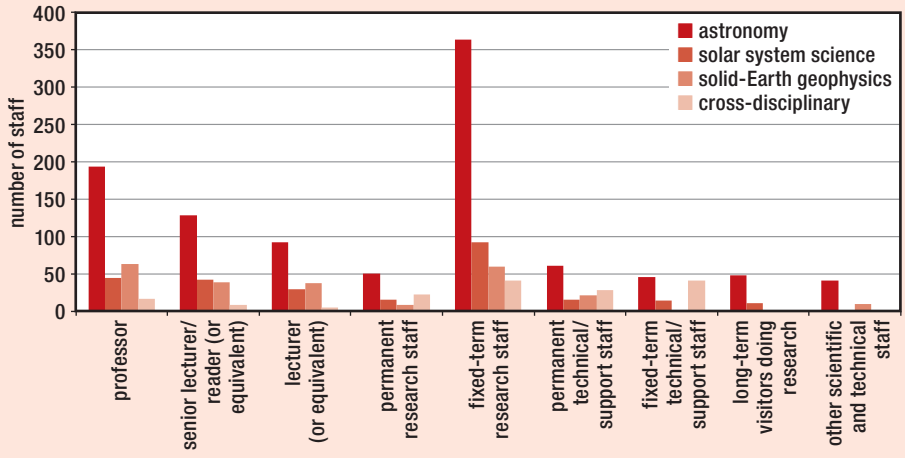
Who are we and what do we do?

Robert Massey summarizes the 2011 Demographic Survey of Astronomy and Geophysics carried out by the RAS.



1: Total number of staff with research interests in astronomy and geophysics.

A central role of the RAS is to collect evidence that helps us make a case for astronomy and geophysics to policy-makers and the general public. To that end, the Society recently commissioned the first demographic survey of UK astronomy and (academic) geophysics research since 1998 (summarized by Tadhunter, 1998). It focused on the state of affairs between 2006 and 2010. This is timely, not only because of the long interval since the previous survey, but also to provide a baseline for assessing the impact of cuts to research funding over the coming years.

This article summarizes its results: a modest expansion in the size of the UK astronomy and solar system science community, a significant increase in the proportion of women employed, and a sizeable number of researchers in the UK originating from other countries in the European Union. The decline in the number of technical staff reported in 1998 has continued. The community is also disproportionately white, and women in senior academic positions are rather less likely to have children than their peers in wider society. The full report is available from the RAS website (McWhinnie 2011).

Getting the data

The RAS used a specialist consultant to carry out the survey. Sean McWhinnie of Oxford Research and Policy worked closely with RAS staff (Robert Massey and Fern Storey) and then Senior Secretary Helen Walker. For this survey, the Society broadened the scope compared to the earlier research to include solid-Earth geophysics and cross-disciplinary work, as well as adding questions on topics such as ethnic origin and movement of staff. Draft questionnaires were circulated to members of the RAS Council for testing and feedback before the final version was distributed.

The new study was divided into two parts. First, heads of departments, research groups and institutions were contacted in the autumn of 2010 and asked to supply data about the profile and turnover of their staff and research students from 2006 to 2010. A total of 41 university departments and four research establishments returned the questionnaire. A further 27 university departments and one research establishment did not respond, but data were available on their websites.

Second, a questionnaire for individuals was assembled online using SurveyMonkey software. The link to this was then circulated to RAS Points of Contact to pass on to their colleagues, and was publicized via the RAS and STFC email lists. Where the response rate for an institution remained low, emails were sent to individual members of the relevant research groups. By the time the survey was closed in the spring of 2011, 902 respondents (37%) had completed the online questionnaire, compared with 1147 (60%) in 1998. The lower completion rate is disappointing, but we have assumed that they are representative of the broad astronomy and geophysics community, using the returns from the completed surveys and the online data.

