

# **Armagh Observatory and Planetarium**

## **Annual Report and Accounts For the year ended 31 March 2022**

*Laid before the Northern Ireland Assembly*

*under clause 8 of The Armagh Observatory and Planetarium (Northern Ireland) Order 1995,*

*as amended by Schedule 1, clause 6 of the Audit and Accountability (Northern Ireland)*

*Order 2003, by the Department for Communities*

*on*

*31 May 2023*

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# Armagh Observatory and Planetarium

## Annual Report and Accounts For the year ended 31 March 2022

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# The Trustees' Annual Report for the year ended 31 March 2022

The Board of Governors, who are the Trustees for Armagh Observatory and Planetarium (AOP) has pleasure in presenting its annual report and financial statements for this charity for the year ended 31 March 2022. These financial statements have been prepared in accordance with the accounting policies set out in note 1 to the accounts, with the guidance issued by the Department of Finance on the form and contents of the Annual Reports and Accounts of Executive Non-Departmental Public Bodies, *The Armagh Observatory and Planetarium (Northern Ireland) Order 1995* and Accounting and Reporting by Charities: Statement of Recommended Practice (SORP) applicable to charities preparing their accounts in accordance with the Financial Reporting Standard applicable in the UK and Republic of Ireland (FRS 102).

The sponsor Department for Armagh Observatory and Planetarium is the Department for Communities (DfC) (the Department).

## Background to Charitable Status

Historically the Armagh Observatory and the Armagh Planetarium were treated as being distinct institutions; being two component divisions of a single statutory corporation and arms-length body (ALB), 'The Governors of The Armagh Observatory and Planetarium' as described in *The Armagh Observatory and Planetarium (Northern Ireland) Order 1995*. This 1995 Order superseded the original 1791 Act of the Irish Parliament entitled '*An Act for Settling and Preserving a Public Observatory and Museum in the City of Armagh For Ever*', and an Amendment ('The University and Collegiate and Scientific Institutions Act [Northern Ireland], 1938').

The principal function of the Armagh Observatory, founded in 1789 as part of Archbishop Richard Robinson's vision to see the creation of a university in the City of Armagh, is to undertake original research of a world-class academic standard that broadens and expands our understanding of astronomy and related sciences.

The Armagh Planetarium was founded by Dr Eric Mervyn Lindsay, the seventh director of the Armagh Observatory, and was officially opened on 1 May 1968. The Planetarium's primary activity is to disseminate scientific and technical knowledge of a wide range of science, technology, engineering, arts and mathematics (STEAM) subjects, and to promote public understanding of astronomy and science through its programme of educational services for schools and the wider public.

From 1 April 2016 the Charity Commission for Northern Ireland has registered *The Governors of The Armagh Observatory and Planetarium* as a charity under reference number NIC 103948.

## Objectives and Activities

The organisation's statutory functions are set out at Article 4 of *The Armagh Observatory and Planetarium (Northern Ireland) Order 1995*. The Order requires that '*the Governors shall, for the purpose of developing and improving the knowledge, appreciation and practice of astronomy and related sciences, maintain and manage the Armagh Observatory and Planetarium and may take such other action as the Governors may think proper for the purpose of acquiring or disseminating knowledge relating to astronomy and related sciences*'.

In accordance with Paragraph 8(1) of Schedule 1 of *The Armagh Observatory and Planetarium (Northern Ireland) Order 1995*, the Armagh Observatory and Planetarium (AOP) Board of Governors has delegated the primary responsibility for the governance and management of AOP to a Management Committee with the statutory purpose of 'developing and improving the knowledge, appreciation and practice of astronomy and related sciences'.

The AOP Management Committee has corporate responsibility for ensuring that AOP fulfils the aims and objectives set by the Department for Communities (our sponsor Department) and approved by the Minister and for promoting the efficient, economic and effective use of resources.

As the primary responsibility for the governance and management of AOP has been delegated to a Management Committee, the Governors consider the role of Charity Trustees would more appropriately align with their remit too. The Board of Governors has agreed in principle to this, and the necessary steps are being taken to enact this change during the 2022-23 financial year.

Armagh Observatory is the oldest scientific institution in Northern Ireland, and the longest continuously operating astronomical research institute in the UK and Ireland. Armagh Planetarium is also the oldest operating planetarium in the UK and Ireland.

Our Mission:

*“Our mission is the pursuit of knowledge and understanding of the cosmos, and the sharing of that knowledge in order to inspire future generations and enrich the intellectual, economic, social and cultural life of all.”*

Our Vision:

*“Our vision is to be recognised as an international centre of scientific excellence for the pursuit of astronomy and the public understanding of science, for our capacity for innovation and our extraordinary heritage, a place our community can be proud of.”*

The organisation operates on the international stage and is underpinned by core funding from the Department and the receipt of external grants from the UK Science and Technology Facilities Council (STFC), and other grant-awarding bodies.

A Strategic Plan for 2021-26 was launched in September 2021 and this is now being implemented. The strategy is built around four strategic themes – Enduring Relevance, National and International Standing, Offering More and Pursuing our Priorities.

As of 31 March 2022, there were 28 full time equivalent permanent employees which comprised approximately one-third Research, one-third Education and one-third Corporate. An additional 6 full time equivalent temporary employees were engaged on short term temporary projects. AOP also employs a number of casual staff on an ad hoc basis to meet operational needs. In addition, there is an Emeritus Director, an Emeritus Research Astronomer and 11 external research associates and academic visitors.

## **Public Benefits**

The Trustees confirm that they have complied with their duty to have regard to the guidance on Public Benefit produced by the Charities Commission of Northern Ireland under section 4(b) of the Charities Act (the public benefit requirement statutory guidance) and that this has informed the activities of the organisation in the year to 31 March 2022. This is demonstrated in the following summary of Principal Activities which provides detail on how the organisation has delivered against its objectives and the public benefit which has flowed from this.

## **Principal Activities**

### **Impact of Covid-19 Pandemic**

Following a prolonged closure from March 2020, the Planetarium re-opened to the public at the end of June 2021 with restricted numbers and continued to operate with reduced capacity for the remainder of the financial year. Following re-opening, admissions income has well exceeded expectations.

AOP is continuing to review its operating arrangements for both office based and front of house functions to establish an acceptable flexible working model for the future.

### **Impact of Brexit**

Some issues have been encountered with recruiting European nationals, claiming certain European research grants and importing some goods from Great Britain. EU residents now need to apply for a visa and pay a healthcare surcharge to live in the UK. Overall, the United Kingdom exit from the European Union has had no significant impact on the operation of AOP.

### **Introduction to AOP Research and its International Standing**

AOP is one of the oldest scientific research institutes in the UK and Ireland with a long-established reputation of research excellence. It is also one of very few astronomical institutions in the world to have a state-of-the-art planetarium through which its research can be effectively communicated and where a research-informed outreach and public engagement activity can be sustained.

AOP is engaged in front-line research in several key areas of astrophysics. These range from the study of our Sun and the Solar System to that of distant galaxies, in keeping with the long and varied history of scientific achievements of the Armagh Observatory and with the desire to be perceived by the public as leaders in of all strands of astronomical research that are communicated through the Planetarium.

Around a third of AOP research is funded by the award of project-specific external grants mainly from the Science & Technology Facilities Council (STFC), together with several ad hoc grants. These grants support projects led by individual research astronomers with the provision of PhD scholarships, post-doctoral research assistant salaries, computing equipment and observation/conference travel funding. Early in 2021 AOP researchers secured two new STFC grants providing funding for additional Post-Doctoral Research Assistants (PDRAs) plus salary staff contribution and estate costs until March 2024, which adds up to similar funding secured early in 2020 and that is already funding a third PDRA until March 2023.

AOP research also requires the use of state-of-the-art observing and computing facilities internationally in order to obtain new astronomical data and allow their analysis. STFC and UK government support provides access to world-class international facilities, and AOP research staff regularly win telescope time on some of the best and most sought-after telescopes in the world such as the European Southern Observatory (ESO) Very Large Telescope (VLT) or the Hubble Space Telescope (HST).

In addition, through the AOP's membership of the UK SALT Consortium, its research staff have access to the 11-metre diameter Southern African Large Telescope (SALT). Similarly, AOP is also a founder member of the international consortia involved with the Gravitational-wave Optical Transient Observer (GOTO) project, a member of the UK consortia involved in building the detectors for Daniel K. Inouye Solar Telescope), LOFAR (LOW Frequency Array (DKIST) radio telescope project and a consortium member of the Cherenkov Telescope Array (CTA) gamma-ray observatory.

These facilities can be extremely expensive to run (e.g. the running cost of one observing night at VLT is about £16,000 and a mid-size observing program with HST would be ten times more) so that through the award of their use, the international astronomical community essentially entrusts AOP to make effective use of the data. On average AOP researchers secure telescope time corresponding to a value of around £250,000 per year.

AOP research staff also play a full role in the international astronomical community. For instance, they serve on committees of bodies such as the Royal Astronomical Society, the UK Science and Technology Facilities Council, the International Astronomical Union (IAU, with three commission vice-presidents and two former presidents), ESO and Transiting Exoplanet Survey Satellite (TESS) time allocation panels, assess grant and research proposals on behalf of external funding agencies, review scientific papers and edit international academic journals, and act as external PhD examiners in the UK and beyond. AOP researchers also sit on scientific advisory panels or lead specific projects with future ground-based observing facilities (Vera Rubin Observatory, ELT-METIS, VLT-BlueMUSE), space satellites and missions (ESA's future Plato and Comet Interceptor missions) and large-scale surveys (MOONs).

This financial year has seen also the completion of a key independent assessment of AOP's research quality. This followed closely the guidelines of the UK-wide 2021 Research Excellence Framework (REF) exercise and the participation of an esteemed panel comprising of Professor Roger Davis (Oxford), Professor Monica Grady (OU) and Professor Don Pollacco (Warwick), Chair. Following the REF guidelines the panel assessed the originality, significance and rigour of research outputs, the reach and significance of research-informed activities and vibrancy and sustainability of the research environment. With 94% of research outputs being deemed either to be world-leading or internationally excellent, the results of this REF-equivalent exercise demonstrated that the panel believed that the research carried out at AOP was internationally competitive. The Panel also recognised the strength of the Institution in having a Planetarium facility, which led to considering 70% of research-informed outreach of public engagement activities to be outstanding or very significant in terms of their reach and significance. The way effectiveness of the outreach programme was measured needed improvement and a better case could have been made to explain how the research informed the outreach programme. Finally, in terms of research environment, the Panel endorsed AOP's vision and mission statement, acknowledged efforts to achieve a better gender balance, recognised that the source of income and funding streams was good compared to other Institutions of AOP's size and strongly supported efforts for maintaining the level of PhD students and the Öpik Research Fellow initiative. Overall, the Panel judgement was that 75% of the environment was conducive to producing research of world-leading quality or internationally excellent quality.

## Research Highlights

To provide a practical understanding of how the work of AOP research contributes to understanding of the cosmos and the region's international reputation, the following provides some highlights of the research undertaken at AOP in the past financial year. This draws from international collaborations and the award of observing time on highly competitive facilities, as well as direct support from DfC allowing AOP to participate in several key international projects (such as SALT, GOTO, IST, I-LOFAR, Comet Interceptor and CTA). Full bibliographic references can be found in the publication list appended to this report.

## Stellar and Galaxy Evolution

### Introduction

When we look up on a dark night, we may think that stars are immutable and isolated. Yet, although stars can live for as long as the age of the Universe, they can also undergo dramatic changes in matter of seconds. They are also not truly disconnected. Some are found in pairs or tight groups and more generally stars are related to each other through the very way in which they form and evolve. Stars are indeed born from giant clouds of gas and return matter to those clouds, seeding the birth of new stars as they fade away or sometimes explode in dramatic events. Furthermore, stars produce the heavy elements necessary to make not only new stars and planets but also us humans. To study and understand stars in all their manifestations it is therefore necessary to understand life as we know it, or as it may be found one day on planets around other stars.

In turn, the formation history of stars relates to the formation and evolution of the galaxies that contain them. Some galaxies indeed no longer appear to form stars, unlike the case of the Milky Way. This may depend on whether fresh gas is available around them, on whether they have collided with other galaxies in the past or possibly also on whether their central supermassive black hole suddenly becomes active and pours out tremendous amounts of energy capable of clearing its host galaxy of any star-forming gas material. Finally, galaxies are carried by the general expansion of the Universe and the evolution of the dominant, yet unknown dark-matter material in which they themselves are embedded. Understanding the formation and evolutions of stars and galaxies therefore ultimately means understanding our origin in relation to the very fabric of the Universe.

### Recent results

AOP stellar studies range from the most massive and brightest young stars to the faintest and ageing stars or stellar remnants such as white dwarfs and black holes. One interesting theoretical investigation was related to the modelling of stellar black holes from stripped stars, particularly relevant for gravitational wave events by LIGO/Virgo. In a team effort lead by Jorick Vink's massive star group, the team predicted black hole masses as a function of chemical abundance. The paper was led by Vink's STFC postdoctoral research assistant Erin Higgins, and also featured former Öpik Fellow Andreas Sander (now in Heidelberg, and still associated with AOP) and STFC grant co-Investigator Raphael Hirschi from Keele University (see *Higgins et al. 2021*).

Using polarimetry, a technique that is sensitive to phenomena that break the symmetry within a radiative source, Stefano Bagnulo and AOP visiting astronomer John Landstreet have published a survey of all nearby white dwarfs and checked them for the presence of a magnetic field. Their work has led to new important evidence about the occurrence of magnetic fields in degenerate stars. In particular, they found that magnetic field is extremely rare in young white dwarfs, and probably originates as the star cools down, at least 500 million years after the star has become a white dwarf (*Bagnulo & Landstreet, 2021, MNRAS 507, 5902*). Bagnulo & Landstreet have obtained 74 additional hours of telescope time, at the ESO VLT, at the Canada-France-Hawaii Telescope and at the Nordic Optical Telescope, to continue their studies of magnetic white dwarfs. Bagnulo and collaborators obtained funding to organise a 4-week workshop in Garching (Germany) on stellar magnetic fields at the Munich Institute for Astro and Particle Physics (<https://www.munich-iapp.de/magnetic-fields>) (MIAPP) in October 2023. MIAPP will offer venue, logistic support and funding for the participation of up to 45 researchers from all over the world.

A theoretical study of pulsation in extreme helium stars has constructed a large grid of non-linear pulsation models and established the conditions necessary for and present in an atmospheric shock wave at minimum radius (*Jeffery et al. 2022*).

Linking to external galaxies, Marc Sarzi continues to co-lead his survey of galaxies in the Fornax cluster producing studies that also relates directly to our understanding the latest stages of stellar evolution. He and his PhD student Pablo Galan de Anta used VLT data to detect to detect Planetary Nebulae (PNe) in the Fornax cluster using the MUSE integral-field data. Focussing on edge-on galaxies, they could explore the abundance of PNe both in the metal-rich regions near the galactic plane and in their metal-poor halos, allowing to check if the metal content of stars indeed has an impact on the evolutionary path of stars. Contrary to previous predictions, they do not find an increased number of PNe in the more metal-poor outer region (*Galan de Anta et al. 2021*). The detection of PNe in external galaxies can also be used to derive their distance, which serves not only to characterise essential parameters such as galaxy mass or luminosity but also makes PNe an important rung in the so-called cosmic ladder with which we measure distances out to further reaches in the Universe. In the final paper led by his former PhD student in Hertfordshire (*Spriggs et al. 2021*), PNe distances obtained with MUSE for 21 Fornax cluster galaxies were shown to be as accurate as measurements based on surface-brightness fluctuations based on Hubble Space Telescope data and led to a revised distance to the overall Fornax cluster. Finally, also related to the Fornax MUSE survey, 2021 saw the fruition of work by PDRA Maritza Lara-Lopez who explored radial variations in the metal content of gas found in the galaxies of this cluster (*Lara-Lopez et al. 2022*). Such metallicity gradients are indeed predicted to take different form depending on how the star-formation activity of galaxies is affected as these enter a galaxy cluster, since in turn star formation indeed increases the gas metallicity over time through the continuous injection of metals by massive yet short-lived stars.



## The role of SALT

The South African Large Telescope (SALT) is the largest telescope in the Southern Hemisphere, providing unparalleled access to the skies for its shareholders, of whom AOP through its membership of the UK SALT consortium is one. Participation in this major international facility brings visibility throughout the worldwide research community and allows AOP and just a few other UK universities to engage in collaborations with other SALT international partners. In turn, through such partnerships, AOP receives a return in terms of telescope time allocation that is equivalent to roughly 10 times its contribution. In 2021 alone, over 146 (2020 165) AOP unique astronomical observations have been made, targeting some of the most exotic stars in the Universe. These will contribute to several upcoming discovery papers and to the training of postgraduate research students at AOP. Participation in SALT also allows AOP to explore opportunities through the SALT Collateral Benefits Programme to develop links between local schools in Northern Ireland and in South Africa. AOP carries out the administration function for the UK SALT consortium, which includes four other academic partners – Keele University, Open University, University of Central Lancashire and University of Southampton.



The 10-metre diameter South African Large Telescope (SALT), in the semi-desert region of the Karoo, South Africa.

Using SALT, Simon Jeffery currently leads a survey of chemically peculiar subdwarf stars in the southern sky. These are stars that are in the final stages of their lives but their histories from birth to the present are very diverse. By exploring the abundances of key elements such as hydrogen, helium, carbon, oxygen, and iron, and of exotic elements such as lead and zirconium, these histories and internal physics can be explored. These AOP-led SALT observations have already led to a first data-release (*Jeffery et al. 2021*) and are now building towards the second data-release, including classifications, coarse analyses and kinematics for over 200 hydrogen-deficient hot subdwarfs. A treasure trove of data for exotic stars still awaits detailed analysis and promises exciting new discoveries. Chief among these is the discovery that the lead-rich subdwarf EC 22536-5304 (*Jeffery & Miszalski 2019*) has a cool faint metal-poor companion in a 450-day orbit (*Dorsch et al. 2021*). If the hot subdwarf was formed from the same material as its companion, then lead is one million times overabundant! The hot subdwarf BPS CS 22940-0009 appears to be a link-object bridging extreme helium stars and hot subdwarfs (*Snowdon et al. 2021 submitted*). We have also investigated the significance of new atomic data for singly- and doubly-ionized germanium for models of chemically-peculiar subdwarfs (*Dunleavy et al. 2021*). In conjunction with observations from ESO, SALT and Gaia observations were used to reclassify the apparent helium-star HD144941 as a main-sequence Bp(He) star with an exceptionally strong magnetic field (*Przybilla et al. 2021*). Jorick Vink and a team of international astronomers are using SALT to study the polarised light from the most famous Luminous Blue Variable Eta Carina, which is quite possibly the most massive star in the Milky Way. Thanks also to AOP's contribution SALT will continue to develop its instrumentation, and the introduction of a new near-infrared spectrograph will facilitate the study of star formation processes in nearby galaxies.

## Transient and Periodic Phenomena

### Introduction

Apart from the bright planets which the Greeks called “wandering stars”, the night sky might appear to be unchanging, with the stars in one season being exactly the same as those seen in the last. However, astronomers from the ancient world detected new stars, “novae”, which suddenly appeared in the night sky and then gradually faded from view. We now know that these “transient” events occur when one star circling its companion unloads enough matter on it to make it explode. The first repeating “variable” star was first detected in the early 17th century when the star

called “Mira” was observed to change in its brightness on a timescale of nearly a year. We now know that Mira is a star which contracts and expands in size over this length of time. In fact, if we were to look at each star with sufficient precision and length of time, we would find that every star is variable in some (and usually many) ways.

Today “Time Domain Astrophysics” is the study of how and why stars and other celestial bodies change their apparent characteristics (such as brightness) over time, either as an unpredictable outburst – the *transients* such as supernova explosions and black hole – black hole collisions – or as a continuum of change – the *periodic* variables. These studies are central to discovering how stars form, live and die. By observing them in detail we can test models which have been proposed to explain their behaviour. If a model cannot account for the observations, then it is back to the drawing board! However, the diversity of variable stars requires different observing strategies. Explosive events are extremely rare and short-lived, so that in order just to catch a glimpse of them it is necessary to observing the entire sky every night. On the other hand, targeted monitoring lasting many months is necessary to unravel the minute vibrations of Sun-like stars, but there are plenty of them.

### *Recent results*

In the study of periodic phenomena, long continuous monitoring with extremely high accuracy has proved necessary to discover the signals due to exoplanets, star spots and gentle vibrations present in or around many stars. For these, space craft are essential to overcome the negative impact of air turbulence in the atmosphere (which makes star twinkle), with Kepler/K2 (NASA 2000-2018), TESS (NASA 2018-ongoing) and Plato (ESA, from 2026) being pivotal missions. Using Kepler/K2 and TESS, Simon Jeffery has continued to study the interior structure of hot subdwarf stars (*Reed et al. 2021*), and extreme helium stars (*Jeffery et al. 2020a*). Amongst the latter, V652 Herculis is a large-amplitude pulsator with a period of 0.1d and a significant shock at minimum radius (*Jeffery et al. 2015*). New non-linear hydrodynamic models of the interior show that the shock is generated whenever the pulsation amplitude is sufficiently large, and this is related to the luminosity of the star and its internal opacity (*Jeffery et al. 2022*). Likely sources of gravitational waves include neutron-star white-dwarf binaries; the gravitational wave signatures of such systems are shown to be time varying and can inform the observer about the evolution stage of the binary (*Yu et al. 2021*). Gavin Ramsay continues to use TESS data to study interacting binary systems, including those with strongly magnetic white dwarfs such as MQ Dra (*Ramsay et al. 2021a*).

### *The role of GOTO*

The announcement of the discovery of gravitational waves from merging black holes by an international team in February 2016 was met with world-wide acclaim and the award of the Nobel Prize for Physics the following year. It was the fruit of half a century of building instruments with the exquisite sensitivity required to detect passing gravitational waves and opened up an entirely new way of studying the universe. Because of the way the detectors work and where they are geographically located, the exact position in the sky of the merging black holes is not known. Instead, their location on the sky is constrained to a wide arc of the sky spanning hundreds of square degrees (the Moon has an apparent diameter of 1/2 degree). If astronomers can locate the optical counterpart of the gravitational wave event, it is possible to derive much more information about it and the underlying physics of the merging objects. This was spectacularly demonstrated with the discovery of the optical counterpart of the merging neutron star binary GW170817 on 17 August 2017.



One of the nodes of the Gravitational-wave Optical Transient Observer (GOTO) on the island of La Palma, Spain (credit: Krzysztof Ulaczyk, University of Warwick).

AOP became a partner of the international project the Gravitational-wave Optical Transient Observer (GOTO) through a successful bid for funds from DCAL in Jan 2015. Its prime goal is to detect the optical counterpart of gravitational wave events such as GW170817. The first GOTO node of telescopes is located on the summit of the island of La Palma in the Canaries, which is one of the world's best sites to observe the night sky. Early in 2020 GOTO was awarded £3.2M by STFC to allow a second node to be built on La Palma and two nodes in Australia. This will complete our vision of imaging the whole sky every few nights, making it a truly world class facility. It will be a resource for astronomers at AOP and an excellent educational tool. In fact, they already form the basis of an on-going PhD project funded by STFC. Gavin Ramsay is a member of the GOTO Executive Board that oversees and manages the project, in particular the expansion of the La Palma node and the development of the Australian node.

Like many projects during the pandemic, the construction and commissioning of the new nodes has been delayed because of the various restrictions on site visits. In addition, the eruption of a volcano on La Palma in September 2021, which was only declared extinct on Christmas day, brought falls of ash and toxic gases at the Observatory. Poor weather has also hampered the commissioning of the new mounts and telescopes. Nevertheless, both nodes on La Palma are now fully operational. Work has commenced on two nodes in Australia and is due to complete before the end of 2022. The next observing run on the Ligo and Virgo gravitational wave observatories is expected to start in December 2022.

During this year, the main paper describing the GOTO project (Steehgs et al 2022), and a series of papers describing how various aspects of the pipelines work (e.g., Killestein et al 2021) were published. Using GOTO and other all-sky optical survey data, Chris Duffy investigated the long-term optical behaviour of a cataclysmic variable called DW Cnc. These data shed important light on how the accretion flow in these binaries change over time (Duffy et al 2022).

## **Solar Physics and Stellar Flares**

### *Introduction*

Although the aurora (or Northern Lights in the northern hemisphere) has been known for thousands of years, it was not until Richard Carrington observed a white light flare on the Sun in 1859, which was followed by aurora only 18 hours later that were recorded in Armagh, that the connection with the Sun was first made. These auroral storms can also cause disruption to human activity – in 1989 the electricity grid in Canada was disrupted by a flare from the Sun causing widespread blackouts. Today such an event is listed in the UK Governments Risk Register. The first flares were seen from low-mass dwarf stars nearly a century ago. In the optical they generally appear as a rapid brightening (by factors up to 4,000) followed by a slower decline and have now been seen at all electromagnetic wavelengths. Research into stellar activity from all types of stars is now very topical for at least three reasons: it can mask or indeed give false positive detections of exoplanets; stellar flares could affect the chemistry of the atmospheres of exoplanets making them unsuitable for life forming, and thirdly that large scale ground based surveys and missions like *Kepler* and *TESS* have been used to search for activity cycles on stars across the main sequence which gains insight to their magnetic field and how often super-flares might occur on the Sun.

### *Recent results*

Solar Physics at AOP is led by Leverhulme Emeritus Fellow Gerry Doyle who supervises PhD student Nived Vilangot Nhalii. In recent work, they report on properties of an active loop above the Sun's photosphere (its visible 'surface') with observations obtained with the highest time resolution using the CRISP Imaging Spectro-Polarimeter (CRISP) mounted on the Swedish 1m Solar Telescope on La Palma together with simultaneous observations made using Solar Dynamics satellite (Nived et al 2022). High speed jets of gas called spicules were detected just above the Sun's photosphere, but only some were seen to cause a corresponding effect in the Sun's outer atmosphere. Nived was able to show using computer modelling that it needs the energy of roughly ten such jets to cause the observed features in the Sun's outer atmosphere. Further, the results of the modelling were also able to explain a peculiar periodic behaviour seen at ultraviolet wavelengths.

In another project, Doyle's team again used observations obtained using the CRISP instrument to study the movement of jets high up in the Sun's atmosphere (Shetye et al 2021). The observations revealed the presence of waves which have a range of frequencies which suggest they have helix (or DNA shaped) like structures. The team propose that these waves may cause the appearance and motion of these jets seen just above the Sun's photosphere.

