Written Evidence

Science Innovation and Technology Committee for the UK Astronomy inquiry

Dr. Nicholas P. Ross (Niparo Ltd.)

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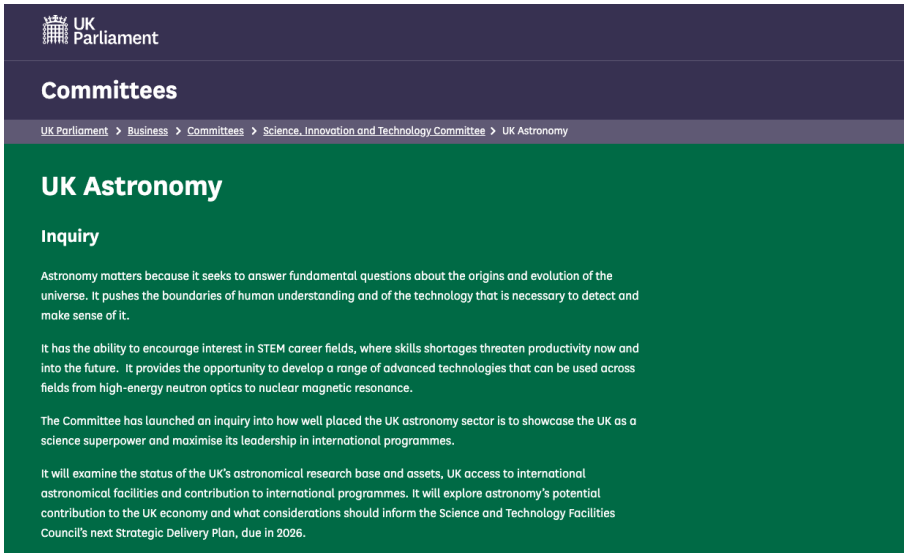

NIPARO

Written Evidence to the Science Innovation and Technology Select Committee for the UK Astronomy inquiry

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Executive Summary

Currently, the UK astronomy sector is very well placed to showcase the UK as a science superpower and maximise its leadership in international programmes. With the foundation of the second best suite of national universities in the world, world leading scientists work in the UK developing and leading frontier pushing astrophysics investigations. Two current examples include the UKs leadership role in the NASA/ESA/CSA *James Webb Space Telescope* (JWST) and the ESA *Gaia* missions. Several other examples of world leading astronomy research, both observational and theoretical, from UK institutes also exist.

UK astronomy wants to continue to be part of world-leading collaborations, experiments and consortia, taking a leadership role wherever appropriate.

Astrophysics research is a truly global effort and astronomy is still driven by discovery, and many of the most important results are often largely unanticipated. Although technology enables advancements and discoveries, it is scientists that design and utilize the technology to unlock the secrets of the Universe. As such, the utmost effort must be made to not only recruit, but more importantly retain, the world's leading scientific, instrumentation and astronomical talent.

UK astronomy is currently in a strong position, and rejoining the Horizon Europe research programme was a very welcome recent boost. New opportunities including continued leadership roles in e.g. ESA missions, as well as exploring sovereign launch capabilities are incoming. However, competition for the world's leading scientists is as fierce now as ever and the allure of the UK's traditional ivory towers is maybe not as powerful as it once was. Care and thought will have to be taken so as not to have UK astronomy left behind as we race into the 2nd quarter of the 21st Century.

Our recommendations are given in (blue) bold italics.

1. Personal Background and Definition of Terms

I submit this evidence on behalf of myself, Dr. Nicholas P. Ross. I have a PhD in Astrophysics from Durham University and have been an active part of the UK Astronomy community from circa 2001 when I was a summer student at Oxford University until the end of 2020, when I was an STFC Ernest Rutherford Fellow at the University of Edinburgh.

By that stage, I was a world leader in the the field of extragalactic observational cosmology, quasar astrophysics and time-domain astronomy. My research involved using a suite of telescopes and data sources, including but not limited to, the Sloan Digital Sky Surveys (SDSS), the *Hubble* Space Telescope, the *Spitzer* Space Telescope, ESO facilities, the ESA *Gaia* mission and the WISE and NEOWISE mission. I was also on the panel that decided the first suite of observations for the NASA/ESA/CSA *James Webb Space Telescope*. Since 2021, I have remained directly engaged with the UK Astronomy community and research activities through my work as Founder and CEO of Niparo Ltd. I have no conflicts of interest.