Respondents were invited to complete a series of questions relating to their age, gender and ethnic origin, area of study, occupation and facilities used. Early-career researchers were also invited to comment more generally on career and other professional issues. Where possible, data were compared with the results of the previous surveys carried out in 1993, 1998 and 2003 (results from the 2003 exercise were not published and there have been significant changes in the research landscape in the past decade).

The size of the research community

The 1998 survey reported that 1881 people were either in employment or undertaking PhD research in astronomy in the UK. In 2011, the areas of study were categorized broadly to reflect those recognized in the RAS mission statement: astronomy, solar system science and solid-Earth geophysics. Using those categories, the full-time equivalent size of the astronomy community stands at 1689, with the equivalent of 371 people in the area of solar system science and 357 in solid-Earth geophysics. Drawing together people working in "space" in the broad sense, the total stands at 2060, 22% higher than in 1998. The equivalent of 204 people indicated that they worked in cross-disciplinary areas, for example terrestrial and planetary atmospheres and Sun-climate studies.

Employment

Across all grades in universities and research establishments, the full-time equivalent of 838 people work in UK astronomy, 222 in solar system science, 190 in solid-Earth geophysics and 167 in cross-disciplinary areas (including in the total 40 long-term visitors doing research).

Although the data are not directly comparable with 1998, there is little evidence of a large overall increase in staff numbers and on some measures there seems to have been a decline. In 1998 the survey reported a total of 1298 people employed in astronomy, over 200 more than the number reported in 2010–11. Even if cross-disciplinary researchers are included, the total is only the equivalent of 1227 posts or 71 (5.5%) fewer than a decade ago. This probably reflects changes including the closure of the Royal Greenwich Observatory (RGO) in late 1998.

The RGO closure was followed by some growth (perhaps better described as a recovery) in employment. Nonetheless, supporting evidence from elsewhere (see for example the Institute of Physics Survey of Academic Appointments in Physics 2004–2008) indicates that employment in astronomy and solar system science has grown no more quickly than physical sciences as a whole.

Permanent academic staff

For the purposes of the study, permanent academic staff were defined as professors, readers, senior lecturers and lecturers. In astronomy and solar system science, the full-time equivalent number of permanent academic staff in universities rose from 292 in 1993, through 312 in 1998 to 498 in 2010–11. At the same time, the number of staff in PPARC/STFC research establishments fell from 246 in 1993 to 89 in 1998 and 75 in 2010–11 (table 1). In solid-Earth geophysics the equivalent of 168 people were employed in universities and 22 in research establishments. All 167 posts in cross-disciplinary fields were in universities.

Alongside this shift is a dramatic increase in the number of staff at professorial level. In 1993 the equivalent of 78 staff in astronomy and solar system science were professors, but by 1998 this had risen to 98 and by 2010–11 it stood at 227. The figure for solid-Earth geophysics is 62.

Thus in universities professors make up 47% of permanent academic staff in astronomy, 39% in solar system science, 47% in solid-Earth geophysics and 56% of staff in cross-disciplinary areas. These are comparatively high fractions in comparison with physics as a whole (36%) and across all research areas in universities (16%).

Fixed-term staff

The number of fixed-term researchers in astronomy and solar system science rose from 323 in 1993 to 384 in 1998 and in this survey stands at 448. Given the cuts to the research budget, we can anticipate a sharp decline in this number over the next few years, a well-documented prospect raised by the Society in parliamentary inquiries and other consultations. Solid-Earth geophysics and cross-disciplinary areas had 60 and 41 fixed-term researchers respectively.

Technical staff

There appears to have been a sharp overall decline in the number of technical staff in astronomy and solar system science since 1998 (table 2). That year the survey recorded 77 permanent and 127 fixed-term technical staff in astronomy and solar system science in universities. In PPARC establishments the corresponding figures were 189 permanent and 63 fixed-term staff, giving a total of 456.

However, the restructuring of facilities makes a direct comparison difficult. On the information we have, there are now 70 permanent technical staff in universities in astronomy and solar system science and a further 6 in research establishments. The number of fixed-term technical staff is 60 in universities and none were identified in research establishments, so the total now stands at 136, a drop of 70% since 1998.