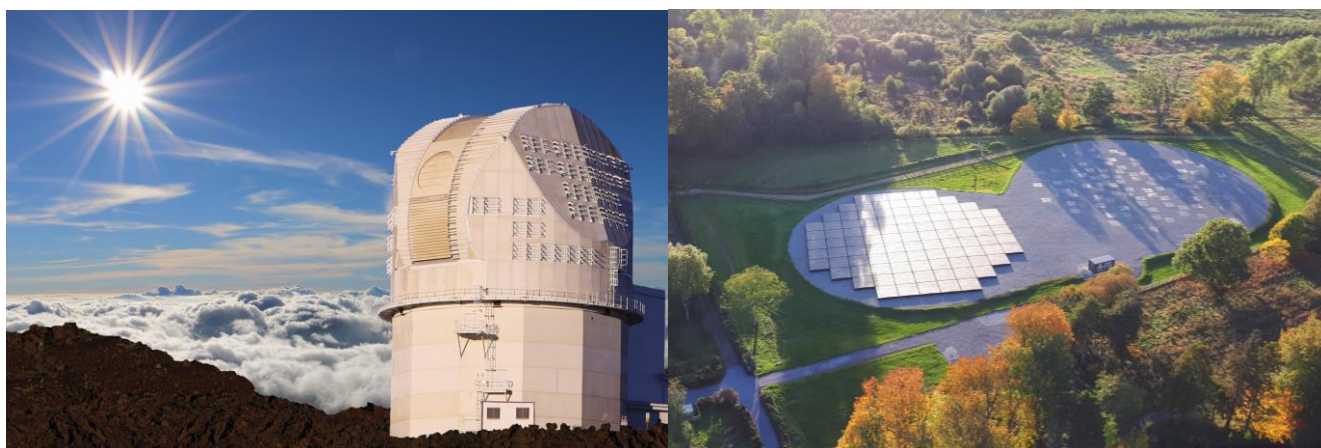
Gavin Ramsay, Gerry Doyle, former PhD student Lauren Doyle (now at Warwick) and Stefano Bagnulo continue to study flares from low-mass stars and Solar type stars. Large-scale events such as flares and coronal mass ejections can be orders of magnitude greater than similar Solar activity which may have implications on the habitability of any orbiting exoplanets. Over the last few years, we have found a population of very rapidly rotating low mass stars which appear to be flare inactive. Since we expect rapidly rotating stars to be very active this is a great surprise. To investigate this further, we obtained spectropolarimetric observations of a sample of fast rotating stars using the ESO VLT (Doyle et al 2022) and a series of spectroscopic observations made using the Nordic Optical Telescope (Ramsay et al 2022). Although the reason why these fast-rotating stars are inactive is still an open question, we have identified

'super-saturation' as a potential mechanism. Further investigations are continuing. Observations of low mass stars made using TESS revealed quasi periodic pulsations from seven stars which allowed us to determine the size of the coronal loops which produced the flares: they are of a similar radius as the star's radius. Several 'super-flares' were observed which would influence the atmosphere of any exoplanet orbiting in the stars habitable zone (Ramsay et al 2021b).

### *The role of IST and I-LOFAR*

IST (Inouye Solar Telescope, previously known as DKIST) is the largest solar telescope in the world with a focus on understanding the Sun's explosive behaviour. It saw first light in January 2020, producing the highest resolution image of the Sun's surface ever taken, enabling the study of features as small as 30 km (18 miles) in size at a distance of 150 million kilometres. AOP was key for the UK being a partner in IST which was due to seed funding in 2015 from Department of Culture, Arts and Leisure (DCAL). Coupled with funding from various UK universities, STFC and Andor Technology, more than £4m was raised, most of which went directly into the Northern Ireland economy. It is the Andor detectors that captured the first-light image which was published world-wide, demonstrating how the involvement in such a major international project raises the profile of Northern Ireland, Armagh and AOP on the international stage of science. Additionally, AOP were also involved in the design of key observing sequences for ESA's Solar Orbiter launched in Feb 2020 with data now becoming available. These two facilitates will become the main source of solar data for AOP research in the coming years.

LOFAR (LOw Frequency ARray) is a flagship European science project that is revolutionising our understanding of the Universe, attracting students into careers in science and technology and driving new developments in IT. It consists of an international network of antennae spread across nine countries including the Netherlands, Germany, England, Poland, France, Sweden, Latvia and Italy as well as Ireland. I-LOFAR, the Irish station, is in the grounds of Birr Castle, which AOP was able to join as a partner thanks to a DCAL capital contribution in 2016 aimed also at strengthening North/South STEM cooperation, resonating with Armagh's and Dunsink's involvement in the first North/South agreement since partition to build the Armagh-Dunsink-Harvard (ADH) telescope in South Africa in 1947.



The four-metre diameter Inouye Solar Telescope on the island of Maui, Hawaii (left) and the Irish LOw Frequency ARray station (I-LOFAR) in Castle Birr, county Offaly (right).

In collaboration with colleagues in Dublin Institute for Advanced Studies (DIAS), Gavin Ramsay and Gerry Doyle supervise Jeremy Rigney (the Lindsay studentship) who is using data from I-LOFAR and the full LOFAR array to explore plasma emission bursts produced by coronal shock fronts and plasma emission bursts produced by coronal shock fronts on the Sun and in other low-mass stars. The team obtained LOFAR time to look for coronal mass ejections from an active low-mass dwarf star as in general the low-frequency radio emission of M dwarfs is currently poorly explored. These radio observations will be complemented by optical data from GOTO and TESS to study stellar flares and in particular to further constrain the incidence of super-flares on solar-like stars and their impact for the habitability of planets around them. In this respect, TESS will allow the observation of ~400 Solar-type stars over the span of several months which will be the equivalent of observing the Sun for thousands of years. They are also involved with the ASKAP array in Australia (Murphy et al 2021), in a project involving simultaneous time from TESS to observe several flaring M dwarfs. Large-scale events such as flares and coronal mass ejections from these stars can be orders of magnitude greater than similar solar events which may have implications on the habitability of any orbiting exoplanets.

## Solar System Studies

### *Introduction*

Our Solar System is an extraordinary natural laboratory to study the formation and evolution of planetary systems around the Sun and other stars. Our work here feeds into fundamental questions about how the Solar System and the Earth formed and the development of life in the Universe. Our study of comets, asteroids and planets impacts on models of solar system formation, the ever-present hazard to civilization if asteroids or comets hit our planet and on the origin of water and organic compounds necessary for life to exist. The space industry benefits from improved detailed knowledge and understanding of the near-Earth and interplanetary environment.

### *Recent results*

Apostolos Christou investigated the existence of asteroids representing leftover debris from the Earth's formation 4 billion years ago and may have been responsible for delivering water and organic material to our planet. These so-called Earth Trojan asteroids are difficult to find with telescopes because, if they exist, they would appear close to the Sun in the sky. Christou initiated a collaboration with Dr Nikos Georgakarakos (Center for Astro, Particle and Planetary Physics, New York University Abu Dhabi, UAE) and, rather than searching directly for these objects, the team focused on whether these Trojans should be there in the first place. In other words, would the Trojans survive against the gravitational push of the other planets and other thermal effects over the 4 Gyr of solar system evolution, or would they be removed - either through ejection or physical destruction - from their initial locations?

For this work, we carried out billion-year simulations of the Trojans on a computing cluster at New York University in Abu Dhabi. An important result is that the Yarkovsky thermal force would have driven away most primordial Trojan asteroids smaller than about a kilometre. This observation places limits on the brightness of any existing Trojans to inform future observational surveys. In addition, we found that objects much larger than a kilometre are not efficiently removed by either planetary perturbations or Yarkovsky. Such objects would be bright enough to have been discovered by now; their non-existence implies that either there were too few of them originally or some additional mechanism, such as collisions, must have acted to remove them from the Earth's orbit. This work was supported by AOP's 2018-2021 STFC Consolidated Grant and published in Monthly Notices of the Royal Astronomical Society in October 2021 (*Christou and Georgakarakos, 2021*).

Another component of the project focused on quantifying the observational difficulty of finding the Earth Trojans. It is not clear, for instance, if observational surveys that will come online soon such as the Rubin Legacy Survey in Space and Time (LSST) or NEO Surveyor are capable of finding these objects or at least provide firm constraints on their existence. Here, joint work with former AOP student Boris Nedelchev contributed to the construction of a simulation tool that will help us better understand how to optimise future surveys. Initial results of this work were presented at the European Planetary Science Congress in September 2021 (*Christou, Nedelchev et al, 2021*).

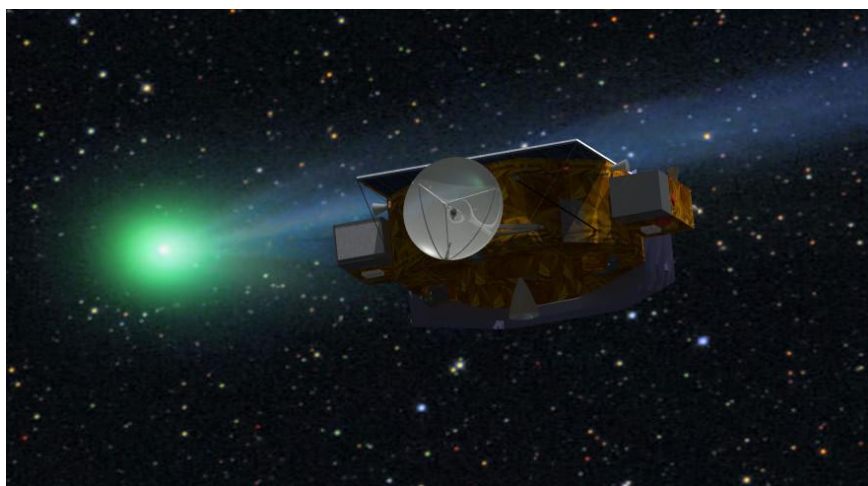
Christou also reports his co-authorship of a publication that appeared in the June 2021 issue of Space Science Reviews (*Janches et al, 2021*) and represents the distillation of a workshop that took place at the International Space Science Institute (ISSI) in Bern, Switzerland in early 2020. The paper reviews our current understanding of how the tenuous atmospheres (also called "exospheres") of bodies such as the Moon and Mercury are affected by the continuous influx of asteroid and comet debris and formulates the main questions to guide future investigation. Christou was invited to contribute to this work because of his acknowledged expertise in modelling the meteoroid flux on the Earth and other planets.

Stefano Bagnulo and his PhD student Zuri Gray have secured telescope time at the ESO VLT to study the consequences of the impact of Double Asteroid Redirection Test (DART), a planetary defence mission to test a method of deflecting an asteroid on course to hit Earth. DART will arrive at near-Earth asteroid Didymos in September 2022. The spacecraft will crash into the asteroid's small moon Dimorphos, testing whether the kinetic impactor technique works. Because of the impact, dust clouds will be ejected from Dimorphos, which will be studied from ground-based telescopes using polarimetric techniques. Bagnulo is also involved as a co-Investigator in another observational project which will use polarimetric techniques to study the nature of cometary bodies of our solar system. The Principal Investigator of this project, Yuna Know, has also applied for Isaac Newton Fellowship to come and work at AOP for two years.

### *The COMET INTERCEPTOR Space Mission*

The European Space Agency (ESA) recently approved a space mission to encounter a comet coming from the edge of our Solar System; the launch is expected in 2028. A novel idea sets this mission apart. So far, spacecraft have approached comets that are already well known and have gone around the Sun already several times. Therefore, it is very likely that the comet material has been "processed" by solar radiation and the space environment, and it is no longer in pristine condition. By contrast, here we are interested in comets on their first trip around the Sun, made

of unprocessed material preserved in the cold outer parts of the solar system. To achieve the goal of visiting such a new comet, the spacecraft will be launched before the comet is found and will wait in deep space for instructions. Once a suitable target comet is found, instructions will be sent from the ground to guide the spacecraft to the comet (hence the name **Comet Interceptor**). Studying the material brought for the first time to the heat and light of the Sun will give us the opportunity to look at the solar system as it was when it formed. AOP is contributing to the development of the instrument that will send to Earth comet images (including polarimetric images) obtained with a fish-eye lens. Stefano Bagnulo is an expert in polarimetric observations and is one of the co-Investigators of the project, and his PhD student Zuri Gray is also involved in the mission team. Presently, STFC funding has been obtained for a six-month long visit at the Institute of Astrophysics of Andalusia in Granada (Spain), where Zuri is being trained to obtain and analyse laboratory data concerning the properties of the light scattered by particles that will be relevant to the design of the Comet Interceptor mission.



*Artist impression of COMET INTERCEPTOR Space Mission*

## High Energy Astrophysics

### *Introduction*

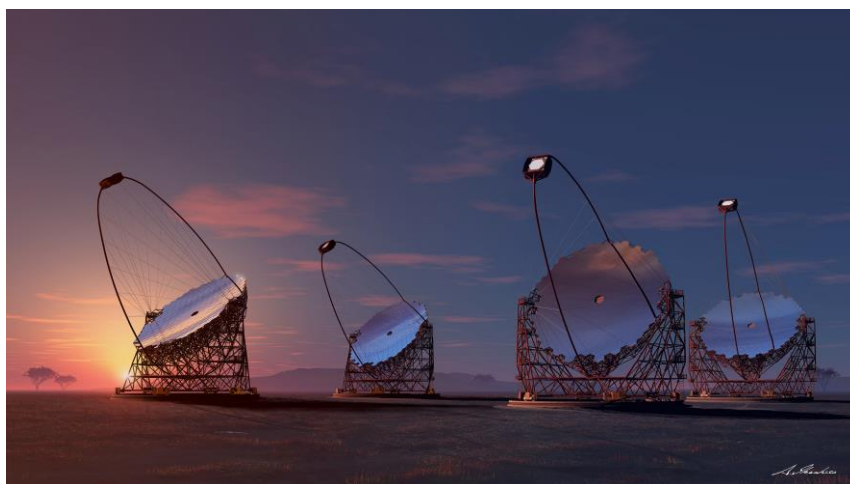
High energy astrophysics is one of the most important and exciting areas of contemporary astronomy, involving the phenomena and physical processes that produce the most energetic photons and particles in the Universe. It allows the study of the properties of matter under physical conditions which cannot yet be reproduced in the laboratory and relates to some of the most dramatic astrophysical phenomena, such as supernovae explosions, the mergers of neutron stars and the origin of gravitational waves, the accretion of matter onto black holes and the acceleration of particles at near light speed in collimated galactic-scale jets. For the most part, high energy astrophysics necessitate space telescope observations, so the drive to fully understand the astrophysical engines of powerful X-ray or gamma-ray sources goes hand in hand with the space industry and innovation.

### *CTA – the Cherenkov Telescope Array*

The Cherenkov Telescope Array (CTA) is an international project to establish the world's first observatory for astronomy in the extreme gamma-ray energy range of the spectrum. More than 1,500 scientists from 31 countries are involved in the project, which will equip sites in the northern and southern hemispheres – in La Palma in the Canary Islands and on the Atacama plateau in Chile – with an array of telescopes. CTA will provide an order-of-magnitude improvement in sensitivity over existing instruments, with substantial gains in angular resolution and energy range. CTA will be transformational for gamma ray astronomy, and a cornerstone of multi-messenger investigations combining data from gravitational wave detectors, longer wavelength electromagnetic observations and neutrino detectors. CTA will investigate topics from fundamental physics, such as searches for dark matter and evidence for axions and quantum gravity, through to astrophysical questions, including particle acceleration, relativistic jets, and the role of high energy particles in star and galaxy formation.

AOP's vision is to be renowned as a centre of excellence for research, education, inspiration and outreach in space and science. This requires continual and sustained efforts to renew, refresh and revitalise both the organisational expertise and infrastructure to ensure that AOP is well-placed to anticipate, maximise and respond to emerging opportunities within the fields of astronomy and space research. AOP has joined the CTA project in response to such an emerging opportunity. AOP is a member of the UK consortium participating in the CTA, together with the Universities of Oxford, Durham, Leicester, Liverpool and Kings College London. The STFC has provided the principal support for the UK's participation in the CTA, with the DfC facilitating AOP's participation in the UK consortium. This will help ensure that Armagh and Northern Ireland can be full participants in a world leading international scientific project with corresponding worldwide name recognition. The UK consortium is leading the design and development

of one of the prototype camera systems being built for the telescope, the CHEC camera (Compact High Energy Camera), able to respond to cascades of blue photons that are generated when gamma rays from celestial sources strike the top of the Earth's atmosphere. These cascades last for only a few billionths of a second, making them extremely challenging to record.



Artist's rendering of *the Cherenkov Telescope Array* (CTA, credit: Akihiro Ikeshita, Mero-TSK, International)

As with many science projects progress has, unfortunately, been delayed during Covid-19, through the limiting of access to the site as well as, locally, difficulties in maintaining university instrument laboratories through lockdown.

AOP is also providing science support for the CTA project through the provision of complementary survey data obtained with the Mopra radio telescope that shows with unprecedented detail the distribution of the cold molecular gas clouds – the very fuel of star formation – within the Milky Way Galaxy. This contribution is important to CTA because much of gamma ray emission from our Galaxy is produced by the interaction of ultra-high energy cosmic rays with the nuclei of molecules found in these cold gas clouds. The Mopra survey will therefore provide the “template” of the distribution of these nuclei needed to interpret gamma ray images that the CTA will produce. The survey has now finished, and the data reduction completed. Data cubes illustrating the kinematics and distribution of molecular gas over  $10^{\circ} \times 2^{\circ}$  regions across  $100^{\circ}$  of Galactic longitude are now available, as are position-velocity plots across the entire survey range.

AOP is further contributing to UK leadership in the provision of outreach to the CTA project, bringing our expertise in planetarium shows and technology. Michael Burton and Kerem Osman Cubuk wrote and produced a new planetarium show “*Exploring the High Energy Universe*” illustrating the multi-wavelength universe and introducing the CTA as the new tool to explore the universe at the highest energies. Senior Education Officer Heather Alexander then recorded the audio track to accompany the show, making this an all-Armagh production. The show has been written for Digistar planetariums and made available through the Digistar cloud. It featured during the International Cosmic Ray Conference, held virtually from Berlin in July 2021.

## Education and Community Outreach

### Planetarium

AOP is a special place that brings together fundamental research and public curiosity about the nature of the cosmos, all within a heritage environment that is rich in scientific history. Four pillars underlie and support the public programme of AOP - education, inspiration, entertainment and outreach. The Planetarium was established in 1968 and is world-renowned as an innovative centre of excellence in promoting the public understanding of science.

At the Planetarium, the primary activity is the education and the dissemination of scientific and astronomical knowledge. The Planetarium also strives to promote public understanding of astronomy and science to a large audience base of all ages, from nursery to seniors via a school's educational programme and science offering to the wider public through both onsite and offline means.

This year our educational offering was affected by the Covid-19 pandemic for the first quarter when we remained closed. During this time, we continued our Science at Home online programme, online StarTrackers and Cosmic Classrooms. The team were also preparing for re-opening, re-training, and assisting with a brand-new exhibition install. Our main objective during the first quarter was to highlight our new facilities such as Changing Places, Sensory Room, new theatre install and of course the brand new tactile exhibition area.

In July 2021 we reopened our doors at 30% capacity in our dome theatre, and due to limited capacity, we found ourselves with sell out shows at that limited capacity and bookings being made weeks in advance. The benefit of

advanced bookings was in the extremely warm weather we found ourselves at maximum restricted capacity when historically at full capacity we would have struggled for the same level of visitors, who would instead opt for the beach and the great outdoors in the sunshine! We also changed our operational model to reflect the growing need to open at the weekends and our hours of opening changed from Monday-Saturday to Tuesday-Sunday. This has increased our non-school audience and increased revenue to a level where we can offer casual hours. It also allows the education team to catch-up on work on a Monday.

Visitor figures during summer 2021 were 12,226 compared with 17,563 in 2019 which must be noted was the 50<sup>th</sup> Anniversary of Apollo 11. Operating at two-thirds of the 2019 figures at only 30% capacity was a huge achievement. The trend in visitor figures has continued and, although schools were slow to arrange visits again, as of March 2022 we were back at our pre-Covid-19 operating figures.

This year we published our “Big Book of Experiments and Bright Ideas” which was funded through a successful funding bid to STFC to make the online Science at Home experiments into a book. The book was distributed free of charge to every primary and special school in Northern Ireland to help with STEM education.

**Comments:**

*“I’ve just been made world around us co-ordinator and am pushing more science experiments to be done in school. It’s great having ideas all in one place!”* Teacher from Bessbrook.

*“I am taking away from the book how simple it is to incorporate science into my lessons”* Teacher from The Loup.

*“I like how these experiments can be altered to suit the needs of all classrooms within the school, from nursery to post 16.”* Teacher from Arvalee.

Towards the end of the financial year, we received funding from DfC to extend the project to schools in the South of Ireland and another 3,240 primary and secondary schools received an experiment book.

**Comments:**

*“What we find in the teaching of primary science is that experiments are great and often readily available but we don’t always have the scientific answers that children might have around the experiment itself so we are very impressed with the part of the book where the science behind each experiment is laid out in clear scientific fact, I think it will really boost teachers’ confidence in teaching the subject so thank you.”* Elaine, Teacher from Cork.

*“I was delighted to open the post this morning and receive a hard copy of this book; staff were recently discussing a desire to have such a resource in the school to help inform their STEM teaching, so thank you to the AOP team for that!”* Eoin, Teacher from Kildare.

We have also made strong links with School Employer Connections (SEC) and have delivered 3 careers events online to Key Stage 3(KS3) pupils who have engaged with our education team and researchers. At the most recent online event we had over 350 KS3 pupils on the call. Many of our staff signed up as STEM Ambassadors this year and we have been able to engage and help on events and vice-versa.

Since re-opening our focus has been on accessibility. Our exhibition is tactile and multi-sensory, and our drive has been to engage with those who are blind/sight impaired or deaf/hearing impaired. We have engaged with the DfC languages department and have arranged visits from people within those communities to assess the level of our offerings. Although not launched yet, this year we downloaded a dome show for the visually impaired called “Audio Universe” and made strides to put British sign language (BSL) and Irish sign language (ISL) on the dome and this will be completed in 2022. We have also engaged with DfC translation department to create an Irish and Ulster Scots version of our dome show “CapCom Go!” and these versions will be launched in 2022 also.

New dome shows were created this year: “Look Up Spring” written by Heather Alexander and programmed by Sinead Mackle; “Our Solar System” written by Martina Glass and programmed by Anna Henley; and “Our Place in the Cosmos” written by Professor Michael Burton (see below). We also screened this show at Armagh at the same time as part of a public understanding of climate change. This year we have also developed a climate change exhibition to go into our main hall. The exhibition is mobile and fully movable to accommodate the multi-functional area.

A new educational programme was piloted called “Weather Ambassadors”. This was rolled out to 3 schools where the pupils have a weather station installed at their school and read the weather every morning – just like AOP have been doing since 1795. Once the schools have completed a season of recording, they will receive certificates and a visit to AOP. A review will take place on the programme with the aim to roll out to further schools in the new term. Senior Education Officer Helen McLoughlin took the lead alongside Anna Taylor.

Through our marketing activities we have produced a steady stream of good news stories from AOP, including highlighting the research we conduct, job roles throughout the organisation and promoting our summer 2022 exhibition Brickosaurs for which we have very healthy pre-sales within the last weeks of March 2022. We were also



part of Tourism NI billboard campaigns, and we arranged an Observatory visit for actress and presenter Siobhan McSweeney for a show that was streamed on More4.

We also participated in the JobStart programme, and our candidate Dylan Smyth helped AOP with digital content. When the scheme ended Dylan allied for a placement through Belfast MET and continued his work at AOP. Dylan learned valuable skills in employment and has now a position as a casual member of staff at AOP.

## Highlights from AOP's Programme of Events in 2021-22

### Onsite Highlights

During 2021-22 AOP opened its doors in July and ran at 30% capacity with small incremental adjustments to capacity reaching 80% dome capacity by year end. The visitor figures have been very encouraging and staff are looking forward to working towards increasing these figures in 2022-23.

Highlights include the introduction of Astropark walks and Observatory tours, created by Heather Alexander and delivered by Rok Nežič. Rok has received 5-star rating for these, and the aim will be to market and create an Embrace a Giant Spirit product for these bespoke tours.

Music dome shows were introduced on Friday nights - for which Pink Floyd has proved most popular - and we will continue these into the new year programme. The return of the NI Science Festival and the success of our half term events allowed us to get back to presentations and delivery onsite and back to organising events. We ran a PhD open afternoon where members of the community met with students and researchers asking questions and looking around the Planetarium. These were well received and the communication and learning from the researchers was a highlight for visitors.

The Fusion Festival was run by Armagh City, Banbridge and Craigavon (ABC) Council in March 2022, when AOP enjoyed 6 sell out music dome shows and the opportunity to see how the hire of grounds could be a revenue stream in the future. The collaboration between the Council and AOP in this event was an opportunity to share ideas and learn from each other on activities that can run at AOP.

The biggest highlight was the return of Mission Santa. Developed and delivered in 2019 we could not run in 2020. We sold out our slots and the feedback was fantastic with comments such as meeting Santa but learning about the planets was a unique and unforgettable experience. We also were successful in a Tourism NI event fund for this event receiving financial support to enhance the experience.

AOP have been collaborating with the Southern Regional College for events and music and in March they performed a live musical rendition of "Our Place in the Cosmos" which is the first officially live event in our dome with the new projectors.

### COP26 ("Conference of the Parties" 26)

A major activity for AOP over the past year has been our participation in COP26, the UN Climate Change summit held in Glasgow, that ran from 1-12 November 2021. We produced a new planetarium show specially for COP26 called "Our Place in the Cosmos". It is about the special, fragile place of the Earth in our Galaxy, the only habitat we yet know able to sustain life. The show utilised the capabilities of AOP's new Digistar system to take the viewer on a journey through the Galaxy and the Solar System, ending by illustrating how we can monitor our planet's health from space to understand humanities impacts on it.

The show drew upon AOP's background and reputation across the three domains of research, education and outreach to contribute to the public understanding of science, presenting a cosmic perspective on the challenges facing our planet and demonstrating our ability to communicate issues of science to society on a global stage.

The show needed to be rendered into the format for Glasgow's projector system (a Uniview projector system rather than AOP's Digistar). The show was produced in-house at AOP, with the Music Department of Southern Regional College composing the backing music and recording the narration. This is the first show produced by AOP to be delivered outside of our own planetarium.

*Our Place in the Cosmos* was presented 14 times in the Green Zone of the Glasgow Science Centre during COP26, being fully booked on each occasion. The shows were accompanied by an introduction and followed by a Q&A session with the Director (generally lasting longer than the shows!).

We estimate that approximately 3,000 people took part in our activities around COP26, with ~2,000 in Glasgow and a further ~1,000 in the associated events we ran in Armagh. This was accompanied by a full social media engagement programme to extend the reach of our message.

## Online Highlights

We have continued to grow our online audience this year with now over 31,000 Facebook followers. This has been a huge highlight, to be able to reach more people, to increase our visibility and to be relevant locally, nationally and internationally. Ria Mee and Helen McLoughlin continued to create experiments for content during this time.

Thanks to Tourism NI marketing funding awards we have been able to market our shows online and through digital means and increase our visibility. The team have produced many online events this year, although not as many as during the lockdowns. Highlights include Unlock the Universe and a James Webb Space Telescope (JWST) event developed and delivered by Courtney Allison with input from Jorick Vink in the James Webb online event. Cosmic classrooms have continued to be booked by schools; however our focus has been on onsite delivery as we re-opened.

## Outreach Highlights

We also attended Tourism NI activations in Belfast and Dublin with Nick Parke in the astronaut costume representing AOP. We also took our outreach dome out on the road to Londonderry and Belfast this year for the first time in two years.

## History and Heritage

### History & Heritage Policy

As the custodian of many valuable and historic scientific instruments, scientific records, books, journals and artworks, AOP is proud of its rich and deep history and heritage. Our heritage policy is to progressively restore and conserve the historic buildings, scientific instruments, and archives in our possession. The objective is to maintain the integrity of the library, archives and historic scientific instruments as a coherent collection for future generations in the City of Armagh and to preserve this historic material and improve the environmental conditions in which it is held. We seek to widen access to this material where possible so that researchers, visitors, and future generations will be able to enjoy our collection and access our material.

During 2021-22 tours of the Observatory Building have begun under the branding of the 'Legendary Telescopes Tour' and these have been received and reviewed very well by the public. The eMuseum, linked to the Collection Management System, had a successful soft launch. The 2021 redesign of the exhibition area has seen the history and heritage of AOP put on display for the public for the first time in over thirty years.

