronomy professionals in BRICS.

Edition 2 – 2023

- This edition delved deeper into astronomy's role in development and transformation. Highlights included:
- Youth engagement programmes and BRICS student workshops.
- Indigenous astronomy practices (e.g. Ethiopia, Brazil).
- Introduction to BITDN – the BRICS Intelligent Telescope & Data Network.
- Gender inclusion and leadership stories in astronomy.

Edition 3 – February 2025 (Latest Issue)

The latest edition is the most comprehensive yet, reflecting the maturing of the project:

- Featured the 10th BRICS Astronomy Working Group Workshop in Kazan, Russia.
- Covered Africa's landmark IAU General Assembly in Cape Town, the first on the continent.
- Launched South Africa's Astrotourism Strategy, linking science with local economic development.
- Introduced the SAPTARISI project, a BRICS-wide AI-enabled sky survey programme.
- Emphasised geodesy and space-based infrastructure development for African growth.
- Continued focus on Women in Astronomy, youth, and inclusive innovation.

3. Purpose & Audience of the Magazine

The BRICS Astronomy Magazine is primarily targeted at:

- Policy-makers and government departments in science and innovation.
- Researchers across astronomy, space science, and data science disciplines.
- Students and early-career scientists, especially from underrepresented regions.
- The broader public, to democratize astronomy through compelling, multilingual storytelling.

The magazine serves to:

- Demonstrate BRICS-wide progress in astronomy cooperation.
- Strengthen visibility of shared projects, e.g. BITDN, SAPTARISI, Open Universe.
- Align with BRICS strategic themes: innovation, inclusion, resilience, and equity.
- Provide a unified platform to encourage future collaboration and investment.

4. Distribution Channels & Media Strategy

The magazine is available through several platforms:

- Website: bricsastronomy.org/brics-astronomy-magazine
- Issuu digital reader: issuu.com/bricsastronomy
- Social Media Campaigns:
  - Facebook: facebook.com/BRICSAstroMag
  - Instagram: instagram.com/bricsastromag
  - X (Twitter): x.com/BRICSAstronomy

This multichannel strategy ensures wide accessibility among academics, educators, and policy communities. Print-ready formats are distributed at science events and BRICS workshops, while the digital editions are shared via institutional networks.

5. Summary of the Latest (Feb 2025) Issue

Strategic Highlights

- 10th BAWG Meeting, Kazan: Over 200 attendees engaged in data pipeline workshops, telescope collaborations, and infrastructure development plans.
- IAU General Assembly, Cape Town: First African-hosted IAU GA, emphasising BRICS' growing role in global astronomy. African observatories and student showcases featured prominently.
- SAPTARISI Project: Joint effort by BRICS researchers to develop AI-driven sky monitoring systems to complement national telescopes.
- Astrotourism Development: South Africa unveiled a framework linking astronomy hubs with tourism ecosystems to support local economies.
- Geodesy & Satellite Infrastructure: Articles on how astronomy tools enhance Africa's space positioning and infrastructure services.

Social & Educational Themes

- Women in Astronomy: New stories of female astronomers leading observatory projects and outreach in India, South Africa, and Brazil.
- Youth Engagement: Highlights from BRICS astronomy Olympiads, hackathons, and remote learning workshops under BITDN.
- Open Science for Development: Reflections from BRICS representatives on how science serves the UN SDGs.

6. India's Translation Initiative

India has committed to translating the first two issues into Hindi, with plans to extend this to the February 2025 edition and beyond. This reflects the shared goal of increasing access to scientific information in local languages, in alignment with national education and digital inclusion policies.

- Translation supports:
- Wider classroom and teacher use.
- Greater visibility of BRICS collaboration at the local government level.
- Strengthened BRICS+ scientific identity.

7. Visual Assets & Figures

This report includes the following visuals to support strategic storytelling:
Figure 1: BRICS Magazine covers – Issue 01, 02 and 03.
Figure 2: BRICS Astronomy Magazine: Issue 01 – Forewords by Dr BE Nzimande, Minister of the Department of Higher Education, Science and Innovation and Mr Chen Xiaodong, Ambassador of the Embassy of the People's Republic of China in the Republic of South Africa.