It may be that the number of technical staff is under-reported in this survey and some technical staff may also have moved to scientific roles.

Table 1: Staff in astronomy and solar system science in 1993, 1998 and 2010*

job type	number of staff		
	1993	1998	2010
permanent academic staff			
professors	78	98	227
senior lecturers/readers	100	97	161
lecturers	115	117	111
permanent research	40	20	50
fixed-term (postdoc) researchers	323	412	448
permanent technical	129	77	70
fixed-term technical	107	137	60
other	19	16	16
total	**908**	**974**	**1142**
staff in (PPARC/STFC) establishments**			
permanent scientific	246	89	75
permanent technical	109	201	6
fixed-term scientific	28	55	8
fixed-term technical	11	64	0
total	**394**	**409**	**89**

*** The figures presented for 1993 and 1998 are astronomy and Earth observation/atmospheric science combined. Data have been rounded to whole numbers and combined as appropriate to enable the earlier data to be comparable with 2010 data.**
**** Data for 10 research establishments are included in 1993 and 1998 figures. Data for five establishments are included in the 2010 figures.**

Table 2: Technical staff in universities and research establishments in 1993, 1998 and 2010

		1993	1998	2010
astronomy and space science	permanent	238	266	76
	fixed-term	118	190	60
solid-Earth geophysics	permanent	–	–	21
	fixed-term	–	–	2
cross-disciplinary	permanent	–	–	28
	fixed-term	–	–	41
total		**–**	**–**	**228**

Despite these factors it is hard to escape the conclusion that there has been a significant decline in the number of people carrying out technical work in astronomy and space science.

In solid-Earth geophysics there are the equivalent of 9 permanent and 2 fixed-term technical staff in universities, and 12 permanent technical staff in research establishments. Cross-disciplinary research areas have 28 permanent and 41 fixed-term staff, all in universities.

Employment moves

In those institutions that responded to the survey, the number of staff employed has remained fairly stable over the past five years, with no change in astronomy and a decline of 5 posts in solar system science. Solid-Earth geophysics saw a net increase of 26 and cross-disciplinary employment increased by 9 posts.

As would be expected, the largest movement was among staff on fixed-term contracts. The equivalent of just over 450 people in astronomy and around 100 in solar system science have left and joined the workforce in the past five years. Geophysics saw the equivalent of 59 people leave and 85 join; cross-disciplinary research had 26 leave and 35 join.

Departments were also asked to provide information on the destinations of leavers (table 3). About 19% of permanent and fixed-term staff left for new jobs in research in the UK. 25% of permanent academic staff and 38% of fixed-term

Table 3: Reasons for leaving employment in astronomy, solar system science, geophysics and cross-disciplinary research*

reason for leaving	staff role						
	permanent academic staff	permanent research staff	fixed-term research staff	permanent technical/ support staff	fixed-term technical/ support staff	other scientific and technical staff	total
early retirement	19.2%	0.0%	0.4%	28.1%	2.9%	8.3%	4.2%
normal retirement	25.1%	17.6%	0.6%	25.0%	2.9%	16.7%	5.4%
new job in academia/ research institute in UK	19.5%	29.4%	19.1%	9.4%	11.8%	16.7%	18.5%
new job in academia/ research inst. abroad	25.1%	35.3%	37.8%	28.1%	2.9%	8.3%	33.4%
new job in industry	1.4%	0.0%	5.5%	3.1%	8.8%	8.3%	5.0%
new job outside scientific research	2.8%	0.0%	4.4%	0.0%	5.9%	0.0%	3.9%
end of contract	2.8%	5.9%	22.5%	0.0%	47.1%	25.0%	20.1%
death in service	2.8%	5.9%	0.8%	0.0%	0.0%	0.0%	1.1%
unknown	1.4%	5.9%	8.8%	6.3%	17.6%	16.7%	8.4%
sample size	**71.8**	**17**	**476**	**32**	**34**	**12**	**642.8**

*** Data are presented only for those departments and research establishments which returned the questionnaire.**

research staff left for research posts overseas, rather more than moved to jobs in the UK.

