Commons Science and Technology Committee: inquiry into UK Astronomy

Written evidence submitted by the Royal Astronomical Society

1. This is the official response from the Royal Astronomical Society (RAS) to the inquiry by the House of Commons Science and Technology Committee into UK space strategy and UK satellite infrastructure.

2. The RAS represents more than 4,000 astronomers and geophysicists, in the UK and around the world, in occupations in academia, industry, education and public engagement, and journalism, as well as others in the wider economy. Our members are described as 'Fellows'.

3. We have included space science and solar system science in our submission, as these are part of the broader family of 'astronomy' research which seeks to understand the universe around us. Where appropriate these categories are disaggregated.

4. This evidence was shaped by input from our governing Council, our Policy Group, RAS Fellows and others in universities and research establishments, and from our partner organisations.

5. We do not believe there are any prejudicial conflicts of interest to declare. For the record, two members of RAS staff, and a number of members of our governing Council, serve in a voluntary capacity on committees supporting the UK Space Agency and the Science and Technology Facilities Council (STFC). RAS Fellows are also in receipt of grant funding from these bodies, and STFC sponsors the Society's annual conference.

6. We welcome the interest of the Committee in our science, and would be delighted to give oral evidence to explore the points in this written submission in more detail.

Executive Summary: key points in our evidence

7. UK astronomy is a strength of our scientific base, and astronomers here benefit from and are represented in leading edge facilities sited around the world and in space. HM Treasury can be confident that investment in our science is excellent value for money.

8. Recent uplifts to core resource grant funding provide some relief from more than a decade of flat cash settlements, amounting to an estimated real terms cut of 25%. Scientific output would be vulnerable to any reversal in support

9. Astronomy has been a key beneficiary of the EU Horizon schemes, and our community expects to benefit from UK association. To maximise the resulting research output, the Government should ensure that the visa system allows for the straightforward movement of people between institutions in the different countries participating in funded projects.

10. Optical and radio interference from satellite constellations remains a key challenge for our field, with global risks to ground-based and some space-based astronomy. We urge the public bodies responsible for the oversight of space to continue engagement with the astronomical community and private industry to develop guidelines and regulation to adequately protect our science.

11. As a UK scientific strength, astronomy has a key role to play in the ambition for the UK to become a science superpower. This requires a political commitment to increase financial support for fundamental research, including astronomy and a reasonable starting point would be restore it to the level it was at before the financial crash in 2008.

12. Astronomy research, and astronomy researchers, offer a plethora of benefits to the wider economy, including spin out technologies, analytical techniques, data science, and a supply of highly trained scientists who move out of academia after completing postgraduate training.

13. On the face of it, astronomy enjoys wide public support and fosters enormous interest in STEM, and there are outstanding examples of its impact.

14. It would be valuable to carry out new and rigorous research into the value of astronomy in encouraging people from traditionally under-represented groups into science, as the principal cited work is more than two decades old. Although diversity in recruitment in astronomy has improved significantly over that time, the demography of the sector is still far from that of society as a whole.

15. Many students and employees in our sector report bullying and harassment, and we collectively recognise the need to work harder to create an inclusive working environment.

The strengths and weaknesses of UK astronomy and how these compare to other nations

16. Professional research astronomy in the UK is strong by international standards, a point reinforced by testimony from our Fellows.

17. The most readily available evidence for this are citations for scientific publications, where the UK remains in second place in global rankings in astronomy[1] and the related disciplines of space science and planetary science[2]. Our position in terms of output of papers has also remained strong for the quarter of a century for which data are available, with the main change being the rise of China to take third place in global rankings after the United States and Germany.

[1] Scimago Journal and Country Rank: astronomy and astrophysics citations 2022: https://www.scimagojr.com/countryrank.php?category=3103&year=2022&order=ci&ord=desc

[2] Scimago Journal and Country Rank: https://www.scimagojr.com/countryrank.php?area=1900&year=2022&order=ci&ord=desc&category=1912

18. Astronomers in the UK benefit from national membership of intergovernmental organisations including the European Southern Observatory (ESO), the Square Kilometer Array Observatory (SKAO), which is headquartered in the UK at Jodrell Bank, and the European Space Agency (ESA).

