FORM FOR THE SUBMISSION OF EVIDENCE

Please complete and return this form to MathematicsIntReview@epsrc.ac.uk by **30th September 2010.** You must limit your submission to no more than 8 pages in length and no smaller than font size 11. *Information submitted on this form will be published on our website unless agreed in advance in which case you must clearly state that the form contains confidential content for the panel only and indicate which information on the form is to be treated as confidential.*

The purpose of this review is to benchmark UK research activity in mathematical sciences against the rest of the world, and it will be used to help inform future strategy and funding policy. It is *not* a review of individual institutions or researchers. Please therefore ensure that your comments address and illuminate for the panel the UK-level issues flagged in the attached evidence framework (see Annex A).

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Statement of interest (please indicate your reasons for making this submission - 200 words max.):

With more than 3500 members ('Fellows'), more than two thirds of whom are resident in Britain, the Royal Astronomical Society (RAS) is the principal body representing the interests of professional astronomers in the UK.

Astronomy in the UK has a thriving theory community with a superb international reputation and is widely regarded as one of the best in the world.

Much of the theoretical astronomy in the UK is undertaken in University Mathematics Departments. Indeed, one of the most active branches of applied mathematics in the UK is theoretical astronomy, in which sophisticated applied mathematical and computational techniques are used to model astronomical phenomena.

The Society is therefore pleased to offer evidence to the International Review.

A. What is the standing on a global scale of the UK Mathematical Sciences research community both in terms of research quality and the profile of researchers?

The UK is certainly world-leading in many areas of theoretical astronomy, especially in magnetohydrodynamics (MHD) and cosmology. A great tradition has grown up in the UK to do internationally leading research in this area and the UK's expertise complements the observational expertise in other parts of the world, notably North America. Input from UK researchers in theoretical astronomy is crucial to gaining a proper understanding of observations from a series of new space satellites launched by NASA, Japan and ESA.

The Society therefore recommends that this work continues to receive the support it needs. In particularly, investment in postdoctoral researchers and research students in applied mathematics in MHD and particle astrophysics should be maintained at

current levels.

There are great opportunities for the future, for example for this work to support the analysis of data from international space missions. However, the Society believes that with the current uncertainty in funding, there is a real threat that the UK's leaders emigrate and that their research groups will not be maintained and enhanced, putting our world-leading role at risk.

B. What evidence is there to indicate the existence of creativity and adventure in UK Mathematical Sciences research?

Creativity and adventure are essential qualities for those researchers who work to explain completely new observations from space and high-resolution ground-based telescopes. However, for young researchers a barrier to more adventurous research is the urgent need for them to build a CV in order to obtain permanent posts.

In recent years the STFC has drastically reduced its spending on young researchers due to its budget shortfall. The focus on large facilities in the remaining funds has had a detrimental impact on other areas of research. The Society therefore believes that there is a need for EPSRC to fund the mathematical aspects of theoretical astrophysics which straddles traditional STFC and EPSRC topics.

C. To what extent are the best UK-based researchers in the Mathematical Sciences engaged in collaborations with world-leading researchers based in other countries?

International collaboration is central to the main theoretical solar system science and astronomy groups in the UK – it is very much an international approach to modern astronomy. This engagement is much closer in these areas than in other parts of mathematical science.

Looking at specific regions, collaboration between UK groups and their counterparts in the USA and Europe is very close and somewhat less so in China, India and Japan.

One issue is the restriction of international travel budgets, which hinders this work. The Society therefore opposes further cuts to this area.

D. Is the UK Mathematical Sciences community actively engaging in new research opportunities to address key technological/societal challenges?

In astronomy and solar system science, the UK is superb at training researchers in computational and theoretical techniques in a broad sense that benefits society in a wide range of applications. These researchers are then able to apply these skills across the broader economy (examples can be seen in the recent RAS publication, "Big Science for the Big Society", available from our website).

To reap the maximum societal benefit from this cadre of highly skilled graduates, it is important that the UK's investment in dedicated computational facilities in this field is maintained.

At present there are many research leaders of international stature, but this is being rapidly undermined by the withdrawal of STFC from many areas which is set to have a detrimental effect on UK mathematical science as a whole.

E. Is the Mathematical Sciences research base interacting with other disciplines and participating in multidisciplinary research?

Yes. In solar system science and astronomy there are active interactions with other disciplines, notably computational science, physics and astronomical observation.

The Society believes there is a need to invest in a programme of research for theoretical plasma physics in general, drawing together the space and astronomical plasma community and the laboratory plasma community.

F. What is the level of interaction between the research base and industry?

There is a reasonable interaction between the research base and both space industry and computational firms, but the Society believes that this could be greatly enhanced. For example, the main space hardware groups such as Mullard Space Science Laboratory, the Rutherford and Appleton Laboratory and Leicester University have active links with the space industry in developing sophisticated instrumentation.

G. How is the UK Mathematical Sciences research activity benefitting the UK economy and global competitiveness?

It is benefitting it enormously by providing flexible, highly talented researchers in computational and mathematical techniques.

In MHD and cosmology, nonlinear and computational techniques are commonly used and are developed there on an ongoing basis.

The Society acknowledges the need for researchers in this area to have more contact with commerce and industry.

H. How successful is the UK in attracting and developing talented Mathematical Sciences researchers? How well are they nurtured and supported at each stage of their career?

Particularly in MHD and cosmology, the UK is superb at attracting highly talented researchers and at nurturing, supporting and training them at each stage of their career. This is a real strength of UK research in these fields.

There is a huge demand from undergraduates to pursue PhD research in these areas but there is a need for more research grants and studentships to supply the demand.

In recent years the supply has increased, but this is now declining sharply as a consequence of recent STFC decisions. Given the multi-disciplinary nature of research in theoretical astronomy, this work could be funded by EPSRC, something which would be a great opportunity for EPSRC to train very highly skilled researchers.

Once in post, early career researchers are very well supported. In common with the physical sciences, there remain some equality concerns regarding recruitment. In this case the gender balance is reasonable but there are few recruits from black and minority ethnic (BME) backgrounds.

One interdisciplinary issue the Society wishes to raise is the need to establish studentships and postdoctoral research posts in plasma theory, cutting across astronomy and laboratory plasma physics.

I. Other Comments – Please use this space to provide any additional information which you believe would be useful for the Review Panel

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EVIDENCE FRAMEWORK

A. What is the standing on a global scale of the UK Mathematical Sciences research community both in terms of research quality and the profile of researchers?

- Is the UK internationally leading in Mathematical Sciences research? In which areas? What contributes to the UK strength and what are the recommendations for continued strength?
- What are the opportunities/threats for the future?
- Where are the gaps in the UK research base?
- In which areas is the UK weak and what are the recommendations for improvement?
- What are the trends in terms of the standing of UK research and the profile of UK researchers?

B. What evidence is there to indicate the existence of creativity and adventure in UK Mathematical Sciences research?

- What is the current volume of high-risk, high-impact research and is this appropriate?
- What are the barriers to more adventurous research and how can they be overcome?
- To what extent do the Research Councils' funding policies support/enable adventurous research?

C. To what extent are the best UK-based researchers in the Mathematical Sciences engaged in collaborations with world-leading researchers based in other countries?

- Does international collaboration give rise to particular difficulties in the Mathematical Sciences research area? What could be done to improve international interactions?
- What is the nature and extent of engagement between the UK and Europe, USA, China, India and Japan[1], and how effective is this engagement?
- How does this compare with the engagement between the UK and the rest of the world?

[1] The countries listed have been identified as strategically important international research partners for the UK

D. Is the UK Mathematical Sciences community actively engaging in new research opportunities to address key technological/societal challenges?

- What are the key technological/societal challenges on which Mathematical Sciences research has a bearing? To what extent is the UK Mathematical Sciences research community contributing to these? Are there fields where UK research activity does not match the potential significance of the area? Are there areas where the UK has particular strengths?
- Are there any areas which are under-supported in relation to the situation overseas? If so, what are the reasons underlying this situation and how can it be remedied?
- Does the structure of the UK's mathematical science research community hamper its ability to address current and emerging technological/societal challenges? If so, what improvements could be implemented?
- Are there a sufficient number of research leaders of international stature in the Mathematical Sciences in the UK? If not, which areas are currently deficient?

E. Is the Mathematical Sciences research base interacting with other disciplines and participating in multidisciplinary research?

- Is there sufficient research connecting mathematical scientists with investigators from a broad range of disciplines including life sciences, materials, the physical sciences, finance and engineering? What is the evidence?
- Where does the leadership of multidisciplinary research involving mathematical sciences originate? In which other disciplines are the mathematical sciences contributing to major advances?
- Are there appropriate levels of knowledge exchange between the Mathematical Sciences community and other disciplines? What are the main barriers to effective knowledge and information flow, and how can they be overcome?
- Have funding programmes been effective in encouraging multidisciplinary research? What is the evidence?

F. What is the level of interaction between the research base and industry?

- What is the flow of trained people between industry and the research base and vice versa? Is this sufficient and how does it compare with international norms?
- How robust are the relationships between UK academia and industry both nationally and internationally, and how can these be improved?
- To what extent does the Mathematical Sciences community take advantage of opportunities, including research council schemes, to foster and support this knowledge exchange? Is there more that could be done to encourage knowledge transfer?
- Nationally and internationally what is the scale of Mathematical Sciences R&D undertaken directly by users? What are the trends? Are there implications for the UK Mathematical Sciences research community, and how well positioned is it to respond? Is there any way that its position could be improved?

G. How is the UK Mathematical Sciences research activity benefitting the UK economy and global competitiveness?

- What are the current and emerging major advances in the Mathematical Sciences area which are benefiting the UK? Which of these include a significant contribution from UK research?
- How successful has the UK Mathematical Sciences community (academic and user-based) been at wealth creation (e.g. spin-out companies, licences etc.)? Does the community make the most of opportunities for new commercial activity? What are the barriers to successful innovation based on advances in the Mathematical Sciences in the UK, and how can these be overcome?

H. How successful is the UK in attracting and developing talented Mathematical Sciences researchers? How well are they nurtured and supported at each stage of their career?

- Are the numbers of graduates (at first and higher degree level) sufficient to maintain the UK Mathematical Sciences research base? Is there sufficient demand from undergraduates to become engaged in Mathematical Sciences research? How does this compare with the experience in other countries?
- Is the UK producing a steady-stream of researchers in the required areas or are there areas of weakness in which the number of researchers should be actively managed to reflect the research climate. What adjustments should be made?
- How effective are UK funding mechanisms at providing resources to support the development and retention of talented individuals in the mathematical sciences?
- How does the career structure for researchers in the Mathematical Sciences in the UK compare internationally?
- Is the UK able to attract international researchers in the Mathematical Sciences to work the UK? Is there evidence of ongoing engagement either through retention within the UK research community or through international linkages?
- Are early career researchers suitably prepared and supported to embark on research careers?
- Is the balance between deep subject knowledge and ability to work at subject interfaces/boundaries appropriate?
- How is the UK community responding to the changing trends in the UK employment market?
- How diverse is the UK mathematical sciences research community in terms of gender and ethnicity and how does this compare with other countries?