AOP has also seen a sharp rise in the number of information requests and enquiries from historic researchers and the public. Since the start of the 2021 fiscal year the Museum Assistant has facilitated 14 requests for information from researchers, up from 4 in the previous year.

In pursuance of our heritage objectives AOP has submitted its application for Museum Accreditation. The Accreditation Scheme is the sector standard for museums and galleries and is overseen in Northern Ireland by the Northern Ireland Museum Council on behalf of the Arts Council. AOP has been working towards Accreditation since 2019 with help from our Museum Mentor, and discussions with the Northern Ireland Museums Council development officers.

Throughout 2021-22 AOP completed its wide-ranging Project Plan for museum accreditation. Several policies have been developed, including a Museum Policy written in accordance with Spectrum 5.0 Guidelines, a Documentation Policy Handbook, a Conservation and Collection Care Policy and an Access policy. With these in hand AOP meets all of the primary procedural requirements of Spectrum 5.0.

AOP has also continued to support the development of the next generation of workers in the Heritage Sector of Northern Ireland. In 2022 AOP has supported another internship from the Queen's University Belfast Public History MA in a joint heritage/education project. AOP has also formalised the loans between itself and the Armagh Robinson Library, as well as loaning objects to the Armagh County Museum for display.

AOP staff have continued to conserve the historic collection. Following advice given by the conservation staff at Royal Museums Greenwich the Grubb 10-inch and 15-inch telescopes underwent preventative conservation. The Museum Assistant ensured that the Grubb 10-inch was also maintained for future use. As part of the Conservation and Collection Care Policy the Grubb 10-inch has been designated as part of the 'operated collection', to be used as an operational instrument. Only trained members of staff will be able to operate the telescope. There are now ongoing training sessions that allow staff to learn the intricacies of the telescope. This training is led by Rok Nežič.

## Library & Archives

The Observatory's suite of technical equipment is complemented by a Library and Archives which, together, represent one of the premier specialist collections of their kind in the world. The Library, Archives and Historic Scientific Instruments collection contains a unique variety of historic books and manuscripts, images, photographic plates, scientific instruments, clocks and other artefacts concerning the development of modern astronomy from the Age of Enlightenment up to the present day with specific reference to the important discoveries and scientific contributions made by the international research community here at Armagh. The library also provides an essential reference resource for AOP research, and especially for its student and young researcher cohort. It contains approximately 3,400 textbooks, monographs, special reports, and conference proceedings covering nearly all disciplines in astronomy. Some 17,000 volumes from nearly 200 scientific journal titles include nearly complete runs of all the major astronomy journals, as well as journals of significant historical interest.

In 2021-22 funding was secured which enabled the book collection to be refreshed with the purchase of some 50 recent volumes, the employment of a temporary librarian to continue with sorting, cataloguing and shelving the book and journal collections, and to commence the task of binding recent journals and conserving special book collections. These funds have provided mobile furniture for the library to display significant book collections and astronomical atlases, as well as to make the space more versatile for meetings and study. Three rooms in the de Groot bungalow have been fitted with rack shelving to store much of the journal collection accessibly.

Sorting through the collection naturally leads to discoveries: highlights have included the T R Robinson's 1841 edition of 'The Law of Storms', an 1862 letter signed by the great physicist and secretary of the Smithsonian Institution Joseph Henry, and the handwritten library catalogue from 1900, as well as countless inscriptions by astronomers both great and unknown. Whilst still under enormous pressure for space, the AOP library is now an attractive space and a more effective research tool, with potential for further development and revenue generation, and increasingly demonstrating its potential for historical discovery as well as astronomical research.

## Meteorological Record

As part of the organisation's primary research role, staff take daily readings of a wide range of meteorological parameters at Armagh and maintain the Observatory's unique 225-year long meteorological record and databank. This is believed to be the longest daily climate series in the UK and Ireland from a single site (though the log book for the period June 1825 to December 1832 appears to have been lost) and one of the longest in the world. The climate station has been continuously maintained since July 1795 with readings currently taken every day at 09:00 (GMT). The World Meteorological Organisation (WMO) has recognised Armagh with centennial station status for its longevity and importance in contributing to the climate record.

Calibration of these data has enabled researchers and government agencies to use the Armagh series for reports and research into global warming. The data contributes to the UK Meteorological Office's main climate database and are released to the general public on a monthly basis through press releases and on our climate website (<http://www.climate.armagh.ac.uk/archives.html>) whilst also contributing to the UK Meteorological Office's main climate database.

Climate change is a subject of strategic importance for Northern Ireland as we move into an era of rapid climate variability, and the Armagh's unique climate record provides an exceptionally long historical baseline, enabling better informed judgements to be made as to how Northern Ireland's climate has responded and is responding to climate change world-wide. As part of AOP's contribution to COP26 in Glasgow Planetarium, we ran a panel discussion on this topic. The panellists were located in Armagh, Berlin and Glasgow, including meteorologist Professor Ed Hawkins whose climate change "stripes" provided a defining image for COP. Our dome show for COP26 "Our Place in the Cosmos" featured the Armagh climate stripes during the scene illustrating the rise in global temperature. We also ran a series of climate change workshops in the Planetarium during COP26 delivered by "Scientific Sue".

An automated weather station was installed by the Met Office in 2019, sampling the weather every minute. This now provides the primary source of weather data in the Met Office records (e.g. temperature, pressure, rain fall, windspeed) since it is automatically uploaded to the Met Office. However, manual collection still continues, and provides the only source for some of the data collected (e.g. sunshine, grass temperature) at Armagh. Maintaining the collection of the meteorological data has been prioritised over the Covid-19 lockdown period and has managed to continue uninterrupted. Three new PhD students were trained in weather observations as part of their scientific training (Zuri Gray, Alice Humpage and Ethan Winch), as well as former staff member Jim McManus (as a Volunteer), and then accredited as Level 1 Met Observers by the Director. Due to Covid-19 restrictions, this training needed to be undertaken individually.

During the past year the information about the weather on our website has been transferred from the previous climate website ([climate.armagh.ac.uk](http://climate.armagh.ac.uk)), revised and further updated, with extensive new material added; see [armagh.space/weather](#). This includes information about the history of the weather record, on the instruments used, the log book, and on publications. Rok Nežič has primarily compiled the material for these web pages.

Further, we have now developed a series of python scripts to store, analyse and provide access to the weather data base via the weather webpages. This includes both the manual data as well as the (recent) automated weather station data. Research Assistant Tom Watts has written this code. This takes the monthly observers log, also provides a means of entering the information via an online log, and in addition automatically downloads the data received from the automated station, to ingest these data sets into a new data base. Analysis scripts then allow this database to be interrogated, e.g. to find climate extrema over any date range of interest. This can then be examined from the website; <https://weather.armagh.space>. This includes enquiring about weather on any single day (as might be used in a visitor display in the Planetarium), as well as examining the data set over any period of interest and searching for climate records (extrema) over a period of interest. The automated weather station data is now also available to inspect online, in addition to the manual data. Plotting tools allow the user to see the weather over any time period, as well as to find when extrema in the various measured parameters occurred.

From our manual weather station, the maximum temperature was measured at 31.3°C at a time of 15:19 BST on 22 July 2021. This is the hottest temperature ever recorded in Armagh since records began in the late 18<sup>th</sup> century. It is hotter than the previous record high temperature of 30.5°C in Armagh that was recorded the previous day, 21 July 2021. Thus, the temperature record in Armagh was broken for two consecutive days; see also our Astronotes blog article at <https://armaghplanet.com/hottest-day-ever-recorded-in-armagh-for-the-second-day-running.html>. This also equals the highest temperature ever reported elsewhere in Northern Ireland, at Castlederg on 21 July 2021.

At the same time our Automated Weather Station, operated with the UK Meteorological Office, recorded a temperature of 31.4°C, i.e. 0.1°C higher. The two measurements use different recording devices, though they are in the same Stevenson Screen. Such temperature fluctuations are normal, two separated devices will often record slightly different values, the temperature peaks last for only a few seconds. Temperature fluctuations are the source of astronomical seeing, the twinkling of the stars, for instance.

However, the set-up for the Armagh automated station is slightly different from other stations in the UK Met Office's network in that it shares the Stevenson Screen with the instruments from our manual station. To allay possible confusion for future measurements we have, in conjunction with the Met Office, decided to install a second Stevenson Screen for use with the AWS recording devices only. This is separated from our current Stevenson Screen, with the area of the Meteorological enclosure expanded to accommodate this. In doing this we also changed the fencing around the weather station to make it less-visually intrusive.

## Support

AOP is committed to ensuring fit for purpose governance and support services to support the delivery of organisational objectives.

### ICT

The comprehensive research computer facilities are used primarily for numerical analysis, computer modelling and data reduction. The computers and peripherals are largely funded by the Department, but occasionally by external research grants. Staff require access to high-end Apple Mac and Linux workstations. In addition to this, Corporate and Education is serviced within a Windows and Office 365 environment.

AOP continues to modernise and improved its centralised ICT hub. In 2021-22 planned renewal of Windows based computers/laptops was completed. A variety of cyber security measures, in particular the use of multi-factor authentication to gain access to AOP systems and network segmentation of the Corporate, Education and Research ICT were implemented. The organisation has noted the recommendations arising from participation in a Cyber Essentials Certification Project and a recent Internal Audit Review and continues to investigate tools to improve Cyber Security without disproportionately inhibiting the ICT requirements of researchers.

An individual Risk Register for ICT has been developed and is regularly reviewed via a monthly senior officers ICT group. On 6 December 2021 ARAC received a presentation from the NI Cyber Security Centre and a separate ARAC workshop on ICT risk is planned.

### Finance

AOP has a well-established finance function. Financial policies and procedures are continually being enhanced to ensure that the organisation meets the governance standards required. This includes the application of public sector procurement controls, meeting prompt payment targets and providing regular and ad hoc financial information within the organisation and to DfC.

It has been recognised since the establishment of the new management structure that AOP's core budget is not sufficient to service the needs of the organisation as outlined in an approved strategic review. In 2021-22 an additional resource allocation to meet the agreed gap was provided along with the core allocation. This greatly assisted AOP to manage its finances more effectively and to bid for in-year funding for projects to add value and support delivery of objectives.

## Human Resources

A Human Resources Action Plan 2021-22 has been implemented to include:

- The New Normal – development of a Working from Home policy and an Internal Communications Strategy is ongoing;
- Employee Engagement – the annual employee survey has been completed and an action plan developed. Two engagement events were held;
- Skills Gaps – a paper has been developed and is kept under review. This informed 2022-23 budget planning;
- Staffing/Recruitment - several recruitment campaigns have been undertaken and JEGS Evaluations completed to ensure appropriate grading for posts created as a result of establishment of the current organisational structure;
- Appraisals – completed and training plan developed and implemented.

A Human Resources Strategy 2022-26 has been developed and approved along with the Action Plan for 2022-23.

## Governance

Governance and accountability continue to be strengthened and improved and risks reduced as demonstrated by external and internal audit reviews. The review of the Terms of Reference of the Board of Governors, Management Committee and its Sub-Committees was concluded in 2021-22 and a new Research and Education Advisory Sub-Committee was established.

One outstanding Internal Audit recommendation in respect of Record Management is currently being addressed. A retention and disposal schedule has been submitted to PRONI for approval. Since the pandemic, the organisation has moved towards paperless record management systems which will be easier to manage and control in accordance with the approved Retention and Disposal policy.

## Estates Management

AOP manages an extensive estate which includes 9 separate buildings, including the Grade A listed Observatory and a 14-acre historic estate. There are also several leases associated with land and property.

During the year, AOP continued to evaluate the options, risks, adequacy and sustainability of the current government subvention for AOP as outlined in its approved Strategic Outline Case for future development. This included a review of future needs to inform a business planning process moving towards a preferred option to meet future need. AOP has proactively engaged in a co-design process with Armagh City, Banbridge and Craigavon Borough Council in respect of a proposed Leisure Village project.

A Joint Agreement between AOP and the ABC Council was signed on 24 September 2021 by the Archbishop and the Lord Mayor for the Armagh Leisure Village, Science and Education Park. A set of 4 principles have been agreed around joint development of the site and an appropriate lighting plan which meets the principles laid out by the International Dark-Sky Association, in particular with regard to their guidelines for sport ground lighting and AOP's intent for accreditation of the Astropark as an Urban Night Sky Space.

## Achievements and Performance

The targets set for AOP in the 2021-22 Business Plan are shown in the following table. Actual performance achieved is shown along with the corresponding achievement in the previous financial year, where appropriate.

Targets were achieved or exceeded in many areas; however, a number were not met. Failure to meet a number of the targets that have been missed is beyond AOP's control in that they are reliant upon other bodies or have been affected by the post-Covid-19 environment. In particular, external verification is required to confirm the quality of research outputs and an unsuccessful funding bid prevented the creation of 3 scholarships. People-centred targets relating to recruitment of volunteers and development of a new membership programme for local citizens were both affected in part due to Covid-19, being closed for part of the year and the pressures of re-opening. The target for achievement of Urban Night Sky Place accreditation was too ambitious as a one-year target as the level of work involved had been underestimated.

KPI	Description	Target	As at 31 March 2022	As at 31 March 2021 (where applicable)	Comments
1	Obtain a world-leading or internationally excellent rating for 75% of AOP research outputs in the 2021 Research excellence Framework exercise	75% excellence rating	Ongoing	Deferred from 2021-22	94% excellence rating scored post year end – see reference on page 3
2	Create new PhD scholarships in October 2021	3	2	New KPI	Application for a Bell Burnell Scholarship unsuccessful
3	Articles published in referred scientific journals	50	67	66	
4	Secure income from scientific sources	£420,000	£420,000	New KPI	
5	Create work experience/placement opportunities for post primary/third level students	10	10	New KPI	2 x JobStart scheme 2 x work experience students at Planetarium 3 final-year students from Trinity College Dublin 3 remote research projects through the British Council IASTE.
6	Organise public events focused on understanding of climate change	2	9	New KPI	
7	Be accepted as a contributor to COP26	Accepted	Accepted	New KPI	
8	Achievement of Urban Night Sky Place accreditation by 31 December 2021	Accreditation	Ongoing	New KPI	Accreditation not achievable by 31 March 2022. Lighting survey completed.
9	Recruit 4 new volunteers (2 to assist with maintaining AOP weather recordings)	4	1	New KPI	1 volunteer recruited. Operational pressures following larger than expected visitor numbers following re-opening have had a corresponding negative impact on resource available to implement a sustainable volunteer programme.
10	Achieve at least 80% evaluation response ratings of 4 or higher for onsite visits and events held by AOP	80%+ evaluation ratings $\geq$ 4	80%+ evaluation ratings $\geq$ 4	New KPI	93% rate visit either a 4 or 5 star experience
11	Attract 12,300 non-school visitors (*30% of pre-Covid-19 baseline)	12,300	37,345	4,026 Affected by Covid-19	
12	Deliver cosmic classroom sessions (10 paid and 15 free for schools with low educational achievement in STEM)	25	27	13	20 paid and 7 free
13a	Deliver public open days	2	2	New KPI	
13b	Attract members to a new membership programme for local citizens	100	0	100	Membership programme is still being developed and will be rolled out in 2022-23. Was not met this year due to the unexpected increase in visitor figures in both school and public as evidenced in KPI 11.
14	Admissions and Trading Income level (*30% of pre-Covid-19 baseline)	£92,000	£364,553	£42,703 Affected by Covid-19	See Accounts notes 2 & 4
15	Special events/open tours of Observatory	10	45	10	

KPI	Description	Target	As at 31 March 2022	As at 31 March 2021 (where applicable)	Comments
16	Submit funding applications to contribute to the development of the AOP future vision.	3	12	New KPI	<p><b>Successful</b>  Tourism NI Marketing  Tourism event support  ABC fund (Costumes)</p> <p><b>Unsuccessful</b>  NLHF  UK Space Agency  STFC Spark Award / AOP Trump Cards  Bell Burnell PhD funding  N/S HEA for PhD school  STFC CDT for PhD school  National Archives</p> <p><b>Pending</b>  Tourism NI Experience Fund  NLHF resubmission</p>

\* If Covid restrictions change these figures may increase.

Progress Key: Achieved, Not Achieved

## Financial Review

### Operating Results

In the financial year to 31 March 2022, the value of charity funds increased by £1.963m, summarised below.

		2022	2021
		£	£
Total incoming resources		4,041,109	3,418,572
Total outgoing resources		(4,034,081)	(3,184,057)
<b>Net income / (expenditure)</b>		<b>7,028</b>	<b>234,515</b>
Gains/(losses) on the revaluation of fixed assets		422,885	(80,721)
Actuarial gains/(losses) on defined benefit pension scheme		1,534,000	(345,000)
<b>Net movement in funds for the year</b>		<b>1,963,913</b>	<b>(191,206)</b>
<b>Movement in Unusable Funds</b>			
Capital financing			
Capital grants received		1,254,000	1,040,000
Government grant fund		(828,152)	(602,687)
Revaluation reserve		185,428	(300,087)
Pension reserve		1,098,000	(580,000)
<b>Movement in Usable Funds</b>			
Restricted		(14,346)	46,325
Unrestricted		268,983	205,243
		<b>1,963,913</b>	<b>(191,206)</b>

The total income for the year was £4.041m, an increase of £0.623m from 2020-21, mainly due to an increase in capital grant income of £0.214m, research grants of £0.074m, operating income of £0.218m and trading income of £0.111m.

Expenditure was £4.034m, an increase of £0.850m from the previous year. Staff costs remain the largest component of operational expenditure. The number of permanent staff in post has increased slightly from the previous year.

Unrestricted operating costs are funded primarily by Departmental Grant-in-aid. The balance of such unrestricted operating costs is funded by contributions from external grants, trading activities and miscellaneous income. We continue to seek other funding streams to maintain this important source of funds. In 2021-22 the Department provided 79% of the total income through recurrent and capital grant allocations (2020-21: 87%).

#### Net Assets

Net assets at 31 March 2022 were £10.609m (31 March 2021: £8.645m).

#### Reserves

The AOP reserves policy is included in note 1 of the accounts. Total accumulated funds are as follows:

<b>Funds at 31st March</b>	<b>2022</b>	<b>2021</b>
	£	£
Restricted funds	174,108	188,454
Unrestricted funds	4,910,146	4,215,315
Revaluation Reserve	7,401,970	7,216,542
Pension Reserve	(1,877,000)	(2,975,000)
<b>Total Charity Funds</b>	<b>10,609,224</b>	<b>8,645,311</b>



## Going Concern

The Trustees are satisfied that the organisation is a going concern on the basis that it has a reasonable expectation that it will continue in operation for the foreseeable future. The financial statements are therefore prepared on a going concern basis.

## Pension Liability

AOP is a member of Northern Ireland Local Government Officers' Superannuation Committee (NILGOSC) which manages Local Government Pension Scheme (LGPS) Northern Ireland, which in turn provides a defined benefits pension to employees. The scheme is currently in deficit and at 31 March 2022 the deficit was calculated by independent actuaries at £1,877,000 (2020-21: £2,975,000).

## Key Risks and Uncertainties

At year end, the key risks were identified as:

- Reputation – loss of confidence in AOP's ability to deliver acceptable level of research of international value;
- Engagement:
  - Visitors – failure to provide experiences that attract new and returning visitors and/or failure to engage local pride in AOP as a cherished asset;
  - Partners and collaborators – failure to attract support and commitment from key stakeholders to be able to deliver future vision;
- Resources
  - Staff - failure to maintain an appropriately skilled, highly motivated and engaged workforce of sufficient capacity to satisfactorily deliver AOP objectives;
  - Budget – insufficient or poor management of budget could result in objectives not being met and/or value for money not being achieved;
- Asset Management
  - Buildings and Heritage – failure to plan for the long term development needs of the estate and assets resulting in increasing reliance on remedial intervention and failure to protect heritage assets from irreparable decline;
  - Other physical assets including ICT – failure to plan for the upkeep and renewal of plant and equipment resulting in reduced service delivery;
  - To protect systems from increased vulnerability to cyber attack due to remote working; and
- Governance and Planning
  - Failure to embed best practice approaches to corporate governance and risk management resulting in loss of confidence and reputational damage and/or legal challenge;
  - Inadequate information/data security measures resulting in information breaches and/or cyber security breaches.

As part of the Risk Management Strategy, management regularly review the inherent level of risk for each of the above and how the risk is currently managed. An Action Plan is documented to reduce the level of risk, mindful of the risk appetite of the organisation. This Risk Register is reviewed on a quarterly basis by the Audit and Risk Assurance Committee and approved by the Management Committee. Many of the above risks derive from the uncertainty around funding. Until AOP has both a budget appropriate to its needs and long-term security of funding, this situation is likely to continue. In managing these funding risks, the organisation has developed and maintained close communication links with the Department and submitted in-year monitoring bids for additional funding while carefully monitoring spend and budgets. For many of the above risks all reasonable steps within AOP's control are being taken to manage the risk.

The above risks also take account of recommendations from internal and external audit investigations and reports. Significant progress has been made in addressing the weaknesses identified in previous years and considerable effort has been put into the management of these risks going forward.

## Plans for Future Periods

In October 2021 AOP published a new Strategy for 2021-26 with four key themes of Enduring Relevance, National and International Standing, Offering More and Pursuing our Priorities.

Leading on from this AOP has submitted a Business Plan for 2022-23 for consideration by DfC.

A key focus for 2022-23 will be the development of an Outline Business Case to support AOP's future development needs. Collaboration with the Department, Council and other stakeholders to pursue funding opportunities to realise these plans will also be a priority.

Ireland has outstanding astronomical heritage through the pioneering role in development of the field of astronomy played by the observatories of Birr, Dunsink and Armagh. Birr with the Leviathan, the largest telescope in the world for 72 years, provided the seeds that led to the concept of other galaxies, as well as the birth of infrared astronomy. Dunsink and Armagh Observatories represent a key step in the development of the telescope itself, when the design of the building they are housed in became central to their function. Armagh has since continuously been occupied by astronomers, with three generations of telescopes from the 19<sup>th</sup> century within that are still extant and illustrate, together with a telescope at Dunsink, the development of the clock-driven equatorial telescope that form the basis for the modern astronomical telescope.

Following the election of the Director, Professor Michael Burton, as Vice-President of the IAU's World Heritage Commission, AOP invited the two previous presidents of the commission (Professor Gudrun Wolfschmidt of University of Hamburg and Professor Clive Ruggles of University of Leicester) on a study tour of these three Irish observatories from 21<sup>st</sup> – 24<sup>th</sup> March 2022 to make an initial assessment of the prospects of seeking such an inscription for UNESCO World Heritage. The Commission were impressed and felt that combining the three observatories together in a single nomination would provide a strong case to go forward. This is expected to be initiated during the coming year as the UK is opening applications to seek nomination for UK World Heritage Tentative List.

## Structure, Governance and Management

Armagh Observatory and Planetarium is a single statutory corporation and arms-length body (ALB). 'The Governors of The Armagh Observatory and Planetarium' are as described in *The Armagh Observatory and Planetarium (Northern Ireland) Order 1995*.

This 1995 Order superseded the original 1791 Act of the Irish Parliament entitled '*An Act for Settling and Preserving a Public Observatory and Museum in the City of Armagh For Ever*', and an Amendment of 1938 ('The University and Collegiate and Scientific Institutions Act [Northern Ireland], 1938').

AOP is a registered charity - reference number NIC 103948.

### Board of Governors

AOP is governed by a Board of Governors. Membership of the Board of Governors consists of:

- the Church of Ireland Archbishop of Armagh;
- the Dean of the Church of Ireland Cathedral of Armagh;
- the other members of the Chapter of the Church of Ireland Cathedral of Armagh;
- one Department nominee;
- one Queen's University Belfast (QUB) nominee; and
- up to three additional members nominated by the Board of Governors.

The Armagh Observatory and Planetarium (Northern Ireland) Order 1995 (the Order) places a statutory duty on "the Governors of Armagh Observatory and Planetarium" to maintain and manage AOP with the purpose of "developing and improving the knowledge, appreciation and practice of astronomy and related sciences."

The Board of Governors (the Board) has retained a role to ensure that the culture and character, history and patrimony embodied in AOP are protected and preserved and that the institution is managed in line with the statutory purpose outlined in the Order. This role will normally be fulfilled through an Annual Review meeting (visitation) where the Board will receive assurance as to the management and performance of AOP from the Management Committee.

### Management Committee of Armagh Observatory and Planetarium

The Board has delegated primary responsibility for the governance and management of AOP to a Management Committee. The Management Committee has corporate responsibility for ensuring that AOP fulfils the aims and objectives set by the Department and approved by the Minister and for promoting the efficient, economic and effective use of resources. The Management Committee provides leadership, challenge, oversight, support and encouragement to the Director and staff.

The Management Committee comprises:

- three nominees from the Board of Governors;
- six nominees from the Department appointed through open competition;
- one nominee of Queen's University, Belfast;
- one nominee of the Science and Technology Facilities Council (STFC);
- one nominee of the Dublin Institute for Advanced Studies (DIAS);
- a Chair appointed through open competition; and
- up to three additional members co-opted by the Board of Governors. This is by exception and subject to Departmental approval.

### Audit and Risk Assurance Committee (ARAC)

The ARAC is a sub-committee of the Management Committee established in accordance with DAO (DFP) 06/13 - Corporate governance in central government departments: Code of Good Practice NI 2013, and in line with the HM Treasury Audit and Risk Assurance Committee Handbook (DoF 03/18) to advise the Board of Governors, the Management Committee and the Director of AOP as Accounting Officer and to support them in their responsibilities for issues of organisational risks, internal control, governance and their associated assurances and in reviewing the reliability and integrity of these assurances.

### Staffing Policy and Remuneration Committee

The Staffing Policy and Remuneration Committee is a sub-committee of the Management Committee and provides advice and recommendations to the Management Committee on employment issues.

### Research and Education Advisory Committee

The Research and Education Advisory Committee is a sub-committee of the Management Committee and advises it on research and education issues.

Further details on the membership of these Committees are set out in the Governance Statement on pages 31 to 41.

## **Reference and Administrative Details**

### **Name of the Charity**

The charity is registered and operates under the name of The Governors of The Armagh Observatory And Planetarium.

### **Charity number**

Registered with the Charity Commission for Northern Ireland 103948

### **Principal Office**

College Hill, Armagh, BT61 9DG

### **Trustees (and Board of Governors)**

Archbishop J McDowell, (Chair)  
The Very Rev Dean S Forster  
The Venerable Archdeacon T Scott  
The Venerable Archdeacon E Cairns  
Rev Canon W M Adair  
Rev Canon W J A Dawson  
Rev Canon D Hilliard  
Rev Canon J Moore  
Rev Canon B Paine  
Rev Canon R J N Porteus  
Rev Canon Dr P Thompson  
Mr G Cox  
Professor A Fitzsimmons  
Mr R Wilson  
Archbishop E Martin  
Ms S Leslie\* (from 1 June 2021)

\*Due to planned changes as outlined on page 1, Ms Leslie has not been registered as a Charity Trustee.

### **Director and Accounting Officer**

Professor Michael Burton

### **Auditors**

Northern Ireland Audit Office, 106 University Street, BELFAST, BT7 1EU

## Internal Auditors

Cavanagh Kelly, 36-38 Northland Row, Dungannon, BT71 6AP

## Bankers

Danske Bank, Donegal Square West, Belfast, BT1 6JS

## Register of Interests

A Register of Interests is maintained for Board and Committee Members and the Executive Team and is available for inspection at the Principal Address. Declared Interests by Board and Committee Members and the Director are available on the AOP website – [www.armagh.space](http://www.armagh.space).

Related party transactions are shown in note 23 of the accounts.