In contrast to the first career destinations of research students (see for example the case studies in the 2010 RAS publication *A New View of the Universe*), relatively few staff on fixed-term contracts are reported to have left for posts in industry. In the institutions that responded, 5.5% of postdocs and 9% of technical staff left for industrial posts, with 4.5% of fixed-term postdocs and 6% of fixed-term technical staff leaving for "other" jobs outside scientific research. A very small fraction (just 1.5%) of permanent staff left for posts outside academia. These figures should be treated with some caution, as a large number of staff on fixed-term contracts are reported to have left after reaching the end of their contract, but no additional destination information was provided.

Nonetheless it seems that once researchers complete PhDs and enter employment in universities or research establishments, they are unlikely to leave for other careers, even if that means relocating overseas.

Age profile

Departments gave information on staff age, broken down into five-year bands. The cohorts in solid-Earth geophysics, solar system science and cross-disciplinary areas were too small for a meaningful analysis, so an assessment was made of astronomy and solar system science combined.

The data indicate a peak in the number of permanent staff in the 40–44 age range, reflecting the expansion of university posts since the previous survey, when there was a broad plateau from 35 to 55 years old. The median age of fixed-term postholders is 30–34 years and there is certainly an ample supply of potential applicants to fill any available permanent posts. If the present decline in funding continues and there are far fewer permanent jobs on offer, we are likely to see a return to a situation where the average age of departments rises over time.

Postgraduate research students

In 2011 there were 869 research students in astronomy, 152 in solar system science, 169 in solid-Earth geophysics and 38 in cross-disciplinary areas. This is a significant increase from 1998, when 472 research students worked in astronomy and is partly explained by the growth in available studentships and the increase in the available duration of grant support. (On average, students are supported for 3.5 years and those in their fifth year or "writing up" were also included in this survey.) The expansion of university departments has also led to a corresponding increase in the number of research students.

Looking at astronomy and solar system science alone, STFC supports approximately 60% of that cohort (66% of UK students) for between three and four years, meaning that a surprisingly large number of students receive funding from other sources, such as from universities or, for overseas students, external sponsorship from other governments. Across the three research areas, NERC-supported students made up 8% of respondents, principally in geophysics and cross-disciplinary work.

Of those students who responded, around 70% are full time and normally based in the UK and 27% are full time and from overseas. Only 3% indicated that they were studying on a part-time basis.