19. UK astronomers have access to world-class facilities on the ground and in space. Examples of these include the e-MERLIN array, centred on Jodrell Bank in Cheshire, an outstanding network of radio telescopes allowing astronomers to obtain high resolution images of the universe. Ground-based optical astronomy is carried out at appropriate sites overseas, including in La Palma in the Canary Islands, and a number of sites in Chile. The UK provides scientific leadership and investment for many of these facilities, via ESO (where nearly half of papers have a UK author[3]) and SKAO, and through agreements with other nations such as the US (e.g. for the new Vera C. Rubin Observatory).

20. Results from our previous surveys of Demographics and Research Interests of the UK Astronomy and Geophysics Communities[4] suggest that astronomers here use the vast majority of significant observatories around the globe, and astronomy space missions operated by spacefaring organisations including ESA, NASA, ISRO (India), JAXA (Japan) and CNSA (China). UK-based scientists hold Principal Investigator positions on the JUICE mission (to the Jovian moons) and Comet Interceptor, and astronomers and engineers here developed the Mid-Infrared Instrument for the James Webb Space Telescope.

21. According to UCAS data and a 2021 survey by the Space Academic Network[5], named undergraduate courses in astronomy and related disciplines are taught in at least 40 universities, and at least 53 carry out research in these areas. These cover most regions in the four nations of the UK.

22. UCAS data also indicate that these courses grew significantly in popularity over the last 15 years. Students accepting places in the envelope of 'astronomy' courses more than tripled in that time, increasing from 520 in 2007 to 1795 in 2022.

23. We welcome the recent agreement on the UK becoming an associate member of Horizon Europe, and the resulting potential for enhanced international collaboration. This has been significant uncertainty in our sector around this in the years following the 2016 referendum on EU membership, despite the underwriting guarantee for the UK components of successful grant applications.

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[3]Socio-economic impact evaluation study of the UK subscription to ESO: https://www.ukri.org/wp-content/uploads/2022/02/STFC-240222-SocioEconomicImpactEvaluationStudyUKSubscriptionESO-FinalReportSummary.pdf

[4] The Demographics and Research Interests of UK Astronomy and Geophysics Communities 2016: https://ras.ac.uk/about-the-ras/diversity/surveys-and-reports

[5] UK Space Science: a summary of the research community and its benefits: https://span.ac.uk/wp-content/uploads/2021/04/SPAN-UK-space-science-nature-benefits-FINAL-REPORT-060421.pdf

24. Astronomy is a significant beneficiary of EU framework schemes in general, notably including the European Research Council. These were previously estimated to provide at least 30% of the resource funding accessed by UK astronomy research groups[6]. *We now hope and expect that UK-based astronomers will apply for EU funding with renewed enthusiasm, and in support of this the Government and EU should enable easier mobility to and from the UK for researchers named on awarded grants.*

25. A domestic weakness of our science is the near-flat cash resource grant funding in place (from STFC) for 12 years after the 2008 financial crisis. In the 2011-12 financial year the grant allocation for astronomy was £40.7m, a figure that changed little over the course of the decade[7]. *Welcome capital investment in new and existing equipment has also often not been accompanied by sufficient resource funding to make full use of those facilities.*

26. In the last two years there have been welcome more recent uplifts to resources (these are harder to track since the creation of UKRI but were shared by the Executive Chair of STFC in RAS meetings[8]), but *nonetheless a reasonable estimate is that inflation has reduced the spending power of the grant allocation by around 25% over the last 15 years.*

27. The most recent report from the STFC Astronomy Grants Panel notes the positive impact of these uplifts, with initial evidence of an improved success. Despite this, there remains much world-class science that could not be supported this time.

28. Some of our Fellows working in planetary science report difficulties with support for staff moving from postdoctoral to permanent academic positions. The STFC schemes supporting this, such as the Ernest Rutherford Fellowships, have too low a budget (£5k) for consumables and lab access, which typically run to £1200 a day. As a result universities may prioritise taking on staff working on theory rather than absorb additional costs.

