

The Armagh Observatory and Planetarium

Annual Report and Accounts For the year ended 31 March 2021

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

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The Armagh Observatory and Planetarium

Annual Report and Accounts

For the year ended 31 March 2021

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The Trustees' Annual Report for the year ended 31 March 2021

The Board of Governors, who are the Trustees for the Armagh Observatory and Planetarium (AOP) has pleasure in presenting its annual report and financial statements for this charity for the year ended 31 March 2021. 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 (FRS102).

The sponsor Department for the 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 This 1995 Order superseded the original 1791 Act of the Irish Parliament entitled '*An Act for Settling and Preserving a Public Observatory and Museum in the City of Armagh For Ever*',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 of 1938 ('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 scientific and 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 (or 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 fall within their remit. However, as the Management Committee role is not formally set out in statute it is not possible to make this change. The Board of Governors consider this is something that needs to be addressed in consultation with the Sponsorship body, Department for Communities.

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.

The Vision Statement for AOP is:

"Armagh Observatory and Planetarium is renowned throughout the world as a unique Centre of Excellence for research, education, inspiration and outreach in space and science."

The Mission of the Armagh Observatory and Planetarium is:

"To advance the knowledge and understanding of astronomy and related sciences through interactive engagement and the execution, promotion and dissemination of astronomical research nationally and internationally, in order to enrich the intellectual, economic, social and cultural life of all members of the community".

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 Corporate Plan for 2018-21 has now been completed and development of a new 5 year strategy is underway.

During 2020-21 there were 26 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 12 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 2021. 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

The restrictions imposed by the UK government in an effort to limit the impact of the Covid-19 pandemic resulted in closure of all AOP facilities from 20 March 2020. All staff commenced remote working. The organisation quickly adopted technology to facilitate good communication and exchange of information, mainly building on the underlying technology of Microsoft 365 which was already in place. Recognition was given to the challenges of lone working, and management were constantly reviewing the various activities, with ongoing consideration for the mental and physical well-being of staff and students.

The various sections of the Annual Report provide some indication of the impact of the restrictions and the response of the various departments.

The Planetarium re-opened to the public at the end of June 2021 with restricted numbers but ultimately, there has been a residual impact to the closure which can not be fully assessed at this stage. However, there is no reason to believe that it will affect the ability of the organisation to continue as a going concern. While admissions income has been drastically reduced, there are substantial savings associated with cancellation of events, reduction in maintenance activity and lower energy usage. In addition, both public sector funding and research grants are being availed of to offset costs associated with the pandemic.

An Internal Audit Review of Covid-19 working arrangements was conducted in October 2020 resulting in a satisfactory assurance rating with no recommendations.

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 all strands of astronomical research that are communicated through the Planetarium.

Between a quarter to one 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 minor 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 that will provide funding for two additional Post-Doctoral Research Assistants (PDRAs) plus salary staff contribution and estate costs for the until March 2024, which adds up to similar funding secured early in 2020 and that is already funding a third PDRA until March 2022.

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 GOTO (Gravitational-wave Optical Transient Observer) project, a member of the UK consortia involved in building the detectors for DKIST, LOFAR (LOw Frequency ARray) radio telescope project and a consortium member of the CTA (Cherenkov Telescope Array) 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.

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), 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 the completion of several PhD thesis at AOP. In Solar System studies, Rok Nezic obtained his PhD in April 2020 (UCL) with his work on comet polarimetry. In stellar physics, Lauren Doyle and Erin Higgins obtained their PhD in May (Northumbria) and June 2020 (QUB), respectively, with Lauren reporting a comparison of Solar eruptions and flares from stars which have internal properties that are quite different to Solar type stars and Erin presenting a detailed modelling effort of massive stars in the pristine environments of nearby dwarf galaxies (the Small and Large Magellanic Clouds). Finally, in the extra-galactic domain, Boris Nedelchev obtained his PhD in August 2020 (Hertfordshire) with an extensive study of neutral-gas outflows in nearby galaxies, to test the role of super-massive black hole in quenching star formation.

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 from DfC direct support allowing AOP to participate in several key international projects (such as SALT, GOTO, IST, DKIST, 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 sometime 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 particularly interesting theoretical investigation was related to the modelling of an “impossible” 85 Solar-mass black hole that was discovered in a recent gravitational wave event by LIGO/Virgo. In an all-Armagh team effort lead by Jorick Vink, the team also involving STFC PDRA Erin Higgins, Öpik Fellow Andreas Sander and PhD student Gautham Sabhahit managed to produce a MESA stellar evolution model that was able to produce heavy black holes in pristine chemical environments (*Vink, Higgins, Sander & Sabhahit, 2021*). Using polarimetry, a technique that reveals how light is reflected by a surface, or affected by the presence of a magnetic field, Stefano Bagnulo and AOP visiting fellow John Landstreet have performed a survey of all nearby white dwarfs and check them for the presence of a magnetic field. Their work has led to the discovery of numerous strongly magnetic white dwarfs in the vicinity of our solar system (*Bagnulo & Landstreet, 2020*), as well as to important conclusions about the origin and characteristics of the magnetic fields in the latest stages of the stellar evolution (*Bagnulo & Landstreet, 2021, submitted*). The presence of exotic atomic species on stellar surfaces is a pointer to unusual physics. The SALT survey of chemically peculiar hot subdwarfs has provided a systematic classification of over 100 hydrogen-deficient stars in end-of-life decline, but with significantly diverse evolution histories (*Jeffery et al. 2021*)

Linking to our Galaxy, Michael Burton worked with his former postdoctoral fellow David Rebolledo in Chile to complete the third paper in a series investigating the nature of the Carina star forming complex, one of the most active stellar nursery known in the Galaxy. Carina serves as a template for studying super star cluster formation in other galaxies. This paper (*Rebolledo et al. 2021*) provides the most detailed radio continuum map yet obtained of an entire star forming complex, revealing a spectacular and complex radio emission distribution with multiple structures such as filaments, shell and ionization fronts. Comparison between radio continuum and our previous work producing hydrogen atomic and molecular gas maps offers a clear view of the bipolar outflow driven by the energy released by the massive stellar clusters that also affects the fraction of molecular gas across the nebula.

Finally, on the extra-galactic side Marc Sarzi continues to co-lead his survey of galaxies in the Fornax cluster producing studies that also relates directly to the processes of star formation and the latest stages of stellar evolution. In particular, he was instrumental to combining the effort his team with that of another group bent on the study of the molecular gas material in the Fornax cluster, which led to the work of *Zabel et al. (2020)* who combined MUSE and Atacama Large Millimeter Array (ALMA) data to explore in detail the impact a crowded galactic environment on the star formation efficiency of spiral galaxies that recently joined the Fornax cluster. On late stellar evolution, his co-supervised PhD student in Hertfordshire developed a novel technique (*Spriggs, Sarzi et al. 2020*) to detect Planetary Nebulae (PNe) in the Fornax cluster using MUSE data. This will lead to final catalogue of over a thousand PNe, which will allow not only to connect the properties of such stellar remnants with that of the parent stellar population of their host galaxies, but also to measure the distance to these galaxies to high precision (*Spriggs et al in prep*).

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, through membership of the UK SALT consortium, AOP 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 2020 (2019) alone, over 165 (120) AOP unique astronomical observations have already been made, targeting some of the most exotic stars in the Universe. These will contribute to several upcoming discovery papers and also 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 N. Ireland and in South Africa.

During 2020, AOP took over the administration role for the UK SALT consortium, which includes five other academic partners – Keele University, Nottingham University, Open University, University of Central Lancashire and University of Southampton.

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 culminated in publication of the low-resolution part of the survey, including classifications and coarse analyses of over 100 hydrogen-deficient hot subdwarfs (*Jeffery et al. 2021*). 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 in prep*). If the hot subdwarf was formed from the same material as its companion, then lead is one million times overabundant! Jorick Vink and AOP visiting student Cormac Larkin are using SALT to complete the census of massive stars in the low-metallicity environment of the Small Magellanic Cloud, their prime search is for the elusive binary 'stripped' Helium stars, which have been hypothesized to exist since the 1960s but which have as yet failed to be revealed in large numbers. Finally, Gavin Ramsay also continues to obtain SALT observations as part of a collaborative programme with Patrick Woudt (U Cape Town) to obtain spectra of short period variables identified using the OmegaWhite. This is essential if the true nature of these stars is to be revealed. 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 types of “transient” events occur when one star circling its companion unloads sufficient amounts of 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-) 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. 2020*, *Østensen et al. 2020*), and extreme helium stars (*Jeffery et al. 2020a*). New classes of pulsating star continue to be discovered. In each case, the oscillation requires a driving mechanism, and in many cases it is novel. Thus, the detection of low-amplitude modes with periods of 0.6 and 1.1 days in two very hot subdwarfs can best be explained by surface Rossby waves – like the standing wave seen in the Earth's circumpolar circulation (*Jeffery 2020*).

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 opens up an entirely new way of studying the universe. Because of the way the detectors work and where they are located, the exact position in the sky of the merging black holes is not known. Instead the

location 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 were able to locate the optical counterpart of the gravitational wave event it would be possible to derive much more information about it and on the underlying physics of the black holes.

AOP was able to become 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. 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. In the summer of 2019 GOTO made a successful bid to the STFC for £3.2M to allow a second node to be built on La Palma and one node in Australia. AOP was able to secure additional investments from DfC, which together with our international partners should secure the funding of a second node in Australia which would complete our vision of imaging the whole sky every few nights, making it a truly world class facility.

Thanks to our involvement in GOTO, AOP astronomers are recognised in the GOTO reports for new supernovae discovered by the consortium (38 this year, e.g. *Galloway et al. 2021*; *Ramsay et al. 2021*) or in follow-up observations of gamma-ray bursts, gravitational-wave and neutrino events (4 this year, e.g. *Mong et al. 2021*). These reports feature in the IAU supported 'Transient Name Server' and 'Gamma-ray Coordination Networks'. Although the prime aim of the project is to detect the optical counterpart of gravitational wave events, the data products will prove to be a treasure trove of information which will allow for the study of supernovae, X-ray transients, interacting binaries, pulsating stars, flare stars, comets and asteroids. It has already led to the discovery and announcements of many supernovae through the Transient Name Server sponsored by the IAU Supernova Working Group. It will be a resource for astronomers at AOP and be an excellent educational tool. In fact, they already form the basis 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. Although the project is still at an early stage, the publications using GOTO data will start to bear fruit over this coming year.

Using GOTO and other all-sky optical survey data, Chris Duffy investigated the long term optical behaviour of ultra-compact binaries called 'AM CVn' stars after their prototype. He examined systems which had orbital periods between 22.5 and 26.8 min. Although this is a very narrow range their properties were diverse indicating the nature and history of the secondary plays a key role in outburst behaviour (*Duffy et al 2021*). One AM CVn which was observed at different wavelengths was ASASSN-14mv which was observed to go into a rare outburst in Aug 2020 (*Ramsay et al 2020*). Ramsay led a series of observations to monitor its outburst using GOTO, Swift (an X-ray/UV telescope), optical telescopes at SAAO and the MeerKat radio array in South Africa.

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 research this year focused on data from the Interface Region Imaging Spectrometer (IRIS) and the yet unsolved problem of what heats the Solar corona, where Solar storms originate. In particular, a project lead by our PhD student, Nived Vilangot Nhalil (*Vilangot Nhalil et al 2020*), used a burst detection algorithm on high-resolution imaging IRIS data to further investigate the bright impulsive events in the very narrow (100 km) layer between the chromosphere and the corona where the temperature rises abruptly from about 8000 to about 500,000 K. The estimated total radiative power obtained for the observed energy distributions for such impulsive event is typically <25% of what would be required to sustain the corona indicating that impulsive events in this energy range are not sufficient to solve coronal heating. Indeed, at best such bursts could provide ~50% of the required energy to account for the coronal heating problem. This suggests an additional source of heating, probably wave heating.

Gavin Ramsay, Gerry Doyle and former PhD student Lauren Doyle (now at Warwick) continue to use *TESS* and other data 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. One study of fast rotating stars showed that the fraction of stars which show flares dropped significantly for stars rotating faster than once every 5 hrs. This was unexpected since the very fastest rotating stars are supposed to be the most active: possible explanations are outlined in *Ramsay et al. (2020)*. A study of solar-like stars using *TESS* showed that flares occur at random times unlike solar flares which are strongly correlated with the appearance of sunspots. Many of these flares are classed as 'super-flares' which if the Sun were to emit such an event would cause significant disruption to human activities on the Earth (*Doyle et al. 2020*).

The role of IST and I-LOFAR

IST The Inouye Solar Telescope (previously known as DKIST) saw its 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 30km (18 miles) in size at a distance of 150 million kilometres. AOP became involved in the project 6 years ago when, via a special call from Department for Culture Arts and Leisure (DCAL), funding was awarded to assist in building detectors for three of the telescope's instruments. In collaboration with Queen's University Belfast we set-up the UK DKIST Consortium, which then received funding from the Science & Technology Facilities Council. Coupled with funding from various UK universities and Andor Technology in excess of £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.

IST is the largest solar telescope in the world with a focus on understanding the Sun's explosive behaviour. The telescope reveals features that are three times smaller than anything seen before and does so multiple times a second. Observing the fingerprints of atoms and ions throughout the solar atmosphere will help us explain the dynamic nature of the Sun and solar-like stars, giving us opportunities for discoveries of processes we had no idea existed. The first call for research proposals will be in May 2020. Gerry Doyle and his PhD student Nived Nhalil will be involved in this project over 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 antennas spread across seven countries including the Netherlands, Germany, England, Poland, France, Sweden and, most recently, 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.

In collaboration with DIAS, AOP have jointly appointed a new Lindsay student (Jeremy Rigney) who will use 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. Gerry Doyle and Gavin Ramsay have recently 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 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.

Jeremy Rigney (Lindsay PhD Scholar, a joint appointment between AOP and DIAS) has been working on LOFAR radio data of the active low mass star EV Lac. Observations were made at the same time using an optical telescope in the Crimea. This is pioneering work on stars which have been little studied so far in these radio frequencies. Together with Gavin Ramsay and Gerry Doyle, Jeremy has also started working with colleagues in Australia to study low mass stars using the ASKAP radio array and to combine these observations made using *TESS*.

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 reports the discovery that an asteroid trailing behind Mars has a composition very similar to the Moon's. Trojans are a class of asteroid that follows the planets in their orbits. They are of great interest to scientists as they represent leftover material from the formation and early evolution of the solar system. A team led by Christou and including scientists from Italy, Bulgaria and the US has been studying the Trojans of Mars to understand what they tell us about the early history of the inner worlds of our solar system, the so-called terrestrial planets. The team used X-SHOOTER, a spectrograph mounted on the European Southern Observatory 8-m Very Large Telescope (VLT) in Chile to obtain a reflectance spectrum of Mars Trojan asteroid (101429) 1998 VF31. Such spectra are diagnostic of surface composition; data obtained previously on the object suggested a composition like a common class of meteorites called ordinary chondrites.

The team instead found that the spectrum did not match well with any type of meteorite or asteroid. Instead, a very close spectral match was obtained with areas of the Moon such as crater interiors and mountains where there is exposed bedrock. Based on this information, the team concluded that the asteroid is most likely an ancient piece of debris, dating back to the gigantic impacts that formed the Moon and the other rocky planets in our solar system like Mars and the Earth. The research, which was published in *Icarus*, also has implications for finding such Trojans associated with the Earth.

Apostolos Christou also reports on the publication of a new model to explain the “oddball” moons of Neptune: Triton, a >2000 km diameter satellite that circles Neptune in the opposite direction that the planet rotates; and 300-km Nereid, the planetary moon with the most elongated orbit in the solar system. Development of the model was led by Daohai Li, Christou's former PhD student and now a postdoctoral researcher at Lund Observatory in Lund, Sweden. The model postulates a close encounter between Neptune and a planetary-sized body, an event that current wisdom suggests may have been commonplace in the distant past. If this scenario is correct, Nereid must have formed closer to Neptune than its current location and may have experienced significant thermal evolution due to tides. Finding evidence of geologic activity on Nereid's surface by a spacecraft mission to Neptune could therefore be used to validate the model. The mechanism proposed by Li & Christou should also operate on moons around extrasolar planets and future surveys will test this. The work was published in the April 2020 issue of *The Astronomical Journal*.

Stefano Bagnulo and collaborators (including AOP researchers Galin Borisov, Apostolos Christou and former PhD student Rok Nezic) have carried out polarimetric observations of 21/Borisov, the first comet not belonging to our solar system discovered by the astronomers. They found that this object is possibly the most pristine comet ever observed. This work has been announced by various press-releases and has attracted strong attention from media all around the world.

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. The images to be obtained from Comet Interceptor will show the view from inside the comet as the spacecraft flies through it and encounters jets of dust and gas emanating from the comet nucleus.

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.