## Gifts

AOP adheres to the limits and rules laid out in its Management Statement approved by the Department and the guidance in Managing Public Money Northern Ireland (MPMNI). There were no gifts made or accepted during the 2021–22 financial year that exceeded these limits.

## Personal data related incidents

AOP has considered the requirement to report personal data related incidents. It is content that there were no such incidents in the year ended 31 March 2022.

## Disclosure of Audit Information

So far as the Accounting Officer is aware, there is no relevant audit information of which AOP's auditors are unaware. The Accounting Officer has taken all necessary steps to make himself aware of any relevant audit information and to establish that AOP's auditors are aware of that information.

## Events after the end of the reporting period

There have been no events since the end of the financial year requiring disclosure.

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**Archbishop John McDowell**  
Chair of the Board of Trustees  
Date: 3 April 2023



**Professor Michael Burton**  
Director  
Date: 3 April 2023

## Remuneration and Staff Report

The remuneration and staff report sets out AOP's remuneration policy for Board members and senior managers, reports on how that policy has been implemented and sets out the amounts awarded to the Director. In addition, the report provides details on remuneration and staff that users see as key to accountability.

### Remuneration Policy

The pay remit for the Northern Ireland (NI) public sector, including senior civil servants (SCS) in the NICS, is approved by the Minister of Finance. The Minister set the 2021-22 NI public sector pay policy in March 2021.

Annual AOP pay awards are made in the context of the wider public sector pay policy. The pay awards for 2020-21 were paid in November 2021. The pay awards for 2021-22 were paid in February 2022. The pay of staff (other than post-doctoral research assistants who are paid in accordance with academic scales in use by Queens University, Belfast) is based on a system of pay scales for each grade, including SCS, containing a number of pay points from minimum to maximum, allowing progression towards the maximum based on performance.

### Board Members

Board members do not receive any remuneration. They receive travel and subsistence allowances at rates and on conditions determined by AOP, subject to Departmental approval. No Board member receives pension benefits or makes pension contributions in their capacity as a Board member.

### Service Contracts

The Director of AOP, Professor M. G. Burton, is the person in a senior position having authority and responsibility for directing and controlling the activities of the organisation. The service contract of the Director commenced on 1<sup>st</sup> August 2016.

Current terms and conditions for staff are those set out in various policies and individual employment contracts. Senior staff are permanent employees of AOP. The notice period for senior staff is three months. Termination payments are in accordance with contractual terms and those of the principal Civil Service Pension Scheme (NI).

### Remuneration (including Salary and Pension Entitlements) (Audited Information)

The following tables provide details of the remuneration and pension entitlements of the Director of the organisation.

Single Total Figure of Remuneration of Director							
Official	Salary (£'000)		Pension Benefits* (£'000)		Total (£'000)		Percentage Change
	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	
M.G. Burton	85-90	80-85	23	29	100-105	100-105	0.65%

\*The value of pension benefits accrued during the year is calculated as (the real increase in pension multiplied by 20) plus (the real increase in any lump sum) less (the contributions made by the individual). The real increases exclude increases due to inflation and any increase or decrease due to a transfer of pension rights.

'Salary' includes gross salary to the extent that it is subject to UK taxation. There was no overtime, benefit-in-kind, bonus or other allowances. The salary of Director shown above is based on the Northern Ireland Senior Civil Service Grade 5 pay scale.

### Pay Ratios

AOP is required to disclose the relationship between the remuneration of the Director and the lower quartile, median and upper quartile remuneration of the organisation's workforce. The banded remuneration of the Director in the financial year 2021-22 was £85,000 - £90,000 (2020-21: £80,000 - £85,000). The relationship between the mid-point of this band and the remuneration of AOP's workforce is disclosed below.

2021-22	25 <sup>th</sup> percentile	Median	75 <sup>th</sup> percentile
Total remuneration	£18,783	£29,307	£39,324
Pay ratio	4.7:1	3.0:1	2.2:1

Total remuneration includes salary, overtime and performance related bonuses. It does not include severance payments, employer pension contributions and the cash equivalent transfer value of pensions. Remuneration ranged from £16,302 to £87,500.

The percentage changes in respect of AOP are shown in the following table. It should be noted that the calculation for the Director is based on the mid-point of the band within which their remuneration fell in each year.

Percentage change for:	2021-22 v 2020-21	2020-21 v 2019-20
Average employee salary and allowances	-2.9%	5.1%
Director's salary and allowances	6.1%	0.0%
Average employee performance pay and bonuses	-24.0%	58.5%

No performance pay or bonus was payable to the Director in these years.

### Pension Entitlements (Audited Information)

Official	Accrued pension at pension age as at 31/03/22	Real increase in pension at pension age	Accrued Lump Sum at 31/03/22	Real Increase in Lump Sum	CETV at 31/03/22	CETV at 31/03/21	Real Increase in CETV
	£'000	£'000	£'000	£'000	£'000	£'000	£'000
M.G. Burton	10	2	-	-	144	115	18

The CETVs above have been calculated in accordance with guidance from the Department of Finance in Employer Pension Notice EPN 12-2022. When calculating the real increase in CETV and the pension benefits accrued during the year 2021-22 for the single total figure of remuneration, NILGOSC takes account of inflation. The CPI increase for September 2021 was 3.1%. The in-service revaluation rate for the Career Average Revalued Earnings Scheme was also 3.1%.

### Pension Scheme

Pension benefits are provided through the Northern Ireland Local Government Officers' Superannuation Committee Pension Scheme (NILGOSC). Retirement pension will be based on 1/49<sup>th</sup> of salary paid in year and pension is based on career average earnings. Details can be obtained at <http://www.nilgosc.org.uk>.

Active members of the pension scheme will receive an Annual Benefit Statement. The accrued pension quoted is the pension the member is entitled to receive when they reach their scheme pension age, or immediately on ceasing to be an active member of the scheme if they are at or over pension age.

Employee contribution rates for all members for the period covering 1 April 2021–31 March 2022 are as follows:

Pensionable Pay	Contribution Rate
£0 to £15,000	5.5%
£15,001 to £23,000	5.8%
£23,001 to £38,400	6.5%
£38,401 to £46,600	6.8%
£46,601 to £92,300	8.5%
More than £92,300	10.5%

Employer contribution rates are determined by the Scheme's actuary every three years. Following the results of the 2019 actuarial valuation, the Committee agreed with its actuary the employer contributions and deficit recovery contributions for the following three years, effective from 1 April 2020. The next valuation was due as at 31 March 2022.

### Cash Equivalent Transfer Values

A Cash Equivalent Transfer Value (CETV) is the actuarially assessed capitalised value of the pension scheme benefits accrued by a member at a particular point in time. The benefits valued are the member's accrued benefits and any contingent spouse's pension payable from the scheme. A CETV is a payment made by a pension scheme or arrangement to secure pension benefits in another pension scheme or arrangement when the member leaves a scheme and chooses to transfer the benefits accrued in their former scheme. The pension figures shown relate to the benefits that the individual has accrued as a consequence of their total membership of the pension scheme, not just their service in a senior capacity to which disclosure applies. The CETV figures include the value of any pension benefit in another scheme or arrangement which the individual has transferred to the NICS pension arrangements.

They also include any additional pension benefit accrued to the member as a result of their purchasing additional years of pension service in the scheme at their own cost. CETVs are calculated in accordance with The Occupational Pension Schemes (Transfer Values) (Amendment) Regulations 2015 and do not take account of any actual or potential benefits resulting from Lifetime Allowance Tax which may be due when pension benefits are taken.

### Real increase in CETV

This reflects the increase in CETV effectively funded by the employer. It does not include the increase in accrued pension due to inflation, contributions paid by the employee (including the value of any benefits transferred from another pension scheme or arrangement) and uses common market valuation factors for the start and end of the period. However, the real increase calculation uses common actuarial factors at the start and end of the period so that it disregards the effect of any changes in factors and focuses only on the increase that is funded by the employer.

### Total Permanently Employed Staff Costs (Audited Information)

	Permanent staff £	Others <sup>1</sup> £	2021-22 £	2020-21 £
Wages and salaries	1,089,991	208,409	1,298,400	1,238,912
Social security costs	116,346	15,728	132,074	118,077
Employer's pension contributions	207,776	30,987	238,763	215,377
Defined benefit pension additional service cost	376,000	-	376,000	183,000
	1,790,113	255,124	2,045,237	1,755,366

<sup>1</sup> "Others" includes £46,080 for agency staff

### Average staff numbers (Audited Information)

	Permanent staff	Others <sup>2</sup>	2021-22 Total Number	2020-21 Total Number
Average staff numbers	24.9	10.0	34.9	32.3

<sup>2</sup> "Others" includes 6.0 fixed term, 2.3 casuals, 1.0 agency staff and 0.7 JobStart

### Staff Composition – permanent employees (full time equivalent)

	Male	Female
Directors/senior managers	2.6	2.0
Other employees	8.3	12.0

### Staff Turnover

	2021-22	2020-21
Leavers as a percentage of average staff in post	8.9%	1.7%

### Sickness Absence (Audited Information)

Staff sickness for the period 1 April 2021 to 31 March 2022 totalled 101 days (2021: 93 days (restated)) which equates to an average per FTE of 1.37% (2021: 1.43% (restated)). 2021 comparisons have been restated to exclude non-working weekends.

### Expenditure on External Consultancy (Audited Information)

Expenditure on external consultancy during the year was £nil (2021-22: £nil).

### Off-payroll Engagements (Audited Information)

There were no "off-payroll" engagements in place as at 31 March 2022, nor were any arrangements entered into between 1 April 2021 and 31 March 2022.



### Exit Packages (Audited Information)

Exit package cost band	No of compulsory redundancies	No of other departures agreed	Total no. of exit packages by cost band	Total no. of exit packages by cost band
	2021-22	2021-22	2021-22	2020-21
Total no. of exit packages	-	-	-	-
Total resource cost	Nil	Nil	Nil	Nil

### Diversity and Inclusion

AOP has an obligation under Section 75 of the Northern Ireland Act to ensure that equality of opportunity and good relations are central to policy making, policy implementation and review as well as service delivery. AOP monitor the composition of their workforce in terms of community background and sex and use an equal opportunities monitoring form questionnaire. AOP complete an annual Fair Employment Monitoring return to the Equality Commission detailing staff composition and that of job applicants to AOP posts.

In the AOP Strategic Plan 2021-26 we state that having Fair and Equitable Employment Policies and Procedures is one of our key elements in delivering high standards. AOP have a number of policies in place including an Equal Opportunities Policy.

AOP signed up for Diversity Mark Accreditation in December 2021 and formally applied for the Bronze Award in July 2022. Three Equality, Diversity and Inclusion targets have been set as follows:

- Develop an Equality, Diversity and Inclusion Strategy;
- To increase the number of female research staff at AOP from 2 to 4; and
- To increase female representation on the AOP Management Committee from 3 to 5.

AOP achieved Juno Practitioner status in June 2019. This is an award scheme that recognises and rewards university physics departments, schools of physics, and related institutes and organisations that can demonstrate they have taken action to address gender equality at all levels and to foster a more inclusive working environment. We are currently in the process of applying for Juno Champion in April 2023. This application is will involve satisfying the following 6 Juno Principles:

- Principle (1) Robust organisational framework - A robust organisational framework to deliver equality of opportunity and reward;
- Principle (2) Appointment and Selection - Appointment and selection processes and procedures that encourage men and women to apply for academic posts at all levels;
- Principle (3) Career Progression and Promotion - Departmental structures and systems that support and encourage the career progression and promotion of all staff and enable everyone to progress and continue in their careers;
- Principle (4) Open and Inclusive Culture - Departmental organisation, structure, management arrangements and culture that are open, inclusive and transparent, and encourage the participation of all staff;
- Principle (5) Flexible Working - Flexible approaches and provisions that enable individuals, at all career and life stages, to optimise their contribution to their department, their institution and to science, engineering and technology; and
- Principle (6) Professional Conduct - An environment where professional conduct is embedded into departmental culture and behaviour.

Signed:



**Professor Michael Burton**  
**Accounting Officer for Armagh Observatory and Planetarium**

**Date: 3 April 2023**

## **Statement of the Responsibilities of the Governors and Accounting Officer**

Under the Audit and Accountability (Northern Ireland) Order 2003, the Governors are responsible for preparing for each financial year and for preparing a statement of accounts in the form and on the basis set out as the Department for Communities, with the approval of the Department of Finance, shall direct. The accounts are prepared on an accruals basis and must give a true and fair view of the state of affairs of AOP and of its income and expenditure, Statement of Financial Activities and cash flows for the financial year.

In preparing the accounts, the Accounting Officer is required to comply with the requirements of the Government Financial Reporting Manual and in particular to:

- observe the accounts direction issued by the Department of Finance, including the relevant accounting and disclosure requirements, and apply suitable accounting policies on a consistent basis;
- make judgements and estimates on a reasonable basis;
- state whether applicable accounting standards as set out in the Government Financial Reporting Manual have been followed, and disclose and explain any material departures in the accounts;
- prepare the accounts on a going concern basis; and
- confirm that the Annual Report and Accounts as a whole is fair, balanced and understandable and take personal responsibility for the Annual Report and Accounts and the judgements required for determining that it is fair, balanced and understandable.

The Department for Communities has appointed Professor M.G. Burton as Accounting Officer of AOP. The responsibilities of an Accounting Officer, including responsibility for the propriety and regularity of the public finances for which the Accounting Officer is answerable, for keeping proper records and for safeguarding AOP's assets, are set out in Managing Public Money Northern Ireland.

## **Statement of Disclosure of Information to the Auditors**

So far as the Accounting Officer of Armagh Observatory and Planetarium, in office at the date of the approval of these financial statements, is aware:

- there is no relevant audit information relating to these respective charitable organisations of which the auditors are unaware;
- he has taken all the steps that he ought to have taken as Accounting Officer in order to make himself aware of any relevant audit information relating to these charitable organisations and to establish that the auditors are aware of that information;
- he confirms that the Annual Report and Accounts as a whole is fair, balanced and understandable; and
- he confirms that he takes personal responsibility for the Annual Report and Accounts and the judgements required for determining that it is fair, balanced and understandable.

# Governance Statement

AOP is a Non-Departmental Public Body established under The Armagh Observatory and Planetarium (Northern Ireland) Order 1995.

## 1. Compliance with Corporate Governance Code

In 2013 the Department of Finance and Personnel published Corporate Governance in Central Government Departments: Code of Good Practice NI. The Code draws on best practice in the public, private and charity sectors by reinforcing the importance of corporate governance as a pre-requisite to achieving good financial management; reflecting changes in governance best practice, including increased emphasis on good leadership; and promoting better governance arrangements within departmental families.

The Code is written for departments, concentrating throughout on key principles which will have wider application for other parts of the public sector. Such bodies (including arms-length bodies (ALBs)) are encouraged to consider and adopt the practices set out in the Code wherever it is relevant and practical and suits their business needs.

AOP in so far as they are relevant for an arms-length body, complies with the principles of good practice in the Corporate Governance Code.

## 2. Governance Framework

### Accounting Officer

Name	Accounting Officer
Professor Michael Burton – Director and Chief Executive	From 1 September 2016 onwards

### Board of Governors

AOP is governed by a Board of Governors. Membership of the Board of Governors consists of:

- the Church of Ireland Archbishop of Armagh;
- the Dean of the Church of Ireland Cathedral of Armagh;
- the other members of the Chapter of the Church of Ireland Cathedral of Armagh;
- one DfC nominee;
- one Queen’s University Belfast (QUB) nominee; and
- up to three additional members nominated by the Board of Governors.

In 2021-22, one Board of Governors’ nominee appointment was made. There are currently no vacant positions on the Board of Governors.

BOARD OF GOVERNORS			
GOVERNOR	DATE OF APPOINTMENT	DATE OF EXPIRY	MEETINGS ATTENDED (max. 2)
Chair: Archbishop J McDowell	28 April 2020	None	2
The Dean Very Rev S Forster	14 February 2021	None	2
The Venerable Archdeacon T Scott	9 November 2006	None	2
The Venerable Archdeacon E Cairns	13 December 2020	None	2
Rev Canon W M Adair	10 September 2008	None	0
Rev Canon W J A Dawson	1998	None	0
Rev Canon D Hilliard	13 March 2016	None	2

Rev Canon J Moore	13 March 2016	None	2
Rev Canon W B Paine	7 May 2017	None	0
Rev Canon R J N Porteus	1998	None	1
Rev Canon Dr P Thompson	13 January 2019	None	2
Professor A Fitzsimmons	18 April 2019	1 May 2024	2
Mr R Wilson	1 December 2019	30 November 2024	1
Archbishop E Martin	1 January 2021	31 December 2025	1
Ms S Leslie	From 1 June 2021	31 May 2026	0 (from 1)
Mr G Cox	1 March 2021	28 February 2026	2

At the annual meeting on 19 May 2021, held via Zoom, the Board of Governors approved the appointment of Ms Sammy Leslie, the continuing membership of Mr Wilson as one of its nominees on the Management Committee and the appointment of Mr Cox as a nominee on the Management Committee. In addition, it noted that the Chapter's nominee to the Management Committee would be effective from the date of nomination when advised.

The Board approved changes to both the Board of Governors and Management Committee Terms of Reference and agreed in principle, to transfer the role of Charity Trustee from the Board to the Management Committee.

The Board reviewed the minutes from the Management Committee and the Audit and Risk Assurance Committee meetings between June 2021 and March 2022.

The Board formally retrospectively approved the Annual Report and Accounts 2019-20 and approved the 2020-21 draft Annual Report and Accounts, subject to the inclusion of outstanding information and any adjustments required as a consequence of same and granted the Archbishop delegated authority to sign them off on its behalf when completed. The Board considered the Management Report for 2020-21 which included the Director's Report, Corporate Plan Objectives, Key Performance Indicators and the Risk Register as at 11 May 2021.

The Board considered the draft 2021-26 Strategic Plan and draft 2021-22 Business Plan and delegated authority to the Management Committee to take both forward to completion.

The Board is satisfied that comprehensive arrangements are in place to ensure that high-quality information is received to enable it to make informed decisions. Internal controls are in place to validate the accuracy and completeness of information presented to the Board.

With regard to a land issue the Board agreed to enter into a Joint Agreement with ABC Council and Royal School, Armagh and to amend an existing lease to allow extended usage of sports pitches and at its Special meeting authorised the granting of a lease of AOP land.

Minutes of meetings record the business carried out and actions agreed.

### **Management Committee of Armagh Observatory and Planetarium**

The Management Committee comprises:

- a Chair appointed through open competition;
- three nominees from the Board of Governors;
- six nominees from DfC;
- one nominee of the Queen's University, Belfast;
- one nominee of the Science and Technology Facilities Council (STFC);
- one nominee of the Dublin Institute for Advanced Studies (DIAS); and
- up to three additional members co-opted by the Board of Governors. This is by exception and subject to Departmental approval.

During 2021-22 appointments were made to two Board of Governors nominee positions. There are currently no vacant positions on the Management Committee. Special Meetings of the Management Committee took place on 5 and 18 May 2021 and 9 February 2022 to consider the land matter in relation to the Joint Agreement referred to above.

<b>MANAGEMENT COMMITTEE</b>				
<b>MEMBER</b>	<b>DATE OF APPOINTMENT</b>	<b>DATE OF EXPIRY</b>	<b>MEETINGS ATTENDED (max. 4)</b>	<b>SPECIAL MEETING (max. 3)</b>
Mr J Briggs (Chair)	1 January 2018	31 December 2027	4	3
Professor L Harra	1 November 2014	30 April 2024	4	2
Mr S Brown	1 November 2014	30 April 2024	4	3
Mr P McGurgan	1 November 2014	30 April 2023	2	3
Professor M Mathioudakis	11 November 2016	10 November 2026	4	3
Mr R Wilson	1 December 2019	30 November 2024	3	Not present due to conflict
Dr C Jackman	1 January 2021	31 December 2025	3	3
Dr M Darnley	1 January 2021	31 December 2025	3	2
Mr P Kennedy	1 March 2021	28 February 2026	4	3
Dr K Lemon	1 March 2021	28 February 2026	3	3
Mr E Rooney	1 March 2021	28 February 2026	4	3
Mr G Cox	19 May 2021	18 May 2026	4	1 (from 1)
Rev Canon W M Adair	15 September 2021	14 September 2026	2 (from 3)	0 (from 1)

During 2021-22 the Management Committee considered a wide range of business. The June meeting was held via Zoom. The subsequent quarterly meetings were of a hybrid nature. In June it reviewed its own Terms of Reference and those of its two sub-committees, the Audit and Risk Assurance Committee and the Staffing Policy and Remuneration Committee. It also considered draft terms of reference for a new sub-committee, the Research and Education Advisory Committee. Membership of all three sub-committees were approved in June.

In September the Committee received a presentation on progress with Museum Accreditation and approved the associated Policy Documentation Handbook. The Terms of Reference for all three sub-committees were approved and the Committee considered proposals to delegate Charity Trustee status from the Board of Governors to the Management Committee and in respect of the Management Committee Annual Board Evaluation. The 2021-2026 Strategic Plan was approved.

Throughout the year the Committee received regular updates from its sub-committees and approved relevant reports. Regular governance reports such as the Bi-Annual Assurance Statement, the Risk Register, Key Performance Indicators and Finance monitoring reports were reviewed and approved.

The Management Committee also received updates on progress in delivering the AOP Vision and held a number of Special Meetings and Workshops associated with the AOP/Armagh Leisure Village Development Proposals.

A summary report of an audit of the Management Committee Skills and Attributes was noted in December 2021.

Internal controls are in place to validate the accuracy and completeness of information presented to the Management Committee.

Minutes of the meetings record the business carried out and actions agreed.

### **Audit and Risk Assurance Committee**

The Audit and Risk Assurance Committee is drawn from the Management Committee and comprises a minimum of four and maximum of five members.

<b>AUDIT AND RISK ASSURANCE COMMITTEE</b>	
<b>MEMBER</b>	<b>MEETINGS ATTENDED (max. 4)</b>
Mr S Brown (Chair) (from June 2021):	4
Professor L Harra	4
Mr P McGurgan	3
Mr P Kennedy	4
Mr E Rooney	4

During 2021-22 the Audit and Risk Assurance Committee considered reports from Internal Audit on progress against their audit plan and progress on outstanding recommendations; reports from external audits on the 2020-21 Annual Report and Accounts; review of the Accounting Officer's Governance Statement and Assurance Statements; the Board's Assurance Statement and review of the risk register. The Risk Register was reformatted to align the risks to the new Strategy. Throughout the year particular attention was given to cyber security and associated risks.

The Committee is satisfied that the integrated approach, the frequency of meetings, the breadth of the business undertaken, the skills of Members and the range of attendees at meetings of the Committee has allowed the Committee to meet the governance requirements of the organisation and assisted the Management Committee to demonstrate its stewardship of the public resources with which it is charged.

The Committee is satisfied that the organisation has robust risk management arrangements in place which are in line with the good practice in the HM Treasury 'Orange Book' and are reviewed regularly by the Management Committee.

There is one Internal Audit recommendation from 2020-21 outstanding and the Committee is satisfied, from the evidence provided at meetings, that a work programme exists to complete this. There were 5 recommendations arising from Internal Audits carried out in 2021-22 which are not yet due.

Minutes of the meetings record the business carried out and actions agreed.

### Staffing Policy and Remuneration Committee

The Staffing Policy and Remuneration Committee is a sub-committee of the Management Committee which meets up to four times a year. Its purpose is to provide advice and recommendations to the Management Committee on employment issues as set out in its Terms of Reference. The membership is drawn from the Management Committee and comprises a minimum of four and maximum of five members.

In 2021-22, amongst other matters, the Committee considered:

- revised terms of reference;
- staffing and recruitment, including skills gaps analysis;
- staff related policies:
- working arrangements post-pandemic;
- staff survey and engagement; and
- was updated on a range of human resources issues including progress against the Human Resources Strategy and Action Plan.

<b>STAFFING POLICY AND REMUNERATION COMMITTEE</b>	
<b>MEMBER</b>	<b>MEETINGS ATTENDED (max. 4)</b>
Mr E Rooney (Chair) (from June 2021)	4
Mr Brown	4
Mr J Briggs	3
Dr K Lemon	3
M P Kennedy	4

### Research and Education Advisory Committee

The Research and Education Advisory Committee is a sub-committee of the Management Committee which was established during the 2021-22 financial year to advise on research and education issues. The membership is drawn from the Management Committee and comprises a minimum of four and maximum of five members.

<b>RESEARCH AND EDUCATION ADVISORY COMMITTEE</b>	
<b>MEMBER</b>	<b>MEETINGS ATTENDED (max. 2)</b>
Prof L Harra (Chair)	2
Prof M Darnley	2
Dr K Lemon	2
Prof M Mathioudakis	2

In 2021-22, amongst other matters, the Committee considered:

- its terms of reference;
- research excellence framework (ref) / ref-equivalent exercise – recent and future;
- funding opportunities;
- outreach and education future excellence assessments; and
- research and education related policies.

### **Conflicts of Interest**

The organisation maintains a register of interests to ensure that potential conflicts of interest can be identified and addressed in advance of Board, Management Committee and other Committee discussions. The register is formally revisited on an annual basis. Where conflicts exist, they are recorded in the Committee minutes and the Chair of the meeting decides the most appropriate way of managing the conflict. This may include that member not taking part in discussions or making decisions on certain matters or being excluded for part or all of that meeting.

The Register of Interests for Board of Governors, Management Committee and senior staff is published on the AOP website in accordance with central government guidance.

### **Directors and Secretary**

Professor Michael Burton, Director and Chief Executive.

The Corporate Manager provides a range of secretarial support services to the Board of Governors, Management Committee and Audit and Risk Assurance Committee, the HR and Policy Officer provides secretarial support to the Staffing Policy and Remuneration Committee and the Executive Officer to the Research and Education Advisory Committee.

## **3. Business Planning and Risk Management**

### **Business Planning**

*‘Our mission is the pursuit of knowledge and understanding of the cosmos, and the sharing of that knowledge in order to inspire future generations and enrich the intellectual, economic, social and cultural life of all.’*

*‘Our vision is to be recognised as an international centre of scientific excellence for the pursuit of astronomy and the public understanding of science, for our capacity for innovation and our extraordinary heritage, a place our community can be proud of.’*

The pillars that support us are – Knowledge, Legacy, People and Engagement.

The five-year Strategic Plan 2021-26 is built around four strategic themes - Enduring Relevance, National and International Standing, Offering More and Pursuing our Priorities.

The Strategic Plan aligns closely with the aims and objectives of the Observatory and Planetarium’s sponsor - the Department for Communities (DfC) - and with the broader aims and objectives of the Northern Ireland Executive’s Programme for Government. The organisation’s Strategic Plan 2021-26 received Departmental approval on 17 August 2021.

The work of the Observatory encompasses both internationally acclaimed research and a unique cultural heritage — scientific, historical, architectural — as well as maintaining the unique daily climate series (the longest daily series from a single site in the UK and Ireland) and undertaking a world-class programme of science in the community, which complements the Planetarium’s main business of education.

The Planetarium’s main business is education, and all age and social groups are welcome to visit. The educational programmes and demonstrations are designed to include participation by children of pre-nursery age up to senior citizens and all age groups in between. The primary educational aim of the Planetarium is to endorse and promote the Science, Technology, Engineering, Arts and Mathematics (STEAM) agenda which promotes scientific careers to young people. All of the ancillary activities support the primary aim, with the additional target of offering excellent value for money, both to the visitors taking part and to the public purse. The Planetarium maintains a focus on being inclusive so that all children can enjoy the Planetarium experience.

Full details of all the Observatory and Planetarium's activities are provided in comprehensive Annual Reports which are available online at: [www.armagh.space](http://www.armagh.space)

No Ministerial Directions have been given regarding the work of AOP.