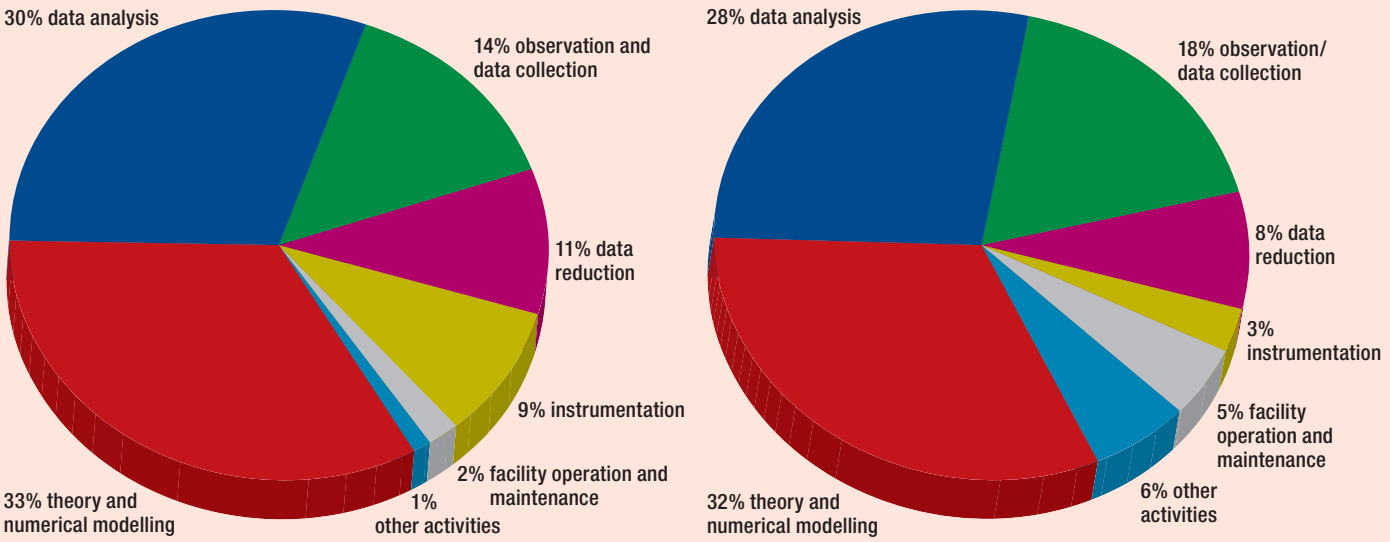
Gender balance

Since the last survey in 1998, the proportion of women in astronomy and solar system science has risen significantly, although in common with other disciplines there is a significant "leakage" of women moving from junior to senior posts.

In astronomy 7% of professors and 28% of lecturers are women. The corresponding figures for solar system science are 11% of professors and 37% of lecturers and for geophysics 8% of professors and 34% of lecturers. At the time of the last survey, women made up only 7% of permanent academic staff.

Among fixed-term postdoctoral research staff, the proportions are similar to lecturers. Women make up 27% of astronomy postdocs, 30% of those working on solar system research and 30% of those working in geophysics. The 1998 survey found that 17% of postdocs aged 25–34 were female and women made up just 12% of the postdoc population aged 35–54. Just over a third of PhD students are female, a figure that is consistent irrespective of mode of study, country of origin and area of research.

These figures are significantly higher than the equivalent figures for physics as a whole, where women make up 17% of postdocs, 20% of lecturers, 11% of readers and 5% of professors. But, overall, just 20% of entrants to A-level physics are girls. Astronomy and geophysics are significantly better at attracting women than other areas of physics, perhaps vindicating much of the outreach work that takes place, particularly in astronomy and space science.



2: What do people do all day? How research time is divided for permanent staff in astronomy (left) and geophysics (right).

Ethnic background

For the first time the individual survey collected data on ethnicity and nationality. We find that among permanent staff in astronomy and geophysics, 78% are British, 12% are from other European countries, 2% are from the USA and 7% are from other countries. 95% of all respondents and 97% of British respondents indicated their ethnicity to be white. In the 2001 UK census, 92.1% of the population were white, so black and minority ethnic (BME) groups are significantly under-represented.

Of postdocs, 61% are British and of these 97% of those who indicated their ethnicity were white. 25% have other EU nationalities and 96% of those indicated that they are white. 10% of the postdocs who indicated their nationality were from outside the EU or United States.

The under-representation of BME groups is a significant challenge for the astronomy and geophysics research community, assuming that we strive to reflect the composition of society as a whole. It also suggests that specific programmes (for example those run by the IoP and STFC) that aim to tackle this deficit have yet to bear fruit.

Children

Children and family commitments are often cited as barriers to success (particularly for women) in reaching senior posts in universities. The individual survey therefore included questions on family size and whether respondents had ever taken career breaks.

Within the cohort of permanent staff, more senior (and therefore probably older) postholders tend to have more children. Despite this, 28% of professors have no children at all, with a far larger number of women (47%) than men (26%) in that position.

Population data from the UK concerning the proportion of people who have children is not easily available. In the US, census data indicate that 20% of women aged between 35 and 39 do not have children, and 19% of those aged between 40 and 44. Very few women have children after the age of 45, so a conservative estimate would be that no less than 15% of the whole adult female population are childless. In the US the birth rate is significantly higher than in the UK, suggesting that the fraction of women without children in the UK general population is somewhat higher. Nonetheless, it seems likely that women in senior positions in astronomy and geophysics are significantly less likely to have children than their peers in the population as a whole.

In line with this, a surprisingly small number of respondents, namely 17 women (9%) and 9 men (3%), had taken career breaks totalling more than three months. Just 14 women and none of the men had taken career breaks for childcare, perhaps indicating that researchers are still concerned that, however justifiable, such absences will impede their career prospects.

Division of labour

A large part of the individual survey looked at the way in which members of the research community divide their time. Among respondents, lecturers, senior lecturers, readers and professors spend 35–39% of their time on research and 9% on postgraduate teaching. Lecturers spend 13% and professors 21% of their time on administration, while professors spend less time (19%) on undergraduate teaching than lecturers (33%). All permanent academic staff spend 4–5% of their time on public engagement and outreach work. More senior staff spend more of their time (7%) on external professional activity than lecturers (3%).

Permanent staff in research institutes and facilities spend 46% of their time on research, while their counterparts (permanent research fellows) in universities spend 58% of their time doing the same. Both these groups spend a similar fraction of their time on administration (14% and 13% respectively) and 8% of their time teaching postgraduates. Research staff in universities and their peers in institutes and facilities spend 2% and 8% of their time respectively teaching undergraduates.

As expected, postdoctoral researchers spend by far the largest fraction of their time (82%) on research, 5% on undergraduate teaching, 2% on postgraduate teaching, 4% on administration and 3% on public engagement and outreach.

Scientific effort

As in 1998, respondents were also asked to indicate the proportions of their time spent on different aspects of research, including field of study, activity, wavelength and facilities used.

Of the 392 permanent staff who responded, 60% stated that they had research interests in astronomy/astrophysics, 9% in particle astrophysics, 29% in solar system science and 15% in solid-Earth geophysics. A number of respondents indicated interests in more than one of these areas.

Within astronomy, 55% of research effort is in ground-based astronomy, 35% in space-based astronomy and 10% in "other" areas. 33% of effort in astronomy research is dedicated to theory and numerical modelling, 30% to data analysis, 14% to observation and data collection, 11% on data reduction and 9% on instrumentation. A further 2% of effort is expended on facility operation and maintenance (figure 2).

Researchers were also asked about their particular interest within the broader fields. In astronomy, the most popular areas were galaxies/extragalactic astronomy (cited by

20% of this group), stars (15%) and cosmology (12%). Four areas were each cited by 5–10% of astronomy researchers: radio, sub-mm and infrared sources or background; UV/X-ray sources or background; interstellar matter; circumstellar matter, debris discs, exoplanets. A further 13 areas were cited by 0–5% of respondents in astronomy.

In solar system science, there is a comparatively even distribution of interests, with only magnetospheres cited by more than 10% of respondents. Eight areas were cited by 5–10% and nine areas by 0–5% of researchers.

In solid-Earth geophysics, Earth structure, seismology and tectonophysics were all cited by more than 10% of respondents. Eight subfields were cited by 5–10% and a further five by 0–5% of respondents.

As in 1998, respondents working in astronomy were also asked about the wavelength bands they used. There is little change in the past 12 years, except for a fall in the proportion of effort relating to X-ray wavelengths from 20% to 10% and a rise in activity at infrared wavelengths where the proportion of effort increased from 17% to 24%. This may mark the advent of and opportunities for UK scientists presented by the infrared Herschel telescope.

Facilities used

Respondents were asked to list the research facilities they had used in the past two years. In that time UK researchers in astronomy, space science and geophysics cited more than 200 different sites and resources, from space-based observatories to research ships. They included facilities where the UK has a direct role and others where researchers only gained access through their membership of an international collaboration.

Of those responding, by far the most popular facility was the European Southern Observatory, used by 77 people. The Hubble Space Telescope had been used by 50 and Gemini by 38 researchers. 29 people had used the Isaac Newton Group, 28 the Spitzer Space Telescope, 27 XMM-Newton and 26 UKIRT. At radio wavelengths, researchers had used a number of facilities around the world, with the most popular being the VLA/EVLA in the United States (25 respondents) and the GMRT in India (12 respondents).

The diversity of facilities in use perhaps reflects the strength of the UK research base (the Thomson/Reuters 2009 citation indices rank us second in the world in space science) and the way in which UK researchers are highly regarded by their peers across the world.

What does all this mean?

Looking first at astronomy and solar system science, there is little doubt that these remain hugely popular areas for both postgraduate students and for employment, with a strong growth over the last 12 years (at least post-RGO closure), even taking into account the recent decline in research funds. The survey also appears to bear out the perception that the UK has, at least until recently, been a very attractive destination for overseas researchers, who see and want to join a thriving scientific environment for part of their career. Cuts to the research base must put at risk that attractiveness and the intellectual capital it brings to the UK.

In geophysics we lack earlier data and of course the survey does not cover the very many geophysicists who work in industry. We do, however, now have a better understanding of the size of the community, with a little fewer than 150 people employed in this area in universities and research establishments, providing a baseline for the future.

The popularity of postgraduate study sits alongside the static or in some cases declining numbers of applicants for undergraduate courses over the broad astronomy and geophysics areas (see e.g. Massey 2011, Khan 2006). Although early figures this year suggest an improvement, the long-term trend poses a question about the effectiveness of these courses as a recruitment tool for postgraduate research. Students still appear to want to become astronomers and, in fewer numbers, geophysicists, but they may not see the title of a first degree course as an important consideration. It may also be that a pure physics degree is seen (however incorrectly) as a better route to employment in general and one that still allows students to pursue the specialist postgraduate study of their choice.

Across the research areas, many staff have been promoted to, or appointed at, the professorial level in universities, with or without a pay rise. There is a question for the community about the resulting profile of departments and the effect this may have on the career prospects of those entering the field today – something that will only become apparent in the medium term. If recruitment slumps in the years ahead, there is a risk that research groups will consist of a static and ageing cohort of professors with a declining number of postdocs supporting their work.

One area for cautious optimism is in the improving recruitment of women. The growth in the fraction of female staff at all levels in the last decade now places astronomy and geophysics well ahead of physics as a whole, although the increase at professorial level has been significantly slower. If we want to make further progress, a part of this must be to improve the supply of undergraduates, something that in turn depends on increasing the number of girls who study A-level physics. However, efforts are also needed to ensure that, in future, women are retained and progress in astronomy and geophysics careers to the same extent as men.

Although the sample is small, women (and men to a lesser extent) working as professors of astronomy or geophysics are much less likely than the population as a whole to have children. Perhaps the dedication required to reach a senior academic position precludes bringing up a family, or maybe women with children tend not to apply for, or get, those positions. Certainly the recent IoP Childcare Survey (2010) indicates that researchers with families are less able to travel, for example to conferences, and would welcome support ranging from additional grants to more flexible working patterns.

This imbalance, together with the compelling evidence that members of BME groups are under-represented in astronomy and geophysics, suggests that the Society may wish to broaden the scope of its work in the area of diversity and perhaps consider tackling it in a more formal way.

Research activity is diverse in all the areas of interest represented by the RAS. The broad distribution of effort across subfields in astronomy, solar system science, solid-Earth geophysics and cross-disciplinary work again indicates the vibrancy of the UK research base. Similarly, UK researchers use many facilities around the world to observe the Earth and the wider universe.

It is hard to imagine that the UK would have such a leading position in astronomy and geophysics without this variety of resources and the people to exploit the data they produce. We can also be proud of the way that our science draws in people, many of whom move on from PhDs to enrich the wider economy. Over the years ahead the RAS will be working hard to make that point. ●

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