Physics for development

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South Africa has recognized the importance of science in the development of its society, in moving away from its apartheid past and striving to eradicate poverty. Opportunities abound in its growing programme of physics research.

South Africa is a society in transition. The building of a broad-based research culture is central to the challenges of our new democracy. We must create the conditions that will retain the best minds, so that talented academics may engage fully with research and, most importantly, consciously and deliberately lead youngsters towards the world of research.

Indeed, the science community bears the burden of a moral responsibility to galvanize science into improving people's quality of life. Analyses of the science system that existed in South Africa before 1994 — the year of the first post-apartheid democratic elections — show a fundamental dislocation of that system from the needs of a developing society. But the 1996 white paper on science and technology declared the importance of the basic sciences for the future development of South Africa, and the establishment of the National System of Innovation (NSI) has been an important step in articulating economic and reconstruction trajectories. The key message of the NSI is that South Africa must participate in technological innovation and not be entirely dependent on foreign inputs.

SCIENCE FOR DEMOCRACY

Even though the role of the South African state in shaping a national research system has expanded in recent years, scientists have nevertheless been at the forefront in setting the research agenda, and they have a crucial role in helping to create higher levels of scientific literacy and in improving the public understanding of science. These are fundamental needs of a developing democracy. The higher education system and the burgeoning science system are an essential part of the fabric of South Africa's progress towards nationhood. They are responsible for the education of a new generation of academics and intellectuals, to ensure that, as a nation, we have sufficient producers of new knowledge, without which we would be hopelessly dependent on other nations.

South African science must develop in its own local context, so that South Africans see themselves represented in that science — only then can South African science strive for an equal place in the global system of science. This means directing inventiveness and innovation towards our most pressing socio-economic challenges, in turn creating opportunities for our industrial base and service sectors to become more competitive.

The NSI strategy is to shift the industrial base from primary to secondary and tertiary sectors. An example is the 'beneficiation' of South Africa's natural resources — that is, making sure that the country retains, at secondary and tertiary levels, some or all of the value derived from the exploitation of those resources. This is also important for science. The establishment of funding drivers — regimes, systems and policies in fertile combination — aids the creation of partnerships that encompass industry, universities and science councils, with the purpose of generating an innovation culture. For the science community itself, this has meant the opening up of new funding streams for applied and product-related research.

Ultimately, this affects our economic well-being, through the creation of jobs and the alleviation of poverty. But most importantly, it helps us to deepen our democracy and our culture of human rights, so that we may shape a kind of society that cares, that removes destitution and permits every child to achieve his or her full potential.

The activity of scientists is critical in creating a culture of open, ethical, unfettered searching for truth. Scientists have been courageous in the past and will have to be so in the future, to enable the wider community in South Africa to realize that science may be depended on for new knowledge and, through it, a means of addressing societal problems, and that this can be achieved outside of political interference and patronage. The universality of science, rooted in clear logical thinking, entrenches democracy.

LEGACY

The legacy of history is plain in South Africa. Our research system is massively racialized, designed in size and shape for our apartheid past. Verwoerdian maxims — that intellectual work was the preserve of white South Africans, for example — defined the way in which this divided society imagined itself. The historically black universities were conceived as no more than training grounds for the racialized civil service and professional classes.

The result is that today South Africa's science system is not self-sustaining. It does not produce sufficient numbers of scholars, with only 0.01% of the population holding PhDs. This points to a serious underlying crisis, especially when one analyses the demographic profile of this group. It is imperative that the science system — as it embodies the hopes and aspirations of

a post-apartheid ideal — should expand and de-racialize its scientific and research cohorts.

The challenge is to achieve this in a manner that is meaningful and substantial; it is not about simply 'colouring up' the problem. We need to focus on quality: all of our efforts will come undone if we do not deliver high-quality graduate students, and high-quality research and teaching. The task requires special, systemic effort. It forces us to re-imagine our science system and its role in society, and to understand the importance of developing new kinds of relationships and role models for students who are drawn from diverse cultural backgrounds.

If we are to address the human-resource needs of a society that is at once developing and developed, globalizing and localizing, then, as a society, we need to develop the capacity to draw larger numbers of black students and female students into our research system. Without a deliberate strategy, we would be hopelessly failing the intellectual needs of our young democracy.

INTERNATIONALIZATION

In the words of Jim Gates (of the University of Maryland, USA), "science knew about globalization well before the world knew about it." Science brings together people from disparate backgrounds, to collaborate on problems of mutual interest, and such international cooperation has a crucial role to play in enhancing local science and development in South Africa.

South Africa has, over the years, signed bilateral agreements with most of the major Western countries, resulting in a considerably increased exchange of scholars. For example, our agreement with Norway brings in annually about R50 million (US$7.2 million) for research and development. The Royal Society of the United Kingdom has been actively engaged in building up research capacity at many universities in South Africa. France, Germany and the USA are intent on helping to develop a stronger scientific base in South Africa. For example, the US National Institutes of Health are by far the largest funder of HIV/AIDS research in South Africa.

More recently, South Africa has signed agreements with India, China, Japan and Russia, and is also beginning to create new relationships with nations in Eastern Europe. Our democracies are relatively new, and we face similar challenges in translating scientific research into output that can directly affect our commerce and industry.

There is also resonance in south–south cooperation. The 'IBSA' protocols, signed in 2003 by India, Brazil and South Africa, bring together strong and comparable regional powers from the Southern Hemisphere. These societies must cope with poverty and high unemployment, and they share the need for infrastructure, housing and safe water. They must also stem the loss of highly skilled workers to the north, and the IBSA forum has led to the establishment of a set of collaborative projects, including academic exchange programmes.

Today, South African researchers are spoilt for opportunities to collaborate with their international counterparts — a far cry from the days of the cultural boycott when South Africa was a pariah state and snubbed by academics around the world for its apartheid system.

EXPANDING SCIENCE

These are the contexts — a developing society, the legacy of apartheid, and new international opportunities — in which South African science is developing, but there is already a structure on which to build. The earliest astronomical observing facilities were set up more than 200 years ago, and the Royal Society of South Africa will celebrate its centenary next year. The Council for Scientific and Industrial Research (CSIR) was established in 1945, and the South African Institute of Physics (SAIP), with a membership of more than 500 physicists, and a growing number from other African countries, is more than 50 years old. South Africa was a founding member of the International Union for Pure and Applied Physics. The Academy of Sciences of South Africa, which was established by an act of parliament little more than a decade ago, is becoming a useful channel in articulating the

Box 1 The renaissance of nuclear science

The global issues of climate change and energy security have brought nuclear energy to the fore once more. South Africa is already a world leader in some sectors of nuclear science and technology, and is committed to growth in this area. The development and commercialization of an inherently safe, generation-IV, high-temperature, gas-cooled reactor, known as the Pebble Bed Modular Reactor, are well advanced.

The government has recently released for comment a draft policy on nuclear power for South Africa[2]. The document announces the intention to develop a globally competitive infrastructure for the peaceful use of nuclear energy and technology. Nuclear generation of 30–70% of the nation's power over the next 20-year period can be expected, as well as local infrastructure for the enrichment and processing of fuel mined in South Africa. The spend will be measured in hundreds of billions of dollars and has already begun.

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A spectrum of related areas, beyond reactor technology, is also developing, such as radiation safety, waste solutions, and legal and institutional frameworks for oversight and control; teaching and research infrastructures are receiving a boost. For example, the Nuclear Energy Corporation of South Africa[3] has a staff of 1,400 to provide leadership and support for R&D projects. The iThemba Laboratories[4], one of the country's six national facilities, comprise several sites around the country: the largest, in the Cape at Faure, runs programmes in nuclear physics, nuclear medicine, isotope production, environmental radiation and materials science; at the Johannesburg site, the Tandem Accelerator (pictured) is being refurbished for accelerator mass spectrometry, and use in projects including archaeology and geosciences.

New teaching and research programmes have, in several cases, led to new capacity at universities that had been marginalized before democracy. Examples are the Masters course at the new Centre for Applied Radiation Sciences and Technology[5] at the Mafikeng Campus of the University of the North-West and the Masters degree in accelerator and nuclear physics at the University of Western Cape. A few months ago, the Nuclear Industry Association of South Africa was launched, and will be a forum in which teaching and research institutions can further promote their interests in the nuclear sector.

views of scientists and interfacing directly with government. So science, and physics in particular, has a strong base from which to expand and to deliver excellence, to be central to the developmental agenda of the country.

In 2003, the South African Institute of Physics teamed up with the governmental Department of Science and Technology and the government agency the National Research Foundation (NRF) to oversee an international panel review of physics in the country[1]. There were several exciting outcomes from the panel investigation, including the creation of a permanent secretariat of the SAIP, and the establishment of the National Institute of Theoretical Physics, which is currently in an interim phase of development, before its full operation next year. The panel report continues to set the business agenda of the SAIP, and will do so for some years to come.

Observational astronomy is, by far, the most important thrust in science in South Africa. The Southern African Large Telescope (Fig. 1), the largest single optical telescope in the Southern Hemisphere (with a mirror reaching 11 m in diameter), is now fully operational and recording high-quality data. So too is the High Energy Stereoscopic System (HESS), an array of four imaging atmosphere Čerenkov telescopes for the detection of cosmic gamma rays; based in Namibia, HESS has strong South African involvement. South Africa is also developing its bid for the Square Kilometre Array, the most sensitive radio instrument yet, and has already commissioned the Karoo Array Telescope, a smaller-scale prototype. There is a long history of radio frequency observation at the Hartebeesthoek Radio Observatory, west of Johannesburg. The Hermanus Magnetic Observatory and South African National Antarctic Programme lead our efforts in space science, including cosmic-ray and plasma physics, and the mapping of the Earth's magnetic field.

South Africa voluntarily dismantled its stockpile of nuclear weapons soon after the new democratic order was ushered in, but interest in nuclear physics has remained strong (Box 1). Redundant laser equipment from the defunct weapons programme was used to set up the National Laser Centre in Pretoria, about a decade ago. There is a growing interest in applications to biological systems, especially with the development of a femtosecond-laser facility at the Laser Research Institute at the University of Stellenbosch. Meanwhile, the Photonics Initiative of South Africa is drawing up a road map for the future of this growing branch of physics, and a proposal to build a synchrotron light source at the iThemba Laboratories near Cape Town has been put together over the past four years. There is real hope that this flagship project will come to fruition soon.

SOUTHERN AFRICAN LARGE TELESCOPE FOUNDATION

Figure 1 The Southern African Large Telescope. Built in a nature reserve in the semi-desert of the Karoo region, this instrument takes full advantage of the excellent optical quality of African skies.

The Centres of Excellence established by the Department of Science and Technology and the NRF have benefited science enormously, and in physics in particular, the Centre of Excellence in Strong Materials has drawn the participation of several universities and government laboratories as well as industries, such as the de Beers Diamond Company. South Africa has a historical interest in natural diamond, of course, and more latterly in synthesized diamond and other related hard materials such as SiC and BN. Materials science and solid-state physics involve the largest number of physicists, and these research endeavours are slowly beginning to have a more direct impact on industrial interests, for example in the photovoltaic industry.

Finally, the programme of NRF research chairs (each of which is very substantially endowed) has created fantastic opportunities to recognize excellence and to attract back to our shores talented South African scientists who have been working abroad. The aim is to create 210 such chairs by 2010, and many physicists have been recognized, even in such diverse fields as string theory — which says a lot about the new-found confidence of the science system in South Africa.

THE FUTURE

In the immediate future, and on a practical level, there is increasing awareness of the need for open-source software, and moves are afoot to increase the bandwidth for internet connectivity for South African scientists, which is fast becoming a problem of crisis proportions.

But a triumph is that South Africa is on track to achieve its goal of committing 1% of its GDP to research and development by 2008. This is also testimony to the fact that, in a country struggling with deep and resistant socio-economic difficulties, there continues to be a positive perception in government and in the private sector of the role that science is playing in development. Before 1994, when the future of the country seemed uncertain, the CSIR aligned itself with private-sector funding. The chief contribution still comes from the private sector, but the public-sector spend has also increased. Today, alongside the NRF, the CSIR has begun to reorient itself more towards basic research. In a time of development and growing opportunities, this augurs well for the future of physics in South Africa.

References

1. *Shaping the Future of Physics in South Africa*. <www.saip.org.za/Reports.html> (2004).
2. <www.dme.gov.za/pdfs/energy/nuclear/nuclear_energy_policy.pdf>
3. <www.necsa.co.za>
4. <www.tlabs.ac.za>
5. <www4.tlabs.ac.za/carst>

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