Results

Key to understanding the astrophysical engines generating high-energy particles is to know their exact distance, since this allows to deduce how intrinsically powerful such sources are. In this respect, Michael Burton assisted in the radio measurements that were instrumental in measuring the expansion rate of the youngest known galactic supernova remnant, G1.9+0.3, to be ~9,000 km/s. This SNR is located in the central regions of the Galaxy (*Luken et al. 2020*). When it comes to accretion of matter on black holes, another key ingredient to understanding the production of collimated jets or the powerful radiation arising from the accretion itself, is the very mass of the black holes. In the case of supermassive black holes (SMBHs, weighting million to billions of Solar masses) at the centre of galaxies, in turn this is important to understand the extent to which such incredible objects can affect the evolution of their host galaxies by means of the fantastic amounts of energy that they can release when clouds of gas or stars happen to fall in them. In this respect, Marc Sarzi has continued to work within a long-term collaboration that exploits the superior capabilities of the Atacama Large Millimetre Array (ALMA) to measure the mass of SMBHs with great precision, following the motion of gas clouds that give away their presence (*e.g., Smith et al. 2021*). Of particular interest, in this respect, is the work of *Davis et al. (2020)* where we measured the mass of the intermediate-mass black hole at the heart of the dwarf elliptical galaxy NGC 404, which is a particularly important measurement as it bridges the gap between black holes resulting from normal stellar evolution and SMBHs, thus providing clues for the formation of the latter.

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 and Liverpool. 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.

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 in order to interpret gamma ray images that the CTA will produce.

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 will be made publicly (and freely) available through the Digistar cloud.

Education and Community Outreach

Planetarium

Armagh Observatory and Planetarium 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.

This year our educational offering was drastically affected by the Covid-19 pandemic and accompanying lockdowns. Almost overnight we had to re-invent ourselves, our educational programme and our public offering to keep astronomy alive. For what we believed might be at the most a few months, we developed a new online programme called "Science at Home". Little did we know that a year later we would only open for a week at Christmas for a Space Lights outdoor experience! Our main objective of the Science at Home programme was to give families help with home-schooling, light relief with fun science experiments and inspiring interviews for older audiences on astronomy and science. Interviews with scientists, experiment videos and informative posts were utilised. This culminated in a successful funding bid to STFC to make the Science at Home experiments into a book which we will give out free to schools in the new school term. This year we made links with ESA and NASA and have utilised their information to keep our online followers right up to date with astronomy news. Astronomically related phenomena form part of our everyday lives through topics such as daylight savings time, Moon phases, the seasons and the calendar. By posting about these subjects and items such as the ISS flyover times, we create a hub of instant information, also facilitating AOP strengthening its reputation as the place to come to for astronomy information that is to be trusted.

The restructuring of our educational communication with schools was vital this year and we achieved this through the development of "Cosmic Classroom". Here the AOP education team are "beamed" into the classroom via zoom to conduct a presentation on the topic of the Solar System with a quiz and further teaching resources provided to the school. During the second lockdown when schools were closed, we developed a family "Kids Takeover". On the same principle as the Cosmic Classroom, but this time for families, the Kids Takeover proved extremely popular with slots booking up within minutes of going live on our ticketing website. We have been able to adapt our online Cosmic Classroom presentations for different age ranges with Under-5 sessions for groups such as Sure Start and sessions for adults with Autism.

As we could not conduct onsite StarTracker evenings we developed an online offering with the education team working alongside Prof. Michael Burton. Our online StarTrackers have gained interest Internationally, as well as locally. Viewers are brought wonders of the stars and planets viewing through telescopes in the Canary Islands, as well as experiencing a virtual planetarium show for the small screen. In all, this year has been challenging with having to think on our feet, develop new content and find new ways to reach people. A positive is that it has shown us other routes to reach our audiences, and has expanded our skills with online presenting, using video conferencing and making multi-media content. The skills we have developed we will now build upon. Certainly, a hybrid approach to the delivery of our programmes in a post-Covid world will now be needed.

Although we have not been open for dome shows, we have developed three in-house stargazing shows, each lasting approx. 40mins called "Look Up" (each show is seasonally adjusted for relevant highlights of the night sky). These have been scripted and written by our own team at the Planetarium, led by Education and Outreach Manager Sinead Mackle. We have also developed a new live children's show where the presenters can bring families to the planets and beyond in a cosmic journey. One of the highlights in our dome theatre was the commissioning of a new planetarium software system, Digistar 6. This was showcased during the Space Lights event which included Pink Floyd dome shows which enabled us to assess the popularity of music shows. We also had new laser projectors installed which provide more clarity and resolution to the stars, as well as requiring less maintenance as no bulbs now need to be changed. However, the biggest benefit is the reduction in the sound of cooling fans from the projectors, which therefore facilitates new activities such as musical performances under the dome. The interior of the dome has also had a facelift with new carpet and seating to give a more comfortable all-round customer experience. These upgrades have all been made during the lockdown.

Five members of our education team were trained up and qualified for Level One British Sign Language and Irish Sign Language during lockdown which will increase our accessibility.

The lockdown has also made us aware of our importance within the local community. Certainly, our grounds were utilised during the lockdown and provided a place for relaxation amongst the beauty in the Astropark. Our community in Armagh is very important to us, we want to build on our commitment to provide a facility that Armagh is proud to

have and a place for all. Space has no borders or boundaries and we live by that ethos. This year we were able to add a Changing Places facility to the Planetarium. This has huge benefits to families who are visiting us and also for the local community as the facility is open for all. We also created a space-themed Sensory Room which will provide a safe space for our visitors and groups that visit us. In addition, we set out on a journey to change our exhibition area, to revamp the area and create an inspiring, tactile and fun learning experience for all that covers the senses from touch to smell to the audio-visual. We aim to build upon the engagement with the local Armagh community and to welcome them back to their Observatory and Planetarium when we are able to open our doors once again.

Through our marketing activities we have produced a steady stream of good news stories from AOP, including highlighting the research we conduct. Our education team have also been working hard to make the Planetarium a safe place for visitors, with increased sanitation stands, signage and one way systems – we are good to go!

Highlights from AOP's Programme of Events in 2020-21

Onsite Highlights

During 2020-21 AOP was open for one week just before Christmas for a Space Lights outdoor experience which attracted approximately 5,000 visitors on a socially distanced walk through our grounds which featured light sculptures, sound and our staff engaging while socially distanced about the work and history of the Observatory. Although Covid-19 meant that we had to restrict numbers in our grounds and Planetarium, we were pleased with the numbers and managing to open the Planetarium for (albeit limited) dome shows. In particular, to screen Pink Floyd for the first time and introduce a musical experience. Overall Space Lights received a 4/5 rating from the participants. However, there are certainly ways that we can improve such an event in a post-covid environment, with more activities and hands-on displays and increased dwell time in the grounds. The event did show us that our grounds can and should be utilised more.

Online Highlights

We have grown our online audience this year by just over 60% on Facebook with similar percentage increases on other social media platforms. 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.

Thanks to a TourismNI funding award we were able to improve our website with armagh.space getting a refreshed look, as well as the introduction of an online shop facility. Our website is now more user friendly and the customer journey more fluid. A weather and night sky button were added, as well as highlighting our Latest News and social media channels. We also utilised TNI grants for marketing and improved visibility during the year.

The team have produced many online events this year, including with the help of Evans and Sutherland, bringing dome shows to the masses online. Highlights include an interview with astronaut Helen Sharman in our "15 minutes with series". "Unlocking the Secrets of the Universe" with Manuel Calderon de la Barca Sanchez was an online event that attracted people internationally which was very well attended. We produced events that featured our own weather recording and brought back past PhD students, but the biggest highlight was an online event with comedian and amateur astronomer Dara Ó Briain, focussed on a discussion about wonders from Armagh's NGC catalogue. This was a big coup for AOP, attracted a huge audience and gained traction through our social channels. It certainly put AOP in the spotlight.

The biggest achievement of the year is our resilience, our never say never attitude and how we have kept together, albeit remotely, through the pandemic. As the AOP team we have kept spirits up with little personal videos for big birthdays and special events, and, as we get ready to re-open for the 2021-22 year those memories will stay with us.

History and Heritage

History & Heritage Policy

As the custodian of many valuable and historic scientific instruments, scientific records, books, journals and artworks, Armagh Observatory and Planetarium is proud of its rich and deep history and heritage. Our heritage policy is to progressively restore the historic buildings, scientific instruments, and historic books and other archives in our possession, placing the restored material where possible, on display, or close to its original location in the Grade A-listed Georgian Observatory building. 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, access our material for individual research projects and appreciate more clearly the context in which the historic material was first acquired and then transferred into the various collection. Eleven virtual tours are available online through our website.

In pursuance of our heritage objectives AOP has been working to achieve the Museum Accreditation Standard. The Accreditation Scheme is the industry standard for museums and galleries. The Scheme outlines and guides

organisations towards best practice in the management and governance of museums. The Scheme does this by supporting and encouraging museums to meet agreed standards in how they: run the museum; manage their collections; and engage with their users. AOP has been working towards Accreditation throughout the year with help from our Museum Mentor, and discussions with the Northern Irish Museum Council.

Throughout 2020-2021 AOP continued to develop and implement a wide-ranging Project Plan for museum accreditation. Museum policy, written in accordance with Spectrum 5.0 Guidelines, has been completed, and a new loans policy approved. The MuseumPlus Collection Management System (CMS) has been implemented and the first objects accessioned into the system. This system has allowed us to bring in our first Museum Interns from the Public History MA in Queens University Belfast, and the Museum Management MA in Ulster University. They have been able to work remotely and conduct important historical research because of the implementation of the system.

AOP has continued to conserve its collection. The Troughton, Grubb 10-inch and 15-inch telescopes, and the King George III Short telescope have all undergone preventative conservation in the last year and condition reports produced detailing the historical imperfections and damage to them. This work has been aided by the installation of 13 atmospheric sensors which produce essential data on the temperature and relative humidity of our collection storage areas.

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 3,000 textbooks, monographs, special reports, and conference proceedings covering nearly all disciplines in astronomy. Some 17,000 scientific journal volumes include nearly complete runs of all the major astronomy journals, as well as journals of significant historical interest.

In 2020-21 funding was secured which enabled the book collection to be refreshed with the purchase of some 80 recent volumes and the recruitment of a temporary librarian to process recent acquisitions, to migrate the library catalogue onto a modern database, and to audit and reshelve the book collection. Meanwhile, the physical library in the Observatory has been modernised to include a full interactive display screen and conferencing technology, and chairs and tables have been refreshed to accommodate more versatile discussion groups. 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.

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.

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. Four new PhD students were trained in weather observations as part of their scientific

training, 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), revised and 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. Dr Rok Nezcic 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 in addition to the manual data.

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.

A review and modernisation programme of ICT requirements to include Research, Education and Corporate needs continued during 2020-21 to ensure compliance with GDPR and other information security requirements; enhance security measures to address increasing risk of cyber-attacks and provide modern and accessible operating environments. An internal audit of GDPR was conducted providing satisfactory assurance.

In November 2020 AOP agreed to participate in a Cyber Essentials Certification Project funded by the NI Cyber Security Centre to assist small public sector bodies to develop their cyber security arrangements. Whilst much of the assessment was positive there are two areas of the review that remain challenging for AOP to comply with due to the complexity of putting in place safeguards whilst still providing the environment for research to flourish. AOP continually reviews these risks and the mitigations in place to minimise risk and has updated risk registers accordingly.

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 2020-21 an additional resource allocation to meet the agreed gap was provided along with the core allocation. A further allocation to cover pressures resulting from Covid-19 was also allocated. 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 strategy has been developed and approved and the Action Plan for 2020-21 included:

- Restructuring – complete
- Conditions of Service and Employment Policies – process of regular policy and 'duty manager' allowance established; Induction and Leaver policies developed and employment policy awareness sessions conducted. Development of a Policy on visiting positions and internships for research staff ongoing.
- Recruitment and Retention – management of recruitment process kept under review and female role models promoted in recruitment materials. Roll out of unconscious bias training yet to be progressed.
- Performance Management – Leadership and Team Development strategy deferred due to remote working; engagement with staff to develop Strategy for 2021-2026 progressed; Student only engagement workshop held; appraisals completed, training plan developed and training delivered where possible.

- Engagement and Culture - annual employee survey completed; engagement events deferred; acknowledgement of achievements recognised through appropriate means and an internal communications strategy to be developed.

Governance

Governance and accountability continue to be strengthened and improved and risk reduced as demonstrated by external and internal audit reviews. During the year, an internal audit of Governance was completed resulting in an overall 'satisfactory' rating. All but one of the recommendations were implemented before year end and the outstanding recommendation will be addressed during 2021-22 when agreeing the Partnership Agreement which will replace the Management Statement and Financial Memorandum. A review of the Terms of Reference of the Board of Governors, Management Committee and its Sub-Committees commenced during 2020-21.

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 a number of 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 completion of a Conservation Management Plan and other surveys to support development of an outline business case to ensure heritage assets are protected and develop the estate to meet future needs.

AOP has also engaged with Armagh City, Banbridge and Craigavon Borough Council and Royal School Armagh (RSA) in respect of a proposed Leisure Village and impacts for the AOP Estate. To date discussions have focused primarily on a lease between AOP and RSA for provision of playing fields. AOP has sought to widen the debate to agree a set of principles that reflect the wider ambitions for development by both AOP and Council and that protect AOP's heritage environment.

Achievements and Performance

The targets set for the Armagh Observatory and Planetarium in the 2020-21 Business plan are shown in the following table. A number of targets were deferred, reduced or re-focused in-year in light of the government restrictions. The actual performance achieved is shown along with the corresponding achievement for the previous financial year, where appropriate.

Targets were achieved or exceeded in many areas, however, a number were not met. In particular, it was not possible to achieve the revised visitor number and income targets due to significantly reduced capacity associated with social distancing requirements. The targets relating to research output, the creation of third level and adult learning partnerships and completion of the OBC to support future development vision were all deferred until 2021-22.

KPI	Description	Target	As at 31 March 2021	Progress	As at 31 March 2020	Comments
1	Number of articles published in refereed scientific journals	50 articles	66	132%	68	
	Level of research outputs from externally validated review (every 3 years) (% of outputs considered internationally excellent or world leading in terms of originality, significance and rigour)	60%	Deferred until 2021-22	Deferred until 2021-22	New KPI	Postponed until 2021-22. Cannot be measured without validated review.
2	Increase research collaborations and partnerships (new partnerships created)	2	2	100%	New KPI	
3	Increase education and non-education visitor numbers by 10% across each segment					
	Overall	10,000 57,987	4,026	40%	52,693	Non-educational numbers reduced to approx 25% of baseline + Winter Lights show Educational numbers reduced by 90% to reflect post-covid environment but mitigated by new KPIs
	Non-educational	9,500 45,023	4,026	42%	New KPI	
	Educational Total	500 12,964	0	0%	New KPI	
	Nursery	23	Refocus	Refocus	New KPI	
	Primary	244	Refocus	Refocus	New KPI	
	Post-Primary	57	Refocus	Refocus	New KPI	
4	Increase income from commercial activity (admissions, facility hire, shop and café sales) by 10% on 2019-20 target	£107,000 £326,000	£42,703	40%	£307,497	Income reduced to reflect closure April-September, reduced capacity October-March, mitigated by income from Winter Lights show
5	Create new partnerships for third level and adult learning (new programmes implemented)	1	Deferred until 2021-22	Deferred until 2021-22	New KPI	Deferred until 2021-22 Education focus - returning to learning
6	Deliver an outreach programme to target hard to reach/deprived schools and increase awareness and promotional activity	10 4	Revised focus to new KPIs 8 and 10	Revised focus to new KPIs 8 and 10	New KPI	See new KPIs 8 and 10 with revised focus
7	Increase tours promoting AOP wider assets (Astropark, Observatory)	60 events			61 events	
	Visitors to Winter Lights event showcase Observatory and Astropark	5,500	4,026	73%	New KPI	Social distancing reduced numbers that could be booked in for Winter Lights
8	Deliver a Virtual Classroom Experience for Schools	10	13	130%	New KPI	
9	Deliver a Virtual Seminar Programme	25	74	296%	New KPI	
10	Develop and deliver a Science at Home programme as an educational resource including a book and app for schools. Secure £14,500 external funding Deliver book to 800 schools	£14,500 funding 800 schools		75%	New KPI	Further funding received to create a mascot for the book to enhance the offering which affected ability to complete by 31 March 2021. Revised target is to aim to send out for new school term.
11	Increase social media engagement by approx 40%	21,000		121%	New KPI	
12	Complete a programme of stakeholder engagement events	5	5	100%		
13	Complete an OBC to support future development vision	OBC completed	Deferred until 2021-22	Deferred until 2021-22		

Financial Review: Armagh Observatory and Planetarium

Operating Results

In the financial year to 31 March 2021, the value of charity funds decreased by £191,206, summarised below.

		2021	2020
		£	£
Total incoming resources		3,418,572	3,750,857
Total outgoing resources		(3,184,057)	(3,281,374)
Net income / (expenditure)		234,515	469,483
Gains/(losses) on the revaluation of fixed assets		(80,721)	28,576
Actuarial gains/(losses) on defined benefit pension scheme		(345,000)	(950,000)
Net movement in funds for the year.		(191,206)	(451,941)
Movement in Unusable Funds			
Capital financing			
Capital grants received		1,040,000	1,452,000
Government grant fund		(602,687)	(513,873)
Revaluation reserve		(300,087)	(189,179)
Pension reserve		(580,000)	(1,147,000)
Movement in Usable Funds			
Restricted		46,325	25,669
Unrestricted		(237,531)	(79,558)
		(191,206)	(451,941)

The total income for the year was £3.419m, a decrease of £0.332m from 2019-20, mainly due to reductions in capital grant income of £0.412m, operating income of £0.190m and trading income of £0.097m, offset by increased recurrent grant-in-aid of £0.247m and research grants of £0.120m.

Expenditure was £3.184m, a decrease of £0.097m from the previous year. Staff costs remain the largest component of operational expenditure. The number of permanent staff in post is consistent with 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 2020-21 the Department provided 87% of the total income through recurrent and capital grant allocations (2019-20: 84%).

Net Assets

Net assets at 31 March 2021 were £8.645m (31 March 2020: £8.837m).

Reserves

Armagh Observatory and Planetarium reserves policy is included in note 1 of the accounts. Total accumulated funds are as follows:

Funds at 31st March	2021	2020
	£	£
Restricted funds	188,454	142,129
Unrestricted funds	4,215,315	3,572,759
Revaluation Reserve	7,216,542	7,516,629
Pension Reserve	(2,975,000)	(2,395,000)
Total Charity Funds	8,645,311	8,836,517

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

Armagh Observatory and Planetarium 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 2021 the deficit was calculated by independent actuaries at £2,975,000 (2020: £2,395,000).

Key Risks and Uncertainties

At year end, the key risks were identified as:

- Lack of sufficient funding to continue growth and support a thriving research and education organisation;
- Failure to safeguard and maintain heritage assets resulting in loss or damage;
- Failure to establish long term ICT Strategy resulting in single point of failure of key systems. Failure to protect systems from increased vulnerability to cyber attack due to remote working; and
- Failure to be able to function effectively due to risk from coronavirus restrictions/loss of staff to illness or quarantine and/or loss of income as a result of enforced closure of the Planetarium and anticipated reduced capacity following reopening.

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 Armagh Observatory and Planetarium 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.

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

Progression of an Outline Business Case, in partnership with the Department, the local council and other stakeholders with an interest in developing on or adjacent to the estate continues to be a high priority.

Armagh Observatory and Planetarium presents a unique social, civic and economic value proposition currently based around three core strands of activity:

- world leading research in astronomy
- education and community outreach in science
- a cultural experience that enhances and complements the wider Northern Ireland tourism offer.

A new Strategy for 2021-2026 is currently being developed with key themes of Enduring Relevance, National and International Standing, Offering More and Pursuing our Priorities.

AOP has submitted a Business Plan for 2021-22 for consideration by DfC.

AOP will follow closely the Northern Ireland Executive Recovery Plans and forward plan in accordance the guidance provided. However, AOP anticipate that Covid-19 will continue to impact its public facing services during 2021-22. AOP has reflected this in its budget projections based on currently available guidance.

Structure, Governance and Management

The 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').

The Armagh Observatory and Planetarium is a registered charity - reference number NIC 103948.

Board of Governors

The Armagh Observatory and Planetarium 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 Armagh Observatory and Planetarium with the purpose of "developing and improving the knowledge, appreciation and practice of astronomy and related sciences."

In accordance with paragraph 8(1) of Schedule 1 of the Order, the Governors have delegated primary responsibility for the governance and management of Armagh Observatory and Planetarium to a Management Committee.

The Board of Governors (the Board) has retained a role to ensure that the culture and character, history and patrimony embodied in Armagh Observatory and Planetarium 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 Armagh Observatory and Planetarium from the Management Committee.

Management Committee of Armagh Observatory and Planetarium

The Board has delegated primary responsibility for the governance and management of Armagh Observatory and Planetarium to a Management Committee. The Management Committee has corporate responsibility for ensuring that Armagh Observatory and Planetarium 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 Armagh Observatory and Planetarium 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 advises it on employment issues and provides assurance that Armagh Observatory and Planetarium employment policies and practices are compliant with legal and statutory requirements.

Further details on the membership of these Committees is set out in the Governance Statement on pages 26 to 35.

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 103498

Principal Office

College Hill, Armagh, BT61 9DG

Trustees (and Board of Governors)

Archbishop J McDowell, (Chair) (from 28 April 2020)
The Very Rev Dean G Dunstan (to 31 October 2020)
The Very Rev Dean S Forster (from 14 February 2021)
The Venerable Archdeacon T Scott
The Venerable Archdeacon E Cairns (from 13 December 2020)
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 W G Berry (to 31 December 2020)
Mr G Cox (from 1 March 2021)
Professor A Hibbert (to 31 December 2020)
Professor R Oudmaijer (to 31 December 2020)
Professor A Fitzsimmons
Mr R Wilson
Archbishop E Martin (from 1 January 2021)

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 AOP website – www.armagh.space.

Related party transactions are shown in note 22 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 2020–21 financial year that exceeded these limits.

Personal data related incidents

Armagh Observatory and Planetarium 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 2021.

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

Apart from issues arising from the Covid-19 pandemic discussed elsewhere in this report, there were no events since the end of the financial year requiring disclosure.



Archbishop John McDowell
Chair of the Board of Trustees
Date: 20 September 2021



Professor Michael Burton
Chief Executive
Date: 20 September 2021

Remuneration and Staff Report — Armagh Observatory and Planetarium

Remuneration Policy

Board Members

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

Senior Managers

The Chair of the Board of Trustees or his nominee is responsible for monitoring and reviewing the performance of the Chief Executive in accordance with the SCS Pay Strategy.

The Chief Executive is responsible for monitoring and reviewing the performance of the Senior Managers in accordance with The Northern Ireland Civil Service Pay Strategy.

Pay and Conditions of Service

The staff of Armagh Observatory and Planetarium, (other than post-doctoral research assistants who were paid in accordance with academic scales in use by Queens University, Belfast) are subject to levels of remuneration within the general NICS pay structure, as approved by the Department and Department of Finance. Current terms and conditions for staff are those set out in its Employee Handbook.

Policy on duration of contracts, notice periods and termination payments

Senior staff, including the Chief Executive, are permanent employees of Armagh Observatory and Planetarium. 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).

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

Remuneration (Audited Information)

Single Total Figure of Remuneration						
	Salary (£'000)		Pension Benefits (£'000)		Total (£'000)	
Official	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20
M.G. Burton	80-85	80-85	29	27	100-115	105-110

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.

Pension Entitlements (Audited Information)

Official	Accrued pension at pension age as at 31/03/21	Real increase in pension at pension age	Accrued Lump Sum at 31/03/21	Real Increase in Lump Sum	CETV at 31/03/21	CETV at 31/03/20	Real Increase in CETV
	£'000	£'000	£'000	£'000	£'000	£'000	£'000
M.G. Burton	5-10	0-2.5	-	-	115	86	21

The CETVs above have been calculated in accordance with guidance from the Department of Finance in Employer Pension Notice EPN 09/2020. When calculating the real increase in CETV and the pension benefits accrued during the year 2020-21 for the single total figure of remuneration, NILGOSC takes account of inflation. The CPI increase for September 2020 was 0.5%. The in-service revaluation rate for the Career Average Revalued Earnings Scheme was also 0.5%.

1. The Director of Armagh Observatory and Planetarium is the person in a senior position having authority and responsibility for directing and controlling the activities of the organisation.
2. The salary of Director shown above is based on the Northern Ireland Senior Civil Service Grade 5 pay scale. No bonus was paid in the year and the Director received no benefits in kind.
3. The service contract of the Director of Armagh Observatory and Planetarium commenced on 01 August 2016.
4. Pension benefits are provided through the Northern Ireland Local Government Officers' Superannuation Committee Pension Scheme (NILGOSC).
5. Retirement pension will be based on 1/49th of salary paid in year and pension is based on career average earnings. Details can be obtained at <http://www.nilgosc.org.uk>.
6. The real increase in pension payable, lump sum and cash equivalent transfer value (CETV) shown above have been adjusted to take account of inflation and market investment factors. The CETV figures include the value of any pension benefit in another scheme that the individual has transferred to NILGOSC.
7. A 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 to secure pension benefits in another scheme when the member leaves a scheme and chooses to transfer the benefits accrued in their former scheme.

Pay Multiples of Permanent Employees (Audited Information)

	2020-21	2019-20 restated
Band of highest paid director's total remuneration (£'000)	80-85	80-85
Median total remuneration*	£38,017	£36,602
Ratio	2.17	2.25

*Total remuneration includes salary. It does not include severance payments, employer pension contributions and the cash equivalent transfer value of pensions.

Reporting bodies are required to disclose the relationship between the remuneration of the highest paid worker in the organisation and the median remuneration of the organisation's workforce. The banded remuneration of the highest paid director in 2020-21 was £80,000 - £85,000 (2019-20: £80,000 - £85,000). No employee received remuneration in excess of the highest paid director. Remuneration of permanent employees ranged from £12,000 to £85,000 (2019-20 £18,000 to £81,000).

Total Staff Costs (Audited Information)

	Permanent staff £	Others ¹ £	2021 £	2020 £
Wages and salaries	1,101,984	136,928	1,238,912	1,208,464
Social security costs	113,723	4,354	118,077	103,094
Employer's pension contributions	204,877	10,500	215,377	205,681
Defined benefit pension additional service cost	183,000	-	183,000	166,000
	1,603,584	151,782	1,755,366	1,683,239

¹ "Others" includes £85,624 for agency staff

Average staff numbers

	Permanent staff	Others ²	2021 Number	2020 Number
Average staff numbers	25.9	6.4	32.3	33.2

² "Others" includes 1.3 fixed term, 2.7 casuals and 2.4 agency staff

Staff banding

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

	2021	2020
£60,000 - £70,000	1	-
£80,001 - £90,000	1	1

Staff Composition – permanent employees (full time equivalent)

	Male	Female
Directors/senior managers	2.6	2.0
Other employees	10.0	11.2

Staff Turnover

	2021	2020
Leavers as a percentage of average staff in post	1.7%	7.2%

Local Government Pension Scheme (LGPS) Northern Ireland

The Local Government Pension Scheme (Northern Ireland) is a defined benefit scheme, which will provide benefits on a career average revalued earnings basis from 1 April 2015. Prior to this date pension benefits were calculated on a final salary basis.

From 1 April 2015 a member will build up pension at a rate of 1/49th of their pensionable pay each year. Any membership during the period from 1 April 2009 to 31 March 2015 provides for a retirement pension calculated at the rate of 1/60th of pensionable pay for each year of membership. Before 1 April 2009, a member of the Scheme accrued retirement benefits at the rate of 1/80th (pension) and 3/80ths (tax-free lump sum) of their pensionable pay for each year of membership up to 31 March 2009. At retirement, members may give up some pension for additional lump sum, subject to HM Revenue and Customs (HMRC) limits. The conversion rate is £12 additional lump sum for every £1 of pension given up.

The Scheme is funded by contributions made by both employees and employers who have been designated as employing authorities or admitted to the Scheme. Prior to 1 April 2009, employees' contribution rates were fixed at 6% of their pensionable remuneration (except for those who were entitled to contribute to the scheme at 5% before 1 February 2003 and have remained in continuous employment). Tiered employee contribution rates, determined by the whole-time equivalent rate of pay, were introduced from 1 April 2009. The rates applicable for 2020-21 were:

Pensionable Pay	Contribution Rate
Up to £15,000	5.5%
£15,001 - £22,900	5.8%
£22,901 - £38,300	6.5%
£38,301 - £46,400	6.8%
£46,401 - £91,900	8.5%
More than £91,900	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 is due as at 31 March 2022.

Sickness Absence

Staff sickness for the period 1 April 2020 to 31 March 2021 totalled 127 days (2020: 47 days) which equates to an average per FTE of 1.85% (2020: 0.72%).

Staff Policies

As an equal opportunities employer, Armagh Observatory and Planetarium does not discriminate against staff or applicants for posts on any grounds, including disability. Care is taken to ensure the needs of disabled applicants are considered in the application process. Armagh Observatory and Planetarium also considers and introduces

reasonable adjustments to support the employment of people with disabilities and to support the continuing employment of staff who have a disability.

Armagh Observatory and Planetarium is committed to the priorities as set out in legislation on equality, disability, discrimination, health and safety, child and vulnerable adult protection, data protection and freedom of information.

Expenditure on External Consultancy

Expenditure on external consultancy during the year was £nil (2019-20: £nil).

Off-payroll Engagements

There were no "off-payroll" engagements in place as at 31 March 2021, nor were any arrangements entered into between 1 April 2020 and 31 March 2021.

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
	2020-21	2020-21	2020-21	2019-20
Total no. of exit packages	-	-	-	-
Total resource cost	Nil	Nil	Nil	Nil

Signed:



Professor Michael Burton
Accounting Officer for the Armagh Observatory and Planetarium

Date: 20 September 2021

Statement of the Responsibilities of the Governors and Accounting Officer

Under the Audit and Accountability (Northern Ireland) Order 2003 the Governors are responsible for keeping proper accounts and proper records in relation to the accounts, and for preparing a statement of accounts in respect of each financial year in such form and containing such information as the Department, with the approval of the Department of Finance, shall direct.

The Accounting Officer has personal responsibility for the propriety and regularity of the public finances for which he is answerable and for the keeping of proper accounts. He is required to sign the accounts thereby accepting personal responsibility for their proper presentation and to sign the Governance Statement. The Accounting Officer's relevant responsibilities, including his responsibilities for the propriety and regularity of the public finances and for the keeping of proper records, are set out in Managing Public Money Northern Ireland.

The accounts are prepared on an accruals basis and give a true and fair view of the organisation's state of affairs at the end of the financial year and of its income and expenditure, total recognised gains and losses and cash flows for the financial year. The accounts have been prepared in accordance 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 (FRS 102). The financial statements comply 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 and in particular:

- suitable accounting policies have been selected and applied consistently (subject to changes arising on the adoption of new accounting standards);
- reasonable and prudent judgements and estimates have been made;
- applicable accounting standards have been followed, subject to any material departures disclosed and explained in the financial statements;
- the financial statements have been prepared on the going concern basis, unless it is inappropriate to presume that the organisation will continue in business.

The Accounting Officer is also responsible for safeguarding the assets of the organisation and hence for taking reasonable steps for the prevention and detection of fraud and other irregularities.

Statement of Disclosure of Information to the Auditors

So far as the Accounting Officer of the 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.

Armagh Observatory and Planetarium: Governance Statement

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.

Armagh Observatory and Planetarium 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. Financial Reporting

The Board of Governors, Management Committee and Directors of the Armagh Observatory and Planetarium are required to prepare a statement of accounts for each financial year to be laid before the Northern Ireland Assembly. The accounts are prepared to show a true and fair view of the Corporation's financial activities during the year and the financial position at the end of the year.

In preparing the Armagh Observatory and Planetarium accounts, the Board of Governors and Management Committee of the Armagh Observatory and Planetarium are required to:

- comply with the Government Financial Reporting Manual;
- observe the accounts direction issued by the government, including the relevant accounting and disclosure requirements, and apply suitable accounting policies on a consistent basis;
- make judgments and estimates that are reasonable and prudent;
- state whether applicable accounting standards and statements of recommended practice have been followed, and disclose and explain any material departures in the financial statements;
- prepare the financial statements on the going concern basis, unless it is inappropriate to presume that the Armagh Observatory and Planetarium will continue in operation.

3. Governance Framework

Accounting Officer

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

Board of Governors

The Armagh Observatory and Planetarium 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.

During 2020-21 Archbishop McDowell was appointed Church of Ireland Archbishop of Armagh and consequently, Chair of the Board of Governors. The Dean of the Church of Ireland Cathedral retired and a new Dean was appointed and there was also an appointment to the vacant position on the Chapter of the Church of Ireland Cathedral of Armagh and hence the Board of Governors. In addition, two Board of Governors' nominees retired and one appointment as a Board of Governors' nominee was made. The term of office of the DfC nominee expired and a replacement was appointed. There is currently one Vacant Board of Governors' nominee position on the Board.

BOARD OF GOVERNORS			
GOVERNOR	DATE OF APPOINTMENT	DATE OF EXPIRY	MEETINGS ATTENDED (max. 1)
Chair: Archbishop J McDowell	28 April 2020	None	1
The Dean Very Rev G Dunstan	4 December 2011	31 October 2020 (Retired)	1
The Dean Very Rev S Forster	14 February 2021	None	n/a
The Venerable Archdeacon T Scott	9 November 2006	None	1
The Venerable Archdeacon E Cairns	13 December 2020	None	n/a
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	1
Rev Canon J Moore	13 March 2016	None	1
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	1
Mr W G Berry	1 January 2011	31 December 2020	1
Mr G Cox	1 March 2021	28 February 2026	n/a
Professor A Fitzsimmons	18 April 2019	1 May 2024	0
Professor R Oudmaijer	20 November 2008	31 December 2020	1
Professor A Hibbert	28 March 2014	31 December 2020	1
Mr R Wilson	1 December 2019	30 November 2024	1
Archbishop E Martin	1 January 2021	31 December 2025	n/a

At the annual meeting on 18 June 2020 the Board of Governors reviewed the minutes from the Management Committee and the Audit and Risk Assurance Committee meetings between June 2019 and March 2020 (draft). The Board formally retrospectively approved the Annual Report and Accounts 2018/19 and approved the 2019-20 draft Annual Report and Accounts, subject to the inclusion of outstanding information and granted the Archbishop delegated authority to sign them off on its behalf when completed and considered the Management Report for 2019-20 which included the Director's Report, Corporate Plan Objectives, Key Performance Indicators and the Risk Register as at 4 June 2020.

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.

Minutes of the meeting 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 2020-21 appointments were made to 3 of the DfC nominee positions; Dublin Institute for Advanced Studies and Science & Technology Facilities Council replaced their nominees; and the term for a Board of Governors nominee to the Management Committee expired. There are currently two Vacant Board of Governors nominee positions.

MANAGEMENT COMMITTEE			
MEMBER	DATE OF APPOINTMENT	DATE OF EXPIRY	MEETINGS ATTENDED (max. 4)
Chair: Mr J Briggs	1 January 2018	31 December 2022	4
Professor T Ray	4 March 2009	31 December 2020	3 (from 3)
Professor M Merrifield	1 January 1999	31 December 2020	3 (from 3)
Professor R Oudmaijer	20 November 2008	31 December 2020	3 (from 3)
Mr B Hannam	1 January 2011	31 December 2020	2 (from 3)
Dr M McKay	1 January 2011	31 December 2020	3 (from 3)
Professor L Harra	1 November 2014	30 April 2023	3
Mr S Brown	1 November 2014	30 April 2023	4
Mr P McGurgan	1 November 2014	30 April 2023	3
Professor M Mathioudakis	11 November 2016	10 November 2021	3
The Dean: Very Rev G Dunstan	10 June 2019	31 October 2020 (retired)	2 (from 2)
Mr R Wilson	1 December 2019	30 November 2024	4
Dr C Jackman	1 January 2021	31 December 2025	1 (from 1)
Dr M Darnley	1 January 2021	31 December 2025	1 (from 1)
Mr P Kennedy	1 March 2021	28 February 2026	1 (from 1)
Dr K Lemon	1 March 2021	28 February 2026	1 (from 1)
Mr E Rooney	1 March 2021	28 February 2026	1 (from 1)

During 2020-21 the Management Committee considered a wide range of business. The Committee received regular updates from its two sub-committees, the Audit and Risk Assurance Committee and the Staffing Policy and Remuneration Committee 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. The Management Committee will continue to guide and contribute to AOP Vision.

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.

AUDIT AND RISK ASSURANCE COMMITTEE	
MEMBER	MEETINGS ATTENDED (max. 4)
Chair (to 31 December 2020): Mr B Hannam	3 (from 3)
Professor L Harra	4
Mr P McGurgan	4
Mr S Brown (appointed Chair 15 March 2021)	4

In 2020 AOP appointed a new Internal Audit service provider effective from 1 April 2020. During 2020-21 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 2019-20 Annual Report and Accounts;

review of the Accounting Officer's Governance Statement and Assurance Statements and the Board's Assurance Statement and review of risk registers.

The Committee is satisfied that the integrated approach, the frequency of meetings, the breadth of the business undertaken 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 now 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.

During 2020-21 all outstanding recommendations from previous Internal Audits were completed. The Committee is satisfied, from the evidence provided at meetings, that a work programme exists to complete the recommendations identified in 2020-21.

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

Staffing Policy and Remuneration Committee

The Staffing Policy and Remuneration Committee aims to meet quarterly, prior to the Management Committee meetings, however, due to the termination of two of its Members on 31 December 2020, there was no meeting in March 2021.

The Committee advises the Directors, Management Committee and/or Board of Governors when there are specific matters relating to the terms of employment, temporary promotions and pay to be considered.

In 2020-21, amongst other matters, the Committee considered:

- Staffing Structures including Temporary Employment;
- Recruitment;
- Staff related policies;
- Coronavirus Recovery Plan; and
- was updated on a range of Human Resources issues including progress against the Human Resources Strategy and Action Plan.

The Committee was also appraised of and received updates on a formal grievance.

The Committee comprises four named members of the Management Committee.

EMPLOYMENT CONDITIONS AND REMUNERATION COMMITTEE	
MEMBER	MEETINGS ATTENDED (max. 3)
Chair: Professor T Ray (to 31 December 2020)	3
Dr M McKay (to 31 December 2020)	3
Mr S Brown	3
Mr J Briggs	3

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 which may include that member not taking part in discussions or making decisions on certain matters or being excluded for part/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, Armagh Observatory and Planetarium

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

4. Business Planning and Risk Management

Business Planning

The Mission of Armagh Observatory and Planetarium is:

“To advance the knowledge and understanding of astronomy and related sciences through interactive engagement and the execution, promotion and dissemination of astronomical research nationally and internationally in order to enrich the intellectual, economic, social and cultural life of all members of the community”.

This aligns closely with the aims and objectives of the Observatory and Planetarium’s sponsor - the Department for Communities (DfC) and also with the broader aims and objectives of the Northern Ireland Executive’s Programme for Government. The organisation’s unified Corporate Plan 2018-2021 received Departmental approval on 6 November 2017. Work has commenced on the development of the next Corporate Plan.

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. Due to restrictions associated with Coronavirus the Planetarium has adapted its activities during 2020-21 through the provision of a wide-range of online programmes.

Full details of all the Observatory and Planetarium’s activities are provided in comprehensive Annual Reports which are available online at: www.armagh.space.

No Ministerial Directions have been given regarding the work of the Armagh Observatory and Planetarium.

Risk Management

Risk Management is an essential element of the Armagh Observatory and Planetarium’s corporate governance framework and is closely linked to the system of internal control and business planning process. A robust risk management process assists the Armagh Observatory and Planetarium 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 Armagh Observatory and Planetarium’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 the Armagh Observatory and Planetarium. 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 the Armagh Observatory and Planetarium. 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.

5. Fraud and Information Risk

The Accounting Officer of the Armagh Observatory and Planetarium 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.

6. Governance and Accountability

The Corporation 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 Corporation in the long term; giving advice and direction in formulating the Corporation'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 Armagh Observatory and Planetarium, leadership was 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 Corporation with a correspondingly wide range of expert knowledge and advice. All the committees of the Corporation 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 proposed governance changes arising from the Review of the effectiveness of the system of internal governance 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.

7. Sources of Independent Assurance

Internal Audit

CavanaghKelly was appointed as Internal Auditors for the 3 years 2020-21 to 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 June 2020 along with the 2020-21 Audit Plan.

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

Audit Assignment	Priority	Assurance rating
Payroll		Satisfactory Assurance
Contingency Plan	Low	
Penetration Testing	Low	
Review of Governance		Satisfactory Assurance
Board and Management Committee Membership	Medium	
Appraisals	Low	
Safeguarding Training	Low	
Covid-19 Contingency Procedures		Satisfactory Assurance
GDPR		Satisfactory Assurance
Data Protection Policy	Low	
Data Breach Management Policy	Low	
Access to Information Policy	Low	
Information Security Policy	Medium	
Information Security Incident Management Policy	Low	
Privacy Notices	Medium	
Records Management Policy	Medium	
Record of Processing Activities	Low	
Follow up on previously accepted recommendations		

There are 4 outstanding recommendations for 2020-21.

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

External Audit

The Comptroller and Auditor General is required to audit the financial statements under the *Armagh Observatory and Planetarium (Northern Ireland) Order 1995*. He is responsible for reporting whether in his 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. He is required to report whether, in his opinion, in light of the knowledge and understanding of AOP and its environment obtained in the course of the audit, he 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 also reports on whether, in his 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.

8. 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 Armagh Observatory and Planetarium 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 the Armagh Observatory and Planetarium for the year ended 31 March 2021 and up to the date of approval of the annual accounts, and accords with Department of Finance guidance.

As previously detailed in Section 3, 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 Armagh Observatory and Planetarium 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 the Corporation's control systems and internal governance are set out within the next section. Upon identification, plans were immediately put into place to address these issues.

9. Internal Governance Divergences

Update on Prior Years:

There are no recommendations outstanding from previous years.

Identification of New Issues:

Of the new issues identified by internal audit during 2020-21 there remain 4 outstanding at 31 March 2021, as follows:

Recommendation	Priority	Status
Governance – Regular appraisals for Board and Management Committee (MC) members. Appraisal of Department nominees to the MC are carried out and submitted to DfC annually. The MSFM states that formal annual appraisals should be carried out for Board and Management Committee members. Currently AOP only conducts appraisals for members appointed by DfC. AOP should consider carrying out annual appraisals for all Board and MC members.	Low	To be considered in the context of reviewing Terms of Reference for Board and Management Committee and also as part of discussions to move from MSFM to a Partnership Agreement.
Payroll - AOP should consider arranging for penetration testing to be carried out on the secure interface used for transfer of payroll data between AOP and LNI, to gain additional assurance over security.	Low	Completed in March 2021.
GDPR – the draft Records Management Policy and Retention and Disposal Schedules should be finalised as soon as possible.	Medium	To be completed in 2021, subject to confirmation by PRONI.
GDPR – the draft ROPA (Record of Processing Activities) should be completed.	Medium	Completed in March 2021.

During 2020-21, NIAO identified one important issue to be addressed by management in their areas of responsibility, as follows:

Recommendation	Priority	Status
<p>While we recognise the difficulty in obtaining information from CPD and/or contractors on a timely basis in relation to capital works (particularly in relation to one contractor, whose services are no longer being used) there is an onus on management to be able to substantiate that capital works accrued for in the year had been completed at the year end.</p> <p>As such, we recommend that management continue to consider what other contemporaneous evidence that they can capture at the year-end to evidence the stage of completion of capital works.</p>	2	AOP management continues to recognise its responsibility to accurately ascertain and reflect the financial state of affairs at year end in accordance with generally accepted accounting principles. At 31 March 2021 and up to the date of audit, every effort was made to ascertain reliable estimates of costs and other evidence in respect of accruals on capital projects, including some photographic evidence and verbal updates from CPD. In future, management will continue to seek contemporaneous evidence and will discuss concerns with CPD.

10. Conclusion

The 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 the 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: 20 September 2021

A handwritten signature in black ink, appearing to read 'm. burton', with a large, stylized loop at the end.

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

Armagh Observatory and Planetarium

Refereed Journal Publications: April 2020 – March 2021

- Abdalla H., et al., inc. **Burton M. G.**, 2021, Sensitivity of the Cherenkov Telescope Array for probing cosmology and fundamental physics with gamma-ray propagation, *Journal of Cosmology and Astroparticle Physics*, 2021, 048, doi:10.1088/1475-7516/2021/02/048, <https://ui.adsabs.harvard.edu/abs/2021JCAP...02..048A>
- Acharyya A., et al., inc. **Burton M. G.**, 2021, Sensitivity of the Cherenkov Telescope Array to a dark matter signal from the Galactic centre, *Journal of Cosmology and Astroparticle Physics*, 2021, 057, doi:10.1088/1475-7516/2021/01/057, <https://ui.adsabs.harvard.edu/abs/2021JCAP...01..057A>
- Ackley K., et al., inc. **Ramsay G.**, 2020, Observational constraints on the optical and near-infrared emission from the neutron star-black hole binary merger candidate S190814bv, *Astronomy & Astrophysics*, 643, A113, doi:10.1051/0004-6361/202037669, <https://ui.adsabs.harvard.edu/abs/2020AA...643A.113A>
- Bagnulo S., Landstreet J. D.**, 2020, Discovery of six new strongly magnetic white dwarfs in the 20 pc local population, *Astronomy & Astrophysics*, 643, A134, doi:10.1051/0004-6361/202038565, <https://ui.adsabs.harvard.edu/abs/2020AA...643A.134B>
- Bagnulo S.**, et al., inc. **Nežić R., Borisov G., Christou A. A.**, 2021, Unusual polarimetric properties for interstellar comet 21/Borisov, *Nature Communications*, 12, 1797, doi:10.1038/s41467-021-22000-x, <https://ui.adsabs.harvard.edu/abs/2021NatCo..12.1797B>
- Bestenlehner J. M., et al., inc. **Vink J. S.**, 2020, The R136 star cluster dissected with Hubble Space Telescope/STIS - II. Physical properties of the most massive stars in R136, *Monthly Notices Royal Astronomical Society*, 499, 1918, doi:10.1093/mnras/staa2801, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.499.1918B>
- Bonito R., et al., inc. **Vink J. S.**, 2020, The Gaia-ESO Survey: A new diagnostic for accretion and outflow activity in the young cluster NGC 2264, *Astronomy & Astrophysics*, 642, A56, doi:10.1051/0004-6361/202037942, <https://ui.adsabs.harvard.edu/abs/2020AA...642A..56B>
- Christou A. A., Borisov G., Dell'Oro A., Cellino A., Devogèle M.**, 2021, Composition and origin of L5 Trojan asteroids of Mars: Insights from spectroscopy, *Icarus*, 354, 113994, doi:10.1016/j.icarus.2020.113994, <https://ui.adsabs.harvard.edu/abs/2021Icar..35413994C>
- Colas F., et al., inc. **Christou A. A.**, 2020, FRIPON: a worldwide network to track incoming meteoroids, *Astronomy & Astrophysics*, 644, A53, doi:10.1051/0004-6361/202038649, <https://ui.adsabs.harvard.edu/abs/2020AA...644A..53C>
- Davis T. A., et al., inc. **Sarzi M.**, 2020, Revealing the intermediate-mass black hole at the heart of the dwarf galaxy NGC 404 with sub-parsec resolution ALMA observations, *Monthly Notices Royal Astronomical Society*, 496, 4061, doi:10.1093/mnras/staa1567, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.496.4061D>
- Devogèle M., et al., inc. **Borisov G.**, 2020, New Evidence for a Physical Link between Asteroids (155140) 2005 UD and (3200) Phaethon, *The Planetary Science Journal*, 1, 15, doi:10.3847/PSJ/ab8e45, <https://ui.adsabs.harvard.edu/abs/2020PSJ.....1...15D>
- Dorsch M., Latour M., Heber U., Irrgang A., Charpinet S., **Jeffery C. S.**, 2020, Heavy-metal enrichment of intermediate He-sdOB stars: the pulsators Feige 46 and LS IV- 14116 revisited, *Astronomy & Astrophysics*, 643, A22, doi:10.1051/0004-6361/202038859, <https://ui.adsabs.harvard.edu/abs/2020AA...643A..22D>
- Doyle L., Ramsay G., Doyle J. G.**, 2020, Superflares and variability in solar-type stars with TESS in the Southern hemisphere, *Monthly Notices Royal Astronomical Society*, 494, 3596, doi:10.1093/mnras/staa923, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.494.3596D>
- Fahrion K., et al., inc. **Sarzi M.**, 2020a, The Fornax 3D project: Globular clusters tracing kinematics and metallicities, *Astronomy & Astrophysics*, 637, A26, doi:10.1051/0004-6361/202037685, <https://ui.adsabs.harvard.edu/abs/2020AA...637A..26F>
- Fahrion K., et al., inc. **Sarzi M.**, 2020b, The Fornax 3D project: Non-linear colour-metallicity relation of globular clusters, *Astronomy & Astrophysics*, 637, A27, doi:10.1051/0004-6361/202037686, <https://ui.adsabs.harvard.edu/abs/2020AA...637A..27F>

- Feijen K., Rowell G., Einecke S., Braiding C., **Burton M. G.**, Maxted N., Voisin F., Wong G. F., 2020, Arcminute-scale studies of the interstellar gas towards HESS J1804-216: Still an unidentified TeV γ -ray source, Publications Astronomical Society Australia, 37, e056, doi:10.1017/pasa.2020.47, <https://ui.adsabs.harvard.edu/abs/2020PASA...37...56F>
- Fernández-Menchero L., **Jeffery C. S.**, Ramsbottom C. A., Ballance C. P., 2020, Opacity modelling of heavy-metal hot subdwarfs: photoionization of Sr^0 , Y^+ , and Zr^{2+} , Monthly Notices Royal Astronomical Society, 496, 2558, doi:10.1093/mnras/staa1710, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.496.2558F>
- Fortin F., Chaty S., **Sander A.**, 2020, Optical and Infrared Study of the Obscured B[e] Supergiant High-mass X-Ray Binary IGR J16318-4848, Astrophysical Journal, 894, 86, doi:10.3847/1538-4357/ab881c, <https://ui.adsabs.harvard.edu/abs/2020ApJ...894...86F>
- Garduño L. E., **Lara-López M. A.**, López-Cruz O., Hopkins A. M., Owers M. S., Pimbblet K. A., Holwerda B. W., 2021, Galaxy And Mass Assembly (GAMA): the interplay between galaxy mass, SFR, and heavy element abundance in paired galaxy sets, Monthly Notices Royal Astronomical Society, 501, 2969, doi:10.1093/mnras/staa3799, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.501.2969G>
- Gompertz B. P., et al., inc. **Ramsay G.**, **Duffy C.**, 2020, Searching for electromagnetic counterparts to gravitational-wave merger events with the prototype Gravitational-Wave Optical Transient Observer (GOTO-4), Monthly Notices Royal Astronomical Society, 497, 726, doi:10.1093/mnras/staa1845, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.497..726G>
- Grassitelli L., Langer N., Mackey J., Gräfenr G., Grin N. J., **Sander A. A. C.**, **Vink J. S.**, 2021, Wind-envelope interaction as the origin of the slow cyclic brightness variations of luminous blue variables, Astronomy & Astrophysics, 647, A99, doi:10.1051/0004-6361/202038298, <https://ui.adsabs.harvard.edu/abs/2021AA...647A..99G>
- Hayashi K., et al., **Burton M.G.**, 2021, Triggered high-mass star formation in the H II region W 28 A2: A cloud-cloud collision scenario, Publications Astronomical Society Japan, 73, S321, doi:10.1093/pasj/psaa054, <https://ui.adsabs.harvard.edu/abs/2021PASJ...73S.321H>
- Jeffery C. S.**, 2020, TESS photometry of helium-rich hot subdwarfs: r modes in BD+37442 and BD+371977, Monthly Notices Royal Astronomical Society, 496, 718, doi:10.1093/mnras/staa1555, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.496..718J>
- Jeffery C. S.**, Zhang X., 2020, Merged white dwarfs and nucleosynthesis, Journal of Astrophysics and Astronomy, 41, 48, doi:10.1007/s12036-020-09669-0, <https://ui.adsabs.harvard.edu/abs/2020JApA...41...48J>
- Jeffery C. S.**, Rao N. K., Lambert D. L., 2020a, SALT revisits DY Cen: a rapidly evolving strontium-rich single helium star, Monthly Notices Royal Astronomical Society, 493, 3565, doi:10.1093/mnras/staa406, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.493.3565J>
- Jeffery C. S.**, Barentsen G., Handler G., 2020b, TESS photometry of extreme helium stars PV Tel and V821 Cen, Monthly Notices Royal Astronomical Society, 495, L135, doi:10.1093/mnrasl/slaa075, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.495L.135J>
- Jeffery C. S.**, Miszalski B., **Snowdon E.**, 2021, The SALT survey of helium-rich hot subdwarfs: methods, classification, and coarse analysis, Monthly Notices Royal Astronomical Society, 501, 623, doi:10.1093/mnras/staa3648, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.501..623J>
- Langer N., et al., inc. **Vink J.S.**, 2020, Properties of OB star-black hole systems derived from detailed binary evolution models, Astronomy & Astrophysics, 638, A39, doi:10.1051/0004-6361/201937375, <https://ui.adsabs.harvard.edu/abs/2020AA...638A..39L>
- Lara-López M. A.**, et al., 2021, Metal-THINGS: On the Metallicity and Ionization of ULX Sources in NGC 925, Astrophysical Journal, 906, 42, doi:10.3847/1538-4357/abc892, <https://ui.adsabs.harvard.edu/abs/2021ApJ...906...42L>
- Li D., **Christou A. A.**, 2020, The Origin of Neptune's Unusual Satellites from a Planetary Encounter, Astronomical Journal, 159, 184, doi:10.3847/1538-3881/ab7cd5, <https://ui.adsabs.harvard.edu/abs/2020AJ....159..184L>
- Li D., Johansen A., Mustill A. J., Davies M. B., **Christou A. A.**, 2020, Capture of satellites during planetary encounters. A case study of the Neptunian moons Triton and Nereid, Astronomy & Astrophysics, 638, A139, doi:10.1051/0004-6361/201936672, <https://ui.adsabs.harvard.edu/abs/2020AA...638A.139L>

- Mathys G., Khalack V., **Landstreet J. D.**, 2020, The 10.5 year rotation period of the strongly magnetic rapidly oscillating Ap star HD 166473, *Astronomy & Astrophysics*, 636, A6, doi:10.1051/0004-6361/201936624, <https://ui.adsabs.harvard.edu/abs/2020AA...636A...6M>
- Mong Y. L., et al., inc. **Ramsay G.**, 2020, Machine learning for transient recognition in difference imaging with minimum sampling effort, *Monthly Notices Royal Astronomical Society*, 499, 6009, doi:10.1093/mnras/staa3096, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.499.6009M>
- Monguió M., et al., inc. **Vink J. S.**, 2020, IGAPS: the merged IPHAS and UVEX optical surveys of the northern Galactic plane, *Astronomy & Astrophysics*, 638, A18, doi:10.1051/0004-6361/201937333, <https://ui.adsabs.harvard.edu/abs/2020AA...638A..18M>
- Morford J. C., et al., inc. **Vink J. S.**, 2020, COBRaS: The e-MERLIN 21 cm Legacy survey of Cygnus OB2, *Astronomy & Astrophysics*, 637, A64, doi:10.1051/0004-6361/201731379, <https://ui.adsabs.harvard.edu/abs/2020AA...637A..64M>
- Mullaney J. R., et al., inc. **Ramsay G.**, **Duffy C.**, 2021, Processing GOTO data with the Rubin Observatory LSST Science Pipelines I: Production of coadded frames, *Publications Astronomical Society Australia*, 38, e004, doi:10.1017/pasa.2020.45, <https://ui.adsabs.harvard.edu/abs/2021PASA...38....4M>
- Murabito M., **Shetye J.**, Stangalini M., Verwichte E., Arber T., Ermolli I., Giorgi F., Goffrey T., 2020, Unveiling the magnetic nature of chromospheric vortices, *Astronomy & Astrophysics*, 639, A59, doi:10.1051/0004-6361/202038360, <https://ui.adsabs.harvard.edu/abs/2020AA...639A..59M>
- Nadolny J., et al., inc. **Lara-López M. A.**, 2021, The OTELO survey as a morphological probe. Last ten Gyr of galaxy evolution. The mass-size relation up to $z = 2$, *Astronomy & Astrophysics*, 647, A89, doi:10.1051/0004-6361/202037861, <https://ui.adsabs.harvard.edu/abs/2021AA...647A..89N>
- Nayana A. J., et al., inc. **Naslim N.**, 2020, ALMA Observations of HCO⁺ and HCN Emission in the Massive Star-forming Region N55 of the Large Magellanic Cloud, *Astrophysical Journal*, 902, 140, doi:10.3847/1538-4357/abb466, <https://ui.adsabs.harvard.edu/abs/2020ApJ...902..140N>
- Østensen R. H., et al., inc. **Jeffery C. S.**, 2020, PHL 417: a zirconium-rich pulsating hot subdwarf (V366 Aquarid) discovered in K2 data, *Monthly Notices Royal Astronomical Society*, 499, 3738, doi:10.1093/mnras/staa3123, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.499.3738O>
- Pilyugin L. S., Zinchenko I. A., **Lara-López M. A.**, Nefedyev Y. A., Vílchez J. M., 2021, Two types of distribution of the gas velocity dispersion of MaNGA galaxies, *Astronomy & Astrophysics*, 646, A54, doi:10.1051/0004-6361/202040029, <https://ui.adsabs.harvard.edu/abs/2021AA...646A..54P>
- Poci A., et al., inc. **Sarzi M.**, 2021, The Fornax3D project: Assembly histories of lenticular galaxies from a combined dynamical and population orbital analysis, *Astronomy & Astrophysics*, 647, A145, doi:10.1051/0004-6361/202039644, <https://ui.adsabs.harvard.edu/abs/2021AA...647A.145P>
- Ramsay G.**, **Doyle J. G.**, **Doyle L.**, 2020, TESS observations of southern ultrafast rotating low-mass stars, *Monthly Notices Royal Astronomical Society*, 497, 2320, doi:10.1093/mnras/staa2021, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.497.2320R>
- Rebolledo D., Green A. J., **Burton M. G.**, Breen S. L., Garay G., 2021, The Carina Nebula and Gum 31 Molecular Complex. III. The Distribution of the 1-3 GHz Radio Continuum across the Whole Nebula, *Astrophysical Journal*, 909, 93, doi:10.3847/1538-4357/abd7a3, <https://ui.adsabs.harvard.edu/abs/2021ApJ...909...93R>
- Reed M. D., et al., inc. **Jeffery C. S.**, 2020, TESS observations of pulsating subdwarf B stars: extraordinarily short-period gravity modes in CD-28 1974, *Monthly Notices Royal Astronomical Society*, 493, 5162, doi:10.1093/mnras/staa661, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.493.5162R>
- Richardson N. D., et al., inc. **Sander A. A. C.**, 2021, The First Dynamical Mass Determination of a Nitrogen-rich Wolf-Rayet Star Using a Combined Visual and Spectroscopic Orbit, *Astrophysical Journal*, 908, L3, doi:10.3847/2041-8213/abd722, <https://ui.adsabs.harvard.edu/abs/2021ApJ...908L...3R>
- Sander A. A. C.**, **Vink J. S.**, 2020, On the nature of massive helium star winds and Wolf-Rayet-type mass-loss, *Monthly Notices Royal Astronomical Society*, 499, 873, doi:10.1093/mnras/staa2712, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.499..873S>

Schootemeijer A., et al., inc. **Vink J. S.**, 2021, A dearth of young and bright massive stars in the Small Magellanic Cloud, *Astronomy & Astrophysics*, 646, A106, doi:10.1051/0004-6361/202038789, <https://ui.adsabs.harvard.edu/abs/2021AA...646A.106S>

Shenar T., et al., inc. **Sander A. A. C.**, 2020, The Wolf-Rayet binaries of the nitrogen sequence in the Large Magellanic Cloud. Spectroscopy, orbital analysis, formation, and evolution (Corrigendum), *Astronomy & Astrophysics*, 641, C2, doi:10.1051/0004-6361/201935684e, <https://ui.adsabs.harvard.edu/abs/2020AA...641C...2S>

Shultz M. E., et al., inc. **Landstreet J. D.**, 2020, The magnetic early B-type stars - IV. Breakout or leakage? H α emission as a diagnostic of plasma transport in centrifugal magnetospheres, *Monthly Notices Royal Astronomical Society*, 499, 5379, doi:10.1093/mnras/staa3102, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.499.5379S>

Siebenmorgen R., Krelowski J., Smoker J., Galazutdinov G., **Bagnulo S.**, 2020, Dark dust and single-cloud sightlines in the ISM, *Astronomy & Astrophysics*, 641, A35, doi:10.1051/0004-6361/202037511, <https://ui.adsabs.harvard.edu/abs/2020AA...641A..35S>

Smith M. D., et al., inc. **Sarzi M.**, 2021a, 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.tmp..775S>

Smith M. D., et al., inc. **Sarzi M.**, 2021b, WISDOM project - VI. Exploring the relation between supermassive black hole mass and galaxy rotation with molecular gas, *Monthly Notices Royal Astronomical Society*, 500, 1933, doi:10.1093/mnras/staa3274, <https://ui.adsabs.harvard.edu/abs/2021MNRAS.500.1933S>

Spriggs T. W., et al., inc. **Sarzi M.**, 2020, Fornax 3D project: Automated detection of planetary nebulae in the centres of early-type galaxies and first results, *Astronomy & Astrophysics*, 637, A62, doi:10.1051/0004-6361/201936862, <https://ui.adsabs.harvard.edu/abs/2020AA...637A..62S>

Srivastava A. K., et al., inc. **Doyle J. G.**, 2020, Velocity Response of the Observed Explosive Events in the Lower Solar Atmosphere. I. Formation of the Flowing Cool-loop System, *Astrophysical Journal*, 894, 155, doi:10.3847/1538-4357/ab86bb, <https://ui.adsabs.harvard.edu/abs/2020ApJ...894..155S>

Sterzik M. F., **Bagnulo S.**, Emde C., Manev M., 2020, The cloudbow of planet Earth observed in polarisation, *Astronomy & Astrophysics*, 639, A89, doi:10.1051/0004-6361/202038270, <https://ui.adsabs.harvard.edu/abs/2020AA...639A..89S>

Tripathi D., **Vilangot Nhalil N.**, Isobe H., Doyle G. G., 2020, On the Ratios of Si IV Lines ($\lambda 1394/\lambda 1403$) in an Emerging Flux Region, *Astrophysical Journal*, 894, 128, doi:10.3847/1538-4357/ab8558, <https://ui.adsabs.harvard.edu/abs/2020ApJ...894..128T>

Tripathi D., **Vilangot Nhalil N.**, Solanki S. K., 2021, Coronal Heating and Solar Wind Formation in Quiet Sun and Coronal Holes: A Unified Scenario, *Astrophysical Journal*, 908, 28, doi:10.3847/1538-4357/abcc6b, <https://ui.adsabs.harvard.edu/abs/2021ApJ...908...28T>

Vilangot Nhalil N., Nelson C. J., Mathioudakis M., **Doyle J. G.**, **Ramsay G.**, 2020, Power-law energy distributions of small-scale impulsive events on the active Sun: results from IRIS, *Monthly Notices Royal Astronomical Society*, 499, 1385, doi:10.1093/mnras/staa2897, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.499.1385V>

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.tmp..901V>

Zabel N., et al., inc. **Sarzi M.**, 2020, AIFoCS + Fornax3D: resolved star formation in the Fornax cluster with ALMA and MUSE, *Monthly Notices Royal Astronomical Society*, 496, 2155, doi:10.1093/mnras/staa1513, <https://ui.adsabs.harvard.edu/abs/2020MNRAS.496.2155Z>

Zhang Q., Hallinan G., Briske W., Bourke S., **Golden A.**, 2020, Multiepoch VLBI of L Dwarf Binary 2MASS J0746+2000AB: Precise Mass Measurements and Confirmation of Radio Emission from Both Components, *Astrophysical Journal*, 897, 11, doi:10.3847/1538-4357/ab9177, <https://ui.adsabs.harvard.edu/abs/2020ApJ...897...11Z>

van Gelder M. L., et al., inc. **Vink J. S.**, 2020, VLT/X-shooter spectroscopy of massive young stellar objects in the 30 Doradus region of the Large Magellanic Cloud, *Astronomy & Astrophysics*, 636, A54, doi:10.1051/0004-6361/201936361, <https://ui.adsabs.harvard.edu/abs/2020AA...636A..54V>

Armagh Observatory and Planetarium

Non Refereed Journal Publications: April 2020 – March 2021

Bagnulo S., 2020, in Wade G., Alecian E., Bohlender D., Sigut A., eds, Vol. 11, Stellar Magnetism: A Workshop in Honour of the Career and Contributions of John D. Landstreet. Fifty Years of Observations of Grw+70() 8247. pp 15–24

Borisov G., Christou A., Bagnulo S., Cellino A., Dell’Oro A., 2020, in European Planetary Science Congress. Light curves and spin rates of Earth co-orbital asteroids. pp EPSC2020–324

Christou A., Dermott S., Li D., 2020, in AAS/Division of Dynamical Astronomy Meeting. Orbital mobility of asteroids in the Inner Main Belt: A closer look at gravitational diffusion. p. 100.05

Cirasuolo M., et al., inc. **Sarzi M.**, 2020, MOONS: The New Multi-Object Spectrograph for the VLT, The Messenger, 180, 10, doi:10.18727/0722-6691/5195, <https://ui.adsabs.harvard.edu/abs/2020Msngr.180...10C>

Daly L., et al., inc. **Christou A.**, 2020, in European Planetary Science Congress. The UK Fireball Alliance (UKFAI); combining and integrating the diversity of UK camera networks to aim to recover the first UK meteorite fall for 30 years. pp EPSC2020–705

Dyer M. J., et al., inc. **Ramsay G.**, 2020, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series. The Gravitational-wave Optical Transient Observer (GOTO). p. 114457G (arXiv:2012.02685), doi:10.1117/12.2561008

Evans C., et al., inc. **Vink J. S.**, 2020, The VLT-FLAMES Tarantula Survey, The Messenger, 181, 22, doi:10.18727/0722-6691/5207, <https://ui.adsabs.harvard.edu/abs/2020Msngr.181...22E>

Galloway, D. K., et al., inc. **Ramsay, G.**, 2020, GOTO detection of the M31 nova M31N 2008-12a, ATel, 14141

Heras A. M., et al., inc. **Ramsay G.**, 2020, in European Planetary Science Congress. The PLATO mission: Studying the diversity of exoplanets orbiting up to the habitable zone of Sun-like stars. pp EPSC2020–396

Jeffery S., 2020, Thomas Richard (Dick) Carson (1930-2019), Astronomy and Geophysics, 61, 2.16, doi:10.1093/astrogeo/ataa021, <https://ui.adsabs.harvard.edu/abs/2020AG....61b2.16J>

Landstreet J. D., 2020, in Wade G., Alecian E., Bohlender D., Sigut A., eds, Vol. 11, Stellar Magnetism: A Workshop in Honour of the Career and Contributions of John D. Landstreet. Reflections on the Discovery of the First Magnetic White Dwarf. pp 239–246 (arXiv:2008.01802)

Li D., **Christou A.**, 2020, in European Planetary Science Congress. An in-situ formation for Triton and Nereid. pp EPSC2020–769

Mong, Y.-L., et al. inc. **Ramsay, G.**, 2021, GRB 210222B: GOTO confirmation of afterglow detection, GCN 29548

Nežić R., Bagnulo S., Jones G., 2020, in European Planetary Science Congress. Effects of heliocentric distance on polarisation of comet C/2010 E6 (STEREO). pp EPSC2020–817

Ramsay, G., et al., 2020, Optical outburst detected from the AM CVn binary ASASSN-14mv, ATel, 13980

Shetye J., 2020, in AAS/Solar Physics Division Meeting. Exploring Magnetic Entanglements within Chromospheric Swirls. p. 201.04

Vink J. S., 2020, Star Formation in the Ultraviolet, Galaxies, 8, 43, doi:10.3390/galaxies8020043, <https://ui.adsabs.harvard.edu/abs/2020Galax...8...43V>

Armagh Observatory and Planetarium Presentations: April 2020– March 2021

Date	AOP Speaker	Title	Location/Mode	Category
01 Apr 2020	R. Nežič	Science at Home: Getting to Know You – Dr Rok Nežič	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
02 Apr 2020	M. Burton	Mapping the Aliphatic Component of Dust in the Interstellar Medium	Armagh Observatory and Planetarium via Zoom	Research/ Internal
03 Apr 2020	M. Sarzi	Science at Home: Facts and Myths of Science Fiction Movies	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
07 Apr 2020	M. Burton	Science at Home: Armagh Astrobytes I – Astronomy and the Birth of Science	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
08 Apr 2020	M. Burton	Science at Home: Introduction to Planetarium Dome Show – Unseen Universe	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
09 Apr 2020	A. Christou	The Origin of Neptune's Peculiar Moons	Discussion Group, Armagh Observatory and Planetarium	Research
10 Apr 2020	M. Sarzi	Science at Home: The Moon	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
14 Apr 2020	M. Burton	Science at Home: Armagh Astrobytes II – Tour of the Solar System – The Inner Planets	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
15 Apr 2020	M. Burton	Science at Home: Introduction to Planetarium Dome Show – Secret Lives of Stars	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
16 Apr 2020	M. Burton	The Mopra CO Survey – An Update from Armagh	Australian CTA Consortium Workshop via Zoom	Research
16 Apr 2020	R. Nežič	Science at Home: Q&A Session – Comets and Asteroids	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
16 Apr 2020	M. Sarzi	On the Initial Stellar Mass Function in Early-Type Galaxies	Online Seminar, Armagh Observatory and Planetarium	Research
17 Apr 2020	M. Sarzi	Science at Home: History of Astrophotography	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
21 Apr 2020	M. Burton	Science at Home: Armagh Astrobytes III – Tour of the Solar System – The Outer Planets	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science Home
22 Apr 2020	M. Burton	Science at Home: Introduction to Planetarium Dome Show – Invaders of Mars	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
22 Apr 2020	J.S. Vink	The Heaviest Stars and Black Holes in the Universe	Online Seminar, Keele University	Research
23 Apr 2020	S. Bagnulo	A High-Precision Survey of Magnetic Fields in White Dwarfs Within 20 Parsec from the Sun	Online Seminar, Armagh Observatory and Planetarium	Research
23 Apr 2020	M. Burton	Science at Home: Getting to Know You – Professor Michael Burton	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
24 Apr 2020	M. Sarzi	Science at Home: The Cosmic Distance Ladder	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home

Date	AOP Speaker	Title	Location/Mode	Category
28 Apr 2020	M. Burton	Science at Home: Armagh Astrobytes IV – Tour of the Solar System – The Minor Bodies	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
29 Apr 2020	M. Burton	Science at Home: Introduction to Planetarium Dome Show – Dynamic Earth	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
30 Apr 2020	C. Byrne	Science at Home: Q&A Session – Stars	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
30 Apr 2020	R. Nežič	Polarimetric Study of 8 Kreutz Comets Observed by STEREO	Online Seminar, Armagh Observatory and Planetarium	Research
05 May 2020	M. Burton	Science at Home: Armagh Astrobytes V – Our Local Star, The Sun	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
06 May 2020	M. Burton	Science at Home: Introduction to Planetarium Dome Show – Robot Explorers	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
07 May 2020	M. Burton	An Introduction to the Cherenkov Telescope Array	Online Seminar, Armagh Observatory and Planetarium	Research/ Internal
07 May 2020	M. Sarzi	Science at Home: Getting to Know You – Dr Marc Sarzi	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
08 May 2020	M. Sarzi	Science at Home: Augmented Reality	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
08 May 2020	R. Nežič and T. Watts	Science at Home: Moon App	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
12 May 2020	M. Burton	Science at Home: Armagh Astrobytes VI – Introduction to the Stars	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
13 May 2020	M. Burton	Science at Home: Introduction to Planetarium Dome Show – Birth of Planet Earth	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
14 May 2020	L. Doyle	Solar and Stellar Flares and their Connection	Online Seminar, Armagh Observatory and Planetarium	Research
14 May 2020	G. Ramsay	Science at Home: Introduction to 'The Binary Zoo' by Mark Garlick	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
19 May 2020	M. Burton	Science at Home: Armagh Astrobytes VII – How Stars are Made	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
20 May 2020	M. Burton	Science at Home: Introduction to Planetarium Dome Show – Super Volcanoes	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
21 May 2021	E. Higgins	Science at Home: AOP PhD Students	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
21 May 2020	E. Higgins	The Evolution of Massive Stars in the Galaxy and Magellanic Clouds	Seminar, Armagh Observatory and Planetarium/Queen's University Belfast	Research
21 May 2020	A.A.C. Sander	Science at Home: Getting to Know You – Dr Andreas Sander	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
26 May 2020	M. Burton	Science at Home: Armagh Astrobytes VIII – The Daily Life of a Star	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
02 Jun 2020	M. Burton	Science at Home: Armagh Astrobytes IX – The Death of Stars	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home

Date	AOP Speaker	Title	Location/Mode	Category
03 Jun 2020	M. Burton	Science at Home: Introduction to Planetarium Dome Show – Mars 1001	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
04 Jun 2020	M. Lara Lopez	Science at Home: Getting to Know You – Dr Maritza Lara Lopez	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
07 Jun 2020	S. Bagnulo	Science at Home: Polarized Light	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
09 Jun 2020	M. Burton	Science at Home: Armagh Astrobytes X – The Milky Way Galaxy – Our Local Star City	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
11 Jun 2020	E. Higgins	The Evolution of Massive Stars in the Galaxy and Magellanic Clouds	Seminar, Trinity College Dublin and ASI Community	Research
11 Jun 2020	G. Ramsay	Science at Home: Getting to Know You – Dr Gavin Ramsay	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
15 Jun 2020	G. Ramsay	Observing Programmes for the O3-O4 Gap	GOTO 2020 Virtual Science Collaboration Meeting	Research
16 Jun 2020	M. Burton	Science at Home: Armagh Astrobytes XI – The Realm of the Galaxies	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
16 Jun 2020	G. Ramsay	Overview of Science Working Groups	GOTO 2020 Virtual Science Collaboration Meeting	Research
16 Jun 2020	G. Ramsay	Observing Open Clusters	GOTO 2020 Virtual Science Collaboration Meeting	Research
18 Jun 2020	A. Christou	Science at Home: Getting to Know You – Dr Apostolos Christou	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
23 Jun 2020	M. Burton	Science at Home: Armagh Astrobytes XII – The Structure of the Universe	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
25 Jun 2020	J.S. Vink	Science at Home: Getting to Know You – Professor Jorick Vink	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
30 Jun 2020	M. Burton	Science at Home: Armagh Astrobytes XIII – Cosmology – The History of the Universe	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Teaching/ Science at Home
30 Jun 2020	M. Burton	Wisdom Begins with Wonder	Historic Environment Division, Department for Communities NI (online)	Outreach/ External
02 Jul 2020	S. Bagnulo	Science at Home: Getting to Know You – Dr Stefano Bagnulo	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
02 Jul 2020	E. Higgins	Constraining Mixing in the M-L plane	e-poster, Virtual European Astronomical Society Annual Meeting	Research
03 Jul 2020	J.S. Vink	Heavy Black Holes Suggest Low Z	Virtual European Astronomical Society Annual Meeting	Research
10 Jul 2020	C.S. Jeffery	Science at Home: Binoculars	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
16 Jul 2020	E. Higgins	Massive Star Evolution in the M-L Plane: Mixing and Mass Loss on the Main Sequence	MOBSTER-1 Virtual Conference	Research
16 Jul 2020	E. Snowdon	Science at Home: Getting to Know You – Ted Snowdon	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
21 Jul 2020	M. Sarzi	Science at Home: Armagh Observatory and Planetarium AR App with Dr Marc Sarzi	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
23 Jul 2020	M. Burton	Science at Home: Q&A Session – Galaxies with Professor Michael Burton	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home

Date	AOP Speaker	Title	Location/Mode	Category
23 Jul 2020	M. Lara Lopez	Identifying the Main Drivers in the Evolution of Galaxies Using Multiwavelength Data and IFU Spectroscopy	Online Seminar, Armagh Observatory and Planetarium	Research
30 Jul 2020	M. Lara Lopez	The Metal-THINGS Survey	Trinity College Dublin	Research
31 Jul 2020	C.S. Jeffery	Science at Home: Q&A Session – Hydrogen Deficient Stars with Professor Simon Jeffery	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
03 Aug 2020	A. Christou	Orbital Mobility of Asteroids in the Inner Main Belt: A Closer Look at Gravitational Diffusion	DDA 51 Virtual Meeting	Research
20 Aug 2020	G. Ramsay	Science at Home: Q&A Session – Binary Stars with Dr Gavin Ramsay	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
04 Sep 2020	M. Burton	Science at Home (with Sinead Mackle, Martina Glass, Heather Alexander and Helen McLoughlin)	British Association of Planetaria Annual Meeting (online)	Research and Education/ External
04 Sep 2020	M. Lara Lopez	An Overview of Evolution of Galaxies	Irish National Astronomy Meeting 2020, Dublin, Ireland (online)	Research
04 Sep 2020	G. Sabhahit	Investigating the Humphreys-Davidson Limit for Galactic, LMC and SMC Metallicities	Irish National Astronomy Meeting 2020, Dublin, Ireland (online)	Research
15 Sep 2020	M. Burton	Armagh Observatory: Past, Present and Future	Senior Management Team Presentation, Historic Environment Division, Department for Communities NI (online)	Outreach/ External
16 Sep 2020	M. Burton	Armagh Observatory: Conservation Challenge in a Living Museum	Scientific Instrumentation Symposium, Science Museum, London (online)	Research/External
24 Sep 2020	R. Nežič	Effects of Heliocentric Distance on Polarisation of Comet C/2010 E6 (STEREO)	Europlanet Science Congress 2020 Virtual Meeting	Research
25 Sep 2020	A.A.C. Sander	Understanding the Nature of WR-Type Mass Loss in Different Environments	Virtual Annual Meeting of the German Astronomical Society	Research
06 Oct 2020	E. Higgins	Evolution of Wolf-Rayet Stars at Low Metallicity	Virtual VLT-Flames Tarantula Meeting	Research
06 Oct 2020	A.A.C. Sander	Mass-Loss Rates for Massive He Stars and the Onset of Wolf-Rayet-Type Winds	Virtual VLT-Flames Tarantula Meeting	Research
06 Oct 2020	J.S. Vink	The HST ULLYSES Programme	Virtual VLT-Flames Tarantula Meeting	Research
08 Oct 2020	R. Mee H. McLoughlin	Cosmic Classroom, KS2	St. Comgall's, 1 Ballymena Road, Antrim, BT41 4JG	Education
13 Oct 2020	M. Burton	The CTA-UK/Armagh Observatory and Planetarium Outreach Programme	CTA Annual Consortium Meeting (online)	Outreach/ External
14 Oct 2020	J.S. Vink	X-Shooting ULLYSES	Virtual ULLYSES Kick Off Meeting	Research
15 Oct 2020	A.A.C. Sander	Mass-Loss Rates for Massive He Stars and the Onset of Wolf-Rayet-Type Winds	Virtual ULLYSES Kick Off Meeting	Research
17 Oct 2020	R. Mee H. McLoughlin	Cosmic Classroom, KS1/KS2	St. Mary's Primary School, Rathlin Island, Co Antrim, BT54 6RT	Education
21 Oct 2020	M. Sarzi	The Hunt for Supermassive Black Holes: A Short History	Irish Astronomical Association Zoom Lecture	Outreach/ External

Date	AOP Speaker	Title	Location/Mode	Category
26 Oct 2020	M. Burton	Wisdom Begins with Wonder – The Vision for the Armagh Observatory and Planetarium	Department for Communities NI (online)	Outreach/ External
27 Oct 2020	M. Burton	Science at Home: The Armagh Observatory and Planetarium Story	Armagh Observatory and Planetarium Social Media Channels	Outreach/ Science at Home
02 Nov 2020	K. Çubuk	CTA Planetarium Show	CTA-Oz Meeting 2020 #2	Outreach/ External
10 Nov 2020	M. Burton	Armagh Observatory and its Landscape	CGY3075 Human Geography Class, Queen's University Belfast (online)	Teaching/ External
11 Nov 2020	N. Parke H. McLoughlin	Cosmic Classroom, KS1	Friends' Prep, 28 Fort Hill, Lisburn, Co Antrim, BT28 3PH	Education
12 Nov 2020	H. McLoughlin	Cosmic Classroom, KS1	St. Mary's Primary School, 16 Lisnagowan Road, Carland, Dungannon, Co Tyrone, BT70 3LH	Education
13 Nov 2020	R. Mee H. McLoughlin	Cosmic Classroom, KS2	Clarawood Special School, Clarawood Park, Belfast, BT5 6FR	Education
14 Nov 2020	C. Allison H. McLoughlin	Cosmic Classroom, KS1	Markethill Primary School, 14 Mowhan Road, Markethill, Co Armagh, BT60 1RQ	Education
16 Nov 2020	M. Burton with H. McLoughlin	Science at Home: StarTracker Online	Armagh Observatory and Planetarium via Zoom	Outreach/ Science at Home
18 Nov 2020	J.S. Vink	30 Years of Hubble Space Telescope: Opening the Treasure Chest	Irish Astronomical Association Zoom Lecture	Outreach/ External
26 Nov 2020	A. Christou	Science at Home: Sky at Night Podcast	Online via Armagh Observatory and Planetarium Facebook Channels	Outreach/ Science at Home
01 Dec 2020	A. Taylor H. McLoughlin	Cosmic Classroom, KS1	Buick Memorial School, 62 Main Street, Cullybackey, BT42 1BW	Education
01 Dec 2020	H. McLoughlin R. Mee	Cosmic Classroom, KS2	St. Nicholas' Primary School, Minorca Place, Carrickfergus, BT38 8AU	Education
02 Dec 2020	C. Allison H. McLoughlin	Cosmic Classroom, KS2	Linn Primary School, Killyglen Road, Larne, BT40 2HT	Education
02 Dec 2020	A. Christou	The Martian Trojan Asteroids: A Natural Experiment in Asteroid Evolution	Astrophysics Research Centre, Queens University Belfast	Research
07 Dec 2020	M.E. Bailey	Comets, Meteoroid Streams and Meteor Showers	Causeway U3A, Portstewart, Co. Antrim (Zoom Presentation)	Outreach/ External
08 Dec 2020	N. Parke H. McLoughlin	Cosmic Classroom, KS2	Carrickfergus Central Primary School, 21 Thomas Street, Carrickfergus, Co. Antrim, BT38 8AL	Education
10 Dec 2020	M. Burton H. McLoughlin	Science at Home: StarTracker Online	Armagh Observatory and Planetarium via Zoom	Outreach/ Science at Home
14 Dec 2020	A.A.C. Sander	The Occurrence and Evolution of Wolf-Rayet Stars in Different Environments	Virtual Annual BRIDGCE UK Meeting	Research
16 Dec 2020	G. Ramsay	Gravitational-Wave Optical Transient Observer (GOTO)	Irish Astronomical Association Zoom Lecture	Outreach/ External
11 Jan 2021	M. Burton H. McLoughlin M. Sarzi	Science at Home: Mini StarTracker and Public Lecture by Professor Chris Lintott	Armagh Observatory and Planetarium via Zoom	Outreach/ Science at Home
12 Jan 2021	A.A.C. Sander	Lecture on Massive Stars	UKRI STFC Introductory Course in Astronomy for New Research Students, Armagh Observatory and Planetarium via Zoom	Research

Date	AOP Speaker	Title	Location/Mode	Category
13 Jan 2021	M. Burton	Outreach and Data Visualisation using a Planetarium	UKRI STFC Introductory Course in Astronomy for New Research Students, Armagh Observatory and Planetarium via Zoom	Research
14 Jan 2021	M. Burton	Our Galaxy – Gas, Dust and Surveys	UKRI STFC Introductory Course in Astronomy for New Research Students, Armagh Observatory and Planetarium via Zoom	Research
21 Jan 2021	H. McLoughlin R. Mee	Science at Home: StarTracker Online – Kids Takeover	Armagh Observatory and Planetarium via Zoom	Education
22 Jan 2021	C.S. Jeffery	Concluding Remarks	Conference on Pulsations in Intermediate-Mass, Massive and/or Multiple Stars, University of Surrey. UK	Research
26 Jan 2021	H. McLoughlin R. Mee	Science at Home: StarTracker Online – Kids Takeover	Armagh Observatory and Planetarium via Zoom	Education
26 Jan 2021	C.J. Butler	Climate Research at Armagh Observatory	Heritage from Home, Libraries NI via Zoom	Outreach/ External
27 Jan 2021	M. Burton H. McLoughlin	Science at Home: StarTracker Online	Armagh Observatory and Planetarium via Zoom	Outreach/ Science at Home
28 Jan 2021	H. McLoughlin R. Mee	Science at Home: StarTracker Online – Kids Takeover	Armagh Observatory and Planetarium via Zoom	Education
02 Feb 2021	C. Allison R. Mee	Science at Home: StarTracker Online – Kids Takeover	Armagh Observatory and Planetarium via Zoom	Education
04 Feb 2021	N. Parke R. Mee	Science at Home: StarTracker Online – Kids Takeover	Armagh Observatory and Planetarium via Zoom	Education
09 Feb 2021	C. Allison R. Mee	Science at Home: StarTracker Online – Kids Takeover	Armagh Observatory and Planetarium via Zoom	Education
10 Feb 2021	E. Higgins	The Evolution of Massive Stars in the Galaxy and Magellanic Clouds	Seminar, University of Sheffield	Research
11 Feb 2021	R. Mee A. Taylor	Science at Home: StarTracker Online – Kids Takeover	Armagh Observatory and Planetarium via Zoom	Education
17 Feb 2021	H. McLoughlin R. Mee	Cosmic Classroom, KS1/KS2 (2 sessions)	Tobin Youth Centre, 8 Ardboe Road, Cookstown, Co. Tyrone, BT80 0HT	Education
18 Feb 2021	H. McLoughlin A. Taylor R. Nežič	Science at Home: StarTracker Online – Kids Takeover – All About Perseverance	Armagh Observatory and Planetarium via Zoom	Education
22 Feb 2021	A.A.C. Sander	Decoding the Light of Stars: Stellar Atmospheres and the Crucial Role of Wolf-Rayet Stars	Online Seminar at the University of Auckland, NZ	Research
23 Feb 2021	H. McLoughlin R. Mee A. Taylor	Cosmic Classroom, KS1	St. Joseph's Primary School, 42 Castle Street, Lisburn, Co. Antrim, BT27 4XE	Education
23 Feb 2021	A. Taylor N. Parke	Science at Home: StarTracker Online – Kids Takeover (KS2)	Armagh Observatory and Planetarium via Zoom	Education
23 Feb 2021	R. Mee C. Allison	Science at Home: StarTracker Online – Kids Takeover – All About Moons	Armagh Observatory and Planetarium via Zoom	Education
24 Feb 2021	M. Burton R. Mee	Science at Home: StarTracker Online	Armagh Observatory and Planetarium via Zoom	Outreach/ Science at Home
24 Feb 2021	C.J. Butler	The Buildings of Armagh Observatory	Armagh City Townscape Heritage Talks, Armagh City, Banbridge and Craigavon Borough Council, via Zoom	Outreach/ External
24 Feb 2021	G. Ramsay	Report on STFC GW 2020 Grants Panel	STFC Science Board via Zoom	Research

Date	AOP Speaker	Title	Location/Mode	Category
25 Feb 2021	H. McLoughlin	Science at Home: StarTracker Online – Kids Takeover – P1 and P2	Armagh Observatory and Planetarium via Zoom	Education
25 Feb 2021	A. Taylor N. Parke	Science at Home: StarTracker Online – Kids Takeover – P3 and P4	Armagh Observatory and Planetarium via Zoom	Education
01 Mar 2021	C.S. Jeffery	Galactic Carbon Stars and White Dwarf Mergers	Astrochronometry Seminar, University of Birmingham, UK	Research
03 Mar 2021	H. McLoughlin C. Allison H. Alexander	Cosmic Classroom, KS1	Nord Anglia International School, Dublin 18, Ireland	Education
03 Mar 2021	A. Taylor N. Parke	Science at Home: StarTracker Online – Kids Takeover (KS2)	Armagh Observatory and Planetarium via Zoom	Education
03 Mar 2021	H. McLoughlin C. Allison	Science at Home: StarTracker Online – Kids Takeover – All About Astronauts	Armagh Observatory and Planetarium via Zoom	Education
05 Mar 2021	S. Bagnulo	Spectropolarimetry with a Beam Splitting Device and a Retarder Waveplate Rotating at Fixed Positions	Department of Physics & Astronomy, East Tennessee State University	Research
05 Mar 2021	H. McLoughlin	Science at Home: StarTracker Online – Kids Takeover – P1 and P2	Armagh Observatory and Planetarium via Zoom	Education
05 Mar 2021	A. Taylor H. McLoughlin	Science at Home: StarTracker Online – Kids Takeover – P3 and P4	Armagh Observatory and Planetarium via Zoom	Education
11 Mar 2021	J.S. Vink	Maximum Black Hole Mass Across Cosmic Time	Virtual VFTS Meeting, Heidelberg	Research
15-16 Mar 2021	A.A.C. Sander	Bringing Stellar Evolution and Feedback Together (workshop title)	Online Workshop at the Lorentz Center, Leiden, NL	Research
18 Mar 2021	Staff and Students	Reach for the Stars: AOP Online Careers Day	Armagh Observatory and Planetarium via Zoom	Outreach/ Education
24 Mar 2021	M. Burton H. Alexander	Science at Home: Dara Ó Briain and the NGC	Armagh Observatory and Planetarium via Zoom	Outreach/ Science at Home
25 Mar 2021	S. Bagnulo	Five Decades of Spectropolarimetry of White Dwarfs	IAU symposium No. 360, "Astropol 2020"	Research
31 Mar 2021	M. Burton H. Alexander	Science at Home: StarTracker Online - the James Webb Space Telescope (JWST)	Armagh Observatory and Planetarium via Zoom	Outreach/ Science at Home

Armagh Observatory and Planetarium Education and Outreach Activities: April 2020 - March 2021 Main Events List

Date	Category	Subject	Channels	Authors
8 Apr 2020	Dome Show	Unseen Universe	Facebook	Sinead, Michael, E&S
15 Apr 2020	Dome Show	Secret Lives of Stars	Facebook	Sinead, Michael E&S
22 Apr 2020	Dome Show	Dynamic Earth	Facebook	Sinead, Michael, E&S
22 Apr 2020	Dome Show	Zulu Patrol: Down to Earth	Facebook	Sinead, E&S
29 Apr 2020	Dome show	Invaders of Mars	Facebook	Sinead, Michael, E&S
06 May 2020	Dome Show	Robot Explorers	Facebook	Sinead, E&S
13 May 2020	Dome Show	Supervolcanoes	Facebook	Sinead, Michael, E&S
20 May 2020	Dome Show	Birth of Planet Earth	Facebook	Sinead, Michael, E&S
27 May 2020	Dome Show	Dinosaurs at Dusk	Facebook	Sinead, E&S
04 Jun 2020	Dome Show	Mars 1001	Facebook	Sinead, Michael, E&S
07 Jun 2020	Q&A	Debra Fischer(5 questions)	FB, You Tube	Heather
04 Jul 2020	Interview	Professor Alyssa Goodman (5 minutes with)	FB, Youtube	Heather
18 Jul 2020	Interview	Dr Mike Brown (5 questions with)	FB, Youtube	Martina
12 Aug 2020	Science Talk	Zoom event: unlock the Universe	Zoom	Heather, Sinead
08 Oct 2020	Cosmic Classroom	Classroom	Zoom	AOP Team
17 Oct 2020	Cosmic Classroom	Classroom	Zoom	AOP Team
11 Nov 2020	Cosmic Classroom	Classroom	Zoom	AOP Team
12 Nov 2020	Cosmic Classroom	Classroom	Zoom	AOP Team
13 Nov 2020	Cosmic Classroom	Classroom	Zoom	AOP Team
14 Nov 2020	Cosmic Classroom	Classroom	Zoom	AOP Team
16 Nov 2020	StarTracker online	Online	Zoom	Helen, Michael
10 Dec 2020	StarTracker online	Online	Zoom	Helen, Michael
16-23 Dec 2020	Space Lights	Onsite	AOP	AOP Team
11 Jan 2021	Event	Professor Chris Lintott lecture	Zoom	Helen, Marc, Michael
21 Jan 2021	Event	Startracker Kids	Zoom	AOP Team
26 Jan 2021	Event	Startracker Kids	Zoom	AOP Team
27 Jan 2021	Event	Startracker	Zoom	Helen, Michael
28 Jan 2021	Event	Startracker Kids	Zoom	AOP Team
02 Feb 2021	Event	Startracker Kids	Zoom	AOP Team
04 Feb 2021	Event	Startracker Kids	Zoom	AOP Team
09 Feb 2021	Event	Startracker Kids	Zoom	AOP Team
11 Feb 2021	Event	Startracker Kids	Zoom	AOP Team
18 Feb 2021	Event 2 per day	Startracker Kids	Zoom	AOP Team
23 Feb 2021	Event 2 per day	Startracker Kids	Zoom	AOP Team
24 Feb 2021	Event	Startracker	Zoom	Ria, Michael
25 Feb 2021	Event 2 per day	Startracker Kids	Zoom	AOP Team

02 Mar 2021	Event 2 per day	Startracker Kids	Zoom	AOP Team
04 Mar 2021	Event 2 per day	Startracker Kids	Zoom	AOP Team
16 Mar 2021	Event 2 per day	Startracker Kids	Zoom	AOP Team
18 Mar 2021	Online careers day	Careers Day	Zoom	Anna, Helen, Sinead, Research Team
24 Mar 2021	Dara and the NGC	Online	Zoom	Heather, Michael, Sinead
31 Mar 2021	Online	Startracker	Zoom	Heather, Michael

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 2021 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. These financial statements have been prepared under the accounting policies set out within them. The financial reporting framework that has been applied in their preparation is applicable law and the Charities SORP.

I have also audited the information in the Trustees' Annual 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 2021 and of its total incoming resources and expenditure of resources for the year then ended; and
- have been properly prepared in accordance with the Armagh Observatory and Planetarium (Northern Ireland) Order 1995 and Department for Communities directions issued thereunder.

Emphasis of Matter

I draw attention to note 10 of the financial statements, which describes the material valuation uncertainties for Land and Buildings due to the consequences of the COVID-19 pandemic. My opinion is not modified in respect of this matter.

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 of the Financial Reporting Council's Revised Ethical Standard 2019, and 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 disclosed in the financial statements any identified material uncertainties that relating to events or conditions that, individually or collectively, may cast significant doubt about 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 require 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 Trustees 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 Trustees 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 Trustees and Accounting Officer for the financial statements

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

- the preparation of the financial statements in accordance with the applicable financial reporting framework and for being satisfied that they give a true and fair view;
- such internal controls as the Trustees and Accounting Officer determines is 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 Trustees and Accounting Officer anticipates 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 regulation, 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 including 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;
- 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. 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.

A handwritten signature in black ink, appearing to read 'K J Donnelly', with a stylized flourish extending from the end of the name.

KJ Donnelly
Comptroller and Auditor General
Northern Ireland Audit Office
1 Bradford Court
BELFAST
BT8 6RB

Date

4th October 2021

Armagh Observatory and Planetarium

Statement of Financial Activities for the year ended 31 March 2021

	Note	Unrestricted Funds 2021 £	Restricted Funds 2021 £	Total Funds 2021 £	Unrestricted Funds 2020 £	Restricted Funds 2020 £	Total Funds 2020 £
Income from:							
Charitable activities	2	2,000,635	1,402,378	3,403,013	1,930,504	1,707,667	3,638,171
Other trading activities	4	15,559	-	15,559	112,686	-	112,686
Total incoming resources		2,016,194	1,402,378	3,418,572	2,043,190	1,707,667	3,750,857
Expenditure on:							
Charitable activities	5	2,968,461	206,653	3,175,114	3,065,947	163,000	3,228,947
Other trading activities	7	8,943	-	8,943	52,427	-	52,427
Total outgoing expenditure		2,977,404	206,653	3,184,057	3,118,374	163,000	3,281,374
Net income / (expenditure)		(961,210)	1,195,725	234,515	(1,075,184)	1,544,667	469,483
Transfers between funds	15	1,149,400	(1,149,400)	-	1,518,998	(1,518,998)	-
Other recognised gains/(losses):							
Gains/(losses) on the revaluation of fixed assets	10	(80,721)	-	(80,721)	28,576	-	28,576
Actuarial gains less provisions on defined benefit pension scheme	15	(345,000)	-	(345,000)	(950,000)	-	(950,000)
Net Movement in Funds		(237,531)	46,325	(191,206)	(477,610)	25,669	(451,941)
Reconciliation of funds							
Total funds brought forward at 1 April 2020		8,694,388	142,129	8,836,517	9,171,998	116,460	9,288,458
Total funds carried forward at 31 March 2021		8,456,857	188,454	8,645,311	8,694,388	142,129	8,836,517

All amounts above relate to continuing operations of the organisation.
The notes on pages 58 to 70 form part of the financial statements.

Armagh Observatory and Planetarium

Balance Sheet as at 31 March 2021

	Note	2021 £	2020 £
Fixed Assets			
Intangible assets	9	265,300	217,250
Tangible assets	10	9,234,641	8,739,283
Heritage Assets	11	2,598,595	2,598,595
Total fixed assets		12,098,536	11,555,128
Current assets			
Stocks	12	17,454	13,913
Debtors	13	130,370	116,484
Cash at bank and in hand	18	466,720	371,486
Total current assets		614,544	501,883
Creditors: amounts falling due within one year	14	(1,092,769)	(825,494)
Net current assets		(478,225)	(323,611)
Total assets less current liabilities		11,620,311	11,231,517
Creditors: amounts falling due after more than one year		-	-
Net assets excluding pension liability		11,620,311	11,231,517
Defined benefit pension scheme liability	19	(2,975,000)	(2,395,000)
Net assets		8,645,311	8,836,517
Funds			
Restricted funds	15	188,454	142,129
Unrestricted funds	15	4,215,315	3,572,759
Revaluation Reserves	15	7,216,542	7,516,629
Pension Reserve	15	(2,975,000)	(2,395,000)
Total Charity Funds		8,645,311	8,836,517

The financial statements on pages 58 to 70 were approved by the Board of Trustees of Armagh Observatory and Planetarium on 20 September 2021 and were signed on its behalf by:



Chair of the Board of Trustees
Archbishop John McDowell



Accounting Officer
Professor Michael Burton

Armagh Observatory and Planetarium

Statement of cash flows for the year ended 31 March 2021

	Note	2021 £	2020 £
Net cash provided by operating activities	17	1,167,072	616,214
Cash flows from investing activities:			
Interest received		15	306
Proceeds from sale of tangible fixed assets		-	2,902
Purchase of intangible fixed assets		(91,000)	(140,000)
Purchase of tangible fixed assets		(980,853)	(707,258)
		(1,071,838)	(844,050)
Increase / (decrease) in cash and cash equivalents		95,234	(227,836)

Further detail is reported in Notes 17 and 18.

Reconciliation of net cashflow to movement in net cash funds

		2021 £	2020 £
Increase / (decrease) in cash and cash equivalents in the year		95,234	(227,836)
Cash and cash equivalents at 1 April 2020		371,486	599,322
Cash and cash equivalents at 31 March 2021	18	466,720	371,486

The notes on pages 58 to 70 form part of the financial statements.

Notes to the financial statements for the year ended 31 March 2021

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 2021.

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 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 global 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	10 - 50%
Office equipment	6.67 - 25%
Scientific equipment	10 - 25%
Astropark	2%
Exhibits and grounds equipment	6.67 - 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 2021. 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. Land and Property Services advise that "as at the valuation date we continue to be faced with an unprecedented set of circumstances caused by COVID-19 and an absence of relevant/sufficient market evidence on which to base our judgements. Our valuation of the client portfolio is therefore reported as being subject to 'material valuation uncertainty' as set out in VPS 3 and VPGA 10 of the RICS Valuation – Global Standards. Consequently, in respect of these valuations less certainty and increased subjectivity – and a higher degree of caution – should be attached to our valuation figures than would normally be the case".

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2021 (continued)

(f) Tangible fixed assets (continued)

Other fixed assets (non Land & Buildings) with a life estimated over 5 years have a net book value of £39,297 at 31st March 2021. This accounts for 0.4% 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.

(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 are due to be further improved in 2021.

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) 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.

(i) Debtors

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

(j) Cash at bank and in hand

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

(k) Creditors

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

(l) 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.

(m) 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 2021 was £389,241 (£183,998 at 31 March 2020).

The reserves are held in a short-term bank deposit account within the NICS banking arrangements, with any interest earned being used to fund operating costs.

Notes to the financial statements for the year ended 31 March 2021 (continued)

2 Income from charitable activities

	Note	Unrestricted Funds 2021 £	Restricted Funds 2021 £	Total Funds 2021 £	Total Funds 2020 £
Grant Income					
DfC Recurrent grant-in-aid		1,951,500	-	1,951,500	1,704,500
DfC VES grant-in-aid		-	-	-	-
DfC In-year capital grant-in-aid		-	1,040,000	1,040,000	1,452,000
Total grant-in-aid from the DfC		1,951,500	1,040,000	2,991,500	3,156,500
Income from other grants and receipts	3	15,013	362,378	377,391	257,829
Total Grant Income		1,966,513	1,402,378	3,368,891	3,414,329
Operating Income					
Admissions		37,176	-	37,176	207,082
Profit/(loss) on disposal of fixed assets		(8,184)	-	(8,184)	2,902
Miscellaneous income		5,130	-	5,130	13,858
Total Operating Income		34,122	-	34,122	223,842
Total Income from Charitable Activities		2,000,635	1,402,378	3,403,013	3,638,171

3 Income from other grants and receipts

	Note	Unrestricted Funds 2021 £	Restricted Funds 2021 £	Total Funds 2021 £	Total Funds 2020 £
STFC Research and Studentship grants		-	311,358	311,358	255,667
UKRI COVID Support grant		-	49,520	49,520	-
Tourism NI grants		11,952	-	11,952	-
British Association of Planetaria		-	500	500	-
Royal Society grant		-	1,000	1,000	-
Sundry donations		3,061	-	3,061	2,162
Total other grants and receipts	2	15,013	362,378	377,391	257,829

4 Income from other trading activities

	Note	Unrestricted Funds 2021 £	Restricted Funds 2021 £	Total Funds 2021 £	Total Funds 2020 £
Shop income		5,527	-	5,527	95,279
Rental income		10,032	-	10,032	17,407
Total Income from other trading		15,559	-	15,559	112,686

5 Expenditure on charitable activities

	Note	Unrestricted Funds 2021 £	Restricted Funds 2021 £	Total Funds 2021 £	Total Funds 2020 £
Research	6	859,022	202,673	1,061,695	1,149,190
Education	6	1,049,937	3,980	1,053,917	1,055,250
Governance and Support	6	1,059,502	-	1,059,502	1,024,507
		2,968,461	206,653	3,175,114	3,228,947

Notes to the financial statements for the year ended 31 March 2021 (continued)

6 Expenditure on charitable activities

	Note	Unrestricted Funds 2021 £	Restricted Funds 2021 £	Total Funds 2021 £	Total Funds 2020 £
Research					
Staff costs		494,719	130,591	625,310	563,288
Direct costs		110,057	64,192	174,249	233,890
Support costs		65,200	7,890	73,090	160,967
Depreciation		189,046	-	189,046	191,045
	5	859,022	202,673	1,061,695	1,149,190
Education					
Staff costs		318,553	-	318,553	323,041
Direct costs		127,902	3,980	131,882	217,196
Support costs		215,108	-	215,108	211,291
Depreciation		388,374	-	388,374	303,722
	5	1,049,937	3,980	1,053,917	1,055,250
Governance and Support					
Staff costs		811,503	-	811,503	796,910
Direct costs		18,746	-	18,746	29,142
Support costs		203,985	-	203,985	179,348
Depreciation		25,268	-	25,268	19,107
	5	1,059,502	-	1,059,502	1,024,507

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

	Unrestricted Funds 2021 £	Restricted Funds 2021 £	Total Funds 2021 £	Total Funds 2020 £
Management Committee expenses	3,851	-	3,851	2,848
Audit	28,002	-	28,002	26,537
	31,853	-	31,853	29,385

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 2021 £	Restricted Funds 2021 £	Total Funds 2021 £	Total Funds 2020 £
Trading				
Direct costs	8,943	-	8,943	52,427
	8,943	-	8,943	52,427

Notes to the financial statements for the year ended 31 March 2021 (continued)

8 Average staff numbers and related costs

	Permanent staff	Others	2021 Number	2020 Number
Average staff numbers	25.9	6.4	32.3	33.2

Staff costs comprise:	Permanent staff £	Others £	2021 £	2020 £
Wages and salaries	1,101,984	136,928	1,238,912	1,208,464
Social security costs	113,723	4,354	118,077	103,094
Employer's pension contributions	204,877	10,500	215,377	205,681
Defined benefit pension additional service cost	183,000	-	183,000	166,000
	1,603,584	151,782	1,755,366	1,683,239

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

	2021 Number	2020 Number
£60,001 - £70,000	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 £101,008 (2020: £97,194).

There was no remuneration paid to trustees during the year (2020: nil). No travel and subsistence expenses were reimbursed to trustees (2020: £801 to 2 trustees).

Average student numbers and related costs (not included above)

	2021 Number	2020 Number
PhD students	8	7

	2021 £	2020 £
Student maintenance grants & stipends	133,081	109,493

Notes to the financial statements for the year ended 31 March 2021 (continued)

9 Intangible fixed assets

	2021 £	2020 £
Cost		
At 1 April 2020	340,450	-
Additions	91,000	140,000
Transfer from Fixed Assets	-	200,450
Disposals	(13,000)	-
At 31 March 2021	418,450	340,450
Depreciation		
At 1 April 2020	123,200	-
Transfer from Fixed Assets	-	83,671
Charge for year	42,950	39,529
Disposals	(13,000)	-
At 31 March 2021	153,150	123,200
Net book value		
At 31 March 2021	265,300	217,250
At 31 March 2020	217,250	-

Intangible fixed assets were previously included in Fixed Assets under the heading of Scientific Equipment. 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 £
Cost or valuation						
At 1 April 2020	7,692,253	673,178	491,980	584,308	1,017,470	10,459,189
Asset revaluation	(300,087)	-	-	-	-	(300,087)
Additions	561,929	355,078	8,371	225	218,397	1,144,000
Disposals	-	(83,811)	-	(35,389)	(144,360)	(263,560)
At 31 March 2021	7,954,095	944,445	500,351	549,144	1,091,507	11,039,542
Depreciation						
At 1 April 2020	-	555,086	3,389	568,416	593,015	1,719,906
Adjustment for asset revaluation	(219,366)	-	-	-	-	(219,366)
Charge for year	219,366	67,121	100,035	2,321	170,894	559,737
Disposals	-	(83,811)	-	(35,389)	(136,176)	(255,376)
At 31 March 2021	-	538,396	103,424	535,348	627,733	1,804,901
Net book value						
At 31 March 2021	7,954,095	406,049	396,927	13,796	463,774	9,234,641
At 31 March 2020	7,692,253	118,092	488,591	15,892	424,455	8,739,283

Tangible fixed asset additions of £1,144,000 as shown above were funded by DfC in-year capital grant-in-aid.

As a result of the recent and ongoing Covid-19 pandemic events, and in line with current RICS guidance, LPS have advised that in the absence of relevant/sufficient market evidence on which to base their judgements, their valuation is reported as being subject to 'material valuation uncertainty'. For the avoidance of doubt this does not mean that the valuations cannot be relied upon. Rather, this 'material valuation uncertainty' declaration has been included to ensure transparency and to provide further insight as to the market context under which the valuation opinion was prepared.

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

	2021 £	2020 £
Cost	3,239,445	2,637,517
Aggregate depreciation	(1,037,068)	(972,557)
Net book value based on historic cost	2,202,377	1,664,960

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2021 (continued)

10 Tangible fixed assets (continued)

Included within Additions above are certain assets under construction:

Freehold Land & buildings	Exhibits	Total
£	£	£
177,758	246,555	424,313

Depreciation on tangible fixed assets for the year was £559,737 (2020: £474,344).

Land and buildings include grounds and buildings with a net book value of £1,957,426 (2020: £1,880,451) 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

	Books	Clocks & Watches	Scientific Equipment	Furniture, Artworks, etc	Total
At Valuation	£	£	£	£	£
Carrying Amount at 1 April 2020	546,975	572,600	1,298,900	180,120	2,598,595
Transfers	-	-	-	-	-
Disposals	-	-	-	-	-
Depreciation / impairment	-	-	-	-	-
Carrying Amount at 31 March 2021	546,975	572,600	1,298,900	180,120	2,598,595

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 2021. £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.

12 Stocks

	2021 £	2020 £
Goods for resale	17,454	13,913

13 Debtors

	2021 £	2020 £
Trade debtors	17,171	4,475
Prepayments and accrued income	29,913	18,877
Other debtors	83,286	93,132
	130,370	116,484

14 Creditors: amounts falling due within one year

	2021 £	2020 £
Trade creditors	351,548	283,313
Accruals and deferred income	708,845	516,603
Taxation and social security	32,376	25,578
	1,092,769	825,494

Notes to the financial statements for the year ended 31 March 2021 (continued)

15 Statement of Funds

	At 1 April 2020	Income	Expenditure	Revaluation	Transfers	At 31 March 2021
	£	£	£	£	£	£
Restricted Funds						
Government grant for fixed assets	-	1,040,000	-	-	(1,040,000)	-
Restricted resource grants	142,129	362,378	(206,653)	-	(109,400)	188,454
Total restricted funds	142,129	1,402,378	(206,653)	-	(1,149,400)	188,454
Unrestricted Funds						
Designated Funds						
Donated assets reserve	1,720,283	-	-	-	-	1,720,283
Government grant for assets	1,668,478	-	-	-	437,313	2,105,791
General fund	183,998	2,016,194	(2,977,404)	-	1,166,453	389,241
	3,572,759	2,016,194	(2,977,404)	-	1,603,766	4,215,315
Undesignated Funds						
Revaluation reserve - Land & Buildings	6,225,155	-	-	(80,721)	(219,366)	5,925,068
Revaluation reserve - Heritage Assets	1,291,474	-	-	-	-	1,291,474
Pension reserve	(2,395,000)	-	-	(345,000)	(235,000)	(2,975,000)
	5,121,629	-	-	(425,721)	(454,366)	4,241,542
Total Unrestricted Funds	8,694,388	2,016,194	(2,977,404)	(425,721)	1,149,400	8,456,857
Total Funds	8,836,517	3,418,572	(3,184,057)	(425,721)	-	8,645,311

Details of Transfers between funds

	£
Release of restricted resource grant available to offset overheads	(109,400)
Release of deferred capital grant	(602,687)
Transfer of defined benefit pension service and interest cost	(235,000)
Transfer of depreciation adjustment on asset revaluation to general fund	(219,366)
General fund	1,166,453

16 Analysis of net assets between funds

	Pension Reserve	Revaluation Reserve	Unrestricted Funds	Restricted Funds	Total Funds
	£	£	£	£	£
Tangible fixed assets	-	5,925,068	3,574,873	-	9,499,941
Heritage assets	-	1,291,474	1,307,121	-	2,598,595
Current assets	-	-	426,090	188,454	614,544
Creditors: amounts falling due within one year	-	-	(1,092,769)	-	(1,092,769)
Pension scheme liability	(2,975,000)	-	-	-	(2,975,000)
Net assets/(liabilities)	(2,975,000)	7,216,542	4,215,315	188,454	8,645,311

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

	2021 £	2020 £
Net expenditure for the year per statement of financial activities	234,515	469,483
Adjustments for:		
Depreciation	602,687	513,873
Interest received	(15)	(306)
Loss/(profit) on disposal of assets	8,184	(2,902)
Defined benefit pension scheme service and interest cost less contributions payable	235,000	197,000
(Increase)/decrease in stock	(3,541)	4,007
Increase in debtors	(13,886)	(11,132)
Increase/(decrease) in creditors	104,128	(553,809)
Net cash provided by operating activities	1,167,072	616,214

Notes to the financial statements for the year ended 31 March 2021 (continued)

18 Analysis of cash and cash equivalents

	31 March 2021 £	1 April 2020 £
Cash at bank and in hand	466,720	371,486
Total cash and cash equivalents	466,720	371,486

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 Hewitt Ltd, has provided the following details for the purposes of accounting for the Observatory and Planetarium's joint share of the scheme deficit in accordance with FRS 102 at 31 March 2021.

Key assumptions used by the actuary were:

	2021 %	2020 %
Discount rate	2.10	2.30
CPI inflation	2.70	2.00
Pension increases	2.70	2.00
Pension accounts revaluation rate	2.70	2.00
Salary increases	4.20	3.50

Mortality assumptions

	2021 Years	2020 Years
Males		
Pensioner member aged 65 at accounting date	21.9	21.8
Active member aged 45 at accounting date	23.3	23.2
Females		
Pensioner member aged 65 at accounting date	25.1	25.0
Active member aged 45 at accounting date	26.5	26.4

Notes to the financial statements for the year ended 31 March 2021 (continued)

19 Pension scheme (continued)

Asset Allocation

	Value at 31/03/2021 %	Value at 31/03/2020 %
Equities	46.3	42.6
Property	8.9	10.0
Government bonds	23.6	26.1
Corporate bonds	12.1	12.6
Cash	5.3	4.7
Other	3.8	4.0
Total	100.0	100.0

Reconciliation of funded and unfunded status to balance sheet

	2021 £'000	2020 £'000
Fair value of assets	10,826	8,918
Present value of funded defined benefit obligation	(13,799)	(11,311)
Funded status (deficit)	(2,973)	(2,393)
Present value of unfunded defined benefit obligation	(2)	(2)
Liability recognised on the balance sheet	(2,975)	(2,395)

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 31/03/2021 £'000	Year to 31/03/2020 £'000
Operating cost		
Current service cost	(402)	(374)
Financing cost		
Interest on net defined benefit liability	(52)	(31)
Pension expense recognised in statement of financial activities	(454)	(405)
Allowance for administrative expenses included in Current Service Cost	6	5

Amounts recognised in statement of funds

	Year to 31/03/2021 £'000	Year to 31/03/2020 £'000
Asset gains/(losses) arising during the period	1,746	(2,007)
Liability gains/(losses) arising during the period	(2,091)	1,057
Total amount recognised in statement of funds	(345)	(950)

Changes to the present value of defined benefit obligation

	Year to 31/03/2021 £'000	Year to 31/03/2020 £'000
Opening defined benefit obligation	11,313	11,979
Current service cost	402	374
Interest expense on defined benefit obligation	257	284
Contributions by participants	86	75
Actuarial losses/(gains) on liabilities	2,091	(1,057)
Net benefits paid out	(348)	(342)
Closing defined benefit obligation	13,801	11,313

Notes to the financial statements for the year ended 31 March 2021 (continued)

19 Pension scheme (continued)

Changes to the fair value of assets

	Year to 31/03/2021	Year to 31/03/2020
	£'000	£'000
Opening fair value of assets	8,918	10,731
Interest income on assets	205	253
Remeasurement gains/(losses) on assets	1,746	(2,007)
Contributions by the employer	219	208
Contributions by participants	86	75
Net benefits paid out	(348)	(342)
Closing fair value of assets	10,826	8,918

Actual return on assets

	Year to 31/03/2021	Year to 31/03/2020
	£'000	£'000
Interest income on assets	205	253
Gain/(loss) on assets	1,746	(2,007)
Actual return on assets	1,951	(1,754)

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)	13.578	13.799	14.034
% change in present value of total obligation	-1.60%		1.7%
Projected service cost (£m)	0.553	0.572	0.591
Approximate % change in projected service cost	-3.30%		3.40%

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)	13.827	13.799	13.771
% change in present value of total obligation	0.2%		-0.2%
Projected service cost (£m)	0.572	0.572	0.572
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)	14.006	13.799	13.606
% change in present value of total obligation	1.5%		-1.4%
Projected service cost (£m)	0.591	0.572	0.553
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)	14.296	13.799	13.302
% change in present value of total obligation	3.6%		-3.6%
Projected service cost (£m)	0.596	0.572	0.549
Approximate % change in projected service cost	4.2%		-4.1%

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's application to the Supreme Court to appeal the Court of Appeal judgement was denied on 27 June 2019. Subsequent to this, the Government announced in a Written Ministerial Statement on 15 July 2019 "... as 'transitional protection' was offered to members of all the main public service pension schemes, the government believes that the difference in treatment will need to be remedied across all those schemes".

Aon Hewitt Ltd 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).

Notes to the financial statements for the year ended 31 March 2021 (continued)

19 Pension scheme (continued)

GMP Indexation and Equalisation

Guaranteed Minimum Pension (GMP) is a portion of pension that was accrued by individuals who were contracted out of the State Second Pension between 6 April 1978 and 6 April 1997.

Prior to 6 April 2016, public service pension schemes and the State Pension worked in tandem to ensure pension increases on State Pension and LGPS Pension kept line with inflation. The LGPS was not required to pay any pension increases on GMPs accrued before April 1988 and was only required to pay limited increases on GMPs accrued after 1988 (CPI inflation capped at 3% p.a.). In return, the Additional Pension (AP) element of the State Pension paid top-up payments to pensioners to give inflation protection on the GMP element where this was not provided by the LGPS.

However, reforms were made to the State Pension system in April 2016 which scrapped AP and therefore removed the facility for central government to fully index the combined pension through AP. In March 2016 the government introduced an 'interim' solution for public sector schemes to pay full inflationary increases on GMPs for those reaching State Pension Age (SPA) between 6 April 2016 and 5 December 2018 to ensure these members continued to receive full inflationary increases on the combined public sector scheme and State pensions. In January 2018 the interim solution was extended to individuals reaching SPA on or before 5 April 2021. Further, the Government has indicated that it is committed to continuing to compensate all members of public sector pension schemes reaching SPA after 5 April 2021. On 7 October 2020 MHCLG consulted on proposed solutions to compensate members reaching State Pension Age after 5 April 2021, which primarily focussed on making further extensions to full GMP indexation followed by ultimate conversion, or instead indefinite indexation as a permanent solution for public sector pension schemes. We expect that full indexation will extend until at least up to April 2024 with conversion to be brought in as a longer term option.

The rate at which GMP was accrued, and the date it is payable, is different for men and women, meaning there is an inequality for male and female members who have GMP. This was a consequence of the State Pension itself being unequal at the time. On 26 October 2018 the High Court ruled in the Lloyds Bank case that equalisation for the effect of unequal GMPs is required. The ruling confirmed that trustees have a duty "to equalise benefits for men and women so as to alter the result which is at present produced in relation to GMPs". HM Treasury have gone on record since the Lloyds judgement to say, "Public sector schemes already have a method to equalise guaranteed minimum pension benefits, which is why Aon Hewitt Ltd will not have to change our method as a result of this judgment."

The AON Hewitt Ltd approach for accounting periods ending in 2021 is therefore to include a liability for GMP Indexation for all members whose State Pension Age is after 6 April 2016 (not just those covered by the second interim solution).

20 Capital commitments

Capital commitments at 31 March 2021 totalled £98,400 (2020: £443,836) in respect of expenditure on projects commenced during the year. DfC has agreed funding for 2021/22.

21 Contingent liabilities

There were no contingent liabilities at the 31st March 2021 (2020: £nil).

22 Remote contingent liabilities (Audited)

There were no remote contingent liabilities at the 31st March 2021 (2020: £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.

24 Losses and special payments (Audited)

There were no losses or special payments during the year.

Notes to the financial statements for the year ended 31 March 2021 (continued)

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 (FReM)

FReM 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 FReM 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 the organisation permission to continue to treat grants as income. If the Observatory and Planetarium were required to comply with the FReM the result of this compliance would be as follows:

Statement of Financial Activities prepared under FReM

	Note	2021 £	2020 £
Incoming resources			
Incoming resources from research and other non-DfC grants	2	377,391	257,829
Operating income	2	34,122	223,842
Trading income	4	15,559	112,686
Total incoming resources		427,072	594,357
Resources expended			
Direct expenditure of the organisation		3,184,057	3,281,374
Total Resources expended		3,184,057	3,281,374
Net deficit for the year		(2,756,985)	(2,687,017)
Loss/(gain) on revaluation of Fixed Assets		(80,721)	28,576
Actuarial (loss)/gain on pension scheme		(345,000)	(950,000)
Amount transferred to funds		(3,182,706)	(3,608,441)

Analysis of funds prepared under the FReM

		2021 £	2020 £
Balance at 1 April 2020		8,836,517	9,288,458
Grant-in-aid received in the year	2	2,991,500	3,156,500
Net operating costs for the year		(3,182,706)	(3,608,441)
Balance at 31 March 2021		8,645,311	8,836,517

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 4th October 2021.