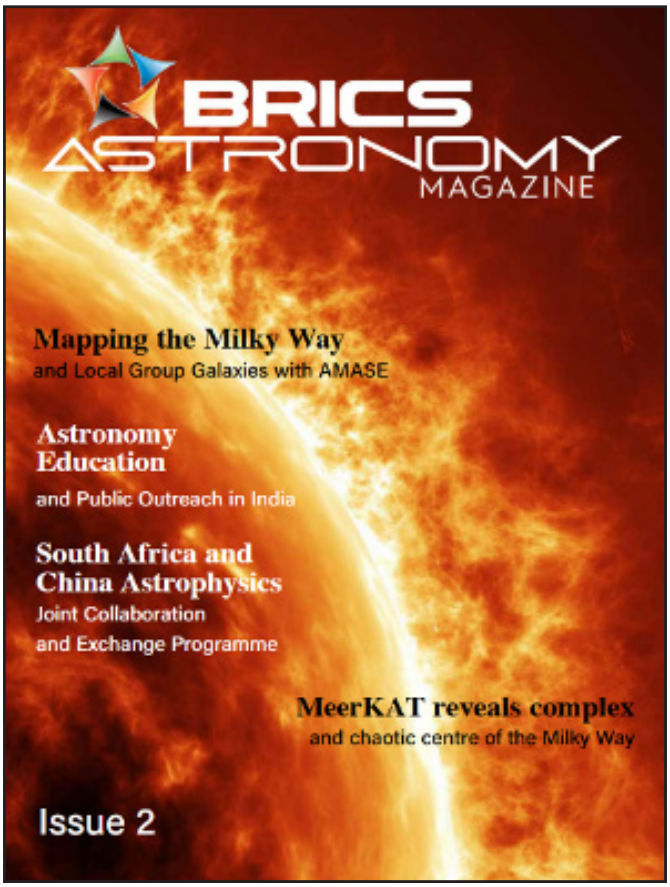


Figure 14: BRICS Astronomy Magazine: Issue 02 – Forewords by Luciana Santos, Minister of State of Science, Technology and Innovation of Brazil.

COLLABORATION AND COOPERATION IS *Key*

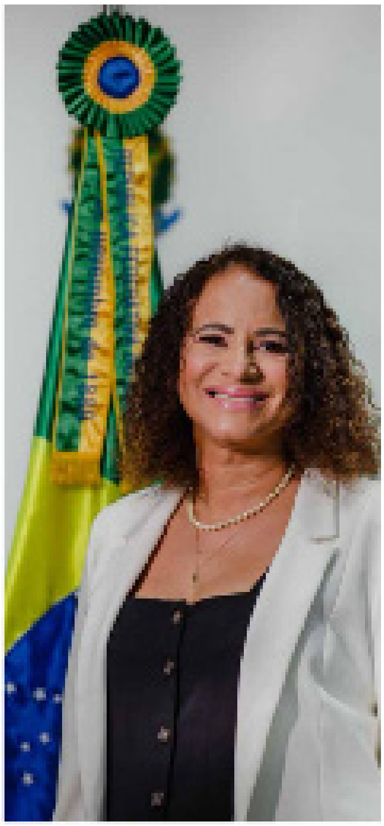
[illegible]

Mr Chen Xiaodong

Ambassador of the Embassy of the People's Republic of China in the Republic of South Africa

ASTRONOMY IS ONE OF THE MOST ANCIENT SCIENCES, BUT AT THE SAME TIME IS ON THE FOREFRONT OF HUMAN KNOWLEDGE AND TECHNOLOGY, HELPING US TO UNDERSTAND OUR UNIVERSE AND IMPROVING OUR LIFE ON EARTH.

[illegible]



THE FUTURE IS WRITTEN IN THE *Stars*

[illegible]

Dr BE Nzimande, MP

Minister of the Department of Higher Education, Science and Innovation

8. Analytics & Audience Reach (Pending Update)

Pending social platform and Issuu analytics, a full engagement breakdown will be included. Suggested metrics include:

- Issuu views and downloads per issue
- Website traffic by region
- Social media post reach, follower growth, and engagement
- Event distribution reach (e.g., IAU GA, workshops, exhibitions)

9. Strategic Outlook & Recommendations

- Translations: Continue roll-out in Hindi, Portuguese, Mandarin, and Russian to increase accessibility.
- School Integration: Develop downloadable astronomy modules based on magazine content for school programs.
- Open-Access Journal: Consider evolving the magazine into a BRICS peer-reviewed science journal.
- Media Partnerships: Collaborate with science media houses in each country for increased coverage.
- Expanded Contributors: Encourage contributions from Ethiopia, UAE, Iran and other BRICS nations.

