

The Armagh Observatory and Planetarium

Annual Report and Accounts For the year ended 31 March 2019

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 Trustees' Annual Report for the year ended 31 March 2019

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 2019. 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) (effective 1 January 2015).

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 This 1995 Order superseded the original 1791 Act of the Irish Parliament entitled '*An Act for Settling and Preserving a Public Observatory and Museum in the City of Armagh For Ever*',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 STEM 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 organization'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*'.

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 of the newly unified organisation 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.'

Mission

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.

The Corporate Plan 2018-21 is underpinned by three themes of research, education and outreach, and history and heritage. These themes are described in the more detailed vision documents on which the corporate plan is built. Added to these is a fourth theme of leadership and governance which enables an efficient, effective, sustainable and accountable operating framework.

At the end of 2018/19 there were 24 employees, 5 temporary staff and 9 PhD students, which included the Director, the Head of Research, 6 Research Astronomers, 2 Post-doctoral Research Assistants (PDRAs) and an Education and Outreach Manager and a team of 7 Education staff (including 1 part-time), together with a Head of Corporate Services, Head of Finance and Income Generation and 9 support and administration staff (including 2 part-time). There are also 12 external research associates and academic visitors.

Public Benefits

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 2019. 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

Introduction to AOP Research

The Northern Ireland Space Strategy, developed by Invest NI, recognises the Space Sector as a significant emerging market encompassing industry, academia and government. The Strategy outlines the critical role that will be played by the Sector in addressing the key challenges facing the human race both now and in the future. It outlines a vision for Northern Ireland as a globally recognised region for space sector innovation and creativity.

AOP is already recognised as a world leader in international science for our work in conducting and facilitating world leading astronomical research. Researchers at AOP have long recognised that involvement in cutting edge research initiatives enhances the organisation's reputation and Northern Ireland's reputation, nationally and internationally. Our research raises the profile of the institution and of the region and increases opportunities for Northern Ireland to attract additional funding for further collaborative and stand-alone research projects. These projects make significant contributions to both global understanding of the cosmos and to the wider Northern Ireland Economy.

At AOP we carry out front-line research in several key areas of astrophysics, involving the Sun and our Solar System, the stars and our Galaxy, and other galaxies. The breadth of these research themes illustrates the primary long-term research function of AOP. The projects are often funded by external (i.e. non-Department) funding agencies with lead times of typically one to two years. They are normally led by an individual Research Astronomer and often require 3–5 years for completion. Given the nature of astronomical research, the outcomes of our research will often contribute to a wider, longer-term research outcome as the global astronomical community builds a greater understanding of the universe, our place in it and the future potential for the exploration of space.

As part of AOP's outreach activities, researchers and students regularly participate in conferences, public talks and seminars throughout the UK and Ireland, and across the world. This broadens the reach of AOP and helps promote our work and enhance both AOP's reputation as a leading scientific institution and Northern Ireland's reputation as an innovative leader in the field of science and technology.

Research Highlights

In order to provide a practical understanding of how the work of AOP research contributes to understanding of the cosmos, and how it supports and enhances the Northern Ireland economy and the region's international reputation, some highlights of the research currently being undertaken at AOP are provided below.

SULIS – Solar cUbesats for Linked Imaging Spectropolarimetry satellites

SULIS (named after a Celtic Sun Goddess) will be a flagship UK-led space science mission to study the Sun. It will provide unprecedented measurements of the magnetic field of the Sun's corona and will answer fundamental questions underpinning the sources of space weather.

Space weather arises from flares from the Sun known as Coronal Mass Ejections (CMEs). These result in winds of energetic particles streaming from the Sun into space, where they can interact with the magnetic field of the Earth causing geomagnetic disturbances. Space weather events can be hazardous to terrestrial infrastructure. The UK

National Risk Register for Civil Emergencies in 2017 lists potential consequences of these space weather events, such as:

- Electricity blackouts, potentially causing fatalities and physical/psychological casualties;
- Loss/disruption of Global Navigation Satellite Systems (e.g. GPS or Galileo);
- Disruption to essential services, particularly air travel, energy and communications; and
- Increases in background radiation doses high in the atmosphere and space.

The UK Space Weather Preparedness Strategy, 2015, considers the risk associated with a space weather event to be in the medium to high likelihood category, together with a medium impact. It considers it likely that, with current technology, there would only be 12 hours warning from the first observation of such an event to its impact on the Earth. Understanding the physics of the causes of space weather is fundamental to improving the predictability of space weather events and, therefore, to protecting critical infrastructures in our society.

Predicting the occurrence and extent of the coronal mass ejections is a key goal for space weather forecasting. SULIS will place three pairs of formation flying CubeSats around the Sun, each with a dimension of 10cm x 20cm x 30cm. Following an eruption from the Sun, they will provide 3D tracking of the motion of the ejected gas away from the Sun towards the Earth. This will allow an early forecast of the potential of the flare to cause disruption to infrastructure on Earth, and so provide more time for measures to be taken to help mitigate their impact.

As well as AOP, the SULIS Consortium involves a diverse mix of organisations in the UK, including Surrey Satellite Technology (the CubeSat provider), Andor Technology in Belfast (developing the detectors) and Queens University. Internationally, the University of Hawaii are developing the instruments for the spacecraft. The Consortium has received US\$2 million of USA National Science Foundation (NSF) funding through its consortium partners in Hawaii to demonstrate the feasibility of the multiplexed spectropolarimeter that will be built to make the necessary measurements. The total projected cost is expected to be in the region of £70 million when complete.

Prof. Gerry Doyle of AOP is Project Academic Partner for SULIS, a member of the consortium who responded to a call from the UK Science & Technology Facilities Council (STFC) for future projects. We now await a call from the STFC and UK Space Agency for a feasibility study for what will be the first UK solar physics space mission. The application of this high-level project highlights the significant role of AOP in the space sciences sector. The intent is for AOP to be involved in project through the scientific analysis, undertaken by post-doctoral research fellows and PhD students, in collaboration with Queens University and Andor Technology.

DKIST – the Daniel K. Inouye Solar Telescope

The Daniel K. Inouye Solar Telescope (DKIST) is under construction on the summit of Haleakalā on Maui, Hawaii to study the Sun's corona – the tenuous, million-degree plasma that surrounds the Sun. To measure the corona a telescope needs to be sited in a place as free as possible of dust, aerosols and pollutants. The isolated islands of Hawaii in the middle of the Pacific provide optimal conditions for clear, "coronal skies".

Armagh Observatory and Planetarium became involved in the DKIST project 4 years ago when, via a special call from Department for Culture Arts and Leisure (DCAL), funding of £100k was awarded to assist in building the detectors for three of the instruments for the telescope. In collaboration with Queen's University Belfast we set-up the UK DKIST Consortium, which then received funding from the Science & Technology Facilities Council (STFC). Coupled with funding from various UK universities and Andor Technology we have raised in excess of £4m, most of which goes directly into the Northern Ireland economy. A beta-type detector has already been delivered to DKIST, with the final detector due in late 2019. First light for the telescope is scheduled for early 2020.

Prof. Gerry Doyle chairs the UK DKIST Science consortium. This has made a significant contribution to raising AOP's profile and enhancing its reputation, nationally and internationally. Doyle has written a series of science cases on specific aspects of the project. These will drive the studies needed to inform the full proposal and so determine the value of allocating telescope time to specific investigations to be carried out using the telescope.

Andor Technology considers the development of these detectors as their main source of income over the next ten years. This project, and AOP's contribution to the Northern Ireland economy is, therefore considerable. Involvement in such a major international project also raises the profile of Northern Ireland, Armagh and AOP on the international stage of science.

PLATO – the PLANetary Transits and Oscillations satellite

A planet around a star other than the Sun is termed an "exoplanet". The first exoplanet was discovered 20 years ago. Since that time, thousands of planets have been confirmed with many more still awaiting confirmation. It is likely that most stars in our Galaxy have planets around them. There have been several space missions, such as NASA's Kepler and TESS (the Transiting Exoplanet Survey Satellite), whose main goal has been to detect exoplanets using the 'transit' method. Here exoplanets with an orbit parallel to our line of sight cause a small dip in the apparent brightness of their host star. By recording a series of dips in the light from the star the orbital period – or planet year – can be determined. Spectroscopic observations are then needed to determine the mass of the object causing the dip.

The European Space Agency (ESA) has a mission planned for launch in 2026, which it has named PLANetary Transits and Oscillations of stars or PLATO. The objective of PLATO is to find and study a large number of extrasolar planetary systems, with an emphasis on uncovering the properties of terrestrial-like planets in the habitable zone around solar-type stars. PLATO has also been designed to investigate seismic activity in stars, enabling the precise characterisation of the planet host star, including its age. To achieve its objective, PLATO will observe several large patches of sky to detect exoplanets around bright stars. The prime goal is to detect Earth-sized planets orbiting at the right distance from their host star so that liquid water can exist on the surfaces of the planets – known as the “Goldilocks” zone where the temperature is just right.

The project is led by ESA with many hundreds of scientists and engineers involved from across Europe and beyond. As a community scientist for the PLATO mission, AOP’s Dr. Gavin Ramsay advises ESA on how the science objectives of the mission can best be met. He is one of twelve members of PLATO’s international science working team. Dr Ramsay’s involvement has raised the visibility of AOP in the scientific and mainstream media and across the wider PLATO community of leading scientists. Being in an influential position in a space mission of international significance, such as PLATO, places Armagh and Northern Ireland securely on the international scientific stage.

The data gathered from PLATO will help astronomers predict and quantify the chance of life existing on individual planets. In the longer-term, this will help space agencies or companies to select where to send their expensive probes to search for extra-solar life. PLATO represents the very early stages of a very long-term aim. It is universally accepted that, should PLATO find evidence that strongly suggests that life exists on an exoplanet, it will be in the distant future before we are capable of sending a probe to reach that planet and unequivocally confirm that life exists outside our solar system. PLATO will, therefore, give rise to future projects of this nature. AOP’s involvement and experience in PLATO can only enhance the prospects of our researchers being involved in further projects of a similar nature, well into the future.

Earthshine

Discovering the existence of habitable exoplanets in the Universe is a prime goal of astronomy. One of the methods used directed towards this goal is the search for planets with an atmosphere similar to that of planet Earth. We know of thousands of exoplanets orbiting around stars other than our Sun. However, we know very little about the atmospheres and surface of these exoplanets, because light coming from a distant exoplanet is overwhelmed by the glare of its host star. This makes an exoplanet very difficult to analyse: it is like trying to study a grain of dust beside a powerful light bulb.

The light reflected by a surface of a planet (for instance the surface of the ocean or the land) is polarised, while the light directly emitted by a star is unpolarised. This is why sunglasses can remove glare reflected from bright surfaces, such as water or snow, as the light is polarized. Observations of polarised light allow us to distinguish the faint reflected light of an exoplanet from the dazzling unpolarised direct starlight. Armagh astronomers, led by Stefano Bagnulo, and our international collaborators are pioneering this technique and using it to experiment on Earth, as this is the planet we know best, and the only planet which we are sure is capable of hosting life.

It is not easy to observe the Earth with astronomical techniques: strictly speaking, one should bring a telescope into the deep space and point it towards the Earth! This is impractical as it is very expensive. Astronomers have, therefore, employed the technique of using the Moon as a giant mirror to look at the Earth with ground-based telescopes, as if they were observing Earth from space. The Sun shines on the Earth and this light is reflected back to the surface of the Moon. The lunar surface acts as a giant mirror and reflects the Earth’s light back again. By observing this “Earthshine”, astronomers have used the largest telescopes in the world to observe the Earth as if it were a distant planet.

By measuring the polarisation of Earthshine, astronomers have been able to demonstrate that the surface of Earth is partially covered by vegetation, and that the atmosphere of our planet contains water and oxygen. In other words, they have independently discovered life on Earth! In particular, though, this is telling the scientists what signatures to look for in the polarized light that provide clear indicators of the presence of life.

We are optimistic that this technique, developed by Earthshine, may be used in the future with the next generation of Extremely Large Telescopes, to search for life elsewhere in the universe.

As a by-product, Earthshine’s polarimetric studies of our atmosphere allow us to monitor our atmosphere. Polarimetry may be used, in particular, to detect and measure atmospheric pollution.

The Earthshine project is carried out in collaboration with astronomers from the European Southern Observatory (the foremost intergovernmental astronomy organisation in Europe and the world’s most productive astronomical observatory), the Meteorological Institute of Ludwig-Maximilians University in Munich, Germany, and the Faculty of Aerospace Engineering, Delft University of Technology, Delft, in the Netherlands, and the Institute of Astrophysics of Canary Islands (Spain).

The project requires the allocation of telescope time, typically a few nights every couple of years. The cost of telescope time is of the order of €50k per night. Access by AOP researchers to these observational facilities is granted on a competitive basis and borne by various European governments.

A potential future benefit of the project is that a PhD position on this subject (of the cost of about €50k over three years) may be funded by the Ludwig-Maximilians University in Munich starting from the end of 2019. ESO may also offer grants to our PhD students to spend extended period of times in Germany.

Over the years, ESO and the University of Delft have provided funding for collaborations and joint visits, overall for a value of the order of a few thousand pounds.

In the longer term it is anticipated that the project will employ polarisation through the use of the next generation of Extremely Large Telescopes to search for life elsewhere in the universe and, in turn, the existence of other habitable planets.

The Earthshine project has brought Northern Ireland to the attention of the international community, for example, through media attention on Armagh thanks to the first observations of Earthshine with radio and TV interviews (including BBC).

In the longer-term, increased attention from the international community will enhance the reputation of Armagh as a scientific and education hub of excellence, thus generating future collaborations, partnership working, student placements and income generation opportunities. This also has wider benefits for Northern Ireland's reputation as a region of scientific excellence.

Other Significant Research Projects

Whilst the above projects provide examples of how the research undertaken at AOP supports the economy and enhances the international reputation of Northern Ireland as a region of scientific excellence, these form only part of the overall picture. They are only a flavour of the range of projects in which our researchers have been focusing over the year. Below is a synopsis of other important research projects being undertaken at AOP.

Cool Stars

Astronomers have observed flares from our Sun and other stars for more than a century. Some of the most active stars are those which are much smaller and less massive than the Sun. These red dwarf stars can emit flares every few hours. Using data obtained by the Kepler satellite, PhD students Lauren Doyle, and Astronomers Gerry Doyle and Gavin Ramsay have been characterising flares from many red dwarfs. These data provide one brightness measurement every few minutes, for lengths lasting months or more, giving unprecedented coverage and sensitivity to flares. This is important because, if there are too many high energy flares, it may disrupt the atmosphere of any planets orbiting the red dwarf and hence determine whether life can survive on such planets. This work has also revealed some unexpected results which show that the distribution of flares in time is not consistent with expectations. This has important implications for how flares, and the magnetic field in these small stars, are generated.

Activities of the cool star research group have focused on three aspects; extracting and analysing stellar flare observations obtained by the Kepler/K2 space mission, extracting ultraviolet data of late type dwarfs observed with the GALEX satellite and the Jansky Very Large Array (JVLA) radio telescope in the USA, and finally reducing and modelling data related to ultra-cool dwarfs observed with the JVLA. For some objects observed with the JVLA, radio data exhibited 100% right-hand circularly polarised bursts in the 2-8 GHz range which show intense narrowband features with a fast-negative frequency drift. These were superimposed on a fainter, broadband emission feature with a total duration of about 20 minutes, and a slow positive frequency drift. This makes it the first such event detected below 4 GHz and the first one exhibiting both positive and negative frequency drifts. We can reproduce the main characteristics of the burst using a model describing the magnetic field of the dwarf as a tilted dipole. We also analyse the origins of the quiescent radio emission and estimate the required parameters of the magnetic field and energetic electrons. This work has led to the first confirmed detection of auroral activity outside of the solar system. Work on the Kepler/K2 and GALEX data continues and has led to the observation of super-flares, 10,000 times more energetic than the largest flares seen from the Sun.

Other Solar Research

Other solar research this year continued to focus on small-jet features involving colleagues from India and our nearest neighbour, Queen's University Belfast. Projects included: (i) the detection of impulsive plasma outflows due to magneto-acoustic shocks, (ii) analysing a micro-flaring region using inversion techniques on spectrophotometric observations taken from the Swedish Solar Telescope, (iii) applying a one-dimensional radiative transfer code in an attempt to reproduce the observed line profiles and simulate the atmospheric conditions of small chromospheric jets, (iv) in a multi-wavelength campaign, using ground and space-based observations in an effort to better understand the extent of these small chromospheric jets in the solar atmosphere. The highlight was a paper in Nature, based on our ground-based data from the Swedish Solar Telescope. In jet-like features called spicules, we detected the presence of high frequency (~12-42 mHz) torsional motions. Numerical model shows that these observations resemble a type of wave called "torsional Alfvén waves". We find that oscillating tubes (spicules) serve as substantial

sources generating Alfvén wave that provide sufficient energy, not only to heat the corona, but also to drive the supersonic solar wind.

Life Cycles of Stars

The spectrum of a star tells us about its surface and its history. A stellar spectrum includes dark bands or lines produced by specific atoms or ions and which carry unique information about temperature, density and chemistry. For example, when all the hydrogen in the core of stars like the Sun is used up, helium starts to burn. Normally, the chemistry of the surface remains almost unchanged, even in rare cases when the surface hydrogen has been stripped away to leave less than 1% of the original star. But a few stars have lost some or all of their surface hydrogen, and the spectrum reveals new features. Such hydrogen-deficient stars represent a brief stage in the life cycle of a few rare stars. Continuing analysis of observations from the Kepler spacecraft has revealed microvariations in the helium-rich supergiant star known as V348 Sgr — possibly revealing the cause its spectacular dust ejection events.

Using the South African Large Telescope (SALT), we have been surveying the sky for new examples and recently discovered star EC22565-5304, a new lead-rich intermediate helium star emblematic of a new class of heavy-metal subdwarfs first discovered by Armagh astronomers. The Armagh-SALT survey, led by Professor Simon Jeffery, of chemically-peculiar hot subdwarfs continues to reveal new discoveries which will help fill in missing pieces of the great stellar evolution jigsaw.

Polarimetry

Polarimetry is a technique that measures certain properties of the way light propagates. These polarimetric properties are determined by several physical phenomena, for instance the presence of a magnetic field, and the reflection from a surface. By measuring the polarisation of the light reflected by planets, comets, or asteroids, astronomers may determine various characteristics of the bodies of our solar system, including our planet Earth. The same technique may be used to detect and model certain features of stars, including our Sun, for instance their magnetic fields. Astronomers at Armagh employ this technique in various areas of stellar astrophysics, and they are also engaged in the characterisation and improvements of the instruments used at the various telescopes around the world.

Magnetic fields in the latest stages of stellar evolution

Magnetic fields play a crucial role in all stages of stellar life, from the time when gas clouds in interstellar space begin to collapse, starting the process of star formation, up to the last stages of stellar evolution, when the star ends its life as a white dwarf or exploding as a supernova. Our Sun exhibits a very complex magnetic field, but astronomers are now routinely detecting and studying the magnetic fields of many other kinds of star. Armagh astronomers are actively involved in the study of magnetic fields of white dwarfs. White dwarfs are stars in the final stage of stellar evolution, but the white dwarf stage itself may last a very long time. Armagh astronomers are interested in measuring how the magnetic field itself changes with time during this stage of stellar evolution. Using spectropolarimetric techniques, they are nearing completion of the largest survey ever performed of such white dwarf stars, with the aim of detecting the weakest fields in all white dwarfs within 20 parsecs from our Sun. The results of this research will lead astronomers to a better understanding of the reason for the occurrence and role of magnetic fields in the life of stars.

The Interstellar Medium

The space between the stars is not empty but contains a very tiny amount of material consisting of a mixture of gas (99% of the total mass, mainly hydrogen and helium molecules) and dust grains (1%). Dust grains are typically less than 1-micron in size, and are made of compounds of carbon, oxygen and silicon, sometimes surrounded by a mantle of water ice. Most of the interstellar gas and dust originates from the death of stars, which return their material to the interstellar space. Scientists are interested in the composition of the interstellar medium because it traces the chemical evolution of the universe. Astronomers at Armagh Observatory and Planetarium have led a polarimetric study of the interstellar medium aimed at improving our knowledge of the size and composition of the dust grains in our Milky Way. Polarimetric observations of the interstellar medium may be used also to map the orientation of the galactic magnetic field, which in turn plays an important, but not fully understood, role in the process of star formation.

Armagh astronomer Michael Burton has developed a new technique to map the amount of carbon found in the solid component of the interstellar medium, specifically that found in the form of aliphatic carbon. This is carbon contained within molecules with hydrocarbon bonds of $-CH_2$ or $-CH_3$. The technique uses infrared imaging through narrow band filters spread across an absorption band at 3.4 microns in order to map its optical depth. This band is produced by the presence of aliphatic compounds in dust grains found in interstellar space. In conjunction with new laboratory astrophysics measurements made of the absorption properties of aliphatic compounds, this allows us to estimate the column density of this solid form of carbon. In the field towards the Galactic centre used for the trial measurements for the new technique the solid component was found to be about one-tenth that of the carbon that is found in the gas phase of the interstellar medium.

The Milky Way

Armagh astronomers lead a major survey mapping the molecular gas along the southern Milky Way using the 22m diameter Mopra radio telescope in Australia. A new 3D map of the distribution of the molecular clouds in our Galaxy

is being made. This map provides an order of magnitude improvement in both the spatial and the spectral resolution over the previous generation map, i.e. 0.6 arc-minute and 0.1 km/s, using the carbon monoxide molecule as a tracer of the distribution of molecular hydrogen. The survey covers 250 square degrees of the Galactic plane. After 8 years of mapping the final measurements were made at the end of the 2018 observing season. The new map extends from galactic longitude $l=+250$ degrees, through the centre of the Galaxy, to longitude $+11$ degrees. In latitude, it covers the central plane of the Galaxy, from $b=-1$ to $+1$ degrees, together with a few extensions where molecular clouds extend beyond this range of the Galactic plane. Armagh PhD student Kerem Osman Cubuk, supervised by AOP Director Michael Burton, is now working on completing the reduction of the data set for his thesis so that the complete survey can be published and the map presented.

The survey also supports Armagh's involvement in the next generation gamma-ray telescope, the Cherenkov Telescope Array (CTA). This is because much of the gamma ray emission from our Galaxy is produced by the interaction of ultra-high energy cosmic rays with the nuclei of molecules found in star forming clouds of the Galactic Plane – the so-called hadronic emission process for the production of gamma rays. The Mopra molecular gas survey will be used to provide the “template” of the distribution of these nuclei in order to interpret gamma ray images. CTA will produce a new gamma ray image of the southern Galactic plane in a survey which will be conducted with telescopes in Chile, near to the European Southern Observatory's (ESO) Paranal Observatory. The CTA telescopes are also beside where the European Extremely Large Telescope (the E-ELT) is now being built – to be the world's largest optical telescope when complete.

Gaia and the distances to stars

Determining the distances to stars has long been a difficult and sometimes controversial task. The European Space Agency (ESA) launched its Hipparcos satellite in 1989 that was able to measure the distances of 118,000 stars out to 300 light years. In 2013, ESA launched Gaia as the successor to Hipparcos and in 2018 released the distances and proper motions of a billion stars. In 2016 ESA first released a catalogue of the distances to the relatively bright stars. This catalogue included 16 ‘Cataclysmic Variables’, which contain a small but dense white dwarf and a low mass red star orbiting around one another on a timescale of an hour to half a dozen hours. One of these, SS Cyg, has been studied for more than a century and shows outbursts every month when it brightens by >10 magnitudes for a week. Using a distance determined using the Hubble Space Telescope, the observations were at odds with the standard accretion disk model which astronomers use to predict the behaviour of outbursts in general. This also contradicted a distance made using the VLA radio telescope in New Mexico. Ramsay and colleagues in the UK and Chile were able to take the new distances derived by Gaia and show that SS Cyg now agrees with the standard accretion disk model. This has put the accretion model on a sounder footing, however it will need be rigorously tested using more distances now the full catalogue has been released.

Gravitational-wave Optical Transient Observer

The announcement by the Laser Interferometer Gravitational-Wave Observatory (LIGO) project in 2016 of the direct detection of gravitational waves from two merging black holes was one of the great triumphs of mankind. LIGO's two detectors, which are separated by several thousand of kilometres, both recorded the event. Since then a number of other gravitational wave events have been detected and three members of the LIGO team won the Nobel Prize for physics in 2017.

These detections are an amazing feat. It is equivalent to measuring the distance to the nearest star to the Sun to within a thickness of a human hair. However, the detectors are not able to pinpoint the location in the sky to great accuracy. Follow-up observations using other telescopes are needed to identify any new object that has appeared in the region of sky where the event is most likely to be. This was spectacularly demonstrated in September 2017 when the optical counterpart of a merging neutron star binary was detected in the halo of the galaxy NGC 4993.

One telescope aiming to detect these counterparts is the Gravitational-wave Optical Transient Observer (GOTO) which is located on La Palma in the Canaries. This is a collaboration between Warwick, Sheffield and Leicester Universities in the UK, Monash University in Australia and NARIT in Thailand, together with the Armagh Observatory and Planetarium. GOTO is currently undergoing commissioning tests but has already observed the optical counterpart of one gamma-ray burst showing that our strategy and instruments are up to the task. Our Phase I deployment consists of four 0.4m telescopes giving a field of view of ~ 20 square degrees. Plans are afoot to duplicate the existing set of telescopes on La Palma, doubling the area of sky which can be recorded in one step, and to site another system in Australia.

The most massive stars in the Universe

In the massive star group at Armagh led by Jorick Vink, the lives and deaths of the most massive stars in the Universe are studied, both observationally and theoretically. On the observational front, the group led the analysis of the most massive stars in a European wide Very Large Telescope (VLT) spectroscopic survey of the Tarantula (VFTS) nebula. A couple of years ago former Armagh PhD student Joachim Bestenlehner discussed the possibility that the isolated superstar VFTS 682 was a runaway star from the young cluster R136, and this year we utilised HST and Gaia DR2 to make an even stronger case for this object to be the most massive runaway star yet known to humankind. Another former Armagh PhD student, Venu Kalari, studied Gaia satellite data in the spectacular star forming region of our Galaxy known as NGC 3603, discovering the most massive runaway star of over 100 solar masses in our own Milky Way.

On the theoretical front, the group has studied one of the key questions in astrophysics concerning the issue of whether there exists an upper-mass limit to stars, and if so, what physical mechanism sets this limit? The answer to this question will also determine if the upper-mass limit depends on its chemical environment. To address this question Vink computed mass-loss predictions from Monte Carlo radiative transfer models for stars up to 1,000 solar masses. It was found that mass-loss rates for such massive stellar monsters can indeed exceed the typical mass-accretion rates during massive-star formation. Even if stellar winds would not directly halt and reverse mass accretion during star formation, if the most massive stars form by stellar mergers, stellar wind mass loss will dominate over the rate at which stellar growth takes place. Vink therefore argues that the upper-mass limit is effectively environment-dependant due to the nature of radiation-driven winds, with dramatic consequences for the most luminous supernovae, gamma-ray bursts, and other black hole formation scenarios at different Cosmic epochs.

This year a new STFC-funded post-doctoral research assistant (PDRA), Andreas Sander, was appointed to predict the mass loss of massive stars just prior to collapse as Wolf-Rayet stars. These are the direct progenitors of black holes, as recently revealed in the detection of gravitational waves by the LIGO/VIRGO interferometer. The big surprise of those discoveries has been that these black holes were heavier than most astronomers considered possible. Already a decade ago Vink predicted the existence of “heavy” black holes when the host galaxy has a chemical fingerprint that was more characteristic of the Early Universe. Over the next couple of years, we will find out if the earlier insights were indeed correct.

Armagh PhD student Erin Higgins introduced a new tool to constrain massive star evolution during the core-hydrogen burning main-sequence phase of evolution: the Mass-Luminosity plane. We anticipate that the tool will become as valuable as the traditional Hertzsprung-Russell diagram (HRD), as it has already been established that massive stars require more internal mixing via core overshooting than is usually assumed.

Galaxy formation and Supermassive Black Holes

The new Head of Research, Marc Sarzi has added the key area of the study of how galaxies formed and evolved to Armagh’s research base. In summary, galaxies grow by forming new stars or by merging together. Whether fresh gas for forming stars is available to them, as well as how often galaxies collide, depends mainly on where galaxies exist. Some galaxies are relatively isolated, other exist in small groups and yet more galaxies, in fact most, are found in huge congregations of hundreds or thousands of galaxies called galaxy clusters. Fresh gas is abundant in and around galaxies that are isolated or in small groups, but in clusters, galaxies lack gas to the extent that star formation no longer occurs in them. On the other hand, in clusters, galaxies can often capture smaller companions, whereas more isolated objects almost never get the chance to grow in this way.

The supermassive black holes that are now known to reside at the centre of most galaxies seem to play a considerable part. In fact, when clouds of gas or stars fall into them, the regions immediately surrounding supermassive black holes become incredibly active, giving off fantastic amounts of energy in the form of light or jets of energetic particles. In turn, such a radiation and jets are thought to be capable of shutting down star formation in galaxies, either by expelling all gas in them or by warming it up to very high temperatures, which also prevents gas from being converted into new stars.

Marc Sarzi is leading two separate efforts. He is at the head of an international effort to study the closest galaxy cluster to us, some 65 million light-years away in the direction of the Fornax constellation in the southern sky. For this he and his team are using the state-of-the-art MUSE integral-field spectrograph mounted on the ESO Very Large Telescope to study in exquisite detail the current gas content and star-formation history of galaxies in Fornax, which revealed how galaxies closer to the cluster centre are much more starved for gas than objects in the cluster outskirts. As regards supermassive black holes, his PhD student Boris Nedelchev has been closely checking how effective these mysterious objects are at expelling gas from their host galaxies. Using a sample of over 600,000 galaxies with optical spectra in the Sloan Digital Sky Survey, Boris has been looking at objects where cold gas, out of which stars form, was actively being expelled from their galaxies, and in particular at objects where this instance was concomitant with an active supermassive black hole. Finding only a couple of dozen objects fitting such a description, his conclusion is that there is little evidence supporting the idea that supermassive black holes can directly suppress star-formation in galaxies. This casts serious doubts on current ideas for their role in galaxy formation at least in the present-day Universe.

Review article on meteors to appear in new CUP book

Armagh astronomer Apostolos Christou completed work as lead author of a review chapter to appear in a new book by Cambridge University Press. The book is written by an international cadre of experts on meteoroids, the solar system’s smallest objects and is intended to become the standard reference text in the field. The chapter led by Christou, in collaboration with Drs Jeremie Vaubaillon (Paris Observatory, France), Ricardo Hueso (U. Bilbao, Spain), Paul Withers (Boston U., USA) and Rosemary Killen (NASA Goddard, USA), deals with the relatively new subject of “extraterrestrial meteors”, in other words the meteor phenomenon as it occurs on planets other than the Earth. It begins by discussing the value of off-the-Earth observations of meteors. Next, it presents the expected

characteristics of meteors relevant to observations on and off the Earth, considering both the optical phenomenon of the meteor itself as well as the after-effects such as ionised metallic layers in the upper atmosphere. It discusses early reports of exo-meteor phenomena, followed by later observations, informed by quantitative theoretical work. Recent high-profile events, such as impact flashes on Jupiter and the 2014 encounter of comet C/2013 A1 (Siding Spring) with Mars, are described in separate sections. The final section discusses future prospects: expected near-term observations, missions & instruments planned or in conceptual stage. The book, which is also co-edited by AOP meteor expert Dr David Asher, is due out in September 2019.

Armagh astronomers find a privileged pedigree for meteorites

New research by Christou in collaboration with Professor Stan Dermott at the University of Florida at Gainesville and others in the US and published in *Nature Astronomy* suggests that meteorites, such as the Bovedy stone that fell near Portadown, Northern Ireland in 1969, as well as the larger objects that pose an ever-present hazard to civilization if they hit our planet, come from a few large, ancient asteroids between Mars and Jupiter. In the new study, the team looked at the distribution of asteroid orbits and their sizes. Studying the Asteroid Belt is complicated by the fact that the orbits continuously change because of the gravitational influence of Jupiter and Saturn. But by taking time averages of the orbital properties, a significant amount of structure becomes apparent: some areas show concentrations of asteroids, elsewhere the Belt is relatively barren. By comparing the mean orbits of asteroids in families with the means for the background asteroids, we found that families and background are quite similar and that this is true for asteroids of all sizes down to a few kilometres across. In fact, some 85% of the asteroids studied are probably derived from the families. The finding has important implications for scientists who study our solar system's history. It suggests that the diversity observed in the tens of thousands of meteorites that now lie in laboratories and private or museum collections across the globe is likely to represent differences in internal structure between comparatively few large parent bodies as opposed to a larger and more compositionally diverse set of smaller asteroids.

International Standing

Armagh Observatory and Planetarium provides a strong, positive image of Northern Ireland on the international stage. Members of staff play a full role in the international astronomical community, for example, serving on committees of bodies such as the Science and Technology Facilities Council (STFC), the Royal Astronomical Society (RAS), the Royal Irish Academy (RIA), the Astronomical Science Group of Ireland (ASGI) and the International Astronomical Union (IAU); assessing grant and research proposals on behalf of external funding agencies and reviewing scientific papers and editing international academic journals.

In addition, staff have access to world-class international facilities provided through STFC and UK Government subscriptions and bilateral agreements and collaborations involving individual researchers. Staff regularly obtain telescope time on international facilities, including the Dunn Solar Telescope at Sacramento Peak Observatory, the New Solar Telescope at Big Bear Solar Observatory and the Mopra radio telescope in Australia, the ESO Very Large Telescope and various spacecraft missions (such as SoHO, SDO, Hinode, Stereo, Swift, XMM-Newton and the Hubble Space Telescope).

Academic staff obtain research grants from a wide range of grant awarding bodies (e.g. the STFC, the Royal Society, the Leverhulme Trust, British Council etc.), and through the organisation's membership of the UK SALT Consortium (UKSC) have access to the 11-metre diameter Southern African Large Telescope (SALT) located at the Sutherland Observatory, South Africa. Armagh is also a member of the international consortia involved with the GOTO (Gravitational-wave Optical Transient Observer) optical, LOFAR (LOw FREquency Array) radio and the CTA (Cherenkov Telescope Array) gamma-ray telescopes. Complementing these international facilities, restoration of the Observatory's historic telescopes has brought opportunities to reintroduce some visual observing from Armagh, while new computer and camera technology has enabled a variety of new automatic observational programmes to be introduced from Armagh, recording data autonomously whenever the sky is clear.

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 distribution of scientific and technical 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 its school's educational programme and science offering to the wider public. Communication of science subjects is kept up to date and is stimulating, for example we added content from the first image of a Black Hole into our educational programme as soon as the information was released.

At the Planetarium creating a legacy around a visit is important and this is promoted through free resources provided

to teachers on our website. These resources include factsheets, videos and informed commentary on the latest astronomical news in our Astronotes blog. From inception, we have responded to a steady stream of astronomical queries from the public and the media.

The unique selling point of the Planetarium is the digital theatre in the Dome, which brings visitors on a journey through the cosmos to the furthest reaches of our Universe – all from the comfort of a seat in Armagh.

In the Dome the education staff deliver not only rendered shows but interactive presentations which have received positive feedback from schools and the general public. Some of the topics that are concentrated on have been meteorite impacts, the planets, current astronomical phenomena and Earth sciences. Through the large number of visitors coming through its doors the Planetarium also plays a key role in promoting and enhancing tourism within the Armagh City, Banbridge and Craigavon Borough Council area.

AOP aims to be the destination where every primary school level child in Northern Ireland experiences the mysteries of cosmos through our Digital Theatre shows, exhibitions and lectures. This accords with the strategic focus of the Department whose overall vision is for ‘a confident, creative, informed, and vibrant community.’ Bringing these aspirations together has led to the Planetarium positioning itself as a place where impressionable young minds can be encouraged to tackle the challenges and rewards of careers in Science, Technology, Engineering and Mathematics (STEM). This STEM agenda is being embraced and promoted all over the world by those governments that are aware of the impelling need to enhance the competitiveness of their workforce in a technologically sophisticated business environment.

Programme of Events

During 2018/19, the Planetarium celebrated its 50th birthday in May and events surrounding this historic occasion included a schools engagement programme where the Ulster Orchestra and local schools created the “Sounds of the Planets”. Women in STEM were celebrated through a women-in-science panel event where Dame Jocelyn Bell-Burnell, discoverer of the first pulsar, was the key note speaker. She was an inspiring speaker, able to relate the importance and significance of science across to the audiences. She had tales to relate taking us back to the building of the Planetarium and the connection to her discovery of pulsars in 1967. Our new brand, corporate plan and logo were also launched at this time through a stakeholder event.

In July our online booking system was installed and commissioned. This has made it easier for customers to make bookings in advance and to see our events and theatre shows on offer. It also allows us to analyse our customer base, for example we can see the number of repeat visitors that we have. Online booking also allows us the ability to communicate quickly to customers who have booked with us, for example in August there was a road closure that we could swiftly email customers to advise them of. The power of online booking was demonstrated with our exclusive Total Eclipse of the Moon and Opposition of Mars event which sold out online within 2 hours of tickets being released. As the result of an enquiry, together with the tool of online ticketing to facilitate its management, we were able to fulfil a special request for a private viewing using the Grubb telescope on a commercial basis. This led to the development of a private tour option for visitors.

In July our summer programme opened with the popular Force Academy Training followed by the 50 Years of Sci-Fi Fan props and sets event which had an attendance of just under 2,000 people over the weekend. Minecraft workshops were brought back and we ended the summer with a student science workshops day. The PhD students, led by Lauren Doyle, created a series of hands-on experiments and talks in the Copernicus hall which brought in over 400 visitors.

Mystery of the Christmas Star proved popular once again this year and we targeted groups, in particular for attendance in the afternoon, and were successful in attracting new customers. In December we also held the Centennial Weather station event with a corporate event in the Observatory and a panel event for schools in the Planetarium.

During the year staff also maintained an active programme of science in the community, for example by providing guided tours of the Observatory and Astropark (such as on European Heritage Day and Armagh Georgian Day), holding special public lectures and exhibitions. Star Trackers continued this year and were well attended due to the new online booking system. A-Level pupils were attracted to courses held at the Planetarium whilst staff also attended the Royal Belfast Hospital for Sick Children to deliver science to children who were in hospital for extended stays. This wasn't just delivering the STEM message but looked to improve young peoples' mental health during such long hospital stays. Regular yearly engagement with popular events such as World Space Week, Maths Week, the NI Science Festival and Sentinelus continued this year. We also linked in with Engineers week holding a panel event for schools and even had staff up from 3am for an early morning lunar eclipse event. Outreach also was aided by education officers attending training in Bournemouth to learn the benefits of the system. Staff also attended World Host Training with a view for all education staff to receive this training in 2019/20.

First time events

This year we embarked on a series of events that we have never provided before. These include Toddler Takeovers

which began in September and have been so popular we are changing our offering to weekly drop-in sessions. The first AOP science conference on “Hydrogen Deficient Stars”, led by Simon Jeffery with a full support team of staff and students also took place in September.

In October we experimented with Facebook Live Q&A sessions and following the success of the first event we have replicated this throughout the year. Also in October we attempted to create the biggest art project ever run at the Planetarium in the form of a “Space Selfie” using children from local schools and our logo cut into the Royal playing fields grass. Although the passing satellite did not photograph our logo due to cloudy weather, we were able to send a drone up and record the event.

For Halloween we had Scientific Sue in for live science workshops which sold out and brought in just over 500 people over two days. We also had a murder mystery evening between the Planetarium and the Observatory. In February we had our most extensive set of events for the science festival. Little Professors was a unique set of experiments for toddlers, Girls Takeover was for teenage girls interested in STEM and provided a tour of the Observatory, Hands-On Science was a set of science experiments delivered by our PhD students and we concluded the festival with After Dark. After Dark was an adult-only event and the first of its kind held here at the Planetarium. We were at our maximum capacity for this event which proved extremely popular.

In March we participated in the St. Patrick’s Day parade and also in that month we successfully concluded a recruitment process to employ part-time education officers to help with the busy school programme. Two new part-time Education Officers were employed. The Copernicus Hall was also upgraded to house full conferencing facilities with new projectors and lighting system.

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 ‘museum’ collection. Eleven virtual tours are available online through our website (www.Armagh.ac.uk).

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.

During 2018/2019 AOP developed and commenced implementation of a wide-ranging Project Plan for museum accreditation. The project plan aims to achieve accreditation within our Corporate Plan target deadline of March 2021. The plan encompasses key areas including planning, management and governance; resource planning; security assessment and planning; collections care, conservation and development; and understanding and developing the experience for users. This work involves developing, updating and implementing comprehensive policies and procedures for the management and care of our collections. For this purpose, AOP engaged the services of an experienced museum expert from its sister museum, the Armagh Robinson Library.

The work being undertaken in these areas is helping AOP ensure that our collections and museum offering are managed sensitively with due consideration being given to the needs of the research function in a full-time operational scientific institution. This work will also support us in catering for the needs of visitors and in meeting the conservation and preservation requirements of our valuable collections.

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. In recent years more than 25,000

records have been added to the on-line, publicly accessible archives and library database, with many linking to associated images or digitized documents. The library catalogue, containing over 3,000 entries, is also available on-line (www.Armagh.ac.uk).

As part of our duty to conserve and care for our collections, AOP undertook a valuation exercise to assess the value of our historic artefacts, both scientific and non-scientific, and of our historic literature collection. The exercise involved experts, commissioned by Sotheby's of London, attending the site to undertake detailed examination of our collections and the provenance of our valuable artefacts. The outcomes of the valuation exercise will be known during the 2019/2020 financial year.

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 220-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 and one of the longest in the world. The climate station has been continuously maintained since December 1794 with readings currently taken every day at 09:00 (GMT).

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.

In December 2018, to highlight the importance of its long-term work in maintaining continuous, accurate weather records, Armagh was officially recognised as a Centennial Observing Station by the World Meteorological Organization (WMO). The WMO sees long-term meteorological observations as:

"...part of the irreplaceable cultural and scientific heritage of mankind that serve the needs of current and future generations for long-term high-quality climate records. They are unique sources of past information about atmospheric parameters, thus are references for climate variability and change assessments."

Armagh became one of only six recognised Centennial Observing Stations in the UK and is the longest running Centennial Observing Station in the UK. There are only five countries in the world with Centennial Observing Station operating longer than Armagh. This highlights the importance of Armagh's weather records from a scientific perspective, and it also underlines the historic importance and heritage associated with this unique and valuable insight into our weather over the past centuries.

A special event was held in the Observatory on December 10 to celebrate Armagh's award of Centennial Station Status, with representatives from the World Meteorological Organisation, the UK Met Office and Met Éireann present. On the following day a public event was held in the Planetarium, including the launch of a short dome show telling the story of Armagh's weather station. UTV also filmed the events for the UTV life programme.

2018 was also the centenary since Theresa Hardcastle kept the Observatory running after her husband, Alfred, tragically died en route to Armagh to take up the Directorship. Theresa Hardcastle found the Observatory building in a dreadful state when she arrived. In her year in Armagh she did much to restore it and make it habitable again, laying the foundation for the Directors to come. Theresa Hardcastle also ensured that the unbroken meteorological record continued. We took the opportunity of the Centennial Station award to celebrate Theresa Hardcastle and her special contributions to Armagh, one century ago, with a living history presentation given by Education Officer Heather Alexander. Her photograph is now on display in the Boardroom. Theresa Hardcastle's granddaughter, Deb Perceval, also attended.

Following the award of Centennial Station status, we have had significant interest in our weather records. A Japanese researcher, Hisashi Hayakawa, visited to inspect the weather records for evidence of past solar activity, such as the Carrington event. This including uncovering a naked eye observation of a sunspot in the observer's log in the 19th century. Andreas Hoy, from Freiberg University in Germany, has been using the Armagh data to help in a project studying climate extrema across Europe. He commented "... after some hours of dealing with the Armagh data today I am even more convinced that Armagh observatory has some of the world's best climate records, being in the same league like the homogenous records from Potsdam observatory (data from 1893), Stockholm observatory (data from 1756, but they may be influenced by city growth) and Hohenpeißenberg observatory (data from 1781)".

The Met Office has now declared the automated weather station fully operational, following a period of data validation. This will now provide the primary source of key 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 will still continue, and provides the only source for some of the data collected (e.g. sunshine) at Armagh.

Gravity Station

The Ordnance Survey of Northern Ireland (OSNI) have installed the concrete base for a Gravity Station near to the stone circle on top of the Hill of Infinity. The intention is to measure absolute gravity, as part of a campaign to create a network of gravity observations across the island of Ireland, in partnership with Ordnance Survey Ireland (OSI). The aim is to use these observations to improve the accuracy of their height networks. An MoU has been signed between AOP and OSNI to facilitate this.

OSNI will visit roughly yearly to place a gravimeter (a cylindrical instrument) on the concrete foundation that has been installed. This allows OSNI to measure, very precisely, the gravitational force. An object is dropped inside a vacuum chamber and its position is monitored very accurately using a laser interferometer. The BIPM (Bureau International de Poids et Mesures) has proclaimed the ballistic freefall method as an official primary method for measuring gravity.

The prominent siting on top of the Hill of Infinity affords the opportunity of engaging in outreach activities associated with the experiment, for example, the science and why gravity measurements are important. There is also a connection to AOP's complete collection of maps from the original Ordnance Survey mapping of Ireland (1829-1842), which is held in the Robinson Public Library.

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 full review and modernisation programme of ICT requirements to include Research, Education and support service needs has been ongoing in 2018/19 to ensure compliance with GDPR and other information security requirements and use of modern and accessible operating environments. This will be further progressed in 2019/20.

Finance

In 2018 AOP established a new finance staffing structure to assist with the stabilisation and modernisation of the organisation and adopt a more commercial and sustainable approach to funding and income. New finance policies and procedures have also been introduced and outstanding internal audit recommendations in relation to financial policies, procurement and asset management have been implemented.

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. Discussions have been ongoing with the Department but there has been a disproportionate reliance on in year funding to maintain a stable organisation.

Human Resources

A Human Resources strategy has been developed and approved and an Action Plan for 2018/19 included:

- Restructuring and recruitment – ongoing
- Review Terms and Conditions of Employment and implement new contracts – complete
- Policy and Procedures review – approximately 80% complete
- Engagement and Culture – employee survey completed in 2018 demonstrated improvements across all areas when compared to 2017 baseline survey

Governance

A new post of Corporate Manager was recruited with responsibility for board secretariat as part of the remit of the post. Governance and accountability have been strengthened and improved and risk reduced as demonstrated by external and internal audit reviews.

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.

In 2018 lifecycle and condition surveys were completed for all property and as a result capital funding was provided for urgent Health and Safety and remedial upgrades identified in the surveys.

In addition, a Strategic Outline Case setting out options to meet the future needs of the organisation was approved by DfC/DoF and some enabling work has commenced to assist the development of an Outline Business Case.

Achievements and Performance

The targets set for the Armagh Observatory and Planetarium in the 2018/19 Business plan are shown in the following table. The actual performance achieved is shown along with the corresponding achievement for the previous financial year (where appropriate).

While targets were achieved or exceeded in most areas, a number were not met. Whilst a Project Juno Practitioner status application had been favourably reviewed, it had not been awarded. 18 closure days during the period affected achievement of the visitor numbers target and this coupled with a lack of resources impacted upon the income target.

Theme	KPI	Description	Target	As at 31 March 2019	Progress	As at 31 March 2018	Comments
Research	1	Number of articles published in refereed scientific journal publications in 2018/19	35	66	189%	70	
	2	Number of citations in refereed scientific journals (in rolling 3 year period)	300	1,225	408%	913	
	3	Sustain a credible PhD student programme by increasing baseline back to 12 students at any one time by 2021	10	On target		NEW KPI	Achieved
	4	By March 2019 to have achieved Project Juno Practitioner status	Achieve satisfactory external evaluation	Resubmit April 2019		NEW KPI	Application favourably reviewed but not awarded.
	5	Host an International Scientific Conference	50 delegates 10 subsidised student places	Achieved		NEW KPI	HDeF September 2018
Education and Community Outreach	6	Delivered and evaluated a collaborative A-level Physics course	50 participants over 3 sessions	55 students	110%	NEW KPI	55 students partook in the A-level course
	7	Increase total number of visitors to AOP	52,000	44,301	85%	51,145	18 closure days during this period (50th preparations/training days/HDeF Conference)
	8	Number of participants in STEM/STEAM programmes onsite at AOP	1,800	6,590	366%	3,015	
	9	Develop and deliver a school's engagement programme	15,000	13,365	89%	NEW KPI	
	10	Percentage of visitors from schools on the Extended Schools Register or with high proportion of free school meals	25% of school engagement programme		48%	27%	
	11	Have delivered a targeted external outreach programme	30 events	42	140%	31	
History and Heritage	12	Implement a single unified website and integrated online presence	31 March 2019		100%	NEW KPI	Interim website now available; however developing new integrated website remains a priority
	13	Raise the profile of AOP through increased media and marketing exposure	5 news articles	achieved		NEW KPI	
	14	By March 2019 to have completed a capital programme to redress urgent remedial and Health and Safety issues identified in lifecycle surveys	Completion of approved capital programme			NEW KPI	Some tails into 2019/20 granted
Leadership and Governance	15	Maintain prompt payment targets processed within 10 days	90%	98%	109%	74%	
	16	By March 2019 to have increased trading income to £181K (baseline £150K) (1)	£181K	£160k	89%	NEW KPI	Reduced admissions early in year as result of lack of resources and 50th anniversary was difficult to recover but some progress made in last quarter
	17	By 25 May 2018 ensure AOP is compliant with new General Data Protection Regulations	Internal Audit assurance of at least 'satisfactory'			NEW KPI	Internal Audit was advisory - no major issues identified

Financial Review: Armagh Observatory and Planetarium

Operating Results

In the financial year to 31 March 2019, the value of charity funds fell by £112,952, summarised below.

	2019	2018
	£	£
Total incoming resources	2,574,744	2,451,014
Total outgoing resources	(2,897,663)	(2,662,763)
Net income / (expenditure)	(322,919)	(211,749)
Gains (losses) on the revaluation of fixed assets	(71,033)	366,699
Gains on the revaluation of heritage assets	-	50,000
Actuarial gains less provisions on defined benefit pension scheme	281,000	213,000
Net movement in funds for the year.	(112,952)	417,950
Movement in Unusable Funds		
Capital financing		
Capital grants received	292,600	196,000
Donated assets reserve	-	(36,285)
Government grant fund	(495,198)	(301,950)
Revaluation reserve	(265,950)	416,699
Pension reserve	200,000	118,000
Movement in Usable Funds		
Restricted	(112,559)	57,112
Unrestricted	268,155	(31,626)
	(112,952)	417,950

The total income for the year was £2.575m, an increase of £0.124m from 2017/18, mainly due to an increase in capital grant income.

Expenditure was £2.898m, an increase of £0.235m 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 Department Grant-in-aid. The balance of such unrestricted operating costs is funded by contributions from external grants and miscellaneous income in an increasingly competitive financial environment. We continue to seek other funding streams to maintain this important source of funds. In 2018/19 the Department provided 79% of the total income through recurrent and capital grant allocations (2017/18: 79%).

Net Assets

Net assets at 31 March 2019 were £9.288m (31 March 2018 (restated): £9.401m).

Reserves

Armagh Observatory and Planetarium has total accumulated funds of £9.275m at 31 March 2019 (31 March 2018 (restated): £9.401m). The reserves policy is included in note 1 of the accounts. Funds are as follows:

Funds at 31st March	2019	2018 (restated)
	£	£
Restricted funds	116,460	229,019
Unrestricted funds	2,714,190	2,648,633
Revaluation Reserve	7,705,808	7,971,758
Pension Reserve	(1,248,000)	(1,448,000)
Total Charity Funds	9,288,458	9,401,410

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 provides a defined benefits pension to employees. The scheme is currently in deficit and at the 31st March 2019 the deficit, including provision for GMP equalisation and the McCloud/Sergeant judgement, was calculated by independent actuaries at £1,248,000 (2018: £1,448,000).

Key Risks and Uncertainties

During the year the Risk Register has been revised to better reflect the key risks, these have been identified as:

- Lack of stable core funding to maintain service levels;
- Failure of Digistar equipment resulting in closure of planetarium;
- Failure to safeguard and maintain assets resulting in loss or damage; and
- Failure to establish long-term ICT Strategy resulting in single point of failure of key systems

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. Good work has been done to address the weaknesses identified in previous years and considerable effort has been put into the management of these risks going forward. While the organisation is within striking distance of establishing sound systems of control, there remains work to be done.

Plans for Future Periods

Baseline core funding remains the number one priority for AOP. Whilst a budget to meet the needs of the organisation has been set for 2019/20, the additional element has not been included in the baseline therefore this does not provide stability for future planning.

Another urgent priority, identified in the course of reviewing lifecycle surveys and future needs, is the requirement to have a Conservation Management Plan for the estate and in particular the Grade A listed Observatory building and historic landscape.

Progression of the 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 is also a high priority.

In addition to this, furtherance of the organisation's core activities in research, education and outreach and history and heritage are set out in its business plan for 2019/20.

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.

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 provide leadership, challenge, oversight, support and encouragement to the Chief Executive 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 (DFP 05/14) 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, the Committee is a sub-committee of the Management Committee and advises it on employment issues and provide 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 page 26.

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

Archbishop Richard Clarke, CHAIR
 The Very Rev G. Dunstan
 The Venerable Archdeacon T. Scott
 The Venerable Archdeacon A. Forster
 Rev Canon W.J.A. Dawson
 Rev Canon W.M. Adair
 Rev Canon R.J.N. Porteus
 Rev Canon Dr P. Thompson
 Rev Canon J. Moore
 Rev Canon D. Hilliard
 Rev Canon B. Paine
 Professor R. Oudmaijer
 Mr W.G. Berry
 Professor A. Hibbert
 Dr K Poppenhaeger (19 April-31 October 2018)

Director and Accounting Officer

Professor Michael Burton

Auditors

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

Internal Auditors

Grant Thornton (NI) LLP, 12-15 Donegall Square West, Belfast, BT1 6JH

Bankers

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

Register of Interests

A Register of Interests is maintained for Board members and the Executive Team and is available for inspection at the Principal Address.

Related party transactions are shown in note 21 of the accounts.

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 2019.

Disclosure of Audit Information

So far as the Accounting Officer is aware, there is no relevant audit information of which the Board'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 the Board's auditors are aware of that information.

Important events since the end of the financial year

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



Archbishop Richard Clarke
Chair of the Board of Trustees
Date: 17 December 2019



Professor Michael Burton
Chief Executive
Date: 17 December 2019

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 those who were paid in accordance with the Joint Negotiating Committee for Higher Education Staff) 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						
Name	Salary 2018/2019	Pension Benefits*	Total 2018/2019	Salary 2017/2018	Pension Benefits 2017/2018	Total 2017/2018
	£'000	£	£'000	£'000	£	£'000
M.G. Burton	80-85	26,803	105-110	70-75	23,054	95-100

*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 or any increase or decreases due to a transfer of pension rights.

Pension Entitlements (Audited Information)

Name	Accrued Pension at 31 March 2018	Real Increase in Accrued Pension	Accrued Lump Sum at 31 March 2018	Real Increase in Lump Sum	CETV at 31 March 2019	CETV at 31 March 2018 (restated)	Real Increase in CETV
	£'000	£'000	£'000	£'000	£'000	£'000	£'000
M.G. Burton	0-5	0-2.5	0	0	59	34	18

The CETVs above have been calculated in accordance with guidance used by the Northern Ireland Civil Service in Employer Pension Notice EPN13/2017. Note that new transfer factors, effective from 7 January 2019, have been used to recalculate the 2017/18 CETV and for the 2018/19 CETV.

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 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. The main benefits payable on retirement for service up to 31 March 2009 are: (i) a retirement pension at a rate of 1/80th of final pensionable pay for each year of membership of the scheme; and (ii) a lump sum retirement grant at a rate of 3/80ths of pensionable pay for each year of membership of the scheme. On death after retirement, the surviving spouse will receive a pension payable for 3 months (6 months if there are dependent children) paid at the same rate as the monthly retirement pension at the date of death and thereafter a spouse's pension of half of the retirement pension for life. On death in service, the scheme pays a lump sum death grant of twice pensionable pay, normally to the surviving spouse or, if the member was not married, to next of kin. For service from 1 April 2009 retirement pension will be at a rate of 1/60th of pensionable pay for membership built up after 31 March 2009 and further rights on pension augmentation, flexible retirement and family pension rights on death were introduced. For service from the 1st April 2015 retirement pension will be based on 1/49th of salary paid in year and pension is based on career average earnings a change from final salary. Details of the changes 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.

Band of highest paid senior post holder (Audited Information)

	2018-19	2017-18
Band of highest paid director's total remuneration (£'000)	80-85	70-75
Median total remuneration	£30,971	£30,514
Ratio	2.65	2.38

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 2018/19 was £80,000 - £85,000 (2017/18: £70,000 - £75,000). No employee received remuneration in excess of the highest paid director.

Total Staff Costs (Audited Information)

	Permanent staff £	Others ¹ £	2019 £	2018 £
Wages and salaries	868,798	314,626	1,183,424	1,117,032
Social security costs	96,201	-	96,201	78,406
Employer's pension contributions	185,815	-	185,815	144,832
Defined benefit pension additional service cost	46,000	-	46,000	95,000
Termination costs	92,500	-	92,500	6,301
	1,289,314	314,626	1,603,940	1,441,571

¹ "Others" includes £95,023 for secondees and £219,603 for agency staff

Average staff numbers

	Permanent staff	Others ²	2019 Number	2018 Number
Average staff numbers	21.0	9.6	30.6	27.1

² "Others" includes 1.8 fixed term, 1.8 secondees and 6.0 agency staff

Staff banding

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

	2019	2018
£80,001 - £90,000	1	1

Staff Composition – employed (full time equivalent)

	Male	Female
Directors/senior managers	2.3	1.0
Other employees	9.2	8.5

Sickness Absence

Staff absenteeism for the period 1 April 2019 to 31 March 2019 was 128.5 days (2018: 119 days) which equates to an average per FTE of 2.66% (2018: 2.33%).

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 (2017/18 £38,750).

Off-payroll Engagements

There were no "off-payroll" engagements in place as at 31 March 2019, nor were any arrangements entered into between 1 April 2018 and 31 March 2019.

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
	2018-19	2018-19	2018-19	2017-18
< £10,000				1
£90,001-£100,000		1	1	
Total no. of exit packages		1	1	1
Total resource cost	Nil	92,500	92,500	6,301

Signed:



Professor Michael Burton
Accounting Officer for the Armagh Observatory and Planetarium

Date: 17 December 2019

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 corporation'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 "Accounting and Reporting by Charities" (SORP 2015). The financial statements comply with the guidance issued by the Department of Finance and Personnel 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 corporation will continue in business.

The Accounting Officer is also responsible for safeguarding the assets of the corporation 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 organizations 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. Scope of Responsibility

The Board of Governors, Management Committee and Director 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.

2. Compliance with Corporate Governance Code

In April 2013 the former Department of Finance and Personnel issued Dear Accounting Officer (DFP) 06/13 regarding the revised Code of Good Practice on Corporate Governance in Central Government Departments.

While the 2013 Code has been written for central government departments, it concentrates throughout on key principles. As such, 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, comply with the principles of good practice in the Corporate Governance Code.

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 2018/19 there was one retirement from and a subsequent appointment to the Chapter of the Church of Ireland Cathedral of Armagh and hence the Board of Governors. There was also an appointment to and retirement from the QUB vacancy. There remains one vacancy from within the Board of Governors nominees.

BOARD OF GOVERNORS			
GOVERNOR	DATE OF APPOINTMENT	DATE OF EXPIRY	MEETINGS ATTENDED (max. 1)
Chair: Archbishop Richard Clarke	15 December 2012	None	1
The Dean Very Rev G Dunstan	4 December 2011	None	1
The Venerable Archdeacon T Scott	9 November 2006	None	0
The Venerable Archdeacon A Forster	11 October 2015	None	0
Rev Canon W J A Dawson	1998	None	0
Rev Canon W M Adair	10 September 2008	None	0
Rev Canon R J N Porteus	1998	None	1
Rev Canon N J Hughes	16 November 2014	15 October 2018	1
Rev Canon J Moore	13 March 2016	None	0
Rev Canon D Hilliard	13 March 2016	None	0
Rev Canon W B Paine	7 May 2017	None	0
Rev Canon Dr P Thompson	13 January 2019	None	0
Professor R Oudmaijer	1 July 2015	None	0
Mr W G Berry	1 January 2016	31 December 2019	1
Professor A Hibbert	28 March 2014	None	1
Dr K Poppenhaeger	19 April 2018	31 October 2019	1

Under the Terms of Reference of the Board of Governors and its Committees it was decided to re-schedule the Board of Governors annual meeting to after year end so that it could receive the minutes of the March Management Committee and its review of year end reports. Therefore, there was no meeting of the Board of Governors in 2017/18, the annual meeting was held in April 2018 to formally approve the reports from the March 2018 Management Committee.

At the annual meeting in May 2019 the Board of Governors reviewed all of the minutes from the Management Committee and the Audit and Risk Assurance Committee meetings. The Board formally approved the Annual Report and Accounts 2017/18, the management report on performance against 2018/19 targets and the direction of the 2019/20 Business Plan.

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 meetings record the business carried out and actions agreed.

Management Committee of Armagh Observatory and Planetarium

The Management Committee comprises:

- a Chair appointed through open competition;
- three nominees from the Board of Governors; (1 vacant)
- 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 2018/19 one of the DfC nominees resigned and the term of three nominees was extended until 30 April 2019. The Management Committee therefore has one vacant DfC nominee position and three DfC nominee positions due to expire. The Board of Governors has one vacant nominee position and three Board of Governors' co-opted positions vacant.

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	None	3
Professor M Merrifield	1 January 1999	None	1
Professor R Oudmaijer	1 November 2008	None	4
Mr B Hannam	1 January 2011	Up to 31 December 2019	4
Dr M McKay	1 January 2011	Up to 31 December 2019	4
Mrs P Wilson	1 November 2014	31 October 2018	1
Professor L Harra	1 November 2014	30 April 2019	4
Mr S Brown	1 November 2014	30 April 2019	3
Mr P McGurgan	1 November 2014	30 April 2019	2
Professor M Mathioudakis	11 November 2016	10 November 2021	3
Canon D Hilliard	7 June 2016	6 June 2021	0

During 2018/19 the Management Committee considered a wide range of business including updates on key performance indicators focusing particularly on ongoing financial pressures and resulting staffing pressures. 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 noted the success of the Planetarium's 50th Anniversary celebrations. The Management Committee also received updates on progress in delivering the AOP Vision, including approval of a Strategic Outline Case and became aware of Armagh City, Banbridge and Craigavon Borough Council's plans to develop an Armagh Leisure Village, with an aspiration to include part of AOP estate. 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: Mr B Hannam	4
Professor L Harra	4
Mr P McGurgan	2
Mr S Brown	3

During 2018/19 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 2016/17 and 2017/18 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 and risk assessment process. The Committee also approved a revised Financial Policy and Procedures policy.

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.

The Committee is also satisfied, from the evidence provided at meetings that a detailed work programme exists with the aim of implementing the recommendations arising from the Internal Audit, external audit and the special investigation. Good progress has been made in implementing outstanding recommendations.

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.

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 2018/19, amongst other matters, the Committee considered the areas of:

- The Voluntary Exit Scheme
- Business Continuity
- Review of Terms and Conditions of Employment and Employment Policies

The Committee comprises four named members of the Management Committee.

EMPLOYMENT CONDITIONS AND REMUNERATION COMMITTEE	
MEMBER	MEETINGS ATTENDED (max. 4)
Chair: Professor T Ray	3
Dr M McKay	4
Mrs P Wilson (resigned June 2018)	1
Mr S Brown (chaired June meeting)	3
Mr J Briggs (joined June 2018)	4

Conflicts of Interest

The organisation also 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.

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 and Audit and Risk Assurance 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 received Departmental approval on 6 November 2017.

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 the ancillary activities support the primary aim, with the additional target of offering excellent value for money, both to the visitors taking part and to the public purse. The Planetarium maintains a focus on being inclusive so that all children can enjoy the Planetarium experience.

Full details of all the Observatory and Planetarium's activities are provided in comprehensive Annual Reports which are available in hard copy on request or 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; and
- ensuring that appropriate action is taken to minimise the risk of similar frauds occurring in future.

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. Following changes in the organisation structure and staffing, Armagh Observatory and Planetarium is conducting a Gap Analysis to ensure that all responsibilities are properly allocated.

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 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

Grant Thornton had been appointed as Internal Auditors for the 3 years 2017/18 – 2019/20 using CPD as the Centre of Procurement Expertise. The appointed firm operates to the standards defined in the Public Sector Internal Audit Standards.

The three year Audit Strategy was approved by the Audit and Risk Assurance Committee in September 2017 and the 2018/19 Audit Plan for the Internal Audit work had been approved in March 2018.

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

Audit Assignment	Priority
Fixed Assets (2017/18)	
Management of Fixed Assets	High
Disposal of Fixed Assets	High
Asset Verification Checks	Low
Safeguarding	Satisfactory Assurance
Procurement	
Compliance with Procedures	Medium
Procurement Training	Low
Budget Monitoring	Low
Contracts Register	Low
(Data Protection) GDPR	
Follow up on previously accepted recommendations	

There are three outstanding recommendations for 2018/19.

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

External Audit

The organisation is also subject to independent scrutiny from the Northern Ireland Audit Office. The Audit Office is independent of Government and is tasked by the Assembly to hold the Northern Ireland Departments and their Agencies to account for their use of public money. The Comptroller and Auditor General works closely with the Assembly's Public Accounts Committee which can require Accounting Officers and senior officials to account for their actions in relation to the management of public funds.

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 2019 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 external auditors to the Audit and Risk Assurance Committee, the Management Committee and the Board of Governors on the material issues relating to the annual accounts, which provide an opinion on whether the accounts give a true and fair view of the affairs of the organisation and of its incoming resources and application 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 governances are set out within the next section. Upon identification, plans were immediately put into place to addresses these issues.

9. Internal Governance Divergences

Update on Prior Years:

Of the 23 internal audit recommendations from previous years, there are currently 8 outstanding, as follows:

Recommendation	Priority	Status
Policies should be reviewed every three years to ensure they comply with legislation	High	Policies updated but some still to be reviewed and approved
Contract Management policy and procedures to be developed	Low	Policy and procedures have been developed, awaiting audit confirmation
All staff to receive training on General Data Protection Regulations (GDPR) and Freedom of Information (FOI) requests	Medium	10 key staff have been trained in GDPR. A broad spectrum of staff have been trained in FOI, awaiting audit confirmation
There should be regular review of guidance documents, and they should contain version control stating when review is required	Medium	Work is ongoing to update all policies and procedures. Version control is included
IT strategy to be developed	Medium	IT strategy development ongoing
IT security policy to be developed	Medium	An overall strategic review of IT has been completed. Security policy is being developed
All staff authorised to procure goods and services to be appropriately skilled	Medium	Staff have received procurement training, awaiting audit confirmation
Oversight and management of external contracts should be formally allocated to an individual within the organisation	Medium	The Contract Manager is now responsible, awaiting audit confirmation

Of the 5 NIAO recommendations from previous years, there is currently 1 outstanding, as follows:

Recommendation	Priority	Status
AOP should ensure that they are monitoring their cash position closely and are only drawing down grant in aid from the Department as required in line with the requirements of MPMNI.	High	Not implemented

Identification of New Issues:

Of the new issues identified by internal audit during 2018/19 there remain 3 outstanding, as follows:

Recommendation	Priority	Status
Management to ensure the procurement and purchasing procedures are followed	Medium	Procurement training, including details of procedures, completed, awaiting audit confirmation
Procurement training to be held for all relevant staff	Low	Procurement training completed, awaiting audit confirmation
Implement a formal mechanism for monitoring purchases against budget prior to approving purchase orders	Low	Management do not consider this to be best use of limited management resource. Finance are tasked with regular monitoring of unusual activity or exceptional expenditure

There were 2 new issues identified by NIAO during 2018/19, as follows:

Recommendation	Priority	Status
While we recognise the difficulty in obtaining information from CPD and/or contractors on a timely basis in relation to capital works 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. We recommend that management consider what other contemporaneous evidence that they can capture at the year-end to evidence the stage of completion of capital works. This may include contemporaneous photos and/or emails/statements from contractors or professional advisers confirming the degree of completion of capital works at the year end.	Medium	AOP management recognise their responsibility to accurately ascertain and reflect the financial state of affairs at year end in accordance with generally accepted accounting principles. In future, where there are capital works just prior to year-end and in the absence of documentary evidence, we will make every effort to gather as much contemporaneous evidence as possible to substantiate capital expenditure records up to 31 March.
AOP should ensure that they are monitoring their cash position closely and are only drawing down grant in aid from the Department as required in line with the requirements of MPMNI.	Medium	AOP use detailed financial modelling to ascertain the required drawdown amounts at the beginning of each month to ensure that sufficient cash is available to meet commitments for the next 6 weeks in order to comply with prompt payment guidelines. Inherent in this is a high degree of prediction of when supplier invoices, especially for capital works, will be received.

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: 17 December 2019

Professor Michael Burton
Accounting Officer
Armagh Observatory & Planetarium

Armagh Observatory and Planetarium Refereed Journal Publications: April 2018 – March 2019

1. Alecian G., **Stift M. J.**, 2019, Time-dependent atomic diffusion in the atmospheres of CP stars. A big step forward: introducing numerical models including a stellar mass-loss, *Monthly Notices Royal Astronomical Society*, 482, 4519, doi:10.1093/mnras/sty3003, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.482.4519A>
2. **Bailey, M. E.**, 2018, Asteroid and Cometary Impact Hazards, in *Frontiers of Space Risk: Natural Cosmic Hazards and Societal Challenges*, R. J. Wilman, C. J. Newman (Eds), Chapter 2, pp.15--35. CRC Press, Taylor & Francis, Boca Raton, Florida, USA.
3. **Bailey M., Byrne C., Nezc R., Asher D.**, Finnegan J., 2018, Historical observations of STEVE, *The Observatory*, 138, 227, <https://ui.adsabs.harvard.edu/abs/2018Obs...138..227B>
4. **Bagnulo S., Landstreet J. D.**, 2018, Searching for the weakest detectable magnetic fields in white dwarfs. Highly-sensitive measurements from first VLT and WHT surveys, *Astronomy & Astrophysics*, 618, A113, doi:10.1051/0004-6361/201833235, <https://ui.adsabs.harvard.edu/abs/2018AA...618A.113B>
5. Baran A. S., et al., inc. **Jeffery, C. S.** 2018, Pulsations and eclipse-time analysis of HW Vir, *Monthly Notices Royal Astronomical Society*, 481, 2721, doi:10.1093/mnras/sty2473, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.481.2721B>
6. **Borisov G., et al.**, 2018a, Rotational variation of the linear polarization of the asteroid (3200) Phaethon as evidence for inhomogeneity in its surface properties, *Monthly Notices Royal Astronomical Society*, 480, L131, doi:10.1093/mnras/sly140, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.480L.131B>
7. **Borisov G., Christou A. A., Colas F., Bagnulo S., Cellino A., Dell'Oro A.**, 2018b, (121514) 1999 UJ₇: A primitive, slow-rotating Martian Trojan, *Astronomy & Astrophysics*, 618, A178, doi:10.1051/0004-6361/201732466, <https://ui.adsabs.harvard.edu/abs/2018AA...618A.178B>
8. Braiding C., et al., inc. **Burton, M. G.** 2018, The Mopra Southern Galactic Plane CO Survey—Data Release 3, *Publications of the Astronomical Society of Australia*, 35, e029, doi:10.1017/pasa.2018.18, <https://ui.adsabs.harvard.edu/abs/2018PASA...35...29B>
9. **Byrne C. M., Jeffery C. S.**, 2018, Post-common envelope binary stars, radiative levitation, and blue large-amplitude pulsators, *Monthly Notices Royal Astronomical Society*, 481, 3810, doi:10.1093/mnras/sty2545, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.481.3810B>
10. **Byrne C. M., Jeffery C. S., Tout C. A., Hu H.**, 2018, The effects of diffusion in hot subdwarf progenitors from the common envelope channel, *Monthly Notices Royal Astronomical Society*, 475, 4728, doi:10.1093/mnras/sty158, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.475.4728B>
11. Cannizzo J. K., **Ramsay G.**, 2019, The Superoutburst Duration versus Orbital Period Relation for AM CVn Stars, *Astronomical Journal*, 157, 130, doi:10.3847/1538-3881/ab04ac, <https://ui.adsabs.harvard.edu/abs/2019AJ....157..130C>
12. Castro N., Crowther P. A., Evans C. J., Mackey J., Castro-Rodriguez N., **Vink J. S.**, Melnick J., Selman F., 2018, Mapping the core of the Tarantula Nebula with VLT-MUSE. I. Spectral and nebular content around R136, *Astronomy & Astrophysics*, 614, A147, doi:10.1051/0004-6361/201732084, <https://ui.adsabs.harvard.edu/abs/2018AA...614A.147C>
13. Cellino A., **Bagnulo S.**, Belskaya I. N., **Christou A. A.**, 2018, Unusual polarimetric properties of (101955) Bennu: similarities with F-class asteroids and cometary bodies, *Monthly Notices Royal Astronomical Society*, 481, L49, doi:10.1093/mnras/sly156, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.481L..49C>
14. Contreras Y., Rebolledo D., Breen S. L., Green A. J., **Burton M. G.**, 2019, Environmental conditions shaping star formation: the Carina Nebula, *Monthly Notices Royal Astronomical Society*, 483, 1437, doi:10.1093/mnras/sty3201, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.483.1437C>
15. CTA Consortium 2019, Science with the Cherenkov Telescope Array, inc. **Burton M. G.**, doi:10.1142/10986.
16. Dermott S. F., **Christou A. A.**, Li D., Kehoe T. J. J., Robinson J. M., 2018, The common origin of family and non-family asteroids, *Nature Astronomy*, 2, 549, doi:10.1038/s41550-018-0482-4, <https://ui.adsabs.harvard.edu/abs/2018NatAs...2..549D>
17. Devogèle M., et al., inc. **Bagnulo S., Borisov G.**, 2018a, New polarimetric and spectroscopic evidence of anomalous enrichment in spinel-bearing calcium-aluminium-rich inclusions among L-type asteroids, Icarus, 304, 31, doi:10.1016/j.icarus.2017.12.026, <https://ui.adsabs.harvard.edu/abs/2018Icar..304...31D>
18. Devogèle M., et al., inc. **Bagnulo S., Borisov G., Christou A. A.**, 2018b, The phase-polarization curve of asteroid (3200) Phaethon^y, *Monthly Notices Royal Astronomical Society*, 479, 3498, doi:10.1093/mnras/sty1587, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.479.3498D>
19. **Doyle J. G.**, et al., 2018a, Stellar flare oscillations: evidence for oscillatory reconnection and evolution of MHD modes, *Monthly Notices Royal Astronomical Society*, 475, 2842, doi:10.1093/mnras/sty032, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.475.2842D>
20. **Doyle L., Ramsay G., Doyle J. G.**, Wu K., Scullion E., 2018b, Investigating the rotational phase of stellar flares on M dwarfs using K2 short cadence data, *Monthly Notices Royal Astronomical Society*, 480, 2153, doi:10.1093/mnras/sty1963, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.480.2153D>
21. Dufton P. L., et al., inc. **Vink J. S.**, 2018, The VLT-FLAMES Tarantula Survey. XXVIII. Nitrogen abundances for apparently single dwarf and giant B-type stars with small projected rotational velocities,

- Astronomy & Astrophysics, 615, A101, doi:10.1051/0004-6361/201732440, <https://ui.adsabs.harvard.edu/abs/2018AA...615A.101D>
22. El Mellah I., **Sander A. A. C.**, Sundqvist J. O., Keppens R., 2019, Formation of wind-captured disks in supergiant X-ray binaries. Consequences for Vela X-1 and Cygnus X-1, Astronomy & Astrophysics, 622, A189, doi:10.1051/0004-6361/201834498, <https://ui.adsabs.harvard.edu/abs/2019AA...622A.189E>
 23. Evans C. J., et al., inc. **Vink J. S.**, 2019, First stellar spectroscopy in Leo P, Astronomy & Astrophysics, 622, A129, doi:10.1051/0004-6361/201834145, <https://ui.adsabs.harvard.edu/abs/2019AA...622A.129E>
 24. Gruner D., et al., inc. **Sander A. A. C.**, 2019, The extreme O-type spectroscopic binary HD 93129A. A quantitative, multiwavelength analysis, Astronomy & Astrophysics, 621, A63, doi:10.1051/0004-6361/201833178, <https://ui.adsabs.harvard.edu/abs/2019AA...621A..63G>
 25. Günay B., Schmidt T. W., **Burton M. G.**, Afşar M., Krechkivska O., Nauta K., Kable S. H., Rawal A., 2018, Aliphatic hydrocarbon content of interstellar dust, Monthly Notices Royal Astronomical Society, 479, 4336, doi:10.1093/mnras/sty1582, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.479.4336G>
 26. Hainich R., Ramachandran V., Shenar T., **Sander A. A. C.**, Todt H., Gruner D., Oskinova L. M., Hamann W. R., 2019, PoWR grids of non-LTE model atmospheres for OB-type stars of various metallicities, Astronomy & Astrophysics, 621, A85, doi:10.1051/0004-6361/201833787, <https://ui.adsabs.harvard.edu/abs/2019AA...621A..85H>
 27. **Hall P. D.**, **Jeffery C. S.**, 2018, The positive binding energy envelopes of low-mass helium stars, Monthly Notices Royal Astronomical Society, 475, 3889, doi:10.1093/mnras/sty055, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.475.3889H>
 28. **Higgins E. R.**, **Vink J. S.**, 2019, Massive star evolution: rotation, winds, and overshooting vectors in the mass-luminosity plane. I. A calibrated grid of rotating single star models, Astronomy & Astrophysics, 622, A50, doi:10.1051/0004-6361/201834123, <https://ui.adsabs.harvard.edu/abs/2019AA...622A..50H>
 29. Kalari V. M., **Vink J. S.**, Dufton P. L., Fraser M., 2018, How common is LBV S Doradus variability at low metallicity?, Astronomy & Astrophysics, 618, A17, doi:10.1051/0004-6361/201833484, <https://ui.adsabs.harvard.edu/abs/2018AA...618A..17K>
 30. Keys P. H., et al., inc. **Doyle J. G.**, 2018, Photospheric Observations of Surface and Body Modes in Solar Magnetic Pores, Astrophysical Journal, 857, 28, doi:10.3847/1538-4357/aab432, <https://ui.adsabs.harvard.edu/abs/2018ApJ...857...28K>
 31. Koumpia E., et al., inc. **Vink J.S.**, 2019, Resolving the MYSO binaries PDS 27 and PDS 37 with VLTI/PIONIER, Astronomy & Astrophysics, 623, L5, doi:10.1051/0004-6361/201834624, <https://ui.adsabs.harvard.edu/abs/2019AA...623L...5K>
 32. Krause M. G. H., inc. **Sarzi M.**, et al., 2019, How frequent are close supermassive binary black holes in powerful jet sources?, Monthly Notices Royal Astronomical Society, 482, 240, doi:10.1093/mnras/sty2558, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.482..240K>
 33. Kubátová B., et al., inc. **Sander A. A. C.**, 2019, Low-metallicity massive single stars with rotation. II. Predicting spectra and spectral classes of chemically homogeneously evolving stars, Astronomy & Astrophysics, 623, A8, doi:10.1051/0004-6361/201834360, <https://ui.adsabs.harvard.edu/abs/2019AA...623A...8K>
 34. Kupfer T., et al., inc. **Ramsay G.**, 2018, LISA verification binaries with updated distances from Gaia Data Release 2, Monthly Notices Royal Astronomical Society, 480, 302, doi:10.1093/mnras/sty1545, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.480..302K>
 35. **Landstreet J. D.**, **Bagnulo S.**, 2019, Discovery of kilogauss magnetic fields on the nearby white dwarfs WD 1105-340 and WD 2150+591, Astronomy & Astrophysics, 623, A46, doi:10.1051/0004-6361/201834638, <https://ui.adsabs.harvard.edu/abs/2019AA...623A..46L>
 36. Lau J. C., et al., inc. **Burton, M. G.** 2019, Probing the origin of the unidentified TeV [Symbol][Symbol]-ray source HESS J1702-420 via the surrounding interstellar medium, Monthly Notices Royal Astronomical Society, 483, 3659, doi:10.1093/mnras/sty3326, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.483.3659L>
 37. Lee Y.-H., Koo B.-C., Lee J.-J., **Burton M. G.**, Ryder S., 2019, Near-infrared [Fe II] and H₂ Emission-line Study of Galactic Supernova Remnants in the First Quadrant, Astronomical Journal, 157, 123, doi:10.3847/1538-3881/ab0212, <https://ui.adsabs.harvard.edu/abs/2019AJ....157..123L>
 38. **Li D.**, **Christou A. A.**, 2018, Long-term self-modification of irregular satellite groups, Icarus, 310, 77, doi:10.1016/j.icarus.2017.12.004, <https://ui.adsabs.harvard.edu/abs/2018Icar..310...77L>
 39. Margonis A., **Christou A A.**, Oberst J., 2018, Observations of meteors in the Earth's atmosphere: Reducing data from dedicated double-station wide-angle cameras, Astronomy & Astrophysics, 618, A99, doi:10.1051/0004-6361/201832927, <https://ui.adsabs.harvard.edu/abs/2018AA...618A..99M>
 40. Maxted N. I., et al., inc. **Burton M. G.**, 2018, Searching for an interstellar medium association for HESS J1534 - 571, Monthly Notices Royal Astronomical Society, 480, 134, doi:10.1093/mnras/sty1797, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.480..134M>
 41. Nedelchev B., et al., inc. **Sarzi M.**, 2019, The properties of the kinematically distinct components in NGC 448 and NGC 4365, Astronomy & Astrophysics, 623, A87, doi:10.1051/0004-6361/201832840, <https://ui.adsabs.harvard.edu/abs/2019AA...623A..87N>
 42. Pagotto I., Corsini E. M., **Sarzi M.**, Pagani B., Dalla Bont`a E., Morelli L., Pizzella A., 2019, A catalogue of nuclear stellar velocity dispersions of nearby galaxies from H α STIS spectra to constrain supermassive black hole masses, Monthly Notices Royal Astronomical Society, 483, 57, doi:10.1093/mnras/sty2918, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.483...57P>

43. Pala A. F., et al., inc. **Landstreet J. D.**, 2019, Evidence for mass accretion driven by spiral shocks onto the white dwarf in SDSS J123813.73-033933.0, Monthly Notices Royal Astronomical Society, 483, 1080, doi:10.1093/mnras/sty3174, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.483.1080P>
44. **Preece H. P.**, Tout C. A., **Jeffery C. S.**, 2018, Tidal Interactions of Close Hot Subdwarf Binaries, Monthly Notices Royal Astronomical Society, 481, 715, doi:10.1093/mnras/sty2091, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.481..715P>
45. Prisinzano L., et al., inc. **Vink J.S.**, 2019, The Gaia-ESO Survey: Age spread in the star forming region NGC 6530 from the HR diagram and gravity indicators, Astronomy & Astrophysics, 623, A159, doi:10.1051/0004-6361/201834870, <https://ui.adsabs.harvard.edu/abs/2019AA...623A.159P>
46. **Ramsay G.**, 2018, Identifying blue large-amplitude pulsators in the Galactic plane using Gaia DR2: a case study, Astronomy & Astrophysics, 620, L9, doi:10.1051/0004-6361/201834604, <https://ui.adsabs.harvard.edu/abs/2018AA...620L...9R>
47. **Ramsay G.**, Marsh T. R., Kupfer T., Dhillon V. S., Steeghs D., Woudt P., Groot P., 2018a, Detection of a 23.6 min periodic modulation in the optical counterpart of 3XMMJ051034.6-670353, Astronomy & Astrophysics, 617, A88, doi:10.1051/0004-6361/201833305, <https://ui.adsabs.harvard.edu/abs/2018AA...617A..88R>
48. **Ramsay G.**, et al., 2018b, Physical properties of AM CVn stars: New insights from Gaia DR2, Astronomy & Astrophysics, 620, A141, doi:10.1051/0004-6361/201834261, <https://ui.adsabs.harvard.edu/abs/2018AA...620A.141R>
49. Reed M. D., et al., inc. **Jeffery C. S.**, 2018, A review of seismic observations of Kepler and K2- Observed sdBV stars, Open Astronomy, 27, 157, doi:10.1515/astro-2018-0015, <https://ui.adsabs.harvard.edu/abs/2018OAst...27..157R>
50. Reed M. D., et al., inc. **Jeffery C. S.**, 2019, Two p-mode-dominated subdwarf B pulsators in binaries with F-star companions observed with K2, Monthly Notices Royal Astronomical Society, 483, 2282, doi:10.1093/mnras/sty3025, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.483.2282R>
51. Renzo M., et al., inc. **Vink J.S.**, 2019, Space astrometry of the very massive 150 M_⊙ candidate runaway star VFTS682, Monthly Notices Royal Astronomical Society, 482, L102, doi:10.1093/mnras/sly194, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.482L.102R>
52. Riquelme D., et al., inc. **Burton M. G.**, 2018, Footpoints of the giant molecular loops in the Galactic center region, Astronomy & Astrophysics, 613, A42, doi:10.1051/0004-6361/201629065, <https://ui.adsabs.harvard.edu/abs/2018AA...613A..42R>
53. Saio H., **Jeffery C. S.**, 2019, The excitation of g-mode pulsations in hot helium-rich sub-dwarfs, Monthly Notices Royal Astronomical Society, 482, 758, doi:10.1093/mnras/sty2763, <https://ui.adsabs.harvard.edu/abs/2019MNRAS.482..758S>
54. **Sander A. A. C.**, Hamann W. R., Todt H., Hainich R., Shenar T., Ramachandran V., Oskinova L. M., 2019, The Galactic WC and WO stars. The impact of revised distances from Gaia DR2 and their role as massive black hole progenitors, Astronomy & Astrophysics, 621, A92, doi:10.1051/0004-6361/201833712, <https://ui.adsabs.harvard.edu/abs/2019AA...621A..92S>
55. Sano H., et al., inc. **Burton M. G.**, 2018, RCW 36 in the Vela Molecular Ridge: Evidence for high-mass star-cluster formation triggered by cloud-cloud collision, Publications of the Astronomical Society of Japan, 70, S43, doi:10.1093/pasj/psy006, <https://ui.adsabs.harvard.edu/abs/2018PASJ...70S..43S>
56. Schneider F. R. N., et al., inc. **Vink J. S.**, 2018a, Response to Comment on "An excess of massive stars in the local 30 Doradus starburst", Science, 361, aat7032, doi:10.1126/science.aat7032, <https://ui.adsabs.harvard.edu/abs/2018Sci...361.7032S>
57. Schneider F. R. N., et al., inc. **Vink J. S.**, 2018b, The VLT-FLAMES Tarantula Survey. XXIX. Massive star formation in the local 30 Doradus starburst, Astronomy & Astrophysics, 618, A73, doi:10.1051/0004-6361/201833433, <https://ui.adsabs.harvard.edu/abs/2018AA...618A..73S>
58. Shetye J., Shelyag S., Reid A. L., Scullion E., **Doyle J. G.**, Arber T. D., 2018, Signatures of quiet Sun reconnection events in Ca II, H α , and Fe I, Monthly Notices Royal Astronomical Society, 479, 3274, doi:10.1093/mnras/sty1548, <https://ui.adsabs.harvard.edu/abs/2018MNRAS.479.3274S>
59. Srivastava A. K., et al., 2018, inc. **Doyle J. G.**, Confined pseudo-shocks as an energy source for the active solar corona, Nature Astronomy, 2, 951, doi:10.1038/s41550-018-0590-1, <https://ui.adsabs.harvard.edu/abs/2018NatAs...2..951S>
60. Sterzik M. F., **Bagnulo S.**, Stam D. M., Emde C., Manev M., 2019, Spectral and temporal variability of Earth observed in polarization, Astronomy & Astrophysics, 622, A41, doi:10.1051/0004-6361/201834213, <https://ui.adsabs.harvard.edu/abs/2019AA...622A..41S>
61. Subramanian S., Kashyap V. L., Tripathi D., Madjarska M. S., **Doyle J. G.**, 2018, Energetics of Hi-C EUV brightenings, Astronomy & Astrophysics, 615, A47, doi:10.1051/0004-6361/201629304, <https://ui.adsabs.harvard.edu/abs/2018AA...615A..47S>
62. Supan L., Castelletti G., Supanitsky A. D., **Burton M. G.**, Wong G. F., Braiding C., 2018a, Natal molecular cloud of SNR Kes 41. Complete characterisation, Astronomy & Astrophysics, 619, A108, doi:10.1051/0004-6361/201833183, <https://ui.adsabs.harvard.edu/abs/2018AA...619A.108S>
63. Supan L., Castelletti G., Supanitsky A. D., **Burton M. G.**, 2018b, Unidentified [Symbol]-ray emission towards the SNR Kes 41 revisited, Astronomy & Astrophysics, 619, A109, doi:10.1051/0004-6361/201834075, <https://ui.adsabs.harvard.edu/abs/2018AA...619A.109S>

64. Toalá J. A., et al., inc. **Sander A. A. C.**, 2018, On the Apparent Absence of Wolf-Rayet+Neutron Star Systems: The Curious Case of WR124, *Astrophysical Journal*, 869, L11, doi:10.3847/2041-8213/aaf39d, <https://ui.adsabs.harvard.edu/abs/2018ApJ...869L..11T>
65. Tziotziou K., Tsiropoula G., Kontogiannis I., Scullion E., **Doyle J. G.**, 2018, A persistent quiet-Sun small-scale tornado. I. Characteristics and dynamics, *Astronomy & Astrophysics*, 618, A51, doi:10.1051/0004-6361/201833101, <https://ui.adsabs.harvard.edu/abs/2018AA...618A..51T>
66. Viaene S., et al., inc. **Sarzi M.**, 2019, The Fornax 3D project: dust mix and gas properties in the centre of early-type galaxy FCC 167, *Astronomy & Astrophysics*, 622, A89, doi:10.1051/0004-6361/201834465, <https://ui.adsabs.harvard.edu/abs/2019AA...622A..89V>
67. **Vink J. S.**, 2018a, Very massive stars: a metallicity-dependent upper-mass limit, slow winds, and the self-enrichment of globular clusters, *Astronomy & Astrophysics*, 615, A119, doi:10.1051/0004-6361/201832773, <https://ui.adsabs.harvard.edu/abs/2018AA...615A.119V>
68. **Vink J. S.**, 2018b, Fast and slow winds from supergiants and luminous blue variables, *Astronomy & Astrophysics*, 619, A54, doi:10.1051/0004-6361/201833352, <https://ui.adsabs.harvard.edu/abs/2018AA...619A..54V>
69. in't Zand J. J. M., et al., inc. **Doyle. J. G.**, 2019, Observatory science with eXTP, *Science China Physics, Mechanics, and Astronomy*, 62, 29506, doi:10.1007/s11433-017-9186-1, <https://ui.adsabs.harvard.edu/abs/2019SCPMA..6229506I>

Armagh Observatory and Planetarium

Non Refereed Journal Publications: April 2018 – March 2019

1. **Bagnulo S.**, Cellino A., **Borisov G.**, **Christou A. A.**, Stam D., Belskaya I., Sterzik M., Muinonen K., 2018, in European Planetary Science Congress. First steps towards a database of polarisation spectra of asteroids. pp EPSC2018–836
2. Bebekovska E. V., **Borisov G.**, Donchev Z., Apostolovska G., 2018, in Recio-Blanco A., de Laverny P., Brown A. G. A., Prusti T., eds, IAU Symposium Vol. 330, Astrometry and Astrophysics in the Gaia Sky. Preliminary Results of Low Dispersion Asteroid Spectroscopy Survey at NAO Rozhen. pp 395–396, doi:10.1017/S174392131700566X
3. Beccari G., et al., inc. **Vink J. S.**, 2018, The Accretion Discs in H α with OmegaCAM (ADHOC) Survey, The Messenger, 173, 17, doi:10.18727/0722-6691/5093, <https://ui.adsabs.harvard.edu/abs/2018Msngr.173...17B>
4. Cellino A., Devogele M., Belskaya I., **Bagnulo S.**, Bendjoya P., 2018, in European Planetary Science Congress. (3200) Phaethon: asteroid or comet?. pp EPSC2018–251
5. **Christou A. A.**, Dermott S., Li D., 2018b, in European Planetary Science Congress. Chaotic transport of Main Belt asteroids in Martian resonances. pp EPSC2018–396
6. **Christou A. A.**, dell'Oro A., **Borisov G.**, **Bagnulo S.**, Cellino A., 2018c, in European Planetary Science Congress. Earth's missing coorbitals. pp EPSC2018–118
7. **Christou A.A.**, Vaubaillon J., Withers P., Hueso R., 2018a, in European Planetary Science Congress. Extra-terrestrial meteors: a review. pp EPSC2018–775
8. **Doyle L.**, **Ramsay G.**, **Doyle J. G.**, 2018, in Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun. Searching for the Origin of Flares in M dwarfs, Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun. p. 81 (arXiv:1811.06594), doi:10.5281/zenodo.1489285
9. Evans C., et al., inc. **Vink J. S.**, 2018, A First Spectroscopic Census of the Dwarf Galaxy Leo P, The Messenger, 174, 24, doi:10.18727/0722-6691/5109, <https://ui.adsabs.harvard.edu/abs/2018Msngr.174...24E>
10. Keys P., et al., inc. **Vink J. S.**, 2018, in AGU Fall Meeting Abstracts. Photospheric Observations of Surface and Body Modes in Solar Magnetic Pores. pp SH23D–3340
11. Kupfer, T., Breed, E., **Ramsay, G.**, Hogd, S., Marsh, T., 2019, ATel, 12558, Detection of a photometric period during outburst in the AMCVn binary SDSS J080710.33+485259.6, <http://www.astronomerstelegam.org/?read=12558>
12. **Li D.**, **Christou A. A.**, 2018, in AAS/Division for Planetary Sciences Meeting Abstracts. Long-term gravitational spreading of irregular satellite families. p. 407.12
13. Littlefield C., Garnavich P., Szkody P., **Ramsay G.**, Howell S., Kennedy M., 2019, in American Astronomical Society Meeting Abstracts #233. Short-cadence K2 observations of an accretion-state transition in Tau 4, the first polar observed by Kepler. p. 374.02
14. Margonis A., Oberst J., **Christou A. A.**, 2018, in European Planetary Science Congress. The Perseids: Results from 7 years of observations with the SPOSH camera. Pp EPSC2018–979
15. Munoz M., Wade G. A., Nazé Y., Bagnulo S., Puls J., 2018, in 3rd BRITE Science Conference. The Of?p Stars of the Magellanic Clouds: Are They Strongly Magnetic?. Pp 43–47
16. **Nezic R.**, **Bagnulo S.**, Jones G. H., **Borisov G.**, 2018, in European Planetary Science Congress. Linear polarisation of comets observed with STEREO. Pp EPSC2018–1016
17. Reed M., et al., inc. **Jeffery C. S.**, 2019, in American Astronomical Society Meeting Abstracts #233. K2 & K1 Precision asteroseismology of hot horizontal branch (subdwarf B) stars. p. 418.04
18. Smette A., **Bagnulo S.**, Snik F., Cox N., Hainaut O., Hutsemekers D., Magalhaes A. M., 2018, in VST in the Era of the Large Sky Surveys. VST: The First Large Survey Telescope for Optical Polarimetry. p. 44, doi:10.5281/zenodo.1304780
19. Steeghs, D., plus 36 co-authors, inc. **Ramsay, G.**, 2019, GCN 24291, LIGO/Virgo S190426c: GOTO optical coverage - no notable counterparts, <https://gcn.gsfc.nasa.gov/gcn/gcn3/24291.gcn3>
20. Steeghs, D., plus 35 co-authors, inc. **Ramsay, G.**, 2019, GCN 24224, LIGO/Virgo S190425z: GOTO observations., <https://gcn.gsfc.nasa.gov/gcn/gcn3/24224.gcn3>
21. Steeghs, D., plus 31 co-authors, inc. **Ramsay, G.**, 2019, GCN 24116, LIGO/Virgo S190412m: GOTO optical coverage - no notable counterparts, <https://gcn.gsfc.nasa.gov/gcn/gcn3/24116.gcn3>
22. Steeghs, D., plus 20 co-authors, inc. **Ramsay, G.**, 2019, GCN 23833, GRB 190202A: GOTO optical observations., <https://gcn.gsfc.nasa.gov/gcn/gcn3/23833.gcn3>
23. Steeghs, D., plus 19 co-authors, inc. **Ramsay, G.**, 2019, GCN 23821, GRB 190129B: GOTO optical observations <https://gcn.gsfc.nasa.gov/gcn/gcn3/23821.gcn3>
24. Steeghs, D., plus 19 co-authors, inc. **Ramsay, G.**, 2019, GCN 23774, GRB 190123A: GOTO optical limit., <https://gcn.gsfc.nasa.gov/gcn/gcn3/23774.gcn3>

Armagh Observatory and Planetarium Presentations: April 2018 – March 2019

Date	Speaker	Title	Location	Country	Category
03 Apr 2018	S. Bagnulo	Optical Spectropolarimetry: Lessons Learnt in the Past Decade, and New Challenges for the Future	European Week of Astronomy and Space Science 2018, Liverpool, England	England	Research
11 Apr 2018	M. Burton	Astronomy in the A Level Physics Syllabus	Armagh Learning Community, Royal School/Armagh Planetarium, Armagh, Co. Armagh	Northern Ireland	Internal Teaching
14 May 2018	S. Bagnulo	Basic Principles and Astronomical Applications of Polarimetry	Delft University of Technology, Delft, The Netherlands	The Netherlands	Research
14 May 2018	Y. Metodieva	Activity in the Bottom of the Main Sequence	Astronomy Ireland Lectures, Trinity College Dublin, Ireland	Ireland	Research
07 Jun 2018	S. Bagnulo	VST: The First Large Survey Telescope for Optical Polarimetry	"VST In the Era of the Large Sky Survey" Conference, Napoli, Italy	Italy	Research
11 Jun 2018	A. Christou	The Insight Mission	Astrobytes, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Internal Outreach
14 Jun 2018	L. Doyle	Searching for the Origin of Flare M Dwarfs	ESPOS Webinar	Worldwide	Research
26 Jun 2018	M. Burton	The Interstellar Medium	Dublin Institute for Advanced Studies Summer School on High-Energy Astrophysics, Dublin City University, Ireland	Ireland	Research
26 Jun 2018	J. Vink	Dark Matter and Dark Energy	Astrobytes, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Internal Outreach
03 Jul 2018	M. Sarzi	F3D: A Survey of Fornax with MUSE	Astrophysics Research Centre, Queen's University Belfast, Co Antrim	Northern Ireland	Research
17 Jul 2018	J. Vink	Massive Star Mass Loss	Ensenada, Mexico	Mexico	Research
26 Jul 2018	J. Landstreet	Searching For and Modelling the Weakest White Dwarf Magnetic Fields	21st European White Dwarf Workshop, University of Texas, Austin, Texas, USA	USA	Research
31 Jul 2018	L. Doyle	Investigating the Rotational Phase of Stellar Flares on M Dwarfs	Cool Stars 20 Conference, Boston University, Boston, Massachusetts, USA	USA	Research
23 Aug 2018	C.S. Jeffery	Pulsations as Probes in Hydrogen-Deficient Atmospheres	XXXth General Assembly of the IAU, Vienna, Austria	Austria	Research
27 Aug 2018	M. Burton	The Mopra Southern Galactic Plane CO Survey	XXXth General Assembly of the IAU, Division H (Interstellar Matter and Nearby Universe) Meeting, Vienna, Austria	Austria	Research
28 Aug 2018	A. Sander	Massive Star Atmospheres and Donar Star Winds in HMXBs (Invited)	XXXth General Assembly of the IAU, Symposium 346, Vienna, Austria	Austria	Research
29 Aug 2018	A. Christou	The Martian Trojans and the Closest Asteroid Family to the Sun	XXXth General Assembly of the IAU, Symposium 346, Vienna, Austria	Austria	Research
29 Aug 2018	J. Vink	Constraining the Progenitor Evolution of GW 150914	XXXth General Assembly of the IAU, Symposium 346, Vienna, Austria	Austria	Research
05 Sep 2018	M. Burton	The Mopra Southern Galactic Plane CO Survey	Irish National Astronomy Meeting, Birr, Co. Offaly, Ireland	Ireland	Research
06 Sep 2018	C. Byrne	Post-Common-Envelope Binary Stars: Radiative Levitation and Blue Large-Amplitude Pulsators	Physics of Oscillating Stars Conference, Banyuls-sur-mer, France	France	Research
06 Sep 2018	M. Sarzi	F3D: A Survey of Fornax with MUSE	Irish National Astronomy Meeting, Birr, Co. Offaly, Ireland	Ireland	Research

Date	Speaker	Title	Location	Country	Category
10 Sep 2018	C.S. Jeffery	Hydrogen-Deficient Stars 2018: Welcome and Introduction	4th Hydrogen Deficient Stars Conference, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Research
10 Sep 2018	P. Martin	Distances and Luminosities of Hydrogen-Deficient Stars in the Galaxy	4th Hydrogen Deficient Stars Conference, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Research
10 Sep 2018	A. Sander	Spectral Modelling and Analyses of High and Low-Mass Wolf-Rayet Stars	4th Hydrogen Deficient Stars Conference, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Research
10 Sep 2018	J. Vink	Mass Loss Predictions for Hydrogen-Deficient Stars	4th Hydrogen Deficient Stars Conference, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Research
12 Sep 2018	M. Sarzi	F3D: A Survey of Fornax with MUSE	Sub-Department of Astronomy, Padova University, Italy	Italy	Research
14 Sep 2018	C. Byrne	Post-Common-Envelope Binary Stars: Radiative Levitation and Blue Large-Amplitude Pulsators	4th Hydrogen Deficient Stars Conference, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Research
14 Sep 2018	C.S. Jeffery	Pulsations as Probes in Hydrogen-Deficient Atmospheres	4th Hydrogen Deficient Stars Conference, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Research
15 Sep 2018	A. Christou	The Armagh Observatory Meteor Camera Project	NEMETODE Meteor Workshop, Dunsink Observatory, Dublin, Ireland	Ireland	Research
17 Sep 2018	A. Christou	Extra-terrestrial Meteors	European Planetary Science Congress 2018, Berlin, Germany	Germany	Research
18 Sep 2018	A. Christou	Earth's Missing Coorbitals	2018 European Planetary Science Congress, Berlin, Germany	Germany	Research
20 Sep 2018	S. Bagnulo	First Step Towards a Dataset of Polarisation Spectra of Asteroids	European Planetary Science Congress 2018, Berlin, Germany	Germany	Research
20 Sep 2018	R. Nežič	Linear Polarisation of Comets Observed with STEREO	European Planetary Science Congress 2018, Berlin, Germany	Germany	Research
08 Oct 2018	A Sander	Unveiling the Role of the Donor Stars in HMXBs with Stellar Atmospheres	Stellar Winds in Wind-fed Systems Workshop, Santander, Spain	Spain	Research
08 Oct 2018	J. Vink	Stellar Winds	Stellar Winds in Wind-fed Systems Workshop, Santander, Spain	Spain	Research
25 Oct 2018	C. Byrne	Atomic Diffusion in Post-Common Envelope Binary Stars	Seminar, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Research
26 Oct 2018	C. Byrne	Atomic Diffusion in Post-Common Envelope Binary Stars	Seminar Series, School of Physics, Trinity College, Dublin, Ireland	Ireland	Research
31 Oct 2018	J. Vink	The Most Massive Stars	University of Warwick, England, UK.	England	Research
13 Nov 2018	P. Martin	Precision Diagnostics of Pulsation and Evolution in Helium-Rich Low-Mass Stars	Trinity College Dublin	Ireland	Research
22 Nov 2018	C.S. Jeffery	Helium Stars, Heavy Metal, Hypervelocities and Explosions?	Xihua University, Nanchong, Sichuan	China	Research
26 Nov 2018	C.S. Jeffery	Helium Stars, Heavy Metal, Hypervelocities and Explosions?	Yunnan Observatory, Kunming, Yunnan	China	Research
29 Nov 2018	C.S. Jeffery	Helium Stars, Heavy Metal, Hypervelocities and Explosions?	Beijing Normal University, Beijing	China	Research
04 Dec 2018	J. Vink	Black Holes and Massive Stars	Astrobytes, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Internal Outreach

Date	Speaker	Title	Location	Country	Category
08 Jan 2018	M. Burton	Radio Astronomy	Astrobytes, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Internal Outreach
09 Jan 2019	A. Sander	Analysing the WC Star Population of M31	Astrophysics of Massive Stars Research Group Seminar, University of Potsdam, Potsdam, Germany	Germany	Research
12 Jan 2019	M. Burton (with M. Sarzi)	Augmented Reality and the Enhanced Orrery at the Armagh Observatory and Planetarium	ESMEA Workshop, University Paris Diderot, Paris, France	France	Research
23 Jan 2019	A. Sander	Understanding Wolf-Rayet Stars and Their Winds	Sheffield Astronomy Seminar, University of Sheffield, England	England	Research
31 Jan 2019	C.S. Jeffery	Helium Stars, Heavy Metal, Hypervelocities and Explosions?	Institute of Astronomy, Cambridge	England	Research
05 Feb 2019	G. Ramsay	Doppler Effect	Astrobytes, Armagh Observatory and Planetarium, Armagh, Co. Armagh	Northern Ireland	Internal Outreach
06 Feb 2019	C.S. Jeffery	The Role of Space Telescopes in Stellar Astronomy	United Arab Emirates University	United Arab Emirates	Research
25 Feb 2019	C.S. Jeffery	Stellar Pulsation: Excitation, Diagnosis and Seismology	Dept of Applied Mathematics and Theoretical Physics, Cambridge	England	Research
26 Feb 2019	A. Christou	Near Earth Asteroid Research at Armagh	UK NEA Community Meeting, Royal Astronomical Society, Burlington House, Piccadilly, London	England	Research
27 Feb 2019	C.S. Jeffery	Helium Stars, Heavy Metal, Hypervelocities and Explosions?	University College, London	England	Research
06 Mar 2019	C.S. Jeffery	Helium Stars, Heavy Metal, Hypervelocities and Explosions?	University of Warwick	England	Research
07 Mar 2019	L. Doyle	The Rotational Phase Distribution of Stellar Flares on M Dwarfs	Kepler and K2 Science Conference V, Los Angeles, USA	USA	Research
12 Mar 2019	S. Bagnulo	Polarisation by Scattering and Biomarkers (Invited)	Meeting to Celebrate the 20th Anniversary of the FORS Instrument, European Southern Observatory, Garching, Germany	Germany	Research
15 Mar 2019	A. Sander	Stellar Winds and Massive Binaries	Seminar at the Institute of Astronomy, KU Leuven, Belgium	Belgium	Research

Armagh Observatory and Planetarium Education and Outreach Activities: April 2018 - March 2019

Date	Event Description	Location	Personnel	Category
11-Apr-18 18-Apr-18	2017/18 A-Level Physics Course in association with Armagh Area Learning Community	Royal School, Armagh, BT61 9DH	M. Burton, Staff and Students	Education
12-Apr-18	Talk: Women in Astronomy from the Maunder Minimum, to Leavitt and Hubble's Expanding Universe	Alley Theatre, Strabane, Co. Tyrone, BT82 8DQ	J. Vink	Outreach
24-Apr-18	Talk: The Heavens Above - The Sun and Its Influence on Life on Earth, Friends of the Armagh Cathedral Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	M. Burton	Outreach
01-May-18	Planetarium 50th Anniversary Event: Ulster Orchestra Schools Event (event preparation included outreach visits by the Ulster Orchestra to 4 local schools to provide music workshops)	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	M. Burton, Staff and Students	Education
02-May-18	Planetarium 50th Anniversary Event: Panel Discussion - Women in Science (an interactive panel discussion with accomplished women shaping the future of science and technology)	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	M. Burton, Staff and Students	Outreach
10-May-18	Talk: Out There – The Search for Other Worlds, General Synod of the Church of Ireland Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	M. Burton	Outreach
21-May-18	Talk: Annie Maunder's Contributions to Science	Annie Maunder Blue Plaque Unveiling, Strabane, Co. Tyrone, BT82 8DG	M. Burton	Outreach
13-Jun-18	Talk: A Short History of Measuring the Heavens from Armagh	Robinson Public Library, 43 Abbey Street, Armagh, Co. Armagh, BT61 7DY	M. Burton	Outreach
21-Jun-18	Solar Telescope Observing, Beaghmore Stone Circles Solstice Event in association with Mid Ulster Council	Beaghmore Stone Circles, Blackrock Road, Cookstown, Co. Tyrone, BT80 9PB	Y. Metodieva	Outreach
25-Jun-18	Talk: Magic of Astronomy and Space Science	MRS Tribal School Idukki, India	A. Sekhar	Outreach
03-Jul-18	