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The South African National Astrophysics and Space Science Programme (NASSP)

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Abstract. South Africa faces the exciting challenge of preparing a new generation of scientists to use the international astronomy facilities which are now available (the Southern African Large Telescope - SALT - in South Africa and the High Energy Stereoscopic System - HESS - in Namibia) and which will be constructed over the next few years (the Karoo Array Telescope - MeerKAT - and possibly even the Square Kilometer Array - SKA - radio telescope). The community has responded to the challenge by joining forces in a collaboration involving 9 universities and 3 national facilities: the National Astrophysics and Space Science Programme - NASSP. Since 2003 NASSP has produced 60 honours graduates from all over the continent as well as from South Africa, equipping them with skills that will be of use not only for careers in astrophysics, but also in many other scientific or technological occupations. This paper describes the rationale behind NASSP.

Keywords. sociology of astronomy, telescopes, education

1. Introduction

Astronomers in South Africa are fortunate to have the benefit of an extraordinarily forward looking government policy in science and technology. This can be seen, for example, from the 2002 strategy document (Department of Science and Technology 2002) and was discussed by Whitelock (2004, 2008). This strategy emphasizes the importance of investing in the areas in which South Africa has a strategic advantage rather than spreading limited resources across many fields. The climate and geographical position of South Africa offer very special advantages to astronomy. This together with the subject's proven ability to draw young people into scientific careers and use of innovative technology has resulted in the investments in infrastructure outlined below.

The NASSP web page can be found at www.star.ac.za. It includes many up-to-date details of the partners, the courses, the students (past and present) and how to apply for participation.

2. Astronomy Facilities

Two of the major new facilities in Southern Africa are described elsewhere in these proceedings: the Southern African Large Telescope (SALT) by Charles (2008) and the High Energy Stereoscopic System (HESS) by de Jager (2008). I will therefore say no more about them here.

In addition to these working facilities South Africa is constructing a major new radio

telescope known as MeerKAT†. This is being done in stages starting with a 15m prototype which is already working at the Hartebeesthoek radio observatory (HartRAO). The next phase, KAT-7, a seven-dish engineering testbed and science instrument near Carnarvon in the Northern Cape Province, will be commissioned towards the end of 2009. The full array of 50 or more dishes should be ready to do science by 2012. A high speed data transfer network will link the telescope site in the Karoo to a remote operations facility, probably in Cape Town.

Although it will be capable of doing very interesting science in its own right, one of the main functions of MeerKAT is as a technology tester for the Square Kilometer Array (SKA)‡. This will be the largest and most sensitive radio telescope ever built. It is being developed as a major international collaboration and its location has not yet been decided, but South Africa and Australia are the only two places left on the short list. If South Africa wins the SKA bid, the core of the telescope (consisting of approximately 3000 antennae) will be located north-west of Carnarvon in the Northern Cape. The other antenna stations will be distributed throughout South Africa and a number of other African countries.

One of the prime science objectives of the SKA is to probe the so-called "Dark Ages", when the early universe was in a gaseous form before the formation of stars and galaxies. This period extends from about 300 000 years to 1 billion years after the Big Bang. The SKA will also provide new insight for a whole range of astronomical investigations, including the enigmatic γ-ray burst sources, radio pulsars and extra-solar planets, and may even detect signals transmitted by intelligent extraterrestrial civilizations.

In summary South Africa has, or has direct access to, facilities across the electromagnetic spectrum, from radio waves to extremely high energy γ-rays. We also have plans for an African Virtual Observatory, linked to the International Virtual Observatory Alliance, to give the African community access to the extensive data from other international projects.

3. SA Astronomy Community

To use these facilities South Africa has only a total of about 65 astronomers spread over 12 facilities. Almost two-thirds of these people are based in the three institutions in or near Cape-Town (SAAO and the Universities of Cape Town and the Western Cape). This is actually a big improvement - the number of astronomers has more than doubled since the first democratic elections in 1994. Nevertheless, unless there is a big investment in people we run the risk that the user community for our excellent facilities will be largely international and that the impact on the science and education system will fall far short of what is possible and desirable.

The legacy of apartheid adds to the challenge faced by the astronomy community. For example, in 2007 less than one percent of black South African matriculants qualified to study maths, physics or engineering at university. There is a huge demand for those who do get good qualifications and lucrative jobs are to be found outside academia for those with high level technical skills. It is within this environment that we must build an internationally competitive astronomy community.

