UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

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7-11 July 2025

Conference Proceedings

PROCEEDINGS EDITOR-IN-CHIEF:
W.A. Horowitz, University of Cape Town

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EDITORIAL

The University of the Witwatersrand (Wits University) hosted the annual South African Institute of Physics (SAIP) Conference during July 2025. The conference took place in the vibrant heart of Johannesburg, a city known for its energy, innovation, and spirit of transformation – qualities that resonated strongly with this year's themes recognising the International Year of Quantum Science and Technology 2025 and the International Decade of Sciences for Sustainable Development 2024-2033. In parallel with the main conference, a Teacher Development Workshop for 110 Physical Sciences educators from the Gauteng region was held, strengthening links between the research and education communities and extending the reach of the conference's impact. Certain papers from this meeting are collected in this peer-reviewed volume. Submissions for the proceedings of SAIP 2025 were handled by an Editorial Board headed by an Editor-in-Chief and Associate Editors responsible for submissions in the various divisions.

The Editorial Board of the SAIP 2025 Proceedings received 180 manuscripts for consideration by the advertised deadline. All of these manuscripts met the relevant criteria and were submitted to a full peer-review process involving many individual reviewers, resulting in a total of 161 papers accepted for publication. The list of reviewer names appears elsewhere in this volume, and it is noted that several reviewers took responsibility for more than one manuscript. The style of these proceedings is inspired from the (British) Institute of Physics Conference Series and the Institute of Electrical and Electronics Engineers transactions, journals and conferences (IEEEtran), similar to previous SAIP Proceedings. Authors were requested to ensure that the defined layout was adhered to in their submitted PDF documents. The Associate Editors conducted the layout review for each manuscript in parallel with the content review in order to expedite the review process. Manuscripts that deviated considerably from the specified layout requirements, while still broadly appropriate in their composition, were referred back to the authors for correction. This was done alongside the content reviews prepared by knowledgeable experts in each field, as well as consideration of Turnitin reports to ensure that all submissions were original and free of plagiarism. The Editorial Board again aimed to reduce the time between submission and publication, with authors informed of the outcome of their submissions before the December holiday closure and the final proceedings published online shortly thereafter.

In accordance with the South African Department of Higher Education and Training (DHET) Research Outputs Policy, the SAIP 2025 Proceedings meet all criteria required for recognition and subsidy. All published contributions are full papers presenting original research and new scholarly findings; no abstracts, extended abstracts, summaries, or poster-type submissions were accepted. Each manuscript underwent a rigorous peer-review process involving a minimum of two independent reviewers. The Proceedings carry a valid ISBN identifier and publication year, and the Editorial Board comprises subject matter experts drawn from multiple South African institutions, with full details listed in this volume. These Proceedings are intended for a specialist scholarly audience, consistent with DHET requirements for academic research dissemination, and include the complete set of published papers, author affiliations, reviewer acknowledgements, and the required publication metadata. All accepted submissions include author affiliations and contact information and the full text of the papers. The Editorial Board affirms that the published output meets all DHET criteria for accredited conference proceedings.

The publication of the SAIP Proceedings depends heavily on the efficiency of the Associate Editors and the goodwill of reviewers from the South African scientific community. The Editor-in-Chief wishes to acknowledge the hard work of the Associate Editors, who devoted significant time and care to evaluating papers and reviewer reports to ensure that acceptable academic standards were met and that the proceedings remain credible. The majority of the content reviews were completed with great diligence and professionalism. The Editorial Board expresses its sincere thanks to all participating Reviewers for their pro bono work, particularly those who reviewed more than one paper. The rigorous peer-review process described above has ensured that these proceedings contain thoroughly reviewed manuscripts of high professional quality, reporting on novel work that has not been published elsewhere.

