ROYAL ASTRONOMICAL SOCIETY

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Advancing Astronomy and Geophysics

The RAS Council has recommended to the government that, provided the proposed Large Facilities Research Council (now known as the Science and Technology Facilities Council) is carefully designed, all of the astronomy funding currently handled by PPARC should come within its remit. At its meeting on May 12 Council agreed, overwhelmingly, the following response, which has been sent to OSI:

Executive Summary

· The RAS welcomes the discussion document '*Science and innovation investment framework 2004-2014: next steps'* for its very positive commitment to science, with science seen as absolutely central to the UK.

· Chapter 6 of *'next steps'* places a strong emphasis on improving the supply of scientists and increasing the uptake of STEM subjects at GCSE and A level. We believe that a vigorous and exciting research programme in astronomy can contribute very strongly to this goal.

· Much RAS science has relevance to industry and has made a very significant contribution to the high international impact of UK science and of UK universities. This has been of great and benefit to the economy, often in critical areas like computing and advanced technology, through the high quality graduates, postgraduates and postdoctoral scientists that we train.

· We welcome the Government's recognition that innovative science often lies at the boundaries of traditional areas of research and its proposals to encourage high-class inter-disciplinary research.

· ***On the related issue of how the remainder of the astronomy funding within PPARC should be handled, Council of the RAS believes, overwhelmingly, that the planning of large facilities needs to be very closely integrated with the development of instrumentation and the scientific exploitation of the facilities, and should come within the remit of a single Research Council***.

1. Introduction

The RAS welcomes the discussion document *'Science and innovation investment framework 2004-2014: next steps'* for its very positive commitment to science, with science seen as absolutely central to the UK and the UK's ability to compete with the emerging economies of China and India.

The RAS was able to consult the astronomical community about the proposals in this document at its National Astronomy Meeting in Leicester on April 3-7th.

The RAS acknowledges that there has been a very significant increase in funding for science and for university infrastructure over the past 9 years. In the particular case of astronomy we have had support for initiatives like joining the European Southern Observatory, e-science and Astrogrid, and Aurora. However, we note that in general, our core programme has not experienced the growth in funding of other science areas and several key projects have been cut just as they become scientifically promising. We plan to make representations about this later this year as part of the discussions leading up to the next Comprehensive Spending Review.

2. Education and Training

Chapter 6 of *'next steps'* places a strong emphasis on improving the supply of scientists and increasing the uptake of STEM subjects at GCSE and A level. We believe that a vigorous and exciting research programme in astronomy can contribute very strongly to this goal. Astronomy and space science are often cited as one of the principal reasons that pupils take up physics and maths at school and pursue it through to a university course. Obviously many then find themselves drawn towards other areas of physics. Our postgraduates and postdoctoral researchers are highly prized by industry and the financial sector for the excellent training they receive in problem solving, cutting edge IT and instrumentation skills, and ability to work in a team. The RAS is keen to work with the Government towards its goal of increasing the uptake of STEM subjects at school and plans to expand its already active education and outreach work. The RAS believes that active involvement by teachers in professional societies like the RAS, for example as members of their education committees, should be recognized as CPD. The UK has been at the forefront of the development of robotic telescopes on good quality astronomical sites to which students in schools can have access, for example the Bradford Robotic Telescope and the JMU Liverpool Telescope, both supported by PPARC. The Faulkes Telescope on Hawaii was built through UK private donation and is being developed into an international network to which schoolchildren around the world will have access.

The RAS remains extremely concerned that not all physics classes in school are being taught by qualified physics teachers. It is also concerned that creationist beliefs of an absurdly short age for the earth and the universe are being given credibility in some schools.

3. Technology and Knowledge Transfer

Although when PPARC was set up many assumed we would not be contributing much towards the industrial exploitation goals set for other research councils, PPARC has in fact worked with the community to improve our performance in knowledge transfer and business links. Thus although our research is curiosity-driven it does have many direct links with industry, especially in the areas of astronomical instrumentation and space instrumentation, can certainly point to long-term economic benefits derived from astronomical research, and has produced some impressive short-term benefits, like commercial benefits of terahertz imaging (Box 3.2 of '*next steps'*). Other examples include: (1) A precision camera developed for gamma-ray astronomy has been used to screen cargo containers for radioactive materials being brought in at airports, border crossings and other security-sensitive areas. (2) Superconducting tunnel junctions (STJs) that are used on telescopes to measure low levels of radiation and its energy are being developed to detect fluorescence from tagged DNA. This will improve the DNA identification that is needed for medical and forensic techniques such as genetic profiling. (3) One of the most successful imaging devices of recent decades has been the charge-coupled device (CCD) developed for astronomy and particle physics, which is now found in cameras bought on the high street as well as in medical X-ray equipment. (4) Adaptive optics is a technology to compensate for the blurring of starlight by the Earth's atmosphere. It is now being applied in medical optics, where there are two distinct uses. The first application is to image the retina in unprecedented detail, opening up the possibility of early detection of disease and abnormalities. The second is to enhance someone's vision to better than normal vision. (5) Imaging by microchannel plate camera, a standard technique in X-ray astronomy, has been developed as a sensitive camera for monitoring cancer treatment, and imaging tumours in the body. (6) Study of reactions

between ions and molecules in the interstellar medium led to the development of a technique to measure trace gases. The same technique is now used as a non-invasive method for clinical diagnosis and therapeutic monitoring (breath testing), and is also finding applications in environmental science (pollution monitoring), health and safety practice (monitoring breath following exposure to hazardous chemicals) and animal husbandry (measuring the release of noxious gases from animal waste and the sulphurous gases and fatty acids emitted by cows). (7) Mathematical techniques designed for processing observations of the Universe as it was just after the Big Bang are being applied in forensic and medical fields. Picture enhancement was first developed and applied to astronomical images, but has been transferred to uses such as reconstructing fuzzy police photos of car number plates, and de-blurring of images of the human body taken by hospital scanners.

More important are the intangible benefits of the very significant contribution of astronomy and solar system science to the high international impact of UK science and of UK universities, and the benefit to the economy, often in critical areas like computing and advanced technology, of the high quality graduates, postgraduates and postdoctoral scientists that we train.

Much RAS science has relevance to industry and to society by providing a deep understanding of environments in which we live. This includes (a) the study of natural hazards (e.g. seismic effects, volcanoes, tsunamis, landslides, near-Earth objects and space weather), (b) the effect of energetic particle radiation from space (cosmic rays) on weather through changes to cloud cover, (c) the application of geophysics to critical environmental problems such as safe sites for waste disposal, (d) academic work on global navigation systems (GPS, Galileo), (d) studies of trans-ionospheric radio propagation, (e) the effect of climate change on the upper atmosphere, (f) the development of high-level computational skills that are invaluable to industry. In all these areas knowledge transfer is primarily concerned with providing an accurate context in which decisions can be made about policy issues and about industrial decisions. The issue of how NERC activities, which support many RAS scientists in geophysics and planetary science, would fit with an LFRC needs to be considered.

4. **Interdisciplinarity**

We welcome the Government's recognition that innovative science often lies at the boundaries of traditional areas of research and its proposals to encourage high-class inter-disciplinary research. Much work in astronomy is highly inter-disciplinary. For example, the recently approved UK participation in ESA's planetary exploration programme (Aurora) requires strong links between groups (in the UK and across Europe) involved in studies of planetary surfaces, atmospheres and radiation environments as well as the growing area of exo-biology. It will also require strong interactions between planetary scientists and the engineering community who will build the innovative instruments needed by this programme. Another example is that scientists within the RAS are deeply involved in inter-disciplinary work on natural hazards such as earthquakes, near-Earth objects and space weather (areas highlighted in the Government's 2005 report on '*The Role of Science in Physical Natural Hazard Assessment*'). A third is the way applied mathematical and computational techniques are being used to understand fundamental plasma processes at work in the Sun and other space environments. We welcome efforts to break down barriers that have limited inter-disciplinary work and build a scientific culture that is open to cross-cutting ideas.

5. **Reorganisation of PPARC/LFRC**

On the specific issue of management of large facilities we query whether any of the problems perceived to be associated with management and procurement of these lie in the astronomy area. Very few details of the thinking behind this proposal are given. Nevertheless we accept that there may be strong reasons for drawing together the whole array of large physics facilities. We would strongly recommend that a new Large Facilities Research Council be carefully designed from scratch and not simply be an extension of CCLRC. Key elements would be:

(A) that it should be a Research Council,

(B) a strong presence on the Council of experienced university researchers to provide scientific input and vision during its discussions,

(C) that it should be advised by a Science Committee which would undertake the necessary strategic reviews needed to plan new facilities, ensure that they are well-instrumented, and make sensible decisions about when facilities have reached the end of

their cutting-edge life.

(D) retention of the very strong element of peer review currently used by PPARC in assessing proposals for new facilities and instrumentation, research grant proposals and applications to exploit facilities.

Most of the major large facilities for astronomy are now accessed through international organisations (ESA, ESO and Gemini), which are governed by international treaties and managed by international boards. UK influence on these organisations is through the participation of leading UK scientists on these management boards. UK astronomers are extremely effective at securing observing time, and leading roles in instrumentation development, on these facilities. Europe now competes effectively with the US in ground-based and space astronomy, and solar system science, and the UK is well-placed to continue to be a big player in European astronomy, space science and solar system science. However resources are needed to support UK excellence. UK scientists won coveted Principal Investigator roles in INTEGRAL and BEPI-COLUMBO instrumentation only to have to relinquish these roles when PPARC was unable to provide the resources to support them.

On the related issue of how the remainder of the astronomy funding within PPARC should be handled, pros and cons were seen for different options. A key issue was that the planning of large facilities needs to be very closely integrated with the development of instrumentation and the scientific exploitation of the facilities. It would be pointless if one Council builds a facility and another, responsible for exploitation, declines to fund grants for the use of the facility. This perception led to a majority of astronomers favouring the remainder of the PPARC astronomy funding, including the very important grants line, being placed with the Large Facilities Research Council. However, there would be a benefit in a single organisation funding and managing support for research students in physics and mathematics. The PPARC community has an emphasis on curiosity-driven research, long-term strategic planning of the programme because of the long gestation time of large ground-based facilities and astronomical space missions, and attaches great value to peer-reviewed Rolling Grants. On balance the planning and strategic issues were seen as overriding.

6. Summary

In conclusion the RAS would welcome the opportunity to take part in detailed discussions on the proposals for restructuring of the research councils, especially PPARC. In doing so RAS Council overwhelmingly prefers a science-led LFRC which would incorporate the current PPARC grants line. The restructuring should be guided by the following principles:

- **There should be guaranteed support for long-term programmes, ie rolling grants (or an equivalent), both for development and exploitation**

- **There needs to be a clearly defined and well-supported grants line that is insulated from the vagaries of exchange rates and over-runs on international projects**

- **Funding should be available for fundamental research and small facilities that are not necessarily linked to large facilities**

- **There needs to be 'joined up thinking' between facilities and exploitation**

- **The principle of peer review for selection of new facilities and their instrumentation, for grants and for allocation of resources like telescope time should be maintained**

- **There must be a rational, objective mechanism for the allocation and support of studentships**

- **Funding processes must reflect the increasing cross-disciplinary nature of science research**

- **The principle of curiosity-driven research needs to be maintained as central to the PPARC research areas**

- **At present there is a range of space science and theory groups where innovation and interactions with the international community are highly effective. This vibrant activity needs to continue to be nourished for the UK's superb international reputation in space science and in theory to continue**

- **The interface with science supported by NERC needs to be carefully defined, and the new Council should have strong links with both NERC and EPSRC**