## **Risk Management**

Risk Management is an essential element of AOP's corporate governance framework and is closely linked to the system of internal control and business planning process. A robust risk management process assists AOP in identifying and managing issues which may hinder the achievement of objectives. The arrangements are regularly reviewed.

As well as ensuring that there is an effective system in place to deal with threats to AOP's aims and objectives, the organisation encourages a proactive approach to innovation and well-managed risk taking where there is potential to realise sustainable improvements in the organisation's research and educational services. For this reason, the organisation's Risk Appetite is 'Open'.

The Management Committee sets the risk appetite for AOP. The Accounting Officer, Senior Management Team and other staff are responsible for ensuring that residual risks are reduced to a level as low as reasonably practicable and wherever possible consistent with the level of risk appetite established by the Management Committee.

Quarterly updates are provided to the Audit and Risk Assurance Committee on the development and implementation of the risk management process across AOP. The Audit and Risk Assurance Committee provides the Accounting Officer with objective advice on issues concerning the risk, control and governance of the organisation and the associated assurances. An update on the main points considered by the Audit and Risk Assurance Committee is provided to the Management Committee following each meeting.

## **4. Fraud and Information Risk**

The Accounting Officer has overall responsibility for managing the risk of fraud including:

- developing a fraud risk profile and undertaking a regular review of the fraud risks associated with each of the key organisational objectives in order to keep the profile current;
- establishing an effective fraud prevention policy and fraud response plan, commensurate with the level of fraud risk identified in the fraud risk profile;
- designing an effective control environment to prevent fraud commensurate with the fraud risk profile;
- operating appropriate pre-employment screening measures;
- establishing appropriate mechanisms for reporting fraud risk issues, reporting significant incidents of fraud, and coordinating assurances about the effectiveness of fraud prevention policies to support the Governance Statement;
- liaising with the Audit and Risk Assurance Committee;
- ensuring that all staff are aware of the organisation's fraud prevention policy and know what their responsibilities are in relation to combating fraud;
- ensuring fraud awareness training is provided as appropriate and, if necessary, more specific fraud prevention training and development is provided to relevant staff;
- ensuring that vigorous and prompt investigations are carried out if fraud occurs, is attempted or is suspected by the establishment of a Fraud Investigation Oversight Group;
- ensuring, where appropriate, legal and/or disciplinary action against perpetrators of fraud;
- ensuring, where appropriate, disciplinary action against supervisors where supervisory failures have contributed to the commission of fraud;
- ensuring, where appropriate, disciplinary action against staff who fail to report fraud;
- taking appropriate action to recover assets and losses;
- ensuring that appropriate action is taken to minimise the risk of similar frauds occurring in future; and
- ensuring that an anti-fraud culture is promoted throughout the organisation in line with the seven Nolan Principles of Public Life.



Risks to data and information held by the organisation are owned and managed by individuals designated as information asset owners. The Executive Officer responds to requests for information under the Data Protection and Freedom of Information Acts following consultation with the Accounting Officer and the organisation's governing committees, as appropriate.

AOP operates a Whistleblowing Policy which informs all members of the organisation of the standards of behaviour expected of them in carrying out their duties, and to provide information on the procedures to follow if a situation arises in which they are required to act in a way which is believed by them to be illegal, improper, or in breach of the Nolan Principles.

## **5. Governance and Accountability**

AOP seeks to achieve excellence in good governance, in particular the precepts: (1) leadership; (2) effectiveness; (3) accountability and (4) sustainability.

The Chair has a particular leadership responsibility for securing the sustainability and vitality of the organisation in the long term; giving advice and direction in formulating AOP's forward look and overall strategy; ensuring that account is taken of guidance provided by the Minister or the Department; promoting the efficient and effective use of staff and other resources; encouraging high standards of probity amongst staff and Board and committee members alike; and ensuring that the Board and its committees meet at regular intervals throughout the year and that the Minutes of meetings accurately record the decisions taken and, where appropriate, the views of individual Board members.

Within the AOP, leadership is exercised by the Director and his Senior Management team who are responsible for the management and effective operation of their organisation. Their operational responsibilities include:

- developing, implementing and monitoring the strategic and operational plans;
- undertaking financial management and Accounting Officer responsibilities;
- managing and developing a team of highly qualified professional and administrative staff;
- identifying and attracting sources of external income;
- promoting their respective organisations in relevant local, national and international arenas; and
- promoting Public Understanding of Science with the objective of improving the level of scientific literacy in the community and to ensure a strong link with government policy and the STEM agenda.

Members of the Board of Governors and of the Management Committee and their various sub-committees exercise an effective challenge function on the leadership team in accord with their respective roles in the organisation. They also provide guidance and advice on strategic and operational matters such as Human Resource issues, accountability and relationships with stakeholders.

The members of these committees are drawn from a very wide community background within, and beyond, Northern Ireland, and provide the organisation with a correspondingly wide range of expert knowledge and advice. All the committees of AOP operate with full transparency and accountability, and over the last year have proved effective in the discharge of their duties and responsibilities.

It was agreed by the Board of Governors and the Management Committee that the governance arrangements in place removed the need for the current Board of Governors to complete an internal self-assessment of its effectiveness.

The Board of Governors and supporting Committees receive assurances from the Director and his Senior Management Team and Internal Audit that the governance and accountability processes are being managed effectively.

## **6. Sources of Independent Assurance**

### **Internal Audit**

CavanaghKelly was appointed as Internal Auditors for the 3 years 2020-21 – 2022-23 using CPD as the Centre of Procurement Expertise. Their work was carried out in accordance with the Public Sector Internal Audit Standards.

The three-year Audit Strategy was approved by the Audit and Risk Assurance Committee in March 2021. The 2022-23 Audit Plan was approved by the Audit and Risk committee in March 2022.

The Audit and Risk Assurance Committee considered reports on the following areas:

<b>Audit Assignment</b>	<b>Assurance Rating</b>
Review of Income	Satisfactory
Review of Fixed & Heritage Assets	Satisfactory
ICT Management	Limited
Internal Audit Follow Up 2021-22	Satisfactory progress

An overall 'satisfactory' internal audit assurance opinion has been provided.

Of the new issues identified by internal audit during 2021-22 there was only one high priority issue:

ICT Conditional Access – many researchers at AOP have admin rights to certain computer systems and this was identified as a significant risk in the Cyber Essentials security assessment in November 2020. When reviewing the Azure multi-factor authentication and the frequency that users must complete the process, internal auditors noted that two users fall into both SMT and Researcher groups and that these users can use one device to complete both roles, effectively meaning that they have the admin rights of researchers and the access rights of SMT members.

AOP have actively continued to assess risk and suitability of mitigations in discussion with expert advisors and other institutions to identify if additional mitigations are required and/or if a more suitable option is viable. This is ongoing and progress reported regularly to Management Committee.

## **External Audit**

The Comptroller and Auditor General (CAG) is required to audit the financial statements under *The Armagh Observatory and Planetarium (Northern Ireland) Order 1995*. The CAG is responsible for reporting whether in his/her opinion the financial statements give a true and fair view and whether they and the part of the Remuneration Report to be audited have been properly prepared in accordance with *The Armagh Observatory and Planetarium (Northern Ireland) Order 1995* and DfC directions made thereunder. The CAG is required to report whether, in his/her opinion, in light of the knowledge and understanding of AOP and its environment obtained in the course of the audit, he/she has identified any material misstatements in the Trustees' Annual Report and whether the information which comprises the Statement of the Responsibilities of the Governors and Accounting Officers and Governance Statement, as included within the Annual Report, is consistent with the financial statements. He/she also reports on whether, in his/her opinion, in all material respects, the expenditure and income presented in the financial statements have been applied to the purposes intended by the Assembly and whether the financial transactions conform to the authorities which govern them.

A representative from the Northern Ireland Audit Office is invited to all Audit and Risk Assurance Committee meetings.

## **7. Review of the Effectiveness of the System of Internal Governance**

The system of internal governance is designed to manage risk to a reasonable level, rather than to eliminate all risk of failure to achieve certain policies, aims and objectives; it can therefore only provide reasonable and not absolute assurance of effectiveness. The system of internal governance is based on an ongoing process designed to identify and prioritise risks to the achievement of the AOP policies, aims and objectives; to assess the likelihood of the events occurring and the impact should they be realised; and to manage the risks effectively, efficiently and economically. The system of internal governance has been in place in AOP for the year ended 31 March 2022 and up to the date of approval of the annual accounts, and accords with Department of Finance guidance.

As previously detailed in Section 2, the responsibilities of the Accounting Officer include the need to maintain a sound system of internal control which supports the achievement of the organisation's policies, aims and objectives. The review of the effectiveness of the system of internal governance has been informed by the assurances provided by relevant parties such as: Internal Audit and the Senior Management Team. Where weaknesses have been identified these have been promptly drawn, through normal reporting mechanisms, to the attention of the Audit and Risk Assurance Committee, Management Committee and/or Board of Governors, as appropriate.

The main procedures in place to monitor the effectiveness of the system of internal governance are as follows:

- ongoing independent assessment of the Observatory’s research outputs;
- regular reports by financial staff on progress against principal financial targets and the projected financial outcome for the year and progress reports by staff responsible for major projects;
- detailed progress reports to the Management Committee and Board of Governors at their regular meetings and inclusion of performance measures and results against targets in the annual operating plan;
- annual reports on the system of internal control from internal auditors to the Audit and Risk Assurance Committee;
- regular Accountability meetings with officials from the Sponsor Department to consider operational and strategic issues and matters relating to the system of internal control;
- Bi-Annual Assurance Statements and ALB Quarterly Monitoring Data Collection Templates submitted to the Sponsor Department;
- periodic review of the AOP Risk Register by the Audit and Risk Assurance Committee, the Management Committee the Accounting Officer and Senior Management Team and the Sponsor Department;
- continuous assessment of the quality of research through peer review of grant applications, applications for telescope time, and the submission of scientific papers to academic journals of international standing by Armagh Observatory staff;
- peer review of the research quality, capability and output of the Observatory, and through participation in an objective external Assurance Committee, which provide an opinion on the adequacy and effectiveness of the system and contain recommendations for improvement; and
- annual reports from Northern Ireland Audit Office to the Audit and Risk Assurance Committee, the Management Committee and the Board of Governors on the annual accounts, providing an opinion on the state of affairs of the organisation and its total incoming resources and expenditure of resources.

All reports based on the internal and external audits include opinions on the adequacy and effectiveness of risk management and the control framework in place. These matters are considered by the Audit and Risk Assurance Committee and are reported by the Audit and Risk Assurance Committee Chair to the Management Committee and the Board of Governors.

A range of weaknesses identified in AOP’s control systems and internal governances are set out within the next section. Upon identification, plans were immediately put into place to addresses these issues.

## 8. Internal Governance Divergences

Of the 4 internal audit recommendations from 2020-21, there is currently 1 partially implemented as follows:

<b>Recommendation</b>	<b>Priority</b>	<b>Status</b>
GDPR – the draft Records Management Policy and Retention and Disposal Schedules should be finalised as soon as possible.	Medium	Draft policy and schedules are with PRONI for consideration. Completion pending confirmation by PRONI.

During its audit for 2021-22, NIAO identified the following issue:

Finding and Recommendation	Priority	Management Response
<p>Following the onset of the Covid-19 pandemic, in March 2020, AOP required urgent server hosting and data storage services in order to facilitate working from home. Due to the urgency, a procurement exercise was not carried out and a direct award contract (DAC) was entered into. Once the initial pressure had passed, this approach should have been reassessed and either a procurement exercise instigated or, if AOP wanted to continue with the DAC, the need for DfC approval should have been considered. From March 2020 to August 2022 expenditure totalled £33,703. This value breached the Accounting Officer's delegated limits and so became irregular.</p> <p>It was recommended that AOP seek DfC approval to regularise this spend. This was received on 20th February 2023. AOP should ensure procedures are put in place to monitor any future DACs so that appropriate approvals can be sought before irregular spend is incurred.</p>	<p>1</p>	<p>The DfC has retrospectively approved the expenditure of £33,703. AOP are named on the NICS collaborative agreement ID 3095831 Collaborative Call Off Contract for Microsoft Licensing Solutions Partner (LSP) - which started on 16/08/2021. AOP's requirements going forward can be met within the terms of that contract and migration to the contract commenced on 21 March 2023.</p>

## 9. Conclusion

Armagh Observatory and Planetarium has an effective governance structure and is operating to a high standard of integrity and probity.

In signing this report, I have taken assurances, where available, from the Audit and Risk Assurance Committee and I will continue to monitor the Internal Audit and Northern Ireland Audit Office recommendations to ensure that all issues are appropriately addressed.

To the best of my knowledge this report provides a fair and accurate reflection of the business of Armagh Observatory and Planetarium and of the status of the controls and checks that have been put in place to regulate and inform the organisation's committees.

Signed:



Date: 3 April 2023

**Professor Michael Burton**  
**Accounting Officer**  
**Armagh Observatory & Planetarium**

## Refereed Journal Publications: April 2021 – March 2022

- Bagnulo S., Landstreet J. D.**, 2021, New insight into the magnetism of degenerate stars from the analysis of a volume-limited sample of white dwarfs, *Monthly Notices Royal Astronomical Society*, 507, 5902, doi:10.1093/mnras/stab2046, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.507.5902B>
- Bellstedt S., et al., inc. **Lara-López M. A.**, 2021, Galaxy and mass assembly (GAMA): the inferred mass-metallicity relation from  $z = 0$  to 3.5 via forensic SED fitting, *Monthly Notices Royal Astronomical Society*, 503, 3309, doi:10.1093/mnras/stab550, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.503.3309B>
- Berdyugin A. V., Piirola V., **Bagnulo S., Landstreet J. D.**, Berdyugina S. V., 2022, Highly sensitive search for magnetic fields in white dwarfs using broad-band circular polarimetry, *Astronomy & Astrophysics*, 657, A105, doi:10.1051/0004-6361/202142173, <https://ui.adsabs.harvard.edu/abs/2022AA...657A.105B>
- Bragaglia A., et al., inc. **Vink J. S.**, 2022, The Gaia-ESO Survey: Target selection of open cluster stars, *Astronomy & Astrophysics*, 659, A200, doi:10.1051/0004-6361/202142674, <https://ui.adsabs.harvard.edu/abs/2022AA...659A.200B>
- Buckley D. A. H., et al., inc. **Bagnulo S.**, 2021, Spectropolarimetry and photometry of the early afterglow of the gamma-ray burst GRB 191221B, *Monthly Notices Royal Astronomical Society*, 506, 4621, doi:10.1093/mnras/stab1791, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.506.4621B>
- Burhanudin U. F., et al., inc. **Ramsay G., Duffy C.**, 2021, Light-curve classification with recurrent neural networks for GOTO: dealing with imbalanced data, *Monthly Notices Royal Astronomical Society*, 505, 4345, doi:10.1093/mnras/stab1545, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.505.4345B>
- Castro N., et al., inc. **Vink J. S.**, 2021, Mapping the core of the Tarantula Nebula with VLT-MUSE. II. The spectroscopic Hertzsprung-Russell diagram of OB stars in NGC 2070, *Astronomy & Astrophysics*, 648, A65, doi:10.1051/0004-6361/202040008, <https://ui.adsabs.harvard.edu/abs/2021AA...648A..65C>
- Cedr s B., et al., inc. **Lara-L pez M. A.**, 2021, The OTELO Survey: The Star Formation Rate Evolution of Low-mass Galaxies, *Astrophysical Journal*, 915, L17, doi:10.3847/2041-8213/ac0a7e, <https://ui.adsabs.harvard.edu/abs/2021ApJ...915L..17C>
- Christou A. A.**, Georgakarakos N., 2021, Long-term dynamical survival of deep Earth co-orbitals, *Monthly Notices Royal Astronomical Society*, 507, 1640, doi:10.1093/mnras/stab2223, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.507.1640C>
- Connolly R., et al., **Butler C. J.**, 2021, How much has the Sun influenced Northern Hemisphere temperature trends? An ongoing debate, *Research in Astronomy and Astrophysics*, 21, 131, doi:10.1088/1674-4527/21/6/131, <https://ui.adsabs.harvard.edu/abs/2021RAA....21..131C>
- Dermott S. F., Li D., **Christou A. A.**, Kehoe T. J. J., Murray C. D., Robinson J. M., 2021, Dynamical evolution of the inner asteroid belt, *Monthly Notices Royal Astronomical Society*, 505, 1917, doi:10.1093/mnras/stab1390, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.505.1917D>
- de Diego J. A., et al., inc. **Lara-L pez M. A.**, 2021, Nonsequential neural network for simultaneous, consistent classification, and photometric redshifts of OTELO galaxies, *Astronomy & Astrophysics*, 655, A56, doi:10.1051/0004-6361/202141360, <https://ui.adsabs.harvard.edu/abs/2021AA...655A..56D>
- Devog le M., et al., inc. **Borisov G.**, 2021, (6478) Gault: physical characterization of an active main-belt asteroid, *Monthly Notices Royal Astronomical Society*, 505, 245, doi:10.1093/mnras/stab1252, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.505..245D>
- Dib S., et al., inc. **Lara-L pez M. A.**, 2021, The structure and characteristic scales of the H I gas in galactic disks, *Astronomy & Astrophysics*, 655, A101, doi:10.1051/0004-6361/202141803, <https://ui.adsabs.harvard.edu/abs/2021AA...655A.101D>
- Dorsch M., **Jeffery C. S.**, Irrgang A., Woolf V., Heber U., 2021, EC 22536–5304: a lead-rich and metal-poor long-period binary, *Astronomy & Astrophysics*, 653, A120, doi:10.1051/0004-6361/202141381, <https://ui.adsabs.harvard.edu/abs/2021AA...653A.120D>

Driver S. P., et al., inc. **Lara-López M. A.**, 2022, Galaxy And Mass Assembly (GAMA): Data Release 4 and the  $z < 0.1$  total and  $z < 0.08$  morphological galaxy stellar mass functions, Monthly Notices Royal Astronomical Society, 513, 439, doi:10.1093/mnras/stac472, <https://ui.adsabs.harvard.edu/abs/2022MNRAS.tmp..552D>

Duffy C., et al., inc. **Ramsay G.**, 2021, Evidence that short-period AM CVn systems are diverse in outburst behaviour, Monthly Notices Royal Astronomical Society, 502, 4953, doi:10.1093/mnras/stab389, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.502.4953D>

Duffy C., et al., inc. **Ramsay G.**, 2022, The return of the spin period in DW Cnc and evidence of new high state outbursts, Monthly Notices Royal Astronomical Society, 510, 1002, doi:10.1093/mnras/stab3402, <https://ui.adsabs.harvard.edu/abs/2022MNRAS.510.1002D>

Dunleavy N. L., Ballance C. P., Ramsbottom C. A., **Jeffery C. S.**, 2021, Electron-impact excitation of Ge III and photoionization of Ge II, Monthly Notices Royal Astronomical Society, 506, 5398, doi:10.1093/mnras/stab1974, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.506.5398D>

Fahrion K., et al., inc. **Sarzi M.**, 2021, Diversity of nuclear star cluster formation mechanisms revealed by their star formation histories, Astronomy & Astrophysics, 650, A137, doi:10.1051/0004-6361/202140644, <https://ui.adsabs.harvard.edu/abs/2021AA...650A.137F>

**Galán-de Anta P. M.**, et al., inc. **Sarzi M.**, **Nedelchev B.**, 2021, The Fornax 3D project: PNe populations and stellar metallicity in edge-on galaxies, Astronomy & Astrophysics, 652, A109, doi:10.1051/0004-6361/202140834, <https://ui.adsabs.harvard.edu/abs/2021AA...652A.109G>

Garcia M., et al., inc. **Vink J. S.**, 2021, Massive stars in extremely metal-poor galaxies: a window into the past, Experimental Astronomy, 51, 887, doi:10.1007/s10686-021-09785-x, <https://ui.adsabs.harvard.edu/abs/2021ExA....51..887G>

**Higgins E. R.**, **Sander A. A. C.**, **Vink J. S.**, Hirschi R., 2021, Evolution of Wolf-Rayet stars as black hole progenitors, Monthly Notices Royal Astronomical Society, 505, 4874, doi:10.1093/mnras/stab1548, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.505.4874H>

Husemann B., Worseck G., Arrigoni Battaia F., **Sander A. A. C.**, Shanks T., 2021, A meeting at  $z \sim 3$ : Young massive galaxies and an AGN within 30 kpc of the luminous QSO LBQS 0302-0019, Astronomy & Astrophysics, 653, A122, doi:10.1051/0004-6361/202140898, <https://ui.adsabs.harvard.edu/abs/2021AA...653A.122H>

Janches D., Berezhnoy A. A., **Christou A. A.**, Cremonese G., Hirai T., Horányi M., Jasinski J. M., Sarantos M., 2021, Meteoroids as One of the Sources for Exosphere Formation on Airless Bodies in the Inner Solar System, Space Science Reviews, 217, 50, doi:10.1007/s11214-021-00827-6, <https://ui.adsabs.harvard.edu/abs/2021SSRv..217...50J>

**Jeffery C. S.**, **Montañés-Rodríguez P.**, Saio H., 2022, Improved hydrodynamic pulsation models for the pulsating extreme helium star V652 Herculis, Monthly Notices Royal Astronomical Society, 509, 1940, doi:10.1093/mnras/stab2876, <https://ui.adsabs.harvard.edu/abs/2022MNRAS.509.1940J>

Killestein T. L., et al., inc. **Ramsay G.**, **Duffy C.**, 2021, Transient-optimized real-bogus classification with Bayesian convolutional neural networks - sifting the GOTO candidate stream, Monthly Notices Royal Astronomical Society, 503, 4838, doi:10.1093/mnras/stab633, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.503.4838K>

Kretschmar P., et al., inc. **Sander A. A. C.**, 2021, Revisiting the archetypical wind accretor Vela X-1 in depth. Case study of a well-known X-ray binary and the limits of our knowledge, Astronomy & Astrophysics, 652, A95, doi:10.1051/0004-6361/202040272, <https://ui.adsabs.harvard.edu/abs/2021AA...652A..95K>

Kwon Y. G., **Bagnulo S.**, Markkanen J., Agarwal J., Kolokolova L., Lévassieur-Regourd A.-C., Snodgrass C., Tozzi G. P., 2022, VLT spectropolarimetry of comet 67P: dust environment around the end of its intense southern summer, Astronomy & Astrophysics, 657, A40, doi:10.1051/0004-6361/202141865, <https://ui.adsabs.harvard.edu/abs/2022AA...657A..40K>

Leblanc F., et al., inc. **Christou A.**, 2022, Comparative Na and K Mercury and Moon Exospheres, Space Science Reviews, 218, 2, doi:10.1007/s11214-022-00871-w, <https://ui.adsabs.harvard.edu/abs/2022SSRv..218....2L>

Makrygianni L., et al., inc. **Ramsay G.**, **Duffy C.**, 2021, Processing GOTO survey data with the Rubin Observatory LSST Science Pipelines II: Forced Photometry and lightcurves, Publications Astronomical Society Australia, 38, e025, doi:10.1017/pasa.2021.19, <https://ui.adsabs.harvard.edu/abs/2021PASA...38...25M>

Manara C. F., et al., inc. **Vink J. S.**, 2021, PENELLOPE: The ESO data legacy program to complement the Hubble UV Legacy Library of Young Stars (ULLYSES). I. Survey presentation and accretion properties of Orion OB1 and  $\sigma$ -Orionis, *Astronomy & Astrophysics*, 650, A196, doi:10.1051/0004-6361/202140639, <https://ui.adsabs.harvard.edu/abs/2021AA...650A.196M>

Martín-Navarro I., et al., inc. **Sarzi M.**, 2021, Fornax 3D project: Assessing the diversity of IMF and stellar population maps within the Fornax Cluster, *Astronomy & Astrophysics*, 654, A59, doi:10.1051/0004-6361/202141348, <https://ui.adsabs.harvard.edu/abs/2021AA...654A..59M>

Mong Y. L., et al., inc. **Ramsay G.**, **Duffy C.**, 2021, Searching for Fermi GRB optical counterparts with the prototype Gravitational-wave Optical Transient Observer (GOTO), *Monthly Notices Royal Astronomical Society*, 507, 5463, doi:10.1093/mnras/stab2499, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.507.5463M>

Montalto M., et al., inc. **Ramsay G.**, 2021, The all-sky PLATO input catalogue, *Astronomy & Astrophysics*, 653, A98, doi:10.1051/0004-6361/202140717, <https://ui.adsabs.harvard.edu/abs/2021AA...653A..98M>

Murphy T., et al., inc. **Doyle J. G.**, **Ramsay G.**, 2021a, The ASKAP Variables and Slow Transients (VAST) Pilot Survey, *Publications Astronomical Society Australia*, 38, e054, doi:10.1017/pasa.2021.44, <https://ui.adsabs.harvard.edu/abs/2021PASA...38...54M>

Murphy P. C., et al., inc. **Golden A.**, **Doyle J. G.**, **Rigney J.**, **Burton M.**, 2021b, First results from the REAL-time Transient Acquisition backend (REALTA) at the Irish LOFAR station, *Astronomy & Astrophysics*, 655, A16, doi:10.1051/0004-6361/202140415, <https://ui.adsabs.harvard.edu/abs/2021AA...655A..16M>

Nascimbeni V., et al., inc. **Ramsay G.**, 2022, The PLATO field selection process. I. Identification and content of the long-pointing fields, *Astronomy & Astrophysics*, 658, A31, doi:10.1051/0004-6361/202142256, <https://ui.adsabs.harvard.edu/abs/2022AA...658A..31N>

Navarro Martínez R., et al., inc. **Lara-López M. A.**, 2021, The OTELO survey. Revealing a population of low-luminosity active star-forming galaxies at  $z \sim 0.9$ , *Astronomy & Astrophysics*, 653, A24, doi:10.1051/0004-6361/202140353, <https://ui.adsabs.harvard.edu/abs/2021AA...653A..24N>

Nived V. N., et al., inc. **Doyle J. G.**, 2022, Implications of spicule activity on coronal loop heating and catastrophic cooling, *Monthly Notices Royal Astronomical Society*, 509, 5523, doi:10.1093/mnras/stab3277, <https://ui.adsabs.harvard.edu/abs/2022MNRAS.509.5523N>

North E. V., et al., inc. **Sarzi M.**, 2021, WISDOM project - VIII. Multiscale feedback cycles in the brightest cluster galaxy NGC 0708, *Monthly Notices Royal Astronomical Society*, 503, 5179, doi:10.1093/mnras/stab793, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.503.5179N>

Ó Fionnagáin D., Kavanagh R. D., Vidotto A. A., Jeffers S. V., Petit P., Marsden S., Morin J., **Golden A.**, 2022, Coronal Mass Ejections and Type II Radio Emission Variability during a Magnetic Cycle on the Solar-type Star? Eridani, *Astrophysical Journal*, 924, 115, doi:10.3847/1538-4357/ac35de, <https://ui.adsabs.harvard.edu/abs/2022ApJ...924..115O>

Pauli D., et al., inc. **Sander, A. A. C.**, 2022, The earliest O-type eclipsing binary in the Small Magellanic Cloud, AzV 476: A comprehensive analysis reveals surprisingly low stellar masses, *Astronomy & Astrophysics*, 659, A9, doi:10.1051/0004-6361/202141738, <https://ui.adsabs.harvard.edu/abs/2022AA...659A...9P>

Pilyugin L. S., et al., **Lara-López M. A.**, 2021, MaNGA galaxies with off-centered spots of enhanced gas velocity dispersion, *Astronomy & Astrophysics*, 653, A11, doi:10.1051/0004-6361/202141012, <https://ui.adsabs.harvard.edu/abs/2021AA...653A..11P>