In 2000 (after the South African expenditure on SALT was approved, but before the country's participation in SKA was much more than a dream) the astronomy community

† where KAT stands for the Karoo Array Telescope and meer is Afrikaans for "more"; see http://www.kat.ac.za.

‡ http://www.ska.ac.za

recognized that the lack of local astronomers, and the extreme lack of black astronomers, was the biggest threat to the future of the discipline. At the same time the lack of high level skills in science and technology was a major national problem. With this in mind the South African astronomers took a close look at how they might work together to develop a local community of astronomers, while supporting the broader need for scientists on the continent. The space physics community, whose skill requirements are similar to those of the astronomers, joined at an early stage.

4. National Astrophysics and Space Science Programme - NASSP

Recognizing that there were people graduating with BSc physics and related degrees, but few going on to start PhDs, the first focus had to be on bridging that BSc to PhD gap. Within the South African context that meant taking students through honours and masters degrees. Thus NASSP was born and the first courses given in early 2003 after the decision had been taken to locate the programme, at least initially, at the University of Cape Town, close to the headquarters of SAAO.

The partnership has grown slowly since then and the present membership stands at 9 Universities and 3 National Facilities whose staff lecture and/or supervise student projects. In addition, the USA National Society of Black Physicists (NSBP) joined the NASSP consortium in 2007 and sent two professors to teach courses in 2008; from 2009 they will also send students.

The organization of NASSP has grown and evolved with the programme, but it has been directed from the start by Peter Dunsby from the UCT Mathematics and Applied Mathematics department, where NASSP was located up to the end of 2007. Since 2008 NASSP has been administratively located in the Astronomy Department at UCT and Prof Dunsby has been assisted by an Executive Committee with members from UCT, SAAO and the University of the Western Cape. The overall strategy for NASSP is set by the Steering Committee, which I chair and which meets at least once a year. Its membership represents the various organizations that teach within the programme.

4.1. *Finance*

The first support for NASSP came from the Ford Foundation, who made it possible to start in 2003 by providing bursaries for students. This first step was vital and NASSP owes the Ford Foundation a great deal for this initial vote of confidence. Not long after that additional support came from the SAAO, HartRAO, UCT, the National Research Foundation, the Mellon Foundation and the Cannon Collins Trust. SKA/MeerKAT have also been strong supporters of NASSP over the past couple of years. From 2006 the SA Department of Science and Technology have covered most of the costs above and beyond those of more standard programmes. The participation of the NSBP was made possible by a generous grant from the Kellogg Foundation.

It is important to the success of NASSP that the students who are accepted onto the programme get all their expenses paid (travel, fees, accommodation and subsistence), including, what is by South African standards, a generous living allowance. This is vital as it allows the students to concentrate fully on their studies. Nevertheless, for many South African students from disadvantaged backgrounds the pressure to get a job with real earning power is very powerful. It therefore remains difficult to attract such students into postgraduate training.

Long term support from the South African government is linked to our ability to attract more black South Africans into NASSP. Strategies for doing this include a two year honours programme, started in 2008, that allows students from disadvantaged universities

to do some extra courses in maths and physics before they get into the intensive full programme.

4.2. *Student Demographics*

Over 60 students have graduated at honours level between 2003 and 2007, the numbers per year varying from 10 to 16; 27 percent of these are women and 58 percent are black. Pictures of all the students can be seen on the web page. Several of those who graduated in 2003 have gone on to get PhDs.

We are particularly pleased at the level of interest that has been shown in NASSP by students from elsewhere in Africa. To date NASSP has had students from Botswana, Ethiopia, Gabon, Kenya, Madagascar, Mozambique, Rwanda, Sudan, Uganda, Zambia and Zimbabwe. They make up about half of the total complement. Although some of these students struggle with English, their physics background, particularly on the theoretical side, is stronger than that of many of their South African counterparts.

The decision to call SALT the *Southern* African Large Telescope was indicative of a political will to engage with Africa. This in turn led to NASSP looking beyond the border for recruits right from inception. It also seems likely that this broad vision helped gain the support of donor agencies, such as the Ford Foundation.

More recently South Africa's vision for the SKA, should we win the bid to host it, involves antennae in many neighboring countries. Thus SKA have been financing, and strongly encouraging, many students from their partner countries in Africa to join NASSP.

4.3. *skills*

Part of the objective of NASSP was to improve the skills base in South Africa. This is vitally important as we do not necessarily expect all those who qualify with a NASSP degree to go into academic or research careers. The courses are therefore intended to equip the the students with the following skills:

- mathematical and statistical ability
- problem solving
- data analysis
- computer programming, including modeling
- science communications, verbal and written.

In the USA and Europe the demand for people with high level training in physics and astronomy outstrips the supply. We would like to to see the same in Africa, but this involves ensuring that those who obtain such a degree have not only the right skills, but also an in-depth understanding of research methodology.

4.4. *The Honours Programme*

Applicants for the honours programme must have, or expect to obtain, a good BSc degree in Physics, Mathematics, Astronomy or Engineering.

The honours programme lasts one year and is preceded by a 3 week summer school held at SAAO which starts in late January. This is compulsory for all students and is intended to acclimatize them to Cape Town, astronomy and space physics. They do courses in basic astronomy, they learn a bit about computers and programming and those who need it start intensive English tuition. They also visit the Hermanus Magnetic Observatory and SALT and the SAAO telescopes at Sutherland. It is also intended to be a bonding experience for the students themselves and most of them enjoy it tremendously.

The honours courses are in the process of changing to reduce the workload on the students and increase the time they can spend on their research project, so anyone

interested should refer to the web page for up-to-date details. In 2008 students were required to take a total of 15 units in order to acquire both a breadth and a depth of knowledge. Each unit corresponds to about 25 lectures and 6 tutorials. The courses were as follows:

- Electrodynamics (2 units)
- General Astrophysics (stellar atmospheres, structure and evolution) (2 units)
- Spectroscopy
- Astrophysical Fluid Dynamics
- General Relativity and Cosmology
- Galaxies
- Computational Methods in Astronomy
- Computational Physics
- Observational Techniques in Optical Astronomy (2 units)
- Observational Techniques in Radio Astronomy
- Research Project (2 units)

4.5. *The Masters Programme*

NASSP honours graduates must get at least 60 percent for their degree to qualify to enter the Masters Programme, but we also take people with other comparable qualifications. The course is in two parts: the first part is taught and lasts for one semester, the second part is research and requires the student to write a mini-thesis over a period of two semesters. The full MSc course should be completed in 1.5 years from start to end.

The taught part of the masters programme requires 5 units. Each unit corresponds to 25 lectures and 6 tutorials. Courses on the following topics were offered in 2008 and the choice depends on the area of in which the student expects to specialize for their research:

- Plasma Physics
- Magnetohydrodynamics
- Geomagnetism and Aeronomy
- Hot Topics in Cosmology
- Cataclysmic Variables
- Extragalactic Astronomy
- Advanced General Relativity
- High Energy Astrophysics and Pulsars
- Stellar Structure and Evolution
- Observational Cosmology
- Space Technology (2 units)
- Particle Cosmology
- Computational Astrophysics

Some of the honours courses are also available for those students who did not first complete the NASSP honours.

For their research, students can choose from projects offered by researchers at any of the partner institutions and there are usually around three times the number of projects on offer as there are students. Students will then go and work at the home institute of the supervisors for that final year.

5. Further Study

We encourage competent students to get started on PhD research as soon as possible, in some cases upgrading the MSc into a PhD after it is clear that the student can handle

the requirement to do original research. There are a few special PhD grants for NASSP students, but numerous other opportunities to obtain grants within South Africa or at institutions around the world. There are some particularly attractive opportunities to go and work with SALT, HESS or SKA partners in Europe, North America and elsewhere. Opportunities for postdoctoral research are also very extensive.

Slightly over half the NASSP honours graduates have gone on to do an MSc or PhD degree, and the first few PhDs are graduating this year.

6. Conclusion

It is NASSP's vision to create an African network of astronomers bonded by the common experience of schooling and interlinked both professionally and personally. The programme offers exciting postgraduate training opportunities for those interested in a career in astro- or space physics. It also offers a challenging opportunity to those who are not certain what career they want, but who are looking to improve their technical competency while learning something really interesting about the universe. Financial support is available and suitably qualified applicants from Africa are encouraged to apply.

Those interested should look at the web page: www.saao.ac.za. Further information can be obtained from the administrator (nassp-admin@nassp.uct.ac.za), the director, Prof Peter Dunsby, (peter.dunsby@uct.ac.za) or from me.

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