I define "the UK astronomy sector" or simply "UK astronomy" as astronomy and astrophysics activities which occur in the U.K. This will predominantly happen at UK universities, Science and Technology Facilities Council (STFC) laboratories, centers or supported facilities. This activity may occur by non-British citizens at UK institutions. I do not include astronomy and astrophysics activities performed by UK citizens abroad (e.g. at USA universities), though there is of course overlap, e.g. UK scientists based at UK universities working at/seconded to ESO, but these instances are generally rare. I also generally use the terms "astronomy" and "astrophysics" interchangeably.

I submit this evidence for three reasons. First, I'm an expert and independent witness. Second, many of my friends and colleagues work in the UK Astronomy sector and need support in order to carry out world-leading research. And third, I have abundant privilege as a middle-class white man and acknowledging this want to help make astronomy a more just and equitable pursuit for all.

2. General Background

By any sensible metric, **the UK is a world leader in physical science research**.[1,2,] and the U.K. can be considered the world number four when it comes to astronomy and

[1] https://ncses.nsf.gov/pubs/nsb20214/publication-output-by-country-region-or-economy-and-scientific-field
[2] https://www.nature.com/nature-index/country-outputs/generate/physical-sciences/global

astrophysics research output quantity (behind the USA, China and Germany) and world number two when it comes to research output quality (behind only the USA).[3] There are many historical reasons for this impressive performance.

As such, the **UK has to be considered a science superpower in astronomy**. However, as barriers to access are lowered globally (which is a good thing holistically), the UK will need new vigor and energy to remain a leader in international programmes and at the forefront of astrophysics research into the latter half of the 21st Century.[4]

I fully agree that astronomy and astrophysics remains a critical science and research endeavor. Astronomy seeks to answer fundamental questions about the origins and evolution of the Universe and pushes the boundaries of human understanding developing new technology that is necessary to perform this task. Astronomy is often correctly called "**the gateway science**" and has the ability to encourage generally and long-lasting interest in STEM career fields. Fundamentally, astronomy improves our quality of life and posits the biggest questions. Why are we here? What is the Universe? And are we alone in the cosmos?

It is hard to fully quantify the impact of astronomy's potential contribution to the UK economy ***and one key recommendation would be for the development of a good ``North Star'' metric to do so*****.**

3. The Strengths of UK astronomy

Overall, the UK astronomy sector is very well placed to showcase the UK as a science superpower. The UK astronomy sector also shows leadership in international programmes.

Universities. Outside of the USA, the UK currently has the best suite of Universities for astronomy research in the world.

Quality of research. In the late 1990s UK based astrophysicists led the way in establishing, both via observation and theory the 'Cold Dark Matter 'paradigm. In the late 1990s/early 2000s some further examples of astronomy research leadership was the discovery and characterization of the `submm' galaxy population and the 2dFGRS/2QZ extragalactic and

[3] https://baas.aas.org/pub/2022i079/release/1K

[4] The next generation of flagship Planetary Science missions currently under discussion have timeframes 2030-mid 2040s e.g. https://www.esa.int/Science_Exploration/Space_Science/Voyage_2050_sets_sail_ESA_chooses_future_science_mission_themes

cosmology survey. Later, the UKIDSS survey discovered (at the time) the most distant luminous quasar.

In the 2010s, examples of UK astrophysics leadership were via the discoveries from ESA *Herschel* and ESA *Planck*. Recently ESA *Gaia* has been shown to be the most scientifically productive satellite mission with a critical U.K. involvement. There was instrumentation and scientific leadership in the completed Dark Energy imaging Survey (DES) and the ongoing Dark Energy Spectroscopic Instrument (DESI) survey, both which continues the UK cosmology push. The SKA is another mega-astronomy project where the UK has direct leadership.

Meanwhile, UK institutions and astrophysicists were gearing up for the discoveries that started to pour in from the Advance-LIGO. This is game-changing astronomy, observing a new form of radiation from acceleration of compact bodies. This is true 21st Century science.

Alongside the observational/data-driven leadership, theoretical leadership, often via supercomputer investigations, the "EAGLE" simulation being a prominent but definitely not the only example.