29. In line with other evidence[9], astronomy researchers report an 'ever increasing' administrative workload. For example, one noted that she has to report her outreach activities four times; to STFC, ResearchFish, to the Higher Education Statistics Agency, and her university. Precarious employment in the higher education workforce, a subset of whom are responsible for the bulk of astronomy research, also presents a risk to future success.

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[6] See e.g. "What do astronomers want from the STFC?", Serjeant S. et al, A&G, 60, 2.13-2.17: https://academic.oup.com/astrogeo/article-pdf/60/2/2.13/28074139/atz096.pdf

[7] Science and Technology Facilities Council (STFC) Annual Report and Accounts 2011-12: https://assets.publishing.service.gov.uk/media/5a75aa43e5274a4368299060/0415.pdf

[8] Direct communication with STFC staff

[9] Independent Review of the UK's Research, Development and Innovation Organisational Landscape Final Report and Recommendations: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1141484/rdi-landscape-review.pdf

30. *Finally, despite the establishment of the UK Space Agency in 2010, some researchers still report difficulty in navigating the 'dual key' for space science projects, where the Agency shares its responsibility with STFC.* They see no clear definition of the approach and clear alignment of long-term strategy between the two bodies, noting a difference in funding timescales, and the need to convince both organisations of the merits of a project, thus doubling the workload.

The opportunities and challenges facing UK astronomy and whether it is receiving sufficient support

31. The overarching opportunity for UK astronomy comes from our involvement in international projects, and to see astronomers here playing a leading global role in future discoveries. Few things could be more inspiring than having UK scientists on teams answering the fundamental questions about our origins and future, and whether there is life elsewhere in the universe.

32. There are some challenges to achieving this, including the restriction of funding referred to in the previous section. *We note that the output of UK researchers in astronomy is very high despite a level of resource investment lower in real terms than it was 15 years ago and that the Treasury should therefore be confident that additional funding would be put to good use. Equally the strength of our science would be vulnerable to any retrenchment in financial support.*

33. Another emerging concern for us is the recruitment of postgraduate students. Initial findings from our most recent demographic survey suggest that the number in astronomy has fallen by more than 30% in the last seven years, perhaps reflecting a decline in overseas recruitment[10]. We plan to investigate whether this is a result of Covid and Brexit, and an end to the home status previously enjoyed by EEA and Swiss nationals. (Among postdoctoral researchers, our survey data suggest that the proportion from the EU has fallen 10 points since 2016.)

34. An ongoing and serious issue is the continuing deployment of large satellite constellations in Low-Earth Orbit. We referred to this in more detail in our submission to the 2021 inquiry into Space Strategy and UK Satellite Infrastructure[11]. In short, large satellite constellations interfere with astronomical observations at radio and optical wavelengths, at best will require expensive software mitigations for data to be suitable for analysis, and at worst can make sets of data unusable, placing an additional financial cost on research. Unlike ground-based light pollution and radio interference, the global operation of satellites means everywhere on Earth is affected, so siting observatories in remote locations is not a solution[12].

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[10] Demographics and Research Interests of the UK Astronomy and Geophysics Community 2023: preliminary results (the full survey will be published early in 2024)

[11] Written evidence submitted by the Royal Astronomical Society: https://committees.parliament.uk/writtenevidence/37228/default/

[12] "Dark and Quiet Skies for Science and Society": https://www.iau.org/static/publications/dqskies-book-29-12-20.pdf

35. The Committee may wish to investigate this impact and the resulting tension in public spending, a good example being the simultaneous investments in the OneWeb system and in astronomy. We do however welcome the statement on this supporting the protection of dark and quiet skies by the UK delegates at UN COPUOS[13]; UK support for this in the communique by G7 science ministers[14]; engagement with the astronomical community by the new Earth Space Sustainability Institute (funded by the UK Space Agency); that protection of dark and quiet skies features in the new Agency consultation on Orbital Liabilities, Insurance, Charging and Space Sustainability[15]; and that OfCom now acknowledges the need to protect radio observatories sited in the UK[16].

36. *We urge these bodies to continue their engagement with the RAS, and with the IAU Centre for the Protection of the Dark and Quiet Sky with Satellite Constellation Interference[17], which brings together experts from astronomy, policymakers and industry, to develop guidelines and regulation that give adequate protection to our science.*

What the aims and focus of UK astronomy should be

37. The RAS is an independent learned society that advocates for the whole field of astronomy as a curiosity-driven science. For that reason we do not make recommendations on scientific aims within the discipline, but we do support a community-led process for establishing those priorities.

38. Recent examples are the STFC Astronomy Advisory Panel[18] and Solar System Advisory Panel Roadmaps[19], the US Decadal Survey on Astronomy and Astrophysics[20], and the forthcoming one for heliophysics, and most recently the pan-European Astronet roadmap[21]. The 2021 National Space Strategy also sets out the goal of "sustaining the UK's competitive edge in science and technology".

39. Most of the science goals of these reviews are aligned. They include understanding the origin and evolution of the universe, stars, and planets; the search for extraterrestrial life; high-energy astrophysics; exploration of the universe using new

[13] UK Statement on Dark and Quiet Skies at UN COPUOS: https://www.gov.uk/government/news/uk-statement-on-dark-quiet-skies-at-the-59th-session-of-the-scientific-and-technical-subcommittee-of-copuos
[14] G7 Science and Technology Ministers' Communique: https://www8.cao.go.jp/cstp/kokusaiteki/g7_2023/230513_g7_communique.pdf
[15] https://www.gov.uk/government/consultations/consultation-on-orbital-liabilities-insurance-charging-and-space-sustainability/consultation-on-orbital-liabilities-insurance-charging-and-space-sustainability
[16] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/247180/statement-extending-access-in-ku-band.pdf
[17] IAU CPS: https://cps.iau.org/
[18] STFC Astronomy Advisory Roadmap 2022: https://www.ukri.org/publications/stfc-astronomy-advisory-roadmap-2022/
[19] SSAP Roadmap for Solar System Research 2022: https://www.ukri.org/publications/ssap-roadmap-for-solar-system-research-2022/
[20] US Decadal Survey on Astronomy and Astrophysics: https://www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020
[21] Astronet Roadmap 2022-35: https://www.astronet-eu.org/?page_id=521

techniques such as gravitational waves, and the causes and consequences of solar activity.

The extent to which UK astronomy contributes to the UK's status as a science superpower

40. A high level of international collaboration underpins work in astronomy. That, and our concomitant membership of international organisations undoubtedly plays an important role in the projection of 'soft power' around the world. The association to Horizon Europe is also an important step forward in shaping the perception of the UK as an important scientific power.

41. The RAS itself has a global membership. We are affiliated to the European Astronomical Society[22], one of 31 societies across the European continent. We are in addition the UK affiliate to the International Astronomical Union[23], the global scientific union for astronomy. Another excellent example of 'science diplomacy' is the Caroline Herschel Medal[24], funded by DSIT, awarded in alternate years to leading women astronomers in the UK and Germany and assessed by ourselves and the Astronomische Gesellschaft.

42. UK leadership through hosting SKAO, membership of ESO, and participation in many space missions and ground- and space-based observatories also ensures that the work of our scientists continues to have a high global profile.

43. The ambition for the UK to become a genuine 'science superpower' by 2030 will depend on ensuring our science, and the STEM sector as a whole, receives the investment it needs. We reiterate that a move to restore and exceed the level it had in the late 2000s would facilitate this.

Whether the UK is maximising the contribution that astronomy can make to the wider UK economy

44. There is compelling evidence that investment in fundamental science, including astronomy, has important economic benefits. The recent Case for Space report indicates a direct return on investment of £6.50 for each £1 invested in science in the space sector[25].

45. Some areas related to astronomy research have potential direct impacts on everyday life. Understanding space weather, the resulting impact solar activity on the terrestrial environment, is essential for ensuring the operation of satellites and

[22] European Astronomical Society: https://eas.unige.ch/
[23] IAU: https://www.iau.org/
[24] Caroline Herschel Medal: https://ras.ac.uk/awards-and-grants/caroline-herschel-medal
[25] The Case for Space: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1170076/the_case_for_space.pdf

power grids[26]. Similarly the long-term risk from near-Earth objects is widely appreciated, and even the smaller natural debris found in meteoroid showers can affect spacecraft in orbit.

46. There are long and short term impacts resulting from astronomy research. In 1919 the RAS co-funded an expedition to observe the force of gravity bending of light from stars near the Sun during a total solar eclipse. The results confirmed Einstein's General Theory of Relativity, which is essential for functioning satellite navigation systems. More recently, in the 1990s radio astronomers developed much improved wi-fi communications allowing its use to become routine.

47. The 2021 Research Excellence Framework (REF) lists 73 examples of the wider impact of astronomy[27]. These include using astronomy imaging techniques to tackle peat fires, data analysis for drought forecasting in Africa, and medical and security imaging.

48. A number of spin-out companies are also associated with astronomers, including Symetrica and its work on gamma ray detection and imaging, with 75 employees, Goonhilly Earth Station in Cornwall, and Blackford Analysis, with 42 staff and a turnover of c. £1 million at the time of the REF submission.

49. Astronomical facilities also have a significant impact. According to the REF 2021 submission by the University of Manchester, the Square Kilometer Array Observatory provided a £122m return to UK business and £6.2m for the local economy in the north west of England. Through ESO UK companies receive an average of £6.1m a year, or 12% of the total across 16 member states, supplying control systems, optics and detectors[28].

50. Perhaps the most important economic benefit of astronomy research is the training of highly skilled people. The Data Intensive Centre for Doctoral Training is an excellent example of this, including students who deploy cutting-edge coding techniques in AI, machine learning and data analysis used in astronomy for industrial applications[29].

51. In instrumentation research groups students develop skills which are directly applicable to high-tech jobs in industry, such as optoelectronics and imaging, sensor development, and space project management.

52. RAS publications include diverse examples of employees using their prior research experience across the economy[30]. The Society itself also contributes to the wider

[26] National Risk Register: Severe space weather: https://access-national-risk-register.service.cabinetoffice.gov.uk/risk-scenario/severe-space-weather
[27] REF 2021: Impact case study database: https://results2021.ref.ac.uk/impact
[28] https://www.ukri.org/wp-content/uploads/2022/02/STFC-240222-SocioEconomicImpactEvaluationStudyUKSubscriptionESO-FinalReportSummary.pdf
[29] Data Intensive Centre for Doctoral Training: https://data-intensive-cdt.ac.uk/
[30] RAS: Impact & Industry: https://ras.ac.uk/ras-policy/impact-and-industry

economy and to UK exports through its successful publishing partnership with Oxford University Press.

What role astronomy is playing in encouraging greater diversity and inclusion in STEM and public interest in science

53. *Our science enjoys remarkable support from the wider public. Each year numerous events take place, from lectures to music festivals, where astronomy makes up a key part of the programme.*

54. Organisations including STFC (and before that the Particle Physics and Astronomy Research Council or PPARC) and the UK Space Agency fund public engagement activities at a national level, initiated in the late 1990s. These are highly valued by the astronomical community, and the value of inspiration and innovation from scientific discovery is also noted in the 'Case for Space' report[31].

55. Complementing these initiatives, in 2013 the RAS launched its own programme in the run up to our bicentenary year in 2020. RAS 200: Sky and Earth took a new approach, specifically stipulating that *projects were led by the communities they sought to engage with*, and was aimed particularly at groups not usually served by astronomy outreach. With a total budget of £1m, the 13 funded programmes reached a total of 221,000 people in three countries.

56. Projects covered groups including young people (via the Prince's Trust, National Youth Agency and Girlguiding UK), autistic people (the National Autistic Society), prisoners (though BounceBack), adult learners (via the Workers' Educational Association), carers (via Care4carers), the National Eisteddfod and Urdd Eisteddfod, and communities in Ireland and South Africa.

57. The majority of project partners and participants report very significant benefits from these programmes. Care4Carers saw friendships and improvements in wellbeing among urban carers taken to a dark sky site for the first time; the Eistedfodd found astronomy to be exceptionally valuable in fostering collaborations and raising cross-cultural interest in diverse audiences; and the Prince's Trust used astronomy to inspire young people to overcome a range of barriers and to use their new STEM skillsets to take up opportunities in the digital and green sectors.

58. The first-hand testimony from RAS 200 participants is particularly compelling. One that will be familiar to the Committee chair came from a former prisoner who had taken part in the Explore programme delivered by the prison education charity BounceBack. At our celebration in Parliament, they described how astronomy had offered hope in the darkest of places: *"[Hawking's] theory proved that the darkest places in the universe actually radiate forth with light and that there is a halo of illumination surrounding the most infinitely hopeless places in existence. Prison is a*

[31] The Case for Space: Investing to realise its potential for UK benefit: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1170076/the_case_for_space.pdf

big black hole, a dark place, a hopeless place, but with programmes like Explore… perhaps a light can shine and supersede the darkness." This participant is now rehabilitated and in employment.

59. Astronomy also stands out as one of a few sciences where amateurs are able to make a genuine contribution, represented formally in our sister national organisations the British Astronomical Association and the Society for Popular Astronomy. There are in addition 192 local astronomy groups affiliated to the Federation of Astronomical Societies. If we assume that each of these has 50 members (some are far larger) than that represents around 10,000 non-professionals who choose to pay regularly for a deeper level of engagement in our subject.

60. Understanding the universe around us also remains a favourite topic for UK and global broadcasters. News bulletins cover milestones in space missions from start to finish, and discoveries of wider public interest can have a huge reach. For example, the report of phosphine on Venus in 2020 (the RAS hosted the press briefing) reached an aggregate readership of 15 billion (so perhaps 3 billion people were on average reading and hearing the story from an average of five different outlets).

61. Similarly, podcasts covering astronomy do exceptionally well. Our own Supermassive[32] podcast goes out monthly, and its cumulative global audience listens now stand at over 1 million, with a large listener base across and beyond the English speaking world.

62. Turning to diversity and inclusion, astronomy recruits slightly more women than 'core' physics, though is far from gender parity at every level. Data suggest that people from under-represented groups who make it on to an undergraduate degree still face significant obstacles to progression to postgraduate study and to permanent academic posts.

63. This information comes from data from UCAS on astronomy courses and from our surveys of the demographics and research interests of the astronomy and geophysics research community.

64. The latter covers scientists from postgraduate students to professors, and the full report on the latest survey should be available early in 2024. Initial complementary desk research from this allows the proportion of women to be tracked over time. This suggests that women are only slowly moving into more senior roles, making up 13% of professors in astronomy and 29% of staff at senior lecturer / reader grade, in both cases doubling since 2010. In the same period the proportion of lecturers who are women rose slightly from 27% to 29%.

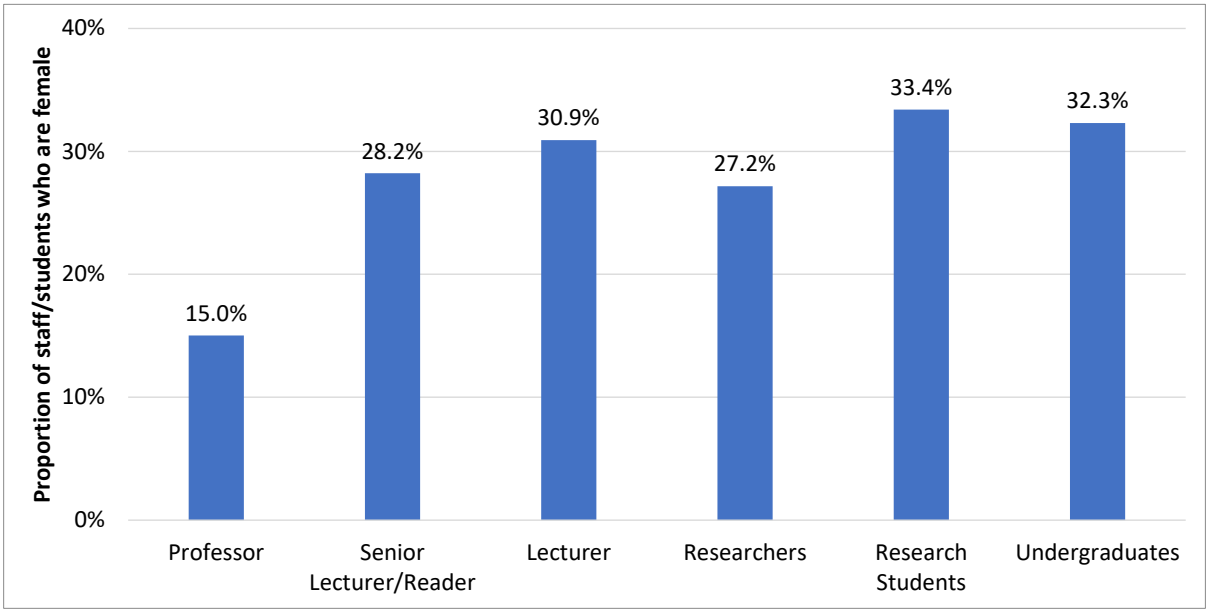
65. Solar system science saw similar changes. Women now make up 21% of professors in this area, up from 13% in 2010. For senior lecturers / readers the proportion rose

[32] The Supermassive podcast: https://audioboom.com/channels/5014098-the-supermassive-podcast

from 23% to 27%, and women comprise 35% of lecturers in this discipline, an increase from 26% in 2010.

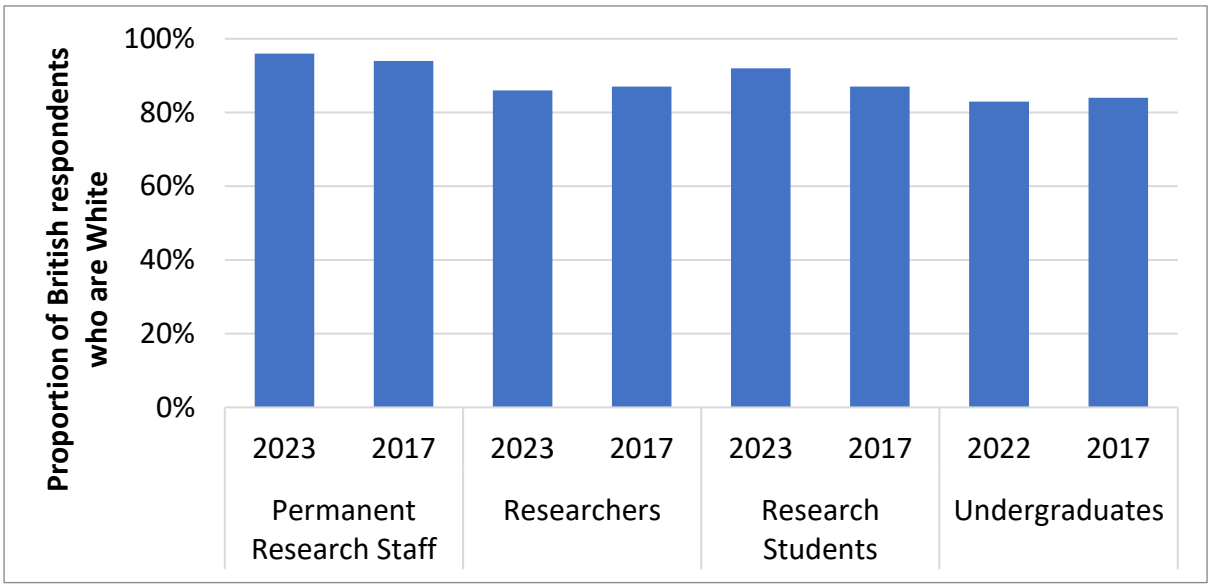
66. Among research students, women make up 31.5% of those in astronomy and 40% of those in solar system science, and UCAS data on astronomy undergraduate courses suggest that the proportion of women accepting places (32%) is broadly unchanged over the last decade.

Gender data in astronomy from RAS desk research and UCAS



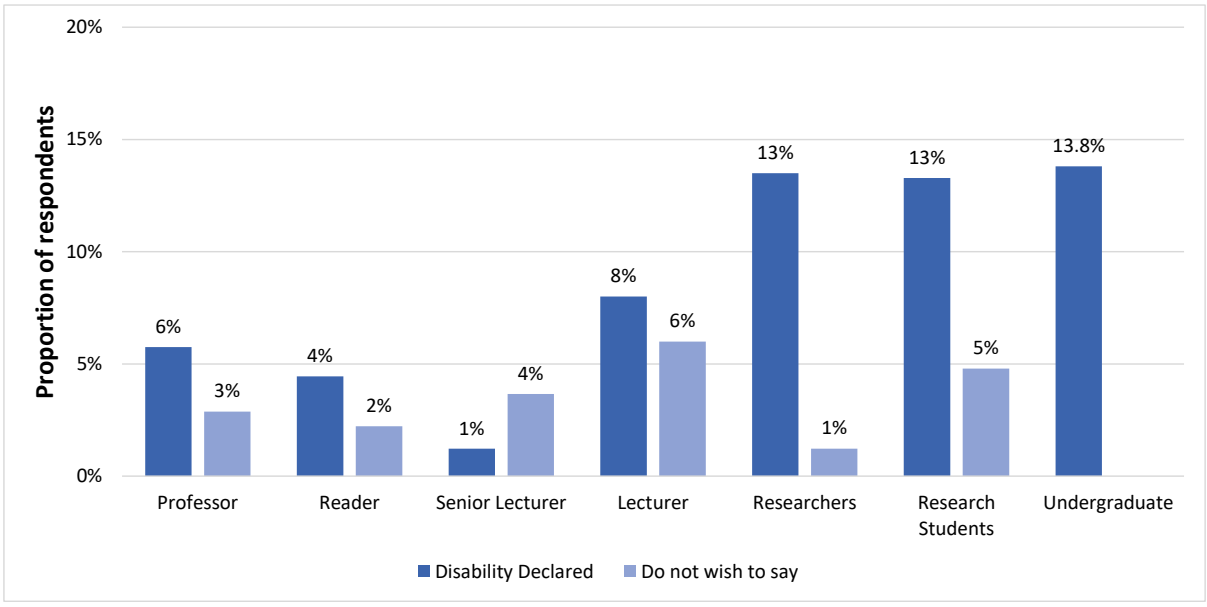
67. We also have provisional data from 2023 on ethnicity and disability. Of those who responded to our survey, 96% of British permanent staff and 86% of British postdoctoral researchers were white, compared with 82% of the (England and Wales) population in the 2021 census. In the same survey 13% of postgraduates and postdocs reported a disability, as did 4% of professors, compared with 23% of the working age population.

Ethnicity data in astronomy from RAS desk research and UCAS



68. In UCAS data from 2022, 83% of those accepting places on undergraduate courses were white. Just under 14% of those responding reported at least one disability.

Disability data in astronomy from RAS desk research and UCAS



69. Research such as the ASPIRES projects[33] suggests that achieving a more representative STEM workforce, including in astronomy, depends on giving greater science capital (again including astronomy) to children at an early age and across their school years, as well as challenging the stereotypes that discourage entry into our field.

[33] ASPIRES research: https://www.ucl.ac.uk/ioe/departments-and-centres/departments/education-practice-and-society/aspires-research

70. One of the main contributions of astronomy across formal and informal education is not necessarily knowledge of the universe, or even its underlying physics, but as a stimulator for wider and deeper engagement with Science and STEM more generally[34].

71. Reaping the full benefit of this therefore also depends on including significant astronomy content in the school curriculum across all ages, instead of confining it to a single GCSE with a relatively small though enthusiastic cohort, and to elective A level physics modules.

72. *It would also be valuable to carry out new research into the impact of astronomy in encouraging people from traditionally under-represented groups into science, as the principal cited work is more than two decades old.*

73. *Our sector undoubtedly also needs to work harder to create an inclusive working environment.* Our 2020 survey covering experiences in astronomy and geophysics research suggests that women, non-binary people, LGBTQ people, disabled people and people from minority ethnic groups all experience disproportionately high levels of bullying and harassment[35]. We will be publishing the full analysis of the survey and recommendations for the sector later this year.

[34] "Pupils' and Parents' View of the School Science Curriculum", J. Osborne, S. Collins, School Science Review, 2000: https://www.semanticscholar.org/paper/Pupils'-and-parents'-views-of-the-school-science-Osborne-Collins/05286c0a117b97d52d45f2582eb6e2e95b3cbcc4

[35] https://ras.ac.uk/news-and-press/news/survey-finds-bullying-and-harassment-systemic-astronomy-and-geophysics