This year, the Editorial Board once again benefited from the expertise of the Technical Associate Editor, Dr Bruno Letarte from North-West University (NWU). He took responsibility for finalising the complete document and ensuring that it met the highest technical standards. The Editor-in-Chief wishes to recognise Dr Letarte's significant contribution in preparing the final document. The Editorial Board deeply appreciates the many hours he dedicated to producing this exceptional publication.

The SAIP2025 Editorial Team
W. A. Horowitz, Editor-in-Chief

THE LOCAL ORGANISERS

It was a great pleasure for the School of Physics, Faculty of Science, University of the Witwatersrand to host the 69th Annual Conference of the South African Institute of Physics.

The conference recognized the "International Year of Quantum Science and Technology", 2025 and the International Decade of Sciences for Sustainable Development, 2024–2033". The conference scientific programme comprised of 300 and 204 oral and poster presentations, respectively, 7 invited plenary speakers, an Industry Day, Physics for Development and Industry Day, the Southern Africa Physics Network (SAPhysNet) Forum meeting, Women in Physics in South Africa (WiPiSA) 20th Anniversary Celebration Panel Discussion and 5 Winter Schools.

The conference served as an enriching experience for 600 delegates that included local and international experts, invited guests, academics, researchers, industry partners, postdoctoral fellows, and postgraduate students across all branches of physics. The conference was a platform that resulted in excellent scientific discussions, exchange of ideas, fostering of collaborations and was a forum to inspire our students and young researchers to continue with a career in Physics. The support of business and government are acknowledged including all the conference exhibitors and sponsors for their involvement in enhancing the success of the conference.

In terms of social events, our students organised an exciting PHYSICS QUIZZ CUP and further all delegates were invited to participate in immersive shows at the Wits Anglo American Digital Dome.

A special thanks to the Minister of DSTI, Professor Blade Nzimande who delivered the official Opening and Keynote Address at the Welcome Reception, the University of the Witwatersrand Vice-Chancellor and Principal, Professor Zeblon Vilakazi and the Dean of Faculty of Science, Professor Nithaya Chetty for their support in ensuring a successful conference. We also wish to congratulate Professor Philemon Mjwara who was elected as a Fellow of the South African Institute of Physics (FSAIP) in recognition of his outstanding contributions to physics education, research, and development in South Africa. The formal presentation of the award was bestowed to Professor Mjwara at the Conference Banquet.

Finally, I would like to express my sincere appreciation to all members of the local organising committee, in particular to Dr Robert Warmbier (Co-Chair), Professor Phil Ferrer (Chair: Scientific Programme), Ms Michelle Gallant (Wits Functions & Events / Advancement Division), Professor Rudolph Erasmus (ex-officio), Dr Angela Dudley, Dr Brian Masara and Mr Tebogo Mokhine (SAIP Office) for their tremendous efforts and time devoted in organising the conference.

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Editor-in-chief:

– **W. A. Horowitz** is an Associate Professor of Physics at the University of Cape Town. Among other honours, Prof Horowitz has received the Claude Leon Merit Award for Early-Career Researchers and the Meiring Naudé Medal for Outstanding Early Career Contributions to Science from the Royal Society of South Africa. Prof Horowitz' research explores the non-trivial emergent many-body properties of the strong force using the methods of perturbative quantum field theory and the AdS/CFT correspondence.

Associate Editors:

- **Physics of Condensed Matter and Materials**
  – **Wendy Bonakele Mdlalose** is a physics lecturer at the University of KwaZulu-Natal, specializing in nanostructured magnetic materials for biomedical, agricultural, and electromagnetic applications. Her research focuses on polymer-coated ferrites for drug delivery, cancer therapy, nano-fertilizers, and microwave absorption. She is an active contributor to multidisciplinary research, supervises postgraduate students, and collaborates across sectors to advance nanotechnology solutions in health, food security, and energy.

  – **Pankaj Mohanty** is a Lecturer in the Department of Physics at the University of Johannesburg, South Africa, specializing in experimental condensed matter physics and materials science. His work explores nanoparticles, thin films, magnetism, and ion irradiation. He has received multiple awards, including the University of Johannesburg Excellence Award for Research (2019) and several international best presentation awards. Dr. Mohanty has supervised numerous postgraduate students to distinction and collaborates with institutions such as NECSA (South Africa), Elettra (Italy), and IUAC (India).

- **Nuclear, Particle, and Radiation Physics**
  – **Mukesh Kumar** Mukesh Kumar is the Deputy Director of the Institute for Collider Particle Physics, the National Coordinator of the SA–CERN Technology Transfer Pillar, and a Senior Lecturer in the School of Physics at the University of the Witwatersrand. He is an NRF Y-rated research physicist in the field of high-energy particle physics. His research focuses on Higgs boson, top quark, and dark matter physics at the Large Hadron Collider (CERN), as well as at future $e^{-}p$ and $e^{+}e^{-}$ colliders. He is a member of the TileCal Speakers Committee for the ATLAS detector at CERN and is involved in diphoton+lepton and dark-photon physics analyses within the ATLAS Collaboration.

  – **Obed Shirinda** is a Senior Lecturer of Physics in the department of Physical and Earth Sciences at the Sol Plaatje University. He is an NRF C-rated research physicist in the field of nuclear physics. His research is focused on nuclear structure physics describing features of rotating nuclei by using nuclear physics models (such as Particle rotor models (PRM), Cranked shell model (CSM), Total Routhian surface (TRS), etc.) and experimental equipment.

- **Photonics**
  – **Pieter Neethling** Pieter Neethling is an Associate Professor in the Physics Department at Stellenbosch University. He is currently the Director of the Stellenbosch Photonics Institute at Stellenbosch University and the Chairman of the Photonics Division of the SAIP. His research focus is applied laser spectroscopy with applications in chemical and biological systems.

- **Astrophysics and Space Science**
  – **Eugene Engelbrecht** is a Professor of Physics at North-West University, whose research covers topics relevant to the transport of charged particles in turbulent astrophysical plasmas, including both theoretical and observational aspects pertaining to cosmic ray modulation, non-linear diffusion theories, and plasma turbulence.

- **Physics for Development, Education, and Outreach**
  – **Dale Taylor** is an Associate Professor in the Physics Department at the University of Cape Town. Her current focus is co-curricular support towards science student success and early alert systems for targeted support. She supervises doctoral students in Physics Education Research and Astronomy Education Research. She has extensive reviewing experience, including 15 international education journals.

- **Applied Physics**
  – **Raesibe Sylvia Ledwaba** is an Associate Professor of Physics and Acting Deputy Director at the Materials Modelling Centre, University of Limpopo. Her current research focus is on All-Solid-State Battery Technology (ASSB), utilizing multiscale modelling and machine-learning approaches to identify suitable solid electrolyte materials to replace flammable liquid electrolytes in lithium-ion batteries. She is involved in several projects cathode and anode materials prediction and development for next-generation battery systems.

  – **Deon Marais** is a Chief Scientist at the South African Nuclear Energy Corporation (Necsa), where he is involved with the development of neutron beamline instrumentation, data acquisition and analysis tools. His work focuses on neutron diffraction and he is actively involved in national initiatives to expand South Africa's neutron-scattering capabilities and user community.

- **Theoretical and Computational Physics**
  – **Aniekan Magnus Ukpong** is a Senior Lecturer in Physics at the University of KwaZulu-Natal and Principal Investigator for the Centre for High-Performance Computing Research Programme No. MATS0941. Dr. Ukpong is a 2019 recipient of the IOP's Outstanding Reviewer Award from the *Journal of Physics: Condensed Matter*. Dr. Ukpong's research leverages scientific computing to understand many-body physics in condensed matter systems using realistic materials as a modelling platform.

- **Technical**
  – **Bruno Letarte** is a Senior Lecturer at the Centre for Space Research of the North-West University. He specialises in observational astronomy, photometry as well as spectroscopy, with his main interest in stellar astrophysics. He manages the optical telescope at the Nooitgedacht observatory, used to train undergraduate and postgraduate students.

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- **Dr Matthew Spangler-Bickell** – GE HealthCare, United States of America
- **Prof Lynndle Square** – North-West University, South Africa
- **Dr Christine Steenkamp** – Stellenbosch University, South Africa

- **Dr Ruhann Steyn** – North-West University, South Africa
- **Dr Rasidi Sule** – Covenant University, Nigeria
- **Dr Taariq GH Surtee** – University of the Witwatersrand, South Africa
- **Prof Hendrik Swart** – University of Free the State, South Africa
- **Dr Adam Takacs** – Heidelberg University, Germany
- **Prof Mark Tame** – Stellenbosch University, South Africa
- **Prof Dale Taylor** – University of Cape Town, South Africa
- **Dr. Henerica Tazvinga** – South African Weather Service, South Africa
- **Dr Nicolas Thantsha** – Tshwane University of Technology, South Africa
- **Dr Charles T Thethwayo** – University of Zululand, South Africa
- **Dr Wasitha Thilakanatne** – Dalhousie University, Canada
- **Dr David Tinarwo** – University of Venda, South Africa
- **Dr Kamohelo Tshabalala** – University of Free State, South Africa
- **Dr David Tshwane** – CSIR/NiTheCS, South Africa
- **Dr Luke Ugwuoke** – Stellenbosch University, South Africa
- **Dr Aniekan Ukpong** – University of KwaZulu-Natal, South Africa
- **Dr Theresa Urban** – University College London, South Africa
- **Prof Kenny Uren** – North-West University, South Africa
- **Dr Zelalem Urgessa** – Nelson Mandela University, South Africa
- **Prof Iyabo Usman** – University of the Witwatersrand, South Africa
- **Dr Paul Vaandrager** – University of Pretoria, South Africa
- **Dr Fanie van den Heever** – North-West University, South Africa
- **Prof Ernest Van Dyk** – Nelson Mandela Universty, South Africa
- **Dr Hendrik Jacobus Van Heerden** – University of the Free State, South Africa
- **Dr Sam van Leuven** – University of the Witwatersrand, South Africa
- **Dr J.J. van Zyl** – Stellenbosch University, South Africa
- **Prof Christo Venter** – North-West University, South Africa
- **Dr Robert Warmbier** – University of the Witwatersrand, South Africa
- **Dr David Waswa** – Nelson Mandela Universty, South Africa
- **Dr Ingrid Webster** – Stellenbosch University, South Africa

- **Dr Jennifer Williams** – Rhodes University, South Africa
- **Prof Hartmut Winkler** – University of Johannesburg, South Africa
- **Dr Dawit Worku** – Cape Peninsula University of Technology, South Africa
- **Prof Shaun Wyngaardt** – Stellenbosch University, South Africa
- **Dr Tawanda Zininga** – Stellenbosch University, South Africa
- **Prof Konstantinos Zoubos** – University of Pretoria, South Africa

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STUDENT PRIZES

The Annual Conference of the South African Institute of Physics provides an important platform for emerging researchers to share their work with the broader physics community. The student prizes awarded at the conference recognise outstanding student contributions and celebrate excellence in research and presentation. This section is dedicated to and celebrates our students, whose achievements point to the vitality and future of physics in South Africa. We are extremely proud of the following prizewinners.

Note that there are several instances of two equal runners up among the prizewinners, both labelled as #2.

A Physics of Condensed Matter and Materials

Honours Poster:

Nicholas Snyman (North-West University)

Wirsam MSc Poster Award (Condensed Matter Physics):

M.S.L. Mthimkulu (University of Johannesburg)

Wirsam MSc Poster Award (Materials Physics):

M.C. Matlala (University of Limpopo)

Busch Vacuum MSc Oral Award (Condensed Matter Physics):

Arthur van der Spuy (University of the Witwatersrand)

Busch Vacuum MSc Oral Award (Materials Physics):

Dineo Motjope (University of Zululand)

Busch Vacuum PhD Poster Award (Condensed Matter Physics):

Irénée Mouadje (University of Johannesburg)

Busch Vacuum PhD Poster Award (Materials Physics):

Arnold Mutubuki (Nelson Mandela University)

Frank Nabarro PhD Oral Award (Condensed Matter Physics & Material Physics):

Murei Mulibana (University of Johannesburg)

Frank Nabarro PhD Oral Award (Semiconductor Physics):

Andi Isni Pujirana (Nelson Mandela University)

Wirsam MSc Publication Award (Condensed Matter Physics & Material Physics):

Arthur van der Spuy (University of the Witwatersrand)

Wirsam MSc Publication Award (Semiconductor Physics):

Katlego L. Morulane (University of the Free State)

PhD Publication Award (Semiconductor Physics):

Vhahangwele Makumbane (University of the Free State)

B Nuclear, Particle, and Radiation Physics

NPRP-1 MSc Poster Award

1. Nosihle Msabala (University of Zululand)
2. Tshegofatso Bokhutlo (Botswana International University of Science and Technology)

NPRP-2 MSc Poster Award

Joshua Browne (University of Cape Town)

NPRP-1 MSc Oral Award

1. Lilian Moremi (Tshwane University of Technology)
2. N.N. Khanyeza (University of Pretoria)

NPRP-2 MSc Oral Award

1. Kutlwano Makgetha (University of the Witwatersrand)
2. Njokweni Mbuyiswa (University of the Witwatersrand)
2. Stephan Potgieter (University of Cape Town)

NPRP-1 PhD Poster Award

Mbulelo Dondolo (University of the Witwatersrand)

NPRP-2 PhD Poster Award

1. Nidhi Tripathi (University of the Witwatersrand)
2. Vongani Chabalala (University of the Witwatersrand)

NPRP-1 PhD Oral Award

1. Sebenzile Magagula (University of the Witwatersrand)
2. Refilwe Emil Molaeng (University of the Witwatersrand)
2. Ayabulela Tsewu (University of Johannesburg)

NPRP-2 PhD Oral Award

1. Cameron Garvey (University of Cape Town)
2. Thabo James Lepota (University of the Witwatersrand)
2. Xola Mapekula (University of Johannesburg)

C Photonics

MSc Poster Award

Jacques Buys (University of Stellenbosch)

MSc Oral Award

Christopher Rawlings (University of the Witwatersrand)
Calvin Groenewald (University of the Witwatersrand)

MSc (Quantum Tech) Oral Award

Fazilah Nothlawala (University of the Witwatersrand)

PhD Poster Award

Cade Peters (University of the Witwatersrand)

PhD Oral Award

Cade Peters (University of the Witwatersrand)
Eugene Fouche (University of Stellenbosch)

PhD (Quantum Tech) Oral Award

Pedro Dinis Ornelas (University of the Witwatersrand)

D Astrophysics and Space Science

Honours (Astrophysics) Poster Award

Christo Pretorius (North-West University)

Honours (Space Science) Encouragement Prize

Thembalethu Zulu (North-West University)

MSc (Astrophysics) Poster Award

Lobone Dire (North-West University)

MSc (Astrophysics) Oral Award

Trevor Nyambe (North-West University)

MSc (Space Science) Oral Award

1. Fanelesibonge Khoza (University of KwaZulu-Natal)
2. Kenny Monontsi (North-West University)

PhD (Astrophysics) Poster Award

Thando Kekana (University of Johannesburg)

PhD (Astrophysics) Oral Award

Tamador Aldowma (University of Johannesburg)

PhD (Space Science) Oral Award

1. Jonathan Stephanus Troskie (North-West University)
2. Sanele Lionel Khanyile (Rhodes University)