Linked to the quality of research is the **high ethical standard** of research, e.g. very few paper withdrawals. Direct quantification of this metric is not abundant, but I would strongly suggest that astronomy research outputs from the UK are the least retracted from peer-review journals of any country. ***We recommend that all UK-based astronomers should have ethics training*** and we strongly suggest that any UK-based astronomer engaging in research malpractice should be expelled from the Academy.

The **UK demonstrates world leadership in astronomical instrumentation**. One major example of this is via the Mid-InfraRed Instrument (MIRI). MIRI is one of four workhorse instruments on the *James Webb Space Telescope* and is the only one covering the mid-infrared wavelength range from 5 to 28.3 microns. It is an extremely versatile instrument, which is supporting all of JWSTs science themes.

MIRI was built by the MIRI Consortium, a group that consists of scientists and engineers from 10 different European countries with the United Kingdom heading the European consortium. The UK Advanced Technology Centre (UK ATC) based at the Royal Observatory in Edinburgh, Scotland was the lead institution.

Critically, due to the nature of bleeding-edge astrophysics, there is a "multiplier effect" and 'virtuous circle" that occurs when an instrument such as MIRI is built at a UK institution. Not only does the UK ATC (and UK astronomy in general) benefit from the contract of designing and building MIRI, but the astronomers co-located at the University of Edinburgh get deep, intimate knowledge firsthand of not only the instrument but also of the whole *James Webb Space Telescope* observatory. This in turn makes their science proposals more competitive in the international arena, leading to 'first dabs' on JWST data and being able to report groundbreaking new results.[5] ***We very strongly recommend that the current practice of world-leading astronomical instrumentation research and development continue to be co-located in the same institutes as UK research astrophysicists.***

The **Science and Technology Facilities Council** (STFC) supports university-based research, innovation and skills development in astronomy and space science (as well as particle and nuclear physics) as well as a range of scientific facilities (including the aforementioned UK ATC). STFC is a good conduit in delivering world-leading national and international research.

The UK Space Agency, the European Space Agency (ESA), ESA missions, the European Southern Observatory and NASA missions (usually via ESA), all have UK participation.

It is ***our recommendation that a holistic approach encompassing all the active astronomy research agents and stakeholders in the UK is taken into account ahead of, and as input to, the next SFTC Strategic Delivery Plan.***

We also recommend that there should be a second, after Space Park Leicester, STFC-UK Space Agency Space Science Astronomy science and innovation laboratory.

The rejoining of **Horizon Europe** is a very significant positive step for strengthening UK astronomy. However, UK astronomy should not rest on its laurels and with the decadal timescales of astro missions, should be advocating now for UK involvement and leadership in the follow-on European Science Framework Programme that commences in 2028 after Horizon Europe.

Senior research fellowships, including the Royal Society University Research Fellowships, the Future Leaders Fellowship and the STFC Ernest Rutherford Fellowship (of which I was

[5] e.g. https://www.bbc.co.uk/news/science-environment-62311562

one) are very attractive options for ambitious and gifted mid-career scientists wanting to perform research in the UK.

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

The salary compensation of UK researchers, and the **salary of Postdoctoral researchers** in particular is a systematic weakness compared to other nations. Non-UK citizen researchers coming to the UK have to pay several upfront costs including e.g. the Immigration health surcharge. These items put off global talent.

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

The is an upcoming opportunity for the UK Astronomy community to develop "Explorer" and CubeSat Class **space missions launch from UK soil.** This is a new capability that the UK has traditional had to outsource to ESA or NASA.

Missions with a mass profile of <300kg could be launched to Low Earth Orbit from the largest rockets from the e.g. Scottish spaceports. NASA has had a long history of delivering bleeding edge technology and science with novel missions designed to address in detail specific science questions. The UKs traditional expertise in the X-ray regime would be a natural fit here. ***We recommend an uplift in the STFC budget for Concept and pre-Phase A studies that would look to take advantage of sovereign UK launch.***

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

Attracting and retaining world leading skills and talent. The challenge remains and continues in attracting world class talent and the necessary skill sets to the UK for astronomy. While UK universities are great research hosts, UK research salaries are not, but a *long way,* competitive compared to. the USA or Switzerland (USA postdocs being paid more than UK professors). Recently it has also become more apparent that the allure of prestigious named Chairs at the very best UK universities can no longer hold onto the world's leading scientists. Astrophysics research is a truly global effort. Resources, access to the best students and postdocs, and general working environment are more important.

Lack of Diversity and Inclusion. UK astronomy, especially in leadership positions, is dominated by one demographic (white men). The whole of UK Astronomy continues to have a horrific problem with diversity. This item is not receiving sufficient support.

7. The aims and focus of UK astronomy

The core aim for UK astronomy should be to perform extraordinary research that can potentially result in scientific paradigm shifts.

The focus for UK astronomy should be to attract the very best researchers and teachers from across the world - and with a long-term horizon of keeping them in the UK.

The UK should remain a key part of ESA with funding at the appropriate level of an leading member state for science. The UK can speak to mission and science leadership in ESA *Planck*, ESA *Herschel*, NASA/ESA/CSA *JWST,* ESA *Gaia* and ESA *Euclid.* The UK is well-placed for leadership in ESA PLATO and ESA ARIEL as well. UK involvement in the next flagship NASA-led missions e.g. the *Nancy Grace Roman* Space Telescope and Habitable Worlds Observatory likely via ESA, should be investigated.

Care now has to be taken to see if UK Astronomy can regain leadership in one or even both if the ESA Athena/NewAthena and ESA LISA missions. Tough choices may have to be taken.

The UK Astronomy community **should not** undertake a US style Decade review. However, the UK astrophysics community would likely benefit from identifying the outstanding science questions of our day and performing a "gap analysis" to see if there is an area where UK astronomy could take leadership advantage in. In particular, we suggest a stringent look at: the access the UK has to various telescopes, observatories and missions, via e.g. ESO and ESA; the advanced computing and supercomputing infrastructure in the UK, e.g. boosting the Distributed Research using Advanced Computing (DiRAC) facility, and the ability to attract - and keep long term - world leading talent, e.g. a 5+ year option to the Global Talent visa.

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

UK astronomy is a key pillar in the UK's status as a science superpower. For this to be maintained continued, and potentially increased investment in STEM education, the university sector and UK space science research projects needs to happen.

9. Is the UK maximising the contribution that astronomy can make to the wider UK economy?

The UK is not maximising the contribution that astronomy can make to the wider UK economy. Simply the put, the largest output from UK astronomy to the UK economy is the

people. Huge efforts should be made to recruit UK astronomers (from all levels, secondary education, undergraduate, postgraduate, advanced researcher) into the wider UK workforce.

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

While astronomy is generally regarded **positively in the public interest i**n science, UK astronomy still struggles to fulfill its destiny when it comes to encouraging greater diversity and inclusion in STEM. Astronomy can be considered the tip of a broader societal discussion, where if young people are asked to 'describe a scientist', an older white man with 'crazy hair' is the traditional stereotype. Academic workplace culture remains hostile to women.[6]

Physics and **Mathematics A-levels** are the gateways to UK Astronomy. The gender balance of A-Level Physics has basically stayed constant for the last 25 years at around 75-80% Male: 25-20% Female.[7,8] This is despite considerable effort by numerous stakeholders. Thus understanding why those efforts seem not to have made a difference is key. ***We recommend a study and a review into the efforts to close the gender gap in Physics and Mathematics at GCSE/Higher/AS and A-Level - what has, and moreover what has not worked.***

Summary

The UK astronomy sector is very well placed to showcase the UK as a science superpower. The UK astronomy sector shows leadership in international programmes. UK leadership in ESO, ESA and Horizon Europe will be crucial in keeping this status. Increased diversity and inclusion will strengthen the STEM pipeline for world-leading UK astronomers and attracting - and keeping - the worlds best astrophysicists will be key to future UK astronomy discoveries and breakthroughs.

Dr. Nicholas P. Ross
26th October 2023

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[6] https://www.nature.com/articles/d41586-023-03251-8
[7] https://www.jcq.org.uk/wp-content/uploads/2018/11/A-AS-VCE-GNVQ-Results-Summer-2001.pdf
[8] https://explore-education-statistics.service.gov.uk/data-tables/permalink/5ab5dbf2-393b-4a43-b7a1-08dbd08e1875