

# **SHAPING THE FUTURE OF PHYSICS IN SOUTH AFRICA**

**REPORT OF THE INTERNATIONAL PANEL APPOINTED BY THE**

DEPARTMENT OF SCIENCE AND TECHNOLOGY

NATIONAL RESEARCH FOUNDATION

SOUTH AFRICAN INSTITUTE OF PHYSICS

APRIL 2004

## ACKNOWLEDGEMENTS

The International Panel would like to record its thanks to a number of groups and people who enabled it to carry out the work encompassed in this Report.

- The three principals, viz. the Department of Science and Technology, the National Research Foundation, and the South African Institute of Physics, who, concerned about the state of Physics in South Africa, gave birth to the project, provided the drive for it, and did much of the initial spadework.
- The Management and Policy Committee, who narrowed down the brief, devised the Terms of Reference, chose the core documentation and the group of interviewees, and set up the Panel.
- The Technical Committee, whose careful work and attention to detail converted the wishes of the MPC into reality, and who not only arranged the programme and all the logistics that that entailed, but also responded to (nearly) every wish that the Panel raised (often at short notice), and kept us on the “straight and narrow”, and reasonably sane.
- All those who responded to the SAIP’s call for inputs to the Panel, and the subsequent SAIP questionnaire, as well as the Heads of academic departments who, at short notice, provided valuable information that was solicited by the Panel.
- The many interviewees, some of whom travelled long distances to see the Panel, and all of whom brought with them an enthusiasm and an interest that bodes well for the future of Physics. Their inputs, both verbal and by email, gave us much food for thought, and formed the core of our deliberations.
- The sizeable audience who attended the presentation made by the Panel at the NRF on 19 March, and raised numerous interested questions.
- Some special individuals, including Edmund Zingu, Khotso Mokhele, Rob Adam, Lizel Kleingbiel, Prins Nevhutalu, Jaynie Padayachee, Anke Rädcl, Gudrun Schirge, Gerhard von Gruenewaldt, and Patricia Whitelock

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April 2004



## **EXECUTIVE SUMMARY**

### **Preamble**

It is recognized worldwide that physics is a basic science, vitally important to the development of mankind and to our understanding of the world - and universe - in which we live.

In South Africa, notable contributions to both fundamental physics and its applications have already been made, and, with the much-improved political situation, the subject is poised to make even more important contributions - on both the national and international stage. Such contributions relate particularly to improvements in the material well-being of individual citizens, to their health and safety and, at the national level, to its prestige and to the stability of the region.

In all this the maintenance, and enhancement, of the science base - of which physics is a key component - is vital.

In particular, physics often acts as a lead science - not only are the physics developments of today the technology of tomorrow, but, inter alia, it also plays the role of the canary in the mine. Thus, if Physics gets seriously ill, it is a warning that science and technology as a whole, and hence the growth of a knowledge-based economy, are in grave danger.

It is the Panel's view that at this stage, Physics in South Africa, although a small community, has a good international reputation, and exhibits significant strengths in a number of areas. However, it is in considerable danger, particularly in view of the ageing cohort of researchers, the trickle of input into the human resource pipeline, the slow pace of transformation in the physics establishments of universities and research institutes, and generally inadequate funding.

The International Panel is particularly impressed by the positive attitude of the present Government to science and is convinced that the physics community, enhanced in the many ways to be suggested, can make an important contribution.

Although not itemized as such, the five topics listed in the Terms of Reference (funding regimes, research capacity, human resources, consolidating existing reviews, and proposing strategies), are all covered by the Report.

In view of time constraints, the Panel has placed less emphasis on "the state of physics in South Africa", but concentrated on formulating "a strategy to revitalize physics in South Africa", and we believe that we had adequate information for the latter.

We regard the recommendations as robust.

After considerable exposure to the community and due deliberation we are able to respond to our brief, to review the state of physics in South Africa and to formulate strategy to revitalize it.

### **The current state of Physics in South Africa**

The Panel is of the opinion that, considering the stresses of recent decades, the physics community is remarkably resilient. Despite the problems all along the line (poor preparation of physics students in schools, patchy support in universities, general under-funding, and the stresses of restructuring in the educational sector) there are some areas of research in universities and institutes that are internationally competitive. Many others are of good national standard. Most importantly, we discovered a physics research and teaching community that is talented and that will - when augmented by bright younger people - be able to take advantage of the new possibilities which are unfolding.

However, the physics community is small and spread over a large geographical area. There are a number of sub-critical research groups, and, apart from some notable exceptions, there is a

lack of coherent collaborative research activity, which needs to be addressed. There is a perceived need for more collaboration and improved inter-personal communication at many levels, and some of our recommendations aim at removing structural difficulties that currently inhibit collaboration. But ultimately, the future of Physics lies in the hands of the Physics community, and its ability to grasp the opportunities for engaging with one another, with contiguous and related disciplines, with engineering groups, with industry and with the broader society.

### **A strategy to revitalize Physics in South Africa**

Our terms of reference refer to the need to “formulate a strategy... to redirect Physics in South Africa.” The Panel’s view is that it is not so much a “redirection” that is required, as a serious and sustainable improvement in the many areas referred to below.

In what follows, we itemize the main recommendations. We regard their implementation as URGENT.

(We expect the institutions in parentheses to take the lead in taking action).

### **THE MAIN RECOMMENDATIONS**

1. In many countries, elementary and secondary school teaching of mathematics and science is a considerable worry. In South Africa this situation is exacerbated in the historically black schools. Although beyond the scope of this inquiry, we must flag this very serious situation. We acknowledge that steps are being taken to address this matter, but urge the relevant authorities to pursue it with even more vigour, as it is a crisis situation. Individuals in the physics community are to be commended for their activity in this regard, but more involvement is needed, particularly at the structural level. [SAIP, NRF, Department of Education]
2. The long-term sustainable future of physics in SA depends on the country’s commitment and investment in the development of a workforce that is representative of its demographic diversity. Evidence indicates that, while there is a rapidly growing cadre of physics students from previously under-represented groups, there are perceived difficulties that need to be addressed by the established physics community and by the funding authorities. Apart from financial barriers to both undergraduate and postgraduate study (addressed below), there are others matters of concern, such as that relating to the integration of students of different cultures into existing departments, particularly in regard to the transfer of students from HBU’s to HWU’s. These questions need to be addressed urgently, and interpersonal communication is of the essence. [University community].
3. Job prospects in Physics are perceived by many young people to be poor, and this affects the take-up of the subject in schools and universities, but this is illusory. Both industry and business welcome them, for both technical and managerial careers, but this is not made apparent. The fault appears to lie on both sides, employers not making it clear that physicists are welcome to apply for their vacancies, and physicists not being sufficiently proactive. We recommend that SAIP mount a “connectivity-campaign”. [SAIP]
4. The “Public Understanding of Science” is increasingly important, not least for a democratic nation where the wide appreciation of science is vital. Much is being done but we recommend more, particularly as “the public” consists of many constituencies, all of which are important. [SAIP]
5. There is considerable concern in the science community about the low level of remuneration in academe, school-teaching and student bursaries. In particular, we propose a revised bursary scheme with the intention of minimising the financial barrier for students to enter physics and to stay in physics, especially in comparison with competing career paths. The proposed bursary scheme is ideally based on the concept of free tertiary education for

science students. We recognise the competing claims on national resources, but an upward revision of salaries and bursaries is essential. A serious “brain-drain” will result if salaries are kept low. [SAIP, NRF, Department of Education, Universities]

6. We recommend the creation of a fast, inexpensive, broadband National Research Information Network to support non-commercial research. This is vital not only for the National Research Digital Library suggested below, but in order to permit the maximum exploitation by South African scientists of data provided by national investments similar in scope to the proposed Square Kilometer Array. Projects of this type are likely to be the trend of the future and the lack of a system like the NRIN will mean that the dissemination of high value knowledge skills will, at a minimum, be severely constricted. [NRF, DST]
7. We recommend the creation of a National Research Digital Library Resource. Such a structure would provide subscription to electronic journals that will be accessible over the internet, and hence available to all universities (both staff and students), and selected non-commercial researchers. If the physics programmes of this nation are to be competitive, this is a vital need. It is clear that such a resource will have a transformational nature also, since even remotely located Universities will also be able to access the latest research findings, with the caveat of the necessity of ready internet access. [NRF, DST]
8. The Panel noted with pleasure the overall level of research and the existence of some excellent projects, although relatively few in number. Particularly impressive is the attitude of researchers towards the new “flagship projects” - projects that we applaud. We recommend that these projects be seen both to act as a focus for much of the scientific work in their respective areas, and to provide links to apparently unrelated branches of physics. [SAIP, DST, Physics community]
9. The onus is on the physics community to develop a long-term strategy for the subject, which addresses national developmental priorities as well as keeping the research internationally competitive. Such a strategy should, inter alia, aim at optimising both access to and the efficient use of, expensive equipment, and to facilitate the use of existing expertise by encouraging collaboration, thereby reducing the barrier to innovation. This may lead to the establishment of a limited number of other “flagship” projects and/or National User Facilities (NUF’s) on a scale more comprehensive than hitherto, and with an emphasis on facilitatory governance. Proposals for such projects should ensure a balance between funds for equipment, including its periodic updating, and those of staffing and maintenance. The concept of a NUF is described in more detail in Chapter 4 and Appendix 4 of the Report. [NRF]
10. Preoccupation with flagship projects and National User Facilities should not lead to the neglect of other areas of research. International experience has shown that “small science” has not only been a major training ground, and the forerunner, scientifically, of many large projects, but has also been a major vehicle for innovation and intellectual property development. Thus there is a need for strong support for “small science”, preferably in the context of collaboration. [NRF, SAIP]
11. There is considerable concern about the state of the research infrastructure. According to the data received, much of the equipment in university departments is out of date or inadequate. The Panel recommends that SA makes a rational investment in modernizing its research infrastructure to meet the scientific requirements, as well as with the objective of training the future generation of young scientists and engineers with globally competitive skills. The Panel recommends that appropriate mechanisms for funding and optimal utilization of existing resources be put in place at all levels of the scientific needs. [NRF, DST, Department of Education]
12. The state of theoretical physics is characterised as internationally competitive in some areas, but there is fragmentation and a coherent policy is needed in the nation. We recommend the establishment of a National Theoretical Physics Facility (either real or

virtual); the theoretical physics community will then be able to respond nimbly to national science policy initiatives. [NRF]

13. An important effect of physics research projects is technological spin-off. Advanced research projects not only bring immediate “rewards” to industry and commerce in the form of orders for technologically advanced equipment, but they also raise the possibility of new, previously unforeseen, developments. “Astro-technology” is an excellent example and we recommend that it be used as a prototype, and that physicists make use of the structures that encourage links to industry and innovation. [NRF, DST, SAIP]
14. We recommend that the Management and Policy Committee should remain in existence as a monitoring body, and that the SAIP, DST and NRF should report back to it in a year from now. The MPC should inform the community on the extent to which the Panel’s recommendations have been implemented. [MPC]

It should be noted that some of above recommendations are presented in more detail, and with some variation in wording, in the main body of the Report, in addition to further recommendations.

In summary, we believe that South African society needs a strong Physics community in the interests of the overall science and technology sector; that South African Physics, although a small community, has considerable strengths; that Physics in South Africa is currently in danger; but that South African Physics can be saved, and indeed can grow.

We commend this Report to the community in general and to the initiators (SAIP, NRF and DST) in particular.

Our view is that if the recommendations are followed there will be an improvement in the areas where the initial concerns prompted the review, viz.

Student numbers will rise, at both undergraduate and postgraduate level;

The demography will be transformed;

Research funding will increase;

Funding for physics in general will increase,

in other words,

## **PHYSICS IN SOUTH AFRICA WILL BE REVITALIZED**

April 2004