Przybilla N., Fossati L., **Jeffery C. S.**, 2021, HD 144941: the most extreme helium- strong star, *Astronomy & Astrophysics*, 654, A119, doi:10.1051/0004-6361/202141625, <https://ui.adsabs.harvard.edu/abs/2021AA...654A.119P>

**Ramsay G.**, Kolotkov D., **Doyle J. G.**, Doyle L., 2021a, Transiting Exoplanet Survey Satellite (TESS) Observations of Flares and Quasi-Periodic Pulsations from Low-Mass Stars and Potential Impact on Exoplanets, *Solar Physics*, 296, 162, doi:10.1007/s11207-021-01899-x, <https://ui.adsabs.harvard.edu/abs/2021SoPh..296..162R>

**Ramsay G.**, Hakala P., Wood M. A., 2021b, Detection of an energetic flare from the M5V secondary star in the Polar MQ Dra, *Monthly Notices Royal Astronomical Society*, 504, 4072, doi:10.1093/mnras/stab1140, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.504.4072R>

Reed M. D., Slayton A., Baran A. S., Telting J. H., Østensen R. H., **Jeffery C. S.**, Uzundag M., Sanjayan S., 2021, Pulsating subdwarf B stars observed with K2 during Campaign 7 and an examination of seismic group properties, *Monthly Notices Royal Astronomical Society*, 507, 4178, doi:10.1093/mnras/stab2405, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.507.4178R>

Roychowdhury S., et al., inc. **Lara-López M. A.**, 2022, The Variation of the Gas Content of Galaxy Groups and Pairs Compared to Isolated Galaxies, *Astrophysical Journal*, 927, 20, doi:10.3847/1538-4357/ac49ea, <https://ui.adsabs.harvard.edu/abs/2022ApJ...927...20R>

**Sabhahit G. N., Vink J. S., Higgins E. R., Sander A. A. C.**, 2021, Superadiabaticity and the metallicity independence of the Humphreys-Davidson limit, *Monthly Notices Royal Astronomical Society*, 506, 4473, doi:10.1093/mnras/stab1948, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.506.4473S>

Shenar T., et al., inc. **Vink J. S.**, 2021, The Tarantula Massive Binary Monitoring. V. R 144: a wind-eclipsing binary with a total mass 140  $M_{\odot}$ , *Astronomy & Astrophysics*, 650, A147, doi:10.1051/0004-6361/202140693, <https://ui.adsabs.harvard.edu/abs/2021AA...650A.147S>

**Shetye J.**, Verwichte E., Stangalini M., **Doyle J. G.**, 2021, The Nature of High-frequency Oscillations Associated with Short-lived Spicule-type Events, *Astrophysical Journal*, 921, 30, doi:10.3847/1538-4357/ac1a12, <https://ui.adsabs.harvard.edu/abs/2021ApJ...921...30S>

Shultz M. E., Alecian E., Petit V., **Bagnulo S.**, Böhm T., Folsom C. P., Wade G. A., MiMeS Collaboration 2021, NGC 6611 601: a hot pre-main-sequence spectroscopic binary containing a centrifugal magnetosphere host star, *Monthly Notices Royal Astronomical Society*, 504, 3203, doi:10.1093/mnras/stab822, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.504.3203S>

Smith M. D., et al., inc. **Sarzi M.**, 2021, WISDOM project - VII. Molecular gas measurement of the supermassive black hole mass in the elliptical galaxy NGC 7052, *Monthly Notices Royal Astronomical Society*, 503, 5984, doi:10.1093/mnras/stab791, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.503.5984S>

Sotillo-Ramos D., et al., inc. **Lara López M. A.**, 2021, Galaxy and mass assembly (GAMA): The environmental impact on SFR and metallicity in galaxy groups, *Monthly Notices Royal Astronomical Society*, 508, 1817, doi:10.1093/mnras/stab2641, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.508.1817S>

Spriggs T. W., et al., inc. **Sarzi M., Galán-de Anta, P. M., Nedelchev B.**, 2021, The Fornax3D project: Planetary nebulae catalogue and independent distance measurements to Fornax cluster galaxies, *Astronomy & Astrophysics*, 653, A167, doi:10.1051/0004-6361/202141314, <https://ui.adsabs.harvard.edu/abs/2021AA...653A.167S>

Thater S., et al., inc. **Sarzi M.**, 2022, Cross-checking SMBH mass estimates in NGC 6958 - I. Stellar dynamics from adaptive optics-assisted MUSE observations, *Monthly Notices Royal Astronomical Society*, 509, 5416, doi:10.1093/mnras/stab3210, <https://ui.adsabs.harvard.edu/abs/2022MNRAS.509.5416T>

Vchkova Bebekovska E., Todorović N., Kostov A., Donchev Z., **Borisov G.**, 2021, The Physical and Dynamical Characteristics of the Asteroid 4940 Polenov, *Serbian Astronomical Journal*, 202, 39, doi:10.2298/SAJ2102039V, <https://ui.adsabs.harvard.edu/abs/2021SerAJ.202...39V>

**Vink J. S., Sander A. A. C.**, 2021, Metallicity-dependent wind parameter predictions for OB stars, *Monthly Notices Royal Astronomical Society*, 504, 2051, doi:10.1093/mnras/stab902, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.504.2051V>

**Vink J. S., Higgins E. R., Sander A. A. C., Sabhahit G. N.**, 2021, Maximum black hole mass across cosmic time, *Monthly Notices Royal Astronomical Society*, 504, 146, doi:10.1093/mnras/stab842, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.504..146V>

Walters N., et al., inc. **Bagnulo S., Landstreet, J. D.**, 2021, A test of the planet-star unipolar inductor for magnetic white dwarfs, *Monthly Notices Royal Astronomical Society*, 503, 3743, doi:10.1093/mnras/stab617, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.503.3743W>

Williams P. M., et al., inc. **Sander A. A. C.**, 2021, Conditions in the WR 140 wind-collision region revealed by the 1.083- $\mu$  m He I line profile, *Monthly Notices Royal Astronomical Society*, 503, 643, doi:10.1093/mnras/stab508, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.503.643W>



Wilson D. J., Toloza O., **Landstreet J. D.**, Gänsicke B. T., Drake J. J., Hermes J. J., Koester D., 2021, Discovery of a young pre-intermediate polar, *Monthly Notices Royal Astronomical Society*, 508, 561, doi:10.1093/mnras/stab2458, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.508..561W>

Yang A. Y., et al., inc. **Eden D.**, 2022, The SEDIGISM survey: A search for molecular out-flows, *Astronomy & Astrophysics*, 658, A160, doi:10.1051/0004-6361/202142039, <https://ui.adsabs.harvard.edu/abs/2022AA...658A.160Y>

Yu S., Lu Y., **Jeffery C. S.**, 2021, Orbital evolution of neutron-star-white-dwarf binaries by Roche lobe overflow and gravitational wave radiation, *Monthly Notices Royal Astronomical Society*, 503, 2776, doi:10.1093/mnras/stab626, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.503.2776Y>

Zabel N., et al., inc. **Sarzi M.**, **Lara-López M. A.**, 2021, AIFoCS + F3D - II. Unexpectedly low gas-to-dust ratios in the Fornax galaxy cluster, *Monthly Notices Royal Astronomical Society*, 502, 4723, doi:10.1093/mnras/stab342, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.502.4723Z>

## Non-Refereed Journal Publications: April 2021 – March 2022

- Apostolovska G., Vchkova Bebekovska E., **Borisov G.**, Kostov A., Donchev Z., 2021, in European Planetary Science Congress. Modeling asteroid shapes using BNAO Rozhen photometric data in combination with sparse data. pp EPSC2021–792, doi:10.5194/esp2021-792
- Bagnulo, S., Landstreet, J.D.**, 2022, in The Messenger, 186. The Isolated Magnetic White Dwarfs, pp 14-18, DOI: 10.18727/0722-6691/5257
- Burton M., Cubuk K. O., Alexander H.**, 2022, in 37th International Cosmic Ray Conference. 12-23 July 2021. Berlin. Outreach for Science Facilities: Armagh Observatory and Planetarium's programme for the Cherenkov Telescope Array. p. 1364
- Burton M.**, 2022, in 37th International Cosmic Ray Conference. 12-23 July 2021. Berlin. Outreach and Education at the International Cosmic Ray Conference: Summary of the Rapporteur Talk. ID.51
- Christou A., Nedelchev B., Borisov G., Dell'Oro A., Cellino A.**, 2021, in European Planetary Science Congress. Earth's blind spot: A closer look at observational biases for Earth coorbital asteroids. pp EPSC2021–92, doi:10.5194/esp2021-92
- CTA et al, inc. **Burton, M.**, in 37th International Cosmic Ray Conference. 12-23 July 2021. Berlin. CTA - the World's largest ground-based gamma-ray observatory. ID 5
- Devogele M., et al., inc. **Borisov G.**, 2021, in AAS/Division for Planetary Sciences Meeting Abstracts. Physical characterization of the active asteroid (6478) Gault from a multi-aparition campaign (2018-2020). p. 309.04
- Doyle L., **Ramsay G., Bagnulo S., Doyle J. G.**, 2021, in Posters from the TESS Science Conference II (TSC2). Magnetic Fields on Low Mass Ultra Fast Rotators using TESS and FORS2. p. 96, doi:10.5281/zenodo.5128900
- Fries M., et al., inc. **Christou A. A.**, 2021, in Bulletin of the American Astronomical Society. The Scientific Need for a Dedicated Interplanetary Dust Instrument at Mars. p. 097, doi:10.3847/25c2cfcb.824a8f73
- Houdebine, E.**, 2021, in SF2A-2021: Proceedings of the Annual meeting of the French Society of Astronomy and Astrophysics. Eds.: A. Siebert, K. Baillié, E. Lagadec, N. Lagarde, J. Malzac, J.-B. Marquette, M. N'Diaye, J. Richard, O. Venot. Ca II Resonance Doublet and H $\alpha$  Fluxes as a Function of Stellar Radius: Indications for a Transition in Dynamo Modes Between 0.500R $\odot$  and 0.330R $\odot$ , pp.189-190.
- Mong Y. L., et al., inc. **Ramsay G.**, 2021, GRB 210610B: GOTO confirmation of afterglow detection, GRB Coordinates Network, 30193, 1, <https://ui.adsabs.harvard.edu/abs/2021GCN.30193....1M>
- Przybilla N., Fossati L., **Jeffery C. S.**, 2021, New Spectropolarimetric Measurements of HD 144941, Research Notes of the American Astronomical Society, 5, 254, doi:10.3847/2515-5172/ac342a, <https://ui.adsabs.harvard.edu/abs/2021RNAAS...5..254P>
- Ramsay G., Kolotkov D., Doyle J. G., Doyle L.**, 2021, in Posters from the TESS Science Conference II (TSC2). Searching for Quasi Periodic Pulsations in flares from low mass stars using TESS data. p. 74, doi:10.5281/zenodo.5126782
- Rauer H., et al., inc. **Ramsay G.**, 2021, in European Planetary Science Congress. The PLATO mission: Overview and status. pp EPSC2021–90, doi:10.5194/esp2021-90
- Richardson N. D., Schaefer G., Thomas J., Lee L., Eldridge J. J., **Sander A.**, Shenar T., 2021, in American Astronomical Society Meeting Abstracts. Visual Orbits for Wolf-Rayet stars from CHARA Interferometry. p. 308.07
- Vink J. S.**, Armagh Observatory Massive Star Group 2021, in American Astronomical Society Meeting Abstracts. Maximum Black Hole Mass Across Cosmic Time. p. 227.02

## **Books and Other Publications Not Listed Above: April 2021 – March 2022**

**Bailey M., Butler C. J.,** Finnegan J. A., **Kelly S. T.**, 2021, Buildings and Location Armagh Observatory, Irish Geography, Vol. 54, No. 2, 109-140

Barden S., Conlin C., Whan R., **Burton M.**, Hegarty R., 2019, Bishops and Buildings, A Pictorial Celebration of Armagh's Architecture, Armagh County Museum, p. 1–80.  
*(Publication of book delayed due to Covid-19)*

**Burton M., Alexander H., McMahon M.**, 2021, Ten Amazing Objects from the Armagh Observatory and Planetarium (AOP), Bulletin of the Scientific Instrument Society, No. 50, p. 36–41

**McLoughlin H., Doyle L., Sarzi M., Burton M. Mee R., Nežič R., Mackle S.**, 2021, Big Book of Experiments and Bright Ideas, Armagh Observatory and Planetarium, p. 1–86

O'Connor S., Murphy C., **Butler J.**, Crampsie A., Ludlow F., Horvath C., Jobbova E., 2021, A weather diary from Donegal, Ireland, 1846–1875, Weather. Vol. 76, No. 12

## Presentations: April 2021 – March 2022

Date	Speaker	Title	Location/Mode	Category
15 Apr 2021	G. Ramsay	Gravitational-Wave Optical Transient Observer	Seminar, Mullard Space Science Laboratory/University College London	Research
16 Apr 2021	M. Burton with O. Dunnett (QUB)	Connecting Urban Centres and Rural Dark Sky Centres	Dark Sky Network Unconference (online)	Research
19 Apr 2021	C.S. Jeffery	The AOP Library	Libraries NI Staff, AOP	Outreach
21 Apr 2021	M. Burton with R. Nežič, Y. Metodieva, C. Byrne, N. Parke, H. Alexander	Weather Insights	NI Science Festival (online)	Outreach
23 Apr 2021	M. Burton	The Armagh Meteorological Station	UK Meteorological Observatories Day (online)	Research
27 May 2021	C.S. Jeffery	Merged White Dwarfs and Hydrogen-Deficient Stars	CAMK Torun, Poland (online)	Research
07 Jun 2021	J.S. Vink	Maximum Black Hole	Press Conference Talk, 238th Virtual Meeting of the American Astronomical Society (AAS)	Outreach
08 Jun 2021	J.S. Vink	Maximum Black Hole Mass Across Cosmic Time	238th Virtual Meeting of the American Astronomical Society (AAS)	Research
12 Jun 2021	M. Burton	A Virtual Tour of the Armagh Observatory and Planetarium	Scientific Instruments Society, UK (online)	Outreach
22 Jun 2021	A.A.C. Sander	The Impact of Stellar Winds	Seminar, Monash University, Australia (online)	Research
22 Jun 2021	J.S. Vink	Introduction to the XShootU Collaboration Meeting	XShootU Collaboration Meeting (online)	Research
25 Jun 2021	M. Burton	Multiwavelength Observations of the ISM for the CTA.	Cherenkov Telescope Array UK Science Meeting (online)	Research
25 Jun 2021	M. Burton with K. Çubuk	A Planetarium Dome Show for the CTA.	Cherenkov Telescope Array UK Science Meeting (online)	Outreach
01 Jul 2021	A.A.C. Sander	The Nature and Occurrence of Wolf-Rayet Type Mass Loss	Virtual EAS2021 Conference	Research
06 Jul 2021	A.A.C. Sander	How to Turn Stellar Atmospheres into a Mass-Loss Laboratory	Seminar, Radboud University, Nijmegen, The Netherlands	Research
13 Jul 2021	M. Burton with K. Çubuk and H. Alexander	Outreach for Science Facilities: AOP's Programme for the Cherenkov Telescope Array	Contributed Talk, International Cosmic Ray Conference (ICRC2021), Berlin, Germany (online)	Research
15 Jul 2021	A.A.C. Sander	Decoding the Light of Stars: Stellar Atmospheres and the Crucial Role of Hot, Massive Stars	Seminar, Astronomisches Rechen-Institut, Heidelberg University, Germany	Research
20 Jul 2021	G. Ramsay	Searching for Flares and QPPs from Low Mass Stars	Contributed Talk, UK National Astronomy Meeting 2021, University of Bath, England (online)	Research
22 Jul 2021	M. Burton	Rapporteur Talk: Education and Outreach at ICRC2021	Plenary talk, International Cosmic Ray Conference (ICRC2021), Berlin, Germany (online)	Research / Education
31 Aug 2021	C.S. Jeffery	HD144941	Seminar, AOP (online)	Research
02 Sep 2021	M. Burton	Astronomy, Ireland and UNESCO World Heritage	Invited Public Talk, Irish National Astronomy Meeting 2021, Ireland (online)	Outreach
02 Sep 2021	C. Duffy	The Gravitational-Wave Optical Transient Observer (GOTO)	Irish National Astronomy Meeting 2021, Ireland (online)	Research
03 Sep 2021	M. Lara Lopez	The Effect of Group Environment in Metallicity Gradients	Irish National Astronomy Meeting 2021, Ireland (online)	Research

Date	Speaker	Title	Location/Mode	Category
04 Sep 2021	M. Burton with S. Mackle, M. Glass, H. Alexander, H. Mcloughlin	After the Lockdown: The New Armagh Planetarium	British Association of Planetarium (BAP) Meeting (online)	Research
05 Sep 2021	A.A.C. Sander	A Wee Bitta Craic! PhD Talk with Dr Andreas Sander	AOP Intergalactic Craic Podcast	Outreach
08 Sep 2021	M. Burton with H. Alexander, H. McLoughlin, R. Nežič	Live with the Legendary Telescopes	European Heritage Open Days (EHOD) – Live from the Armagh Observatory and Planetarium, (online)	Outreach
09 Sep 2021	J.S. Vink	Hubble and Beyond	Virtual, Autism Ireland	Outreach
15 Sep 2021	C. Duffy	The Gravitational-Wave Optical Transient Observer and Cataclysmic Variables	Irish Astronomical Association Zoom Lecture	Outreach
28 Sept - 02 Dec 2021	C.S. Jeffery	16 Lectures and Tutorials in Stellar Structure and Evolution	Trinity College Dublin, Dublin, Ireland	Teaching
23 Sep 2021	M. McMahon	Experiences of Taking on Interns as a Non-Standard Museum	Northern Ireland Museum Council AGM	Heritage
29 Sep 2021	M. Burton	Astronomy, Ireland and UNESCO World Heritage	Irish Astronomical Association Zoom Lecture	Outreach
19 Oct 2021	J.S. Vink	Accretion Rate Versus Age and Mass	Star Formation: From Clouds to Discs, Dublin Institute for Advanced Studies, Dublin, Ireland	Research
21 Oct 2021	M.E. Bailey	Near-Earth Objects: Origins, Impacts and Risk (Invited)	Mexborough and Swinton Astronomical Society, Mexborough, South Yorkshire, England (online)	Outreach
26 Oct 2021	M.E. Bailey	Light Pollution and Its Impact: Inspiring Astronomy at Davagh Forest	Rotary Newtownabbey, Newtownabbey, Co. Antrim (online)	Outreach
01 Nov - 12 Nov 2021	M. Burton	14 "Our Place in the Cosmos" Planetarium Shows + Q&A	COP26 Green Zone, The Planetarium at the Glasgow Science Centre 14 shows in total. (01x2, 02x1, 03x2, 04x2, 05x1, 06x1, 07x1 10x1, 11x2,12x1)	Outreach
02 Nov 2021	M. Burton	Our Place in the Cosmos	Southern Regional College Presentation during COP26, AOP	Outreach
03 Nov 2021	M. Burton	Climate Change: Past, Present and Future Panel Event (with Ed Hawkins, Louise Jeffery, Jonathan Bell and Nichola Hughes, compere Louise Small)	Our Place in the Cosmos, What Can You Do? Panel Event, AOP and COP26 Glasgow	Outreach
03 Nov 2021	J.S. Vink	The Link Between Hot and Cool Outflows	The Origin of Outflows in Evolved Stars, IAU Symposium 366, Virtual Meeting, KU, Leuven, Belgium	Research
04 Nov 2021	R. Nežič	Remembering Bovedy	History Day 2021: Collecting Nature Memories: An Interactive Workshop (online)	Outreach
08 Nov 2021	S. Bagnulo	New Insight into the Magnetism of Degenerate Stars from the Analysis of a Volume-Limited Sample of White Dwarfs	Nicolaus Copernicus University (NCU), Toruń, Poland	Research
15 Nov 2021	J.S. Vink	SN Progenitors and Stellar Envelope Physics	SuperVirtual 2021 - From Common to Exotic Transients	Research
18 Nov 2021	S. Bagnulo	New Insight into the Magnetism of White Dwarfs"	Italian National Academy of Sciences, Torino, Italy	Research
23 Nov 2021	C.S. Jeffery	Hydrogen-Deficient Stars in the Galaxy	Seminar, AOP (online)	Research
24 Nov 2021	M. Burton	Education and Outreach at the International Cosmic Ray Conference	CTA Annual Consortium Meeting (online)	Research

Date	Speaker	Title	Location/Mode	Category
30 Nov 2021	J. Landstreet	What's Going on With All Those Magnetic White Dwarfs?	Department of Physics and Astronomy, University of Delaware, USA	Research
30 Nov 2021	J.S. Vink	First Light with JWST	Building the Stars - James Webb Telescope Online Event, hosted by AOP	Outreach
06 Dec 2021	M.E. Bailey	Near-Earth Objects: Origins, Impacts and Risk	Causeway U3A, Portstewart, Co. Antrim (online)	Outreach
07 Dec 2021	J.S. Vink	Stellar Winds and Interior Transport	Kavli Institute of Theoretical Physics, University of California, Santa Barbara, USA	Research
02 Jan 2022	M. Burton	The Cherenkov Telescope Array – An Introduction to TeV-Energy Gamma-Ray Astronomy	Macclesfield Astronomical Society – via Zoom	Outreach
06 Jan 2022	M. Burton	Astronomy in Antarctica	Cardiff Astronomical Society – via Zoom	Outreach
19 Jan 2022	G. Ramsay	Super-flares on the Sun and Solar Type Stars	Online Colloquium, Department of Physics, University of Warwick	Research
22 Feb 2022	C.J. Butler	Architecture and Buildings of Armagh Observatory	Probus Group Armagh, County Armagh Golf Club, Armagh Co. Armagh	Outreach
22 Feb 2022	G. Ramsay	Photometry: The Art of Measuring a Star's Brightness	Student Discussion Meeting, Hybrid Meeting, AOP	Research
22 Feb - 25 Feb 2022	M. Burton with K. Çubuk	Exploring the High Energy Universe” – A Planetarium Full Dome Show	Northern Ireland Science Festival, AOP	Outreach
24 Feb 2022	D. Eden	MAJORS: Massive, Active, JCMT–Observed Regions of Star Formation	James Clerk Maxwell Telescope Users' Meeting (online)	Research
24 Feb 2022	D. Eden	CLOGS: CO Large Outer Galaxy Survey	James Clerk Maxwell Telescope Users' Meeting (online)	Research
01 Mar 2022	M. Sarzi	Hubble from Space and Integral-Field Spectroscopy from the Ground: Seeing both the Forests and the Trees	Space Telescope Science Institute Public Lecture Series (online)	Research
24 Mar 2022	D. Eden	What Causes Stars to Form?	Seminar, AOP	Research
24 Feb 2022	J. Vink	First Light of JWST and with JWST	Astrobytes, AOP	Internal Outreach
10 Mar 2022	A. Christou	Eclipses I've Been To, Including a Total Solar Eclipse / Astrophotography Off the Cuff	Astrobytes, AOP	Internal Outreach
28 Mar 2022	A. Christou	The Three Body Problem in Action: A Menagerie of Solar System Coorbitals	COOMOT Workshop, Milan, Italy (online)	Research
31 Mar 2022	M. Burton	Our Place in the Cosmos	Astrobytes, AOP	Internal Outreach
31 Mar 2022	A. Christou	The Three Body Problem in Action: A Guided Tour of the Coorbital Zoo	Astrobytes, AOP	Research

## Education and Outreach: April 2021 – March 2022

Date	Event Description
21 Apr 2021	StarTracker Online: Astrobytes Extra: Weather Insights
26 May 2021	StarTracker Online/Irish Astronomical Association: Online Telescope Clinic
17 Jun 2021	Online Careers Event: KS3
Aug 2021 - Mar 2022	The Legendary Telescope Tours at Armagh Observatory
08 Sept 2021	StarTracker Online/European Heritage Open Days: Online Event: 'Live from AOP's Legendary Telescopes'
12 Sept 2021	European Heritage Open Days: Astropark Tours
24 Sept 2021	The Great Big Green Week - David Attenborough: A Life on Our Planet Event
07 Oct 2021	Online Careers Event: GCSE, A Level
29 Oct 2021	The Creepy Climate Change Science Show with Scientific Sue
31 Oct 2021	Tall Tales and Terror at Armagh Observatory
03 Nov 2021	"Our Place in the Cosmos" Climate Change: What Can You Do? Panel Event
03/09 Nov 2021	"Our Place in the Cosmos" Free Dome Shows, COP 26 Event
06 Nov 2021	The Climate Change Science Show with Scientific Sue
24 Nov 2021	Robinson Lecture and Dome Show: Robinson Medallist Professor Caitriona Jackman, Dublin Institute for Advanced Studies, Lecture Title: Adventures in the Outer Solar System
30 Nov 2021	StarTracker Online: Building Stars - James Webb Space Telescope with Professor Jorick Vink (AOP) and Dr Olivia Jones (UK Astronomy Centre at Royal Observatory in Edinburgh)
25 Jan 2022	StarTracker Online: An Introduction to Stargazing
11 Feb 2022	Meet our PhD Students Event
12 Feb 2022	Meet our PhD Students Event
18 Feb 2022	NI Science Festival 2022 Event: The AOP Big Quiz Night
22 Feb 2022	StarTracker Online/NI Science Festival 2022 Event: Beyond the Atmosphere
25 Feb 2022	NI Science Festival 2022 Event: Made in Armagh Dome Shows
25 Feb 2022	NI Science Festival 2022 Event: From Mercury with Love Music Show and Talk
26/27 Feb 2022	NI Science Festival 2022 Event: The Climate Change Show with Scientific Sue
11 Mar 2022	Weather Ambassador School Visit: Longtower Primary School, Longtower Street, Derry/Londonderry, BT48 6QQ
15 Mar 2022	Weather Ambassador School Visit: Mount St. Catherine's Primary School, Windmill Avenue, Armagh, BT60 4BR
16 Mar 2022	Weather Ambassador School Visit: Hart Memorial PS, Charles Street, Portadown, BT62 4BD
31 Mar 2022	Online Careers Event: KS3, GCSE, A Level

## Cosmic Classroom: April 2021 – March 2022

Date	School / Organisation	Year Group
26 Apr 2021	Arke SureStart, Unit 15, Armagh Shopping Centre, Armagh. BT61 7AE	Pre-School
06 May 2021	Specialisterne Northern Ireland, 239 Newtownards Road, Belfast, BT4 1AF	KS3/KS4
07 May 2021	Arke SureStart, Unit 15, Armagh Shopping Centre, Armagh. BT61 7AE	Pre-School
11 May 2021	Brackenagh West Primary School, 22 Church Road, Newry, BT34 4QB	KS2
20 May 2021	Dungannon SureStart, 5 Ballygawley Road, Dungannon, BT70 1TU	Pre-school
21 May 2021	Sullivan Upper Preparatory Department, 1 Alexandra Park, Hollywood, BT18 9EP	KS1
25 May 2021	Glencraig Integrated Primary School, 32 Seahill Road, Hollywood, BT18 0DJ	KS2
27 May 2021	Specialisterne Northern Ireland, 239 Newtownards Road, Belfast, BT4 1AF	Adults
02 Jun 2021	Holy Family Primary School, 1 Drumnaconagher Road, Crossgar, Downpatrick, BT30 9AN	
25 Jun 2021	Cairnshill Primary School, 6a Cairnshill Drive, Belfast, BT8 6RT	
08 Oct 2021	Knockbreda Primary School, Wynchurch Road, Belfast, BT6 0JW	KS2
09 Nov 2021	Larne and Inver Primary School, 1a Glynn Road, Larne, Co Antrim, BT40 3AY	KS2
10 Nov 2021	Linn Primary School, Killyglen Road, Larne, BT40 2HT	KS2
11 Nov 2021	St. Mary's Primary School, Portglenone, Ballymena, BT44 8BL	KS2
12 Nov 2021	Central Integrated Primary School, Thomas Street, Carrickfergus, BT38 8AL	KS2
09 Dec 2021	Rathmore Primary School, Rathmore Road, Bangor, BT19 1DJ	KS2
18 Jan 2022	Knocknagoney Primary School, Knocknagoney Road, Belfast, BT4 2NR and St Patrick's Primary School, Church View, Hollywood, BT18 9LN, Shared Education	KS2
26 Jan 2022	Towerview Primary School, 100 Towerview Crescent, Bangor, Co Down, BT19 6AZ	KS2
02 Feb 2022	Blackbox	Adults
22 +23 Feb 2022	St. Colman's	KS2
01 Mar 2022	Buick Memorial Primary School, Main Street, Cullybackey, Ballymena, BT42 1BW	KS1
02 Mar 2022	Nord Anglia International School, Dublin, D18 T672, Ireland	KS2
03 Mar 2022	Holywell Education Together National School, Swords, Co. Dublin, K67AP99, Ireland	KS2



## Intergalactic Craic Podcasts: April 2021 – March 2022

Date	Podcast Title
16 Apr 2021	Rocks to Rockets: 4 More Amazing Women in Science!
30 Apr 2021	Wee Bitta Craic! 21/Borisov 101 with Dr Rok
14 May 2021	Strange Matter; The Most Dangerous Stuff in the Universe
11 Jun 2021	The Size of The Universe! Ft Prof. Michael Burton
16 Jul 2021	The Big Lad: Hefty Jupiter
05 Sep 2021	Wee Bitta Craic! PhD Talk with Dr Andreas Sander
17 Sep 2021	Heavy Metal Stars with Prof. Simon Jeffery
15 Oct 2021	What's Goo-d?! Global Catastrophic Scenarios
26 Nov 2021	Here's Me What? Featuring Guest Host Dr Rok
22 Dec 2021	So Earth is Ruined – Where Next?
21 Jan 2022	Why Alien Fish on Europa = DOOM
25 Feb 2022	The Craic with Climate
17 Mar 2022	Space Is Cloudy, Who Knew? Featuring Kerem Çubuk

Presenters: H. Alexander and C. Allison  
All published via [anchor.fm/intergalacticcraic](https://anchor.fm/intergalacticcraic)

# **THE ARMAGH OBSERVATORY AND PLANETARIUM**

## **THE CERTIFICATE AND REPORT OF THE COMPTROLLER AND AUDITOR GENERAL TO THE NORTHERN IRELAND ASSEMBLY**

### **Opinion on financial statements**

I certify that I have audited the financial statements of the Armagh Observatory and Planetarium for the year ended 31 March 2022 under the Armagh Observatory and Planetarium (Northern Ireland) Order 1995. The financial statements comprise: the Statement of Financial Activities, the Balance Sheet, the Cash Flow Statement; and the related notes including significant accounting policies. The financial reporting framework that has been applied in their preparation is applicable law and United Kingdom accounting standards including FRS 102, the Financial Reporting Standard applicable in the UK and Republic of Ireland (United Kingdom Generally Accepted Accounting Practice).

I have also audited the information in the Trustees' Annual Report and the Remuneration and Staff Report that is described in that report as having been audited.

In my opinion the financial statements:

- give a true and fair view of the state of the Armagh Observatory and Planetarium's affairs as at 31 March 2022 and of its total incoming resources and expenditure of resources for the year then ended;
- have been properly prepared in accordance with the Financial Reporting Standard applicable in the UK and Republic of Ireland (FRS 102); and
- have been properly prepared in accordance with the Armagh Observatory and Planetarium (Northern Ireland) Order 1995 and Department for Communities directions issued thereunder.

### **Opinion on regularity**

In my opinion, in all material respects the expenditure and income recorded in the financial statements have been applied to the purposes intended by the Assembly and the financial transactions recorded in the financial statements conform to the authorities which govern them.

### **Basis for opinions**

I conducted my audit in accordance with International Standards on Auditing (ISAs) (UK), applicable law and Practice Note 10 'Audit of Financial Statements of Public Sector Entities in the United Kingdom'. My responsibilities under those standards are further described in the Auditor's responsibilities for the audit of the financial statements section of this certificate.

My staff and I are independent of the Armagh Observatory and Planetarium in accordance with the ethical requirements that are relevant to my audit of the financial statements in the UK, including the Financial Reporting Council's Revised Ethical

Standard, and we have fulfilled our other ethical responsibilities in accordance with these requirements.

I believe that the audit evidence obtained is sufficient and appropriate to provide a basis for my opinions.

### **Conclusions relating to going concern**

In auditing the financial statements, I have concluded that the Armagh Observatory and Planetarium's use of the going concern basis of accounting in the preparation of the financial statements is appropriate.

Based on the Armagh Observatory and Planetarium work I have performed, I have not identified any material uncertainties that relating to events or conditions that, individually or collectively, may cast significant doubt on the Armagh Observatory and Planetarium's ability to continue as a going concern for a period of at least twelve months from when the financial statements are authorised for issue.

The going concern basis of accounting for the Armagh Observatory and Planetarium is adopted in consideration of the requirements set out in the Government Reporting Manual, which requires entities to adopt the going concern basis of accounting in the preparation of the financial statements where it anticipated that the services which they provide will continue into the future.

My responsibilities and the responsibilities of the Governors and the Accounting Officer with respect to going concern are described in the relevant sections of this report.

### **Other Information**

The other information comprises the information included in the Trustees' annual report other than the financial statements, the parts of the Trustees' annual report described in that report as having been audited, and my audit certificate and report. The Governors and the Accounting Officer are responsible for the other information included in the annual report. My opinion on the financial statements does not cover the other information and except to the extent otherwise explicitly stated in my report, I do not express any form of assurance conclusion thereon.

My responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the financial statements or my knowledge obtained in the audit or otherwise appears to be materially misstated. If I identify such material inconsistencies or apparent material misstatements, I am required to determine whether this gives rise to a material misstatement in the financial statements themselves. If, based on the work I have performed, I conclude that there is a material misstatement of this other information, I am required to report that fact.

I have nothing to report in this regard.

### **Opinion on other matters**

In my opinion, based on the work undertaken in the course of the audit:

- the parts of the Remuneration and Staff Report to be audited have been properly prepared in accordance with Department for Communities

directions made under the Armagh Observatory and Planetarium (Northern Ireland) Order 1995; and

- the information given in the Trustees' Annual Report for the financial year for which the financial statements are prepared is consistent with the financial statements.

### **Matters on which I report by exception**

In the light of the knowledge and understanding of the Armagh Observatory and Planetarium and its environment obtained in the course of the audit, I have not identified material misstatements in the Trustees' Annual Report.

I have nothing to report in respect of the following matters which I report to you if, in my opinion:

- adequate accounting records have not been kept; or
- the financial statements and the parts of the Remuneration and Staff Report to be audited are not in agreement with the accounting records; or
- certain disclosures of remuneration specified by the Government Financial Report Manual are not made; or
- I have not received all of the information and explanations I require for my audit; or
- the Governance Statement does not reflect compliance with the Department of Finance's guidance.

### **Responsibilities of the Governors and Accounting Officer for the financial statements**

As explained more fully in the Statement of the Governors' and Accounting Officer Responsibilities, the Governors and the Accounting Officer are responsible for:

- the preparation of the financial statements and for being satisfied that they give a true and fair view;
- such internal controls as the Governors and Accounting Officer determines are necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error;
- assessing the Armagh Observatory and Planetarium's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless the Governors and Accounting Officer anticipate that the services provided by the Armagh Observatory and Planetarium will not continue to be provided in the future.

### **Auditor's responsibilities for the audit of the financial statements**

My responsibility is to examine, certify and report on the financial statements in accordance with the Armagh Observatory and Planetarium (Northern Ireland) Order 1995.

My objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error and to issue a certificate that includes my opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with ISAs (UK) will always detect a material misstatement when it exists.

Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

I design procedures in line with my responsibilities, outlined above, to detect material misstatements in respect of non-compliance with laws and regulations, including fraud.

My procedures included:

- obtaining an understanding of the legal and regulatory framework applicable to the Armagh Observatory and Planetarium through discussion with management and application of extensive public sector accountability knowledge. The key laws and regulations I considered included Armagh Observatory and Planetarium (Northern Ireland) Order 1995;
- making enquires of management and those charged with governance on the Armagh Observatory and Planetarium's compliance with laws and regulations;
- making enquiries of internal audit, management and those charged with governance as to susceptibility to irregularity and fraud, their assessment of the risk of material misstatement due to fraud and irregularity, and their knowledge of actual, suspected and alleged fraud and irregularity;
- completing risk assessment procedures to assess the susceptibility of Armagh Observatory and Planetarium's financial statements to material misstatement, including how fraud might occur. This included, but was not limited to, an engagement director led engagement team discussion on fraud to identify particular areas, transaction streams and business practices that may be susceptible to material misstatement due to fraud. As part of this discussion, I identified potential for fraud in the following areas: revenue recognition, expenditure recognition and posting of unusual journals;
- engagement director oversight to ensure the engagement team collectively had the appropriate competence, capabilities and skills to identify or recognise non-compliance with the applicable legal and regulatory framework throughout the audit;
- documenting and evaluating the design and implementation of internal controls in place to mitigate risk of material misstatement due to fraud and non-compliance with laws and regulations;
- designing audit procedures to address specific laws and regulations which the engagement team considered to have a direct material effect on the financial statements in terms of misstatement and irregularity, including fraud. These audit procedures included, but were not limited to, reading board and committee minutes, and agreeing financial statement disclosures to underlying supporting documentation and approvals as appropriate; and
- addressing the risk of fraud as a result of management override of controls by:
  - performing analytical procedures to identify unusual or unexpected relationships or movements;
  - testing journal entries to identify potential anomalies, and inappropriate or unauthorised adjustments;

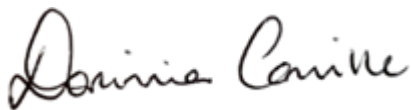
- assessing whether judgements and other assumptions made in determining accounting estimates were indicative of potential bias; and
- investigating significant or unusual transactions made outside of the normal course of business.

A further description of my responsibilities for the audit of the financial statements is located on the Financial Reporting Council's website [www.frc.org.uk/auditorsresponsibilities](http://www.frc.org.uk/auditorsresponsibilities). This description forms part of my certificate.

In addition, I am required to obtain evidence sufficient to give reasonable assurance that the expenditure and income recorded in the financial statements have been applied to the purposes intended by the Assembly and the financial transactions recorded in the financial statements conform to the authorities which govern them.

## **Report**

I have no observations to make on these financial statements.



*Dorinnia Carville Comptroller and Auditor General  
Northern Ireland Audit Office  
106 University Street  
BELFAST  
BT7 1EU*

*Date 18<sup>th</sup> April 2023*

## Armagh Observatory and Planetarium

### Statement of Financial Activities for the year ended 31 March 2022

	Note	Unrestricted Funds 2022 £	Restricted Funds 2022 £	Total Funds 2022 £	Unrestricted Funds 2021 £	Restricted Funds 2021 £	Total Funds 2021 £
<b>Income from:</b>							
Charitable activities	2	2,174,574	1,739,637	<b>3,914,211</b>	2,000,635	1,402,378	<b>3,403,013</b>
Other trading activities	4	126,898	-	<b>126,898</b>	15,559	-	<b>15,559</b>
<b>Total incoming resources</b>		<b>2,301,472</b>	<b>1,739,637</b>	<b>4,041,109</b>	<b>2,016,194</b>	<b>1,402,378</b>	<b>3,418,572</b>
<b>Expenditure on:</b>							
Charitable activities	5	3,713,489	251,535	<b>3,965,024</b>	2,968,461	206,653	<b>3,175,114</b>
Other trading activities	7	69,057	-	<b>69,057</b>	8,943	-	<b>8,943</b>
<b>Total outgoing expenditure</b>		<b>3,782,546</b>	<b>251,535</b>	<b>4,034,081</b>	<b>2,977,404</b>	<b>206,653</b>	<b>3,184,057</b>
<b>Net income / (expenditure)</b>		<b>(1,481,074)</b>	<b>1,488,102</b>	<b>7,028</b>	<b>(961,210)</b>	<b>1,195,725</b>	<b>234,515</b>
<b>Transfers between funds</b>	15	<b>1,502,448</b>	<b>(1,502,448)</b>	<b>-</b>	<b>1,149,400</b>	<b>(1,149,400)</b>	<b>-</b>
<b>Other recognised gains/(losses):</b>							
Gains/(losses) on the revaluation of fixed assets and heritage assets	10 & 11	422,885	-	<b>422,885</b>	(80,721)	-	<b>(80,721)</b>
Actuarial gains less provisions on defined benefit pension scheme	15 & 19	1,534,000	-	<b>1,534,000</b>	(345,000)	-	<b>(345,000)</b>
<b>Net Movement in Funds</b>		<b>1,978,259</b>	<b>(14,346)</b>	<b>1,963,913</b>	<b>(237,531)</b>	<b>46,325</b>	<b>(191,206)</b>
<b>Reconciliation of funds</b>							
Total funds brought forward at 1 April 2021		8,456,857	188,454	8,645,311	8,694,388	142,129	8,836,517
<b>Total funds carried forward at 31 March 2022</b>		<b>10,435,116</b>	<b>174,108</b>	<b>10,609,224</b>	<b>8,456,857</b>	<b>188,454</b>	<b>8,645,311</b>

All amounts above relate to continuing operations of the organisation.  
The notes on pages 62 to 74 form part of the financial statements.

## Armagh Observatory and Planetarium

### Balance Sheet as at 31 March 2022

	Note	2022 £	2021 £
<b>Fixed Assets</b>			
Intangible assets	9	378,538	265,300
Tangible assets	10	9,600,160	9,234,641
Heritage Assets	11	2,698,595	2,598,595
<b>Total fixed assets</b>		<b>12,677,293</b>	<b>12,098,536</b>
<b>Current assets</b>			
Stocks	12	16,230	17,454
Debtors	13	81,628	130,370
Cash at bank and in hand	18	382,787	466,720
<b>Total current assets</b>		<b>480,645</b>	<b>614,544</b>
<b>Creditors: amounts falling due within one year</b>	14	<b>(671,714)</b>	<b>(1,092,769)</b>
<b>Net current assets</b>		<b>(191,069)</b>	<b>(478,225)</b>
<b>Total assets less current liabilities</b>		<b>12,486,224</b>	<b>11,620,311</b>
<b>Creditors: amounts falling due after more than one year</b>		<b>-</b>	<b>-</b>
<b>Net assets excluding pension liability</b>		<b>12,486,224</b>	<b>11,620,311</b>
<b>Defined benefit pension scheme liability</b>	19	<b>(1,877,000)</b>	<b>(2,975,000)</b>
<b>Net assets</b>		<b>10,609,224</b>	<b>8,645,311</b>
<b>Funds</b>			
Restricted funds	15	174,108	188,454
Unrestricted funds	15	4,910,146	4,215,315
Revaluation Reserves	15	7,401,970	7,216,542
Pension Reserve	15	(1,877,000)	(2,975,000)
<b>Total Charity Funds</b>		<b>10,609,224</b>	<b>8,645,311</b>

The financial statements on pages 59 to 74 were approved by the Board of Trustees of Armagh Observatory and Planetarium on 16 March 2023 and were signed on its behalf by:

+ *John McDowell*

Chair of the Board of Trustees  
Archbishop John McDowell

*m.g.burton*

Accounting Officer  
Professor Michael Burton



## Armagh Observatory and Planetarium

### Statement of cash flows for the year ended 31 March 2022

	Note	2022 £	2021 £
<b>Net cash provided by operating activities</b>	17	1,259,845	1,167,072
<b>Cash flows from investing activities:</b>			
Interest received		13	15
Purchase of intangible fixed assets	9	(203,568)	(91,000)
Purchase of tangible fixed assets		(1,149,080)	(980,853)
Sale of tangible fixed assets		8,857	-
		(1,343,778)	(1,071,838)
<b>Increase / (decrease) in cash and cash equivalents</b>		(83,933)	95,234

Further detail is reported in Notes 17 and 18.

### Reconciliation of net cashflow to movement in net cash funds

		2022 £	2021 £
<b>Increase / (decrease) in cash and cash equivalents in the year</b>		(83,933)	95,234
Cash and cash equivalents at 1 April 2021		466,720	371,486
<b>Cash and cash equivalents at 31 March 2022</b>	18	382,787	466,720

The notes on pages 62 to 74 form part of the financial statements.

## Notes to the financial statements for the year ended 31 March 2022

### 1 Summary of significant accounting policies

#### (a) Basis of accounting

These financial statements have been prepared in accordance with the historical cost convention as modified by the revaluation of certain assets. The accounts comply with relevant accounting standards and disclosure requirements issued by the Department of Finance. In all other aspects the financial statements comply with the Statement of Recommended Practice applicable to charities preparing their accounts in accordance with the Financial Reporting Standard applicable in the UK and Republic of Ireland (FRS102) (Charities SORP (FRS102)).

The Trustees of Armagh Observatory and Planetarium confirm that they have complied with their duty to have regard to the guidance on Public Benefit produced by the Charities Commission of Northern Ireland under section 4(b) of the Charities Act (the public benefit requirement statutory guidance) and that this has informed the activities of the organisation in the year to 31 March 2022.

The Trustees are satisfied that the organisation is a going concern on the basis that it has a reasonable expectation that it will continue in operation for the foreseeable future. The financial statements are therefore prepared on a going concern basis.

#### (b) Incoming resources

Grant income from Department for Communities (DfC) is shown in the Statement of Financial Activities (SOFA) in the year in which it is received. Grants that relate to specific capital expenditure are initially recognised in the SOFA and transferred to a restricted fund, Government Grant for Fixed Assets. Where no restriction on the use of the assets exists the value is transferred to an unrestricted fund. Grants that relate to specific research projects are recognised in the Statement of Financial Activities and transferred to a restricted fund. Once the relevant conditions for recognition (entitlement and certainty of value) have been met, they are transferred to funds to match the relevant expenditure. Other grants are credited to the Statement of Financial Activities when receivable.

#### (c) Resources expended

Resources expended are accounted for on an accruals basis. Expenditure is classified under the principal charitable activities of Research, Education and Governance & Support.

#### (d) Pension scheme

The organisation provides pension benefits to its employees by participating in the Local Government Pension Scheme for Northern Ireland, administered by Northern Ireland Local Government Officers' Superannuation Committee (NILGOSC), which is a defined benefit scheme. Annual contributions to the NILGOSC scheme are determined by the scheme and based on actuarial advice. The operating costs of providing retirement benefits to the organisation's employees are recognised in accounting periods in which the benefits are earned by employees, and the related finance costs and other changes in value of the assets and liabilities are recognised in the period in which they arise.

#### (e) Intangible fixed assets

Intangible fixed assets represent contributions to international astronomical research projects, financed by capital grant. They are identifiable, for example, as part of a major telescope installation. The organisation gains benefit in the form of research participation or collaboration, which in turn contributes to the research outputs. Intangible fixed assets are stated at cost and amortised over the expected life of the project.

#### (f) Tangible fixed assets

The cost of tangible fixed assets is their purchase cost or valuation together with any incidental costs of acquisition. Depreciation is calculated so as to write off the cost or valuation of tangible fixed assets, less their estimated residual values, on a straight-line basis over the expected useful economic lives of the assets concerned. Land is not depreciated.

The principal annual depreciation rates used are as follows:

Buildings	Remaining asset life as valued
Digistar	20%
Fixtures and fittings	20 - 50%
Office equipment	25%
Scientific equipment	10 - 25%
Astropark	2%
Exhibits and grounds equipment	10 - 25%
Motor Vehicles	20%

Land and buildings are included in the balance sheet at depreciated replacement cost, estimated value in use or market value. Land and buildings are professionally revalued at least every 5 years in accordance with accounting guidance. Land and buildings were last revalued as at the 31st March 2022. Revaluation gains (losses) are transferred to a revaluation reserve. Land and buildings in years where no revaluation occurs are restated using indices.

The valuations of Land and Buildings have been undertaken having regard to International Financial Reporting Standards (IFRS) as applied to the United Kingdom public sector and in accordance with HM Treasury guidance, International Valuation Standards and the requirements of the Royal Institution of Chartered Surveyors Global Standards.

Other fixed assets (non Land & Buildings) with a life estimated over 5 years have a net book value of £62,549 at 31st March 2022. This accounts for 0.7% of the net book value of fixed assets. The Trustees do not consider it appropriate to carry out an annual indexation of such assets on grounds of immateriality.

## Armagh Observatory and Planetarium

### Notes to the financial statements for the year ended 31 March 2022 (continued)

#### (g) Heritage Assets

Armagh Observatory was founded in 1789 and from this date the Observatory has collected through its operations scientific items, books, furniture and other artefacts which would be considered heritage assets. It is not the policy of Armagh Observatory and Planetarium to acquire heritage assets but has collected such assets through donations and operations. At 31 March 2019, the majority (92% by value) of heritage assets were valued by Sotheby's of London for insurance purposes with reference to auction estimates for replacement. The remainder were valued by Ulster Museum and experienced members of management. It is policy to regularly review the valuation of heritage assets. The heritage assets are being documented on the Collections Database and environmental controls were further improved in 2022.

Heritage assets are summarised in four categories: Books; Clocks and watches; Scientific instruments; and Furniture, Artworks, etc, and are recorded in catalogues and on databases. Historic buildings which have heritage value are included within operational assets. These were included within the recent property revaluation as operational assets and continue to be used for operational purposes.

#### (h) Leases

IFRS 16 Leases replaces IAS 17 Leases and is effective with EU adoption from 1 January 2019. In line with the requirements of the FReM, IFRS 16 will be implemented, as interpreted and adapted for the public sector, with effect from 1 April 2022. IFRS 16 has the effect of largely eliminating the current 'off-balance sheet' treatment of operating leases under IAS 17. AOP have a small number of highly immaterial leases. Based on the AOP's review to date of operating leases associated with land, buildings, equipment and other assets there is likely to be minimal financial impact on the 2022/23 financial statements.

#### (i) Stocks

Stocks are stated at the lower of cost and net realisable value. In general, cost is determined on a first in first out basis. Provision is made where necessary for obsolete, slow moving and defective stocks.

#### (j) Debtors

Debtors comprise amounts due from customers, grants due, prepaid expenses and value added tax.

#### (k) Cash at bank and in hand

Cash held in bank accounts payable on demand and cash floats.

#### (l) Creditors

Creditors comprise payments due to suppliers and accruals for amounts due at the year end.

#### (m) Fund accounting

The organisation has various types of funds for which it is responsible, and which require separate disclosure. These are as follows:

##### Restricted funds

Grants or donations received which are earmarked by the donor for specific purposes. Such purposes are within the overall aims of the organisation.

##### Unrestricted funds

Unrestricted funds, comprising designated funds and undesignated funds, are those which are expendable at the discretion of the trustees in furtherance of the objectives of the organisation. In addition to expenditure on the provision of services, such funds may be held in order to finance capital investment and working capital.

Designated funds include the donated assets fund, the government grants fund and the general fund. The general fund is the day to day operating fund.

Donated assets are the buildings and grounds donated to the organisation in 1790 by its founder Archbishop Richard Robinson. The value is adjusted annually by any revaluation of the underlying assets.

The government grant fund represents the capital financing of the Charity's tangible fixed assets. The fund is reduced annually by a value equivalent to depreciation charged on the related assets.

Undesignated funds - These represent the revaluation reserve which records the movement from the revaluation of the Charity's assets and a pension reserve which matches the long term liability of an underfunded defined benefits pension scheme.

#### (n) Reserves policy

The Armagh Observatory and Planetarium adopts a risk-based approach to establishing a sound system of control covering all types of risks to the aims and objectives of the organisation. There is a need to retain a sufficient level of unrestricted cash reserves to meet the risks associated with financial contingencies, uncertainties and demands.

Armagh Observatory and Planetarium budgets to operate on an annual basis within a balanced funding formula of grant in aid and self generated income. Annual operating surpluses / (deficits) are kept to a minimum and are transferred to an unrestricted general reserve at 31 March each year. The policy is reviewed on an annual basis. The level of general funds at 31 March 2022 was £658,224 (£389,241 at 31 March 2021).

Notes to the financial statements for the year ended 31 March 2022 (continued)

2 Income from charitable activities

	Note	Unrestricted Funds 2022 £	Restricted Funds 2022 £	Total Funds 2022 £	Total Funds 2021 £
<b>Grant Income</b>					
DfC Recurrent grant-in-aid		1,927,000	-	1,927,000	1,951,500
DfC In-year capital grant-in-aid		-	1,254,000	1,254,000	1,040,000
Total grant-in-aid from the DfC		1,927,000	1,254,000	3,181,000	2,991,500
Income from other grants and receipts	3	28	480,615	480,643	377,391
<b>Total Grant Income</b>		<b>1,927,028</b>	<b>1,734,615</b>	<b>3,661,643</b>	<b>3,368,891</b>
<b>Operating Income</b>					
Admissions		237,655	-	237,655	37,176
Profit/(loss) on disposal of fixed assets		3,835	5,022	8,857	(8,184)
Miscellaneous income		6,056	-	6,056	5,130
<b>Total Operating Income</b>		<b>247,546</b>	<b>5,022</b>	<b>252,568</b>	<b>34,122</b>
<b>Total Income from Charitable Activities</b>		<b>2,174,574</b>	<b>1,739,637</b>	<b>3,914,211</b>	<b>3,403,013</b>

3 Income from other grants and receipts

	Note	Unrestricted Funds 2022 £	Restricted Funds 2022 £	Total Funds 2022 £	Total Funds 2021 £
STFC Research and Studentship grants		-	385,289	385,289	311,358
UKRI COVID Support grant		-	49,520	49,520	49,520
Tourism NI grants		-	32,500	32,500	11,952
British Association of Planetaria		-	-	-	500
Royal Society grant		-	-	-	1,000
JobStart scheme		-	13,306	13,306	-
Sundry donations		28	-	28	3,061
Total other grants and receipts	2	28	480,615	480,643	377,391

4 Income from other trading activities

	Unrestricted Funds 2022 £	Restricted Funds 2022 £	Total Funds 2022 £	Total Funds 2021 £
Shop income	113,308	-	113,308	5,527
Rental income	13,590	-	13,590	10,032
<b>Total Income from other trading</b>	<b>126,898</b>	<b>-</b>	<b>126,898</b>	<b>15,559</b>

5 Expenditure on charitable activities

	Note	Unrestricted Funds 2022 £	Restricted Funds 2022 £	Total Funds 2022 £	Total Funds 2021 £
Research	6	1,016,544	237,913	1,254,457	1,061,695
Education	6	1,396,967	13,622	1,410,589	1,053,917
Governance and Support	6	1,299,978	-	1,299,978	1,059,502
		<b>3,713,489</b>	<b>251,535</b>	<b>3,965,024</b>	<b>3,175,114</b>

## Armagh Observatory and Planetarium

### Notes to the financial statements for the year ended 31 March 2022 (continued)

#### 6 Expenditure on charitable activities

Note	Unrestricted Funds 2022 £	Restricted Funds 2022 £	Total Funds 2022 £	Total Funds 2021 £
<b>Research</b>				
Staff costs	501,164	137,672	638,836	625,310
Direct costs	152,865	90,018	242,883	174,249
Support costs	102,993	10,223	113,216	73,090
Depreciation	259,522	-	259,522	189,046
5	1,016,544	237,913	1,254,457	1,061,695
<b>Education</b>				
Staff costs	397,007	-	397,007	318,553
Direct costs	177,554	10,260	187,814	131,882
Support costs	287,030	3,362	290,392	215,108
Depreciation	535,376	-	535,376	388,374
5	1,396,967	13,622	1,410,589	1,053,917
<b>Governance and Support</b>				
Staff costs	1,009,394	-	1,009,394	811,503
Direct costs	39,325	-	39,325	18,746
Support costs	218,005	-	218,005	203,985
Depreciation	33,254	-	33,254	25,268
5	1,299,978	-	1,299,978	1,059,502

Included within Governance and Support costs are the following governance costs:

	Unrestricted Funds 2022 £	Restricted Funds 2022 £	Total Funds 2022 £	Total Funds 2021 £
Management Committee expenses	429	-	429	3,851
Audit	28,086	-	28,086	28,002
	28,515	-	28,515	31,853

The cost of audit shown above includes £18,000 fees payable to Northern Ireland Audit Office for statutory audit. NIAO does not provide any other service.

#### 7 Expenditure on trading activities

	Unrestricted Funds 2022 £	Restricted Funds 2022 £	Total Funds 2022 £	Total Funds 2021 £
<b>Trading</b>				
Direct costs	69,057	-	69,057	8,943
	69,057	-	69,057	8,943

## Armagh Observatory and Planetarium

### Notes to the financial statements for the year ended 31 March 2022 (continued)

#### 8 Average staff numbers and related costs

	Permanent staff	Others	2022 Number	2021 Number
Average staff numbers	24.9	10.0	34.9	32.3

Staff costs comprise:	Permanent staff £	Others £	2022 £	2021 £
Wages and salaries	1,089,991	208,409	1,298,400	1,238,912
Social security costs	116,346	15,728	132,074	118,077
Employer's pension contributions	207,776	30,987	238,763	215,377
Defined benefit pension additional service cost	376,000	-	376,000	183,000
	1,790,113	255,124	2,045,237	1,755,366

The number of employees whose employee benefits (excluding employer pension costs) exceeded £60,000 was:

	2022 Number	2021 Number
£60,001 - £70,000	1	1
£80,001 - £90,000	1	1

The key management personnel of the organisation comprise the trustees and the executive director.

The total amount of employee benefits (including employer pension contributions) received by the executive director for his services to the organisation was £101,661 (2021: £97,194).

There was no remuneration paid to trustees during the year (2021: nil). No travel and subsistence expenses were reimbursed to trustees (2021: £801 to 2 trustees).

#### Average student numbers and related costs (not included above)

	2022 Number	2021 Number
PhD students	8	8

	2022 £	2021 £
Student maintenance grants & stipends	162,149	133,081

## Armagh Observatory and Planetarium

### Notes to the financial statements for the year ended 31 March 2022 (continued)

#### 9 Intangible fixed assets

	2022 £	2021 £
<b>Cost</b>		
At 1 April 2021	418,450	340,450
Additions	203,568	91,000
Disposals	-	(13,000)
<b>At 31 March 2022</b>	<b>622,018</b>	<b>418,450</b>
<b>Depreciation</b>		
At 1 April 2021	153,150	123,200
Charge for year	90,330	42,950
Disposals	-	(13,000)
<b>At 31 March 2022</b>	<b>243,480</b>	<b>153,150</b>
<b>Net book value</b>		
<b>At 31 March 2022</b>	<b>378,538</b>	<b>265,300</b>
<b>At 31 March 2021</b>	<b>265,300</b>	<b>217,250</b>

Additions this year were funded by DfC in-year capital grant-in-aid.

#### 10 Tangible fixed assets

	Freehold Land & buildings £	Exhibits grounds and Astropark £	Digistar Projection System £	Scientific Equipment £	Other Equipment & Vehicles £	Total £
<b>Cost or valuation</b>						
At 1 April 2021	7,954,095	944,445	500,351	549,144	1,091,507	11,039,542
Asset revaluation	85,428	-	-	-	-	85,428
Additions	314,462	212,829	-	175,235	77,930	780,456
Disposals	-	-	-	(14,151)	(37,128)	(51,279)
<b>At 31 March 2022</b>	<b>8,353,985</b>	<b>1,157,274</b>	<b>500,351</b>	<b>710,228</b>	<b>1,132,309</b>	<b>11,854,147</b>
<b>Depreciation</b>						
At 1 April 2021	-	538,396	103,424	535,348	627,733	1,804,901
Adjustment for asset revaluation	(237,457)	-	-	-	-	(237,457)
Charge for year	237,457	154,067	99,232	43,065	204,001	737,822
Disposals	-	-	-	(14,151)	(37,128)	(51,279)
<b>At 31 March 2022</b>	<b>-</b>	<b>692,463</b>	<b>202,656</b>	<b>564,262</b>	<b>794,606</b>	<b>2,253,987</b>
<b>Net book value</b>						
<b>At 31 March 2022</b>	<b>8,353,985</b>	<b>464,811</b>	<b>297,695</b>	<b>145,966</b>	<b>337,703</b>	<b>9,600,160</b>
<b>At 31 March 2021</b>	<b>7,954,095</b>	<b>406,049</b>	<b>396,927</b>	<b>13,796</b>	<b>463,774</b>	<b>9,234,641</b>

Tangible fixed asset additions of £780,456 as shown above were funded by DfC in-year capital grant-in-aid.

If the land and buildings had not been valued, they would have been included at the following amounts:

	2022 £	2021 £
Cost	3,511,908	3,239,445
Aggregate depreciation	(1,106,149)	(1,037,068)
<b>Net book value based on historic cost</b>	<b>2,405,759</b>	<b>2,202,377</b>

## Armagh Observatory and Planetarium

### Notes to the financial statements for the year ended 31 March 2022 (continued)

#### 10 Tangible fixed assets (continued)

Included within Additions above are certain assets under construction:

Freehold Land & buildings	Total
£	£
<u>22,446</u>	<u>22,446</u>

Depreciation on tangible fixed assets for the year was £737,822 (2021: £559,737).

Land and buildings include grounds and buildings with a net book value of £2,101,361 (2021: £1,957,426) which were donated to the organisation in 1790 by Archbishop Richard Robinson, the founder of the organisation.

Armagh Observatory and Planetarium includes in fixed assets any expenditure over £1,500 (on an item or group of related items) which is expected to be used for more than a year.

#### 11 Heritage assets

At Valuation	Books	Clocks & Watches	Scientific Equipment	Furniture, Artworks, etc	Total
	£	£	£	£	£
<b>Carrying Amount at 1 April 2021</b>	546,975	572,600	1,298,900	180,120	2,598,595
Additions	-	-	-	-	-
Revaluation	-	-	-	100,000	100,000
Disposals	-	-	-	-	-
Depreciation / impairment	-	-	-	-	-
<b>Carrying Amount at 31 March 2022</b>	<u>546,975</u>	<u>572,600</u>	<u>1,298,900</u>	<u>280,120</u>	<u>2,698,595</u>

It is policy to regularly review the valuation of heritage assets and to carry out a formal revaluation at least once every five years. Given that they were last valued in March 2019, and that the heritage assets remain in the same condition, the Trustees are content that this valuation is still appropriate.

#### Summary of heritage asset transactions

There were no purchases, donations, charges for impairment or disposals of heritage assets in the five years ended 31 March 2022. £60,061 of historic telescopes and £5,100 of meteorites were transferred from tangible fixed assets to heritage assets during the year ended 31 March 2019. Ordnance Survey maps of Ireland and map chests owned by Armagh Observatory & Planetarium but held in Robinson Library, Armagh, were valued for the first time in 2021-22 at £100,000.

#### 12 Stocks

	2022	2021
	£	£
Goods for resale	<u>16,230</u>	<u>17,454</u>

#### 13 Debtors

	2022	2021
	£	£
Trade debtors	12,933	17,171
Prepayments and accrued income	25,929	29,913
Other debtors	42,766	83,286
	<u>81,628</u>	<u>130,370</u>

#### 14 Creditors: amounts falling due within one year

	2022	2021
	£	£
Trade creditors	127,045	351,548
Accruals and sundry creditors	511,264	708,845
Taxation and social security	33,405	32,376
	<u>671,714</u>	<u>1,092,769</u>



## Armagh Observatory and Planetarium

### Notes to the financial statements for the year ended 31 March 2022 (continued)

#### 15 Statement of Funds

	At 1 April 2021	Income	Expenditure	Revaluation	Transfers	At 31 March 2022
	£	£	£	£	£	£
<b>Restricted Funds</b>						
Government grant for fixed assets	-	1,254,000	-	-	(1,254,000)	-
Profit on disposal of assets	-	5,022	-	-	(5,022)	-
Restricted resource grants	188,454	480,615	(251,535)	-	(243,426)	174,108
<b>Total restricted funds</b>	<b>188,454</b>	<b>1,739,637</b>	<b>(251,535)</b>	<b>-</b>	<b>(1,502,448)</b>	<b>174,108</b>
<b>Unrestricted Funds</b>						
<b>Designated Funds</b>						
Donated assets reserve	1,720,283	-	-	-	-	1,720,283
Government grant for assets	2,105,791	-	-	-	425,848	2,531,639
General fund	389,241	2,301,472	(3,782,546)	-	1,750,057	658,224
	<b>4,215,315</b>	<b>2,301,472</b>	<b>(3,782,546)</b>	<b>-</b>	<b>2,175,905</b>	<b>4,910,146</b>
<b>Undesignated Funds</b>						
Revaluation reserve - Land & Buildings	5,925,068	-	-	322,885	(237,457)	6,010,496
Revaluation reserve - Heritage Assets	1,291,474	-	-	100,000	-	1,391,474
Pension reserve	(2,975,000)	-	-	1,534,000	(436,000)	(1,877,000)
	<b>4,241,542</b>	<b>-</b>	<b>-</b>	<b>1,956,885</b>	<b>(673,457)</b>	<b>5,524,970</b>
<b>Total Unrestricted Funds</b>	<b>8,456,857</b>	<b>2,301,472</b>	<b>(3,782,546)</b>	<b>1,956,885</b>	<b>1,502,448</b>	<b>10,435,116</b>
<b>Total Funds</b>	<b>8,645,311</b>	<b>4,041,109</b>	<b>(4,034,081)</b>	<b>1,956,885</b>	<b>-</b>	<b>10,609,224</b>

#### Details of Transfers between funds

	£
Release of restricted resource grant available to offset overheads	(243,426)
Release of deferred capital grant	(828,152)
Profit on disposal of assets reinvested in capital equipment	(5,022)
Transfer of defined benefit pension service and interest cost	(436,000)
Transfer of depreciation adjustment on asset revaluation to general fund	(237,457)
<b>General fund</b>	<b>1,750,057</b>

#### 16 Analysis of net assets between funds

	Pension Reserve	Revaluation Reserve	Unrestricted Funds	Restricted Funds	Total Funds
	£	£	£	£	£
Tangible fixed assets	-	6,010,496	3,968,202	-	9,978,698
Heritage assets	-	1,391,474	1,307,121	-	2,698,595
Current assets	-	-	306,537	174,108	480,645
Creditors: amounts falling due within one year	-	-	(671,714)	-	(671,714)
Pension scheme liability	(1,877,000)	-	-	-	(1,877,000)
<b>Net assets/(liabilities)</b>	<b>(1,877,000)</b>	<b>7,401,970</b>	<b>4,910,146</b>	<b>174,108</b>	<b>10,609,224</b>

#### 17 Reconciliation of net expenditure to net cash flow from operating activities

	2022 £	2021 £
Net expenditure for the year per statement of financial activities	7,028	234,515
Adjustments for:		
Depreciation	828,152	602,687
Interest received	(13)	(15)
(Profit)/Loss on disposal of assets	(8,857)	8,184
Defined benefit pension scheme service and interest cost less contributions payable	436,000	235,000
Decrease/(increase) in stock	1,224	(3,541)
Decrease/(increase) in debtors	48,742	(13,886)
(Decrease)/increase in creditors	(52,431)	104,128
<b>Net cash provided by operating activities</b>	<b>1,259,845</b>	<b>1,167,072</b>

Notes to the financial statements for the year ended 31 March 2022 (continued)

18 Analysis of cash and cash equivalents

	31 March 2022 £	1 April 2021 £
Cash at bank and in hand	382,787	466,720
<b>Total cash and cash equivalents</b>	<b>382,787</b>	<b>466,720</b>

19 Pension scheme

**Introduction**

The disclosures below relate to the funded liabilities within the Northern Ireland Local Government Officers' Superannuation Pension Fund (the "Fund") which is part of the Local Government Pension Scheme (Northern Ireland) (the "LGPS") and certain related unfunded liabilities which have been separately disclosed. The LGPS is a funded defined benefit plan with benefits earned up to 31 March 2015 being linked to final salary. Benefits after 31 March 2015 are based on a Career Average Revalued Earnings scheme. Details of the benefits earned over the period covered by this disclosure are set out in 'The Local Government Pension Scheme Regulations (Northern Ireland) 2014' (as amended) and 'The Local Government Pension Scheme (Amendment and Transitional Provisions) Regulations (Northern Ireland) 2014' (as amended). The unfunded pension arrangements relate to termination benefits made on a discretionary basis upon early retirement in respect of members of the Local Government Pension Scheme under the 'Local Government (Early Termination of Employment) (Discretionary Compensation) Regulations (Northern Ireland) 2007'.

**Funding / Governance Arrangements of the LGPS**

The funded nature of the LGPS requires participating employers and their employees to pay contributions into the Fund, calculated at a level intended to balance the pension liabilities with investment assets. Information on the framework for calculating contributions to be paid is set out in 'The Local Government Pension Scheme Regulations (Northern Ireland) 2014' and the Fund's Funding Strategy Statement. The last actuarial valuation was at 31 March 2019 and the contributions to be paid until 31 March 2023 resulting from that valuation are set out in the Fund's Rates and Adjustment Certificate. The Northern Ireland Local Government Officers' Superannuation Committee is responsible for the governance of the Fund.

**Assets**

The assets allocated to the Employer in the Fund are notional and are assumed to be invested in line with the investments of the Fund for the purposes of calculating the return over the accounting period. The Fund holds a significant proportion of its assets in liquid investments. As a consequence there will be no significant restriction on realising assets if a large payment is required to be paid from the Fund in relation to an employer's liabilities. The assets are invested in a diversified spread of investments and the approximate split of assets for the Fund as a whole (based on data supplied by the Committee) is shown in the disclosures. The Committee may invest a small proportion of the Fund's investments in the assets of some of the employers participating in the Fund if it forms part of their balanced investment strategy.

The NILGOSC actuary, Aon Solutions UK Ltd (AON), has provided the following details for the purposes of accounting for the Armagh Observatory and Planetarium's joint share of the scheme deficit in accordance with FRS 102 at 31 March 2022.

**Key assumptions used by the actuary were:**

	31/03/2022	31/03/2021
Discount rate	2.8%	2.1%
CPI inflation	3.1%	2.7%
Pension increases	3.1%	2.7%
Pension accounts revaluation rate	3.1%	2.7%
Salary increases	4.6%	4.2%

**Mortality assumptions**

	31/03/2022 Years	31/03/2021 Years
<b>Males</b>		
Pensioner member aged 65 at accounting date	21.8	21.9
Active member aged 45 at accounting date	23.2	23.3
<b>Females</b>		
Pensioner member aged 65 at accounting date	25.0	25.1
Active member aged 45 at accounting date	26.4	26.5

## Armagh Observatory and Planetarium

### Notes to the financial statements for the year ended 31 March 2022 (continued)

#### 19 Pension scheme (continued)

##### Asset Allocation

	Value at 31/03/2022	Value at 31/03/2021
Equities	42.9%	46.3%
Property	10.0%	8.9%
Government bonds	24.7%	23.6%
Corporate bonds	2.2%	12.1%
Multi Asset Credit	13.1%	0.0%
Cash	4.0%	5.3%
Other	3.1%	3.8%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>

##### Reconciliation of funded and unfunded status to balance sheet

	Value at 31/03/2022 £'000	Value at 31/03/2021 £'000
Fair value of assets	11,620	10,826
Present value of funded defined benefit obligation	(13,495)	(13,799)
Funded status (deficit)	(1,875)	(2,973)
Present value of unfunded defined benefit obligation	(2)	(2)
<b>Liability recognised on the balance sheet</b>	<b>(1,877)</b>	<b>(2,975)</b>

The split of the liabilities at the last valuation between the various categories of members is as follows:

Active members	34%
Deferred pensioners	25%
Pensioners	41%

##### Amounts recognised in statement of financial activities

	Year to 31/03/2022 £'000	Year to 31/03/2021 £'000
<b>Operating cost</b>		
Current service cost	(620)	(402)
<b>Financing cost</b>		
Interest on net defined benefit liability	(60)	(52)
<b>Pension expense recognised in statement of financial activities</b>	<b>(680)</b>	<b>(454)</b>
Allowance for administrative expenses included in Current Service Cost	6	6

##### Amounts recognised in statement of funds

	Year to 31/03/2022 £'000	Year to 31/03/2021 £'000
Asset gains/(losses) arising during the period	584	1,746
Liability gains/(losses) arising during the period	950	(2,091)
<b>Total amount recognised in statement of funds</b>	<b>1,534</b>	<b>(345)</b>

##### Changes to the present value of defined benefit obligation

	Year to 31/03/2022 £'000	Year to 31/03/2021 £'000
Opening defined benefit obligation	13,801	11,313
Current service cost	620	402
Interest expense on defined benefit obligation	287	257
Contributions by participants	90	86
Actuarial losses/(gains) on liabilities	(950)	2,091
Net benefits paid out	(351)	(348)
<b>Closing defined benefit obligation</b>	<b>13,497</b>	<b>13,801</b>

Notes to the financial statements for the year ended 31 March 2022 (continued)

19 Pension scheme (continued)

Changes to the fair value of assets

	Year to 31/03/2022 £'000	Year to 31/03/2021 £'000
Opening fair value of assets	10,826	8,918
Interest income on assets	227	205
Remeasurement gains/(losses) on assets	584	1,746
Contributions by the employer	244	219
Contributions by participants	90	86
Net benefits paid out	(351)	(348)
Closing fair value of assets	11,620	10,826

Actual return on assets

	Year to 31/03/2022 £'000	Year to 31/03/2021 £'000
Interest income on assets	227	205
Gain/(loss) on assets	584	1,746
Actual return on assets	811	1,951

Sensitivity Analysis

Funded LGPS benefits

Discount rate assumptions

Adjustment to discount rate	+0.1%pa	Base Figure	-0.1%pa
Present value of total obligation (£m)	13.279	13.495	13.724
% change in present value of total obligation	-1.6%		1.7%
Projected service cost (£m)	0.562	0.581	0.601
Approximate % change in projected service cost	-3.3%		3.4%

Rate of general increase in salaries

Adjustment to salary increase rate	+0.1%pa	Base Figure	-0.1%pa
Present value of total obligation (£m)	13.522	13.495	13.468
% change in present value of total obligation	0.2%		-0.2%
Projected service cost (£m)	0.581	0.581	0.581
Approximate % change in projected service cost	0.0%		0.0%

Rate of increase to pensions in payment and deferred pension assumption, and rate of revaluation of pension account assumptions:

Adjustment to pension increase rate	+0.1%pa	Base Figure	-0.1%pa
Present value of total obligation (£m)	13.697	13.495	13.306
% change in present value of total obligation	1.5%		-1.4%
Projected service cost (£m)	0.601	0.581	0.562
Approximate % change in projected service cost	3.4%		-3.3%

Post retirement mortality assumption

Adjustment to mortality age rating assumption	-1 year	Base Figure	+1 year
Present value of total obligation (£m)	13.967	13.495	13.023
% change in present value of total obligation	3.5%		-3.5%
Projected service cost (£m)	0.605	0.581	0.558
Approximate % change in projected service cost	4.1%		-4.0%

## Notes to the financial statements for the year ended 31 March 2022 (continued)

### 19 Pension scheme (continued)

#### McCloud Judgement

In December 2018 the Government lost a Court of Appeal case (the 'McCloud/Sargeant' judgement) which found that the transitional protection arrangements put in place when the firefighters' and judges' pension schemes were reformed amounted to illegal age discrimination. The Government has acknowledged that the difference in treatment will need to be remedied across all public service schemes, including the LGPS. Protections applied to all active members of schemes who were within 10 years of their Normal Pension Age on 1 April 2012. In relation to the LGPS, all members joined the new Scheme for membership after 1 April 2015, but members within 10 years of normal retirement were given an underpin (or 'better of both') promise, so their benefits earned after that date would be at least as valuable in terms of amount and when they could be drawn, as if they had remained in the pre-reformed final salary scheme.

AON assume the remedy applies to all members in service on 1 April 2012, on retirement or prior withdrawal, and with extension to benefits payable to the dependants of those members. Figures are calculated using an average cost factor for each individual active member based on their age, sex, and pensionable pay in the latest valuation data. On grounds of practicality and pragmatism Aon Hewitt Ltd only consider the active membership data in the latest valuation (and believe any potential liabilities for members who have left employment between the date of the scheme reforms and the latest valuation data are unlikely to be significant for most employers).

AON's method for valuing the McCloud remedy is closely aligned with the method proposed by the Department for Communities in its consultation issued in November 2020.

#### Guaranteed Minimum Pension (GMP) Equalisation and Indexation

AON's standard approach is to value full CPI inflation pension increases on GMPs of members whose State Pension Age (SPA) is on or after 6 April 2016. This is an approximate method of recognising the cost of the Government's commitment to compensate public service scheme members from the removal of the Additional Pension element of the State Pension from this date, and for the outcome of the Lloyds judgement which found GMPs to be illegally sex discriminatory. Government has consulted on its approach to compensating affected members and announced on 23 March 2021 that it would adopt a long term policy of uprating GMPs in line with CPI inflation for members whose SPA is on or after 6 April 2016. The consultation response recognised that this solution will not address all sex inequalities for a minority of members. We are expecting further guidance from the Department for Levelling Up, Housing and Communities (in England and Wales) and the Department for Communities (in Northern Ireland) (to an undefined timetable) on how they propose to deal with this. We expect any remaining sex inequalities to be small and we believe that our approach, in line with current government policy, is a reasonable estimate.

### 20 Capital commitments

Capital commitments at 31 March 2022 totalled £136,000 (2021: £98,400) in respect of expenditure on projects commenced during the year. DfC has agreed funding for 2022/23.

### 21 Contingent liabilities

#### Pension liability - Goodwin judgement

As detailed in Note 19, AOP has recognised a Pension liability of £1.877m (2021: £2.975m) for the NILGOSC defined benefit scheme. In June 2020, an Employment Tribunal ruled that the Teachers' Pension Regulations 2010 (as amended) directly discriminated on grounds of sexual orientation in relation to the provision of adult survivor pensions and thereby result in a breach of the non-discrimination rule in section 61(1) to the Equality Act 2010. The provisions found that survivor's benefits of a female member in an opposite sex marriage are less favourable than for a female in a same sex marriage or civil partnership, and that treatment amounts to direct discrimination on grounds of sexual orientation. Although there is a similar differential treatment under the regulations governing the LGPS(NI), it is more limited in scope. The differential applies only where the marriage or civil partnership is entered into after the member has left the scheme (either as a pensioner or becoming a deferred member). As a result any future remedy, regardless of its retrospective scope, is therefore considered likely to be immaterial. The actuary for the scheme currently estimates the Goodwin judgement could add around 0.2% to the defined benefit obligation for a typical employer (and no higher than 0.5%), however the impact will vary depending on the membership profile. AOP's defined benefit obligation disclosed in Note 19 at 31 March 2022 is £13.497m.

There were no other contingent liabilities at the 31st March 2022 (2021: nil).

### 22 Remote contingent liabilities (Audited)

There were no remote contingent liabilities at the 31st March 2022 (2021: nil).

### 23 Related-party transactions

None of the members of the Board of Governors, the Management Committee, the Director or other related parties have undertaken any material transactions with the Armagh Observatory and Planetarium during the year. The Armagh Observatory and Planetarium has had various material transactions with a number of Government Departments, Executive Agencies and Non-Departmental Public Bodies in Northern Ireland and the UK. Most of these transactions have been with DfC, Construction and Procurement Delivery (CPD), Strategic Investment Board (SIB), the Science and Technology Facilities Council (STFC) and the Education Authority (EA). DfC provides recurrent and capital grant-in-aid (note 2), SIB provides professional advisory services, the STFC provides grants for research projects (note 2) and CPD and EA are the Centres of Procurement Expertise for the organisation. The Royal School Armagh leases land for playing fields at a nominal rent.

No other related party transactions took place in the year, other than certain trustees' expenses already disclosed in note 8.

## Armagh Observatory and Planetarium

### Notes to the financial statements for the year ended 31 March 2022 (continued)

#### 24 Losses and special payments (Audited)

There were no losses or special payments during the year (2021: nil).

#### 25 Financial instruments

As the cash requirements of the Observatory and Planetarium are met through grants from DfC and other grant funding bodies, financial instruments play a more limited role in creating risk than would apply to a non-public sector body of a similar size. The majority of financial instruments relate to contracts to buy non-financial items in line with the Observatory's expected purchase and usage requirements and the Observatory and Planetarium is therefore exposed to little credit, liquidity or market risk.

#### 26 Additional disclosures to comply with the Financial Reporting Manual (FRoM)

FRoM requires non-departmental public bodies to regard grant-in-aid received as contributions from controlling bodies giving rise to a financial interest in the residual interest of the body and hence accounting for as financing, that is by crediting them to income and expenditure reserve. In addition FRoM requires grant-in-aid to be accounted for on a cash basis.

However, as the organisation is required to prepare accounts in accordance with the SORP for charities, DfC has given AOP permission to continue to treat grants as income. If AOP were required to comply with the FRoM the result of this compliance would be as follows:

##### Statement of Financial Activities prepared under FRoM

	Note	2022 £	2021 £
<b>Incoming resources</b>			
Incoming resources from research and other non-DfC grants	2	480,643	377,391
Operating income	2	252,568	34,122
Trading income	4	126,898	15,559
<b>Total incoming resources</b>		<b>860,109</b>	<b>427,072</b>
<b>Resources expended</b>			
Direct expenditure of the organisation		4,034,081	3,184,057
<b>Total Resources expended</b>		<b>4,034,081</b>	<b>3,184,057</b>
<b>Net deficit for the year</b>		<b>(3,173,972)</b>	<b>(2,756,985)</b>
Loss/(gain) on revaluation of Fixed Assets and Heritage Assets		422,885	(80,721)
Actuarial (loss)/gain on pension scheme		1,534,000	(345,000)
<b>Amount transferred to funds</b>		<b>(1,217,087)</b>	<b>(3,182,706)</b>

##### Analysis of funds prepared under the FRoM

		2022 £	2021 £
<b>Balance at 1 April 2021</b>		<b>8,645,311</b>	<b>8,836,517</b>
Grant-in-aid received in the year	2	3,181,000	2,991,500
Net operating costs for the year		(1,217,087)	(3,182,706)
<b>Balance at 31 March 2022</b>		<b>10,609,224</b>	<b>8,645,311</b>

#### 27 Events after the Reporting Date

##### 1) Adjusting Events:

There were no events after the reporting date which would require adjustment to the financial statements.

##### 2) Non-adjusting Events:

There were no events after the reporting date which would require disclosure in the financial statements.

The Accounting Officer authorised the issue of these financial statements on 18 April 2023.