10. Conclusion

The BRICS Astronomy Magazine is more than a publication; it is a strategic tool for international scientific visibility, policy engagement, and public outreach. It demonstrates the success of BRICS collaboration and the capacity of science to unite nations, empower communities, and inspire future generations.

Other conferences

BRICS Research Conference 2024: A Collaborative Step Towards Global Sustainability

The **BRICS Committee** f**or International Cooperation in Culture and Art**, in collaboration with the **BRICS Research Institution** and the **Durban University of Technology**, hosted the 3rd BRICS Research Conference in Beijing, China, from 25 to 27 September 2024. The two-day event brought together global leaders, academics, researchers, and professionals to discuss innovative solutions for fostering growth and sustainability within the BRICS nations. Supported by the **South African Think Tank and the National Institute for the Humanities and Social Sciences (NIHSS)**, the conference focused on the following key themes:

- Sustainable development in the Global South,
- Cultural integration through tourism,
- Law, governance, and multilateralism, and
- The impact of digitalization, AI, and the Fourth Industrial Revolution (4IR) on business.

At the conference, BRICS Astronomy's **Moleboge Lekoloane** presented in the Sustainable Development in the Global South parallel session. In his presentation, he highlighted the significant contributions of the **BAWG** to sustainable development in the Global South, showcasing the group's efforts in fostering research collaboration, technological innovation, and knowledge exchange within the group.

In his presentation, he highlighted the BRICS Astronomy flagship project, the BRICS Intelligent Telescope and Data Network (BITDN). In 2015, BRICS developed and adopted the BRICS Science,

Technology, and Innovation Work Plan 2015–2018, in which Astronomy was established as one of five thematic science areas to advance the technological and scientific boundaries. The BITDN flagship project developed a network of astronomical telescopes, some already existing, and an associated intelligent data network, which is the enabler for the science program. The project leverages existing and planned new telescope and cyber facilities within the BRICS countries and will also draw on the opportunities presented by other multi-wavelength space- and ground-based facilities within, or accessed by, the BRICS countries. In the presentation, Moleboge Lekoloane highlighted how BRICS Astronomy contributes towards sustainable development in the region, particularly through the flagship project and the transfer of skills.

International Astronomical Union General Assembly 2024

In 2024, South Africa hosted the 32nd International Astronomical Union General Assembly in Cape Town. The General Assembly was hosted on the African continent for the first time in the more than 100-year history of the IAU. This presented an exceptional opportunity to showcase the incredible scientific capacity within the continent and to connect like never before with the rest of the world's astronomers. It marked a historic moment for the global astronomy community by highlighting Africa's growing scientific capacity and embodying the African spirit of Ubuntu.

The bid to host the GA was explicitly presented as an African initiative, led by South Africa. The event provided an exceptional opportunity to showcase Africa's scientific capabilities and foster connections between African astronomers and the wider international community. Notably, it was the first open-access IAU GA, with sessions freely streamed live on YouTube. The event innovated with a hybrid poster session that allowed online and in-person interaction, and a VR-compatible immersive online space was developed. The GA attracted 2,648 participants (2,045 in-person and 603 virtual) from 107 countries, including 28 African nations. The community's reaction was overwhelmingly positive, with participants expressing appreciation for the venue, the organizing team's support, and numerous social, outreach, and networking opportunities. Over 600 participants volunteered for education and outreach initiatives, reaching approximately 28,000 school learners, 85 educators, and 3,800 members of the public.

The event also integrated African culture, including an African craft market that positively impacted local small businesses, and provided free childcare and social events, emphasizing the humanity of scientists. The organizers hope that this unprecedented event will inspire future large astronomy meetings to adopt similar principled positions on accessibility, impact, and sustainability, demonstrating the possibilities when the community is bold in its ambitions.

BRICS Astronomy was heavily involved in the conference, **Duduzile Kubheka** served as the co-chair of the Education and Outreach committee, that were able to reach over 28,000 learners and teachers in the Western Cape. **Moleboge Lekoloane** served as the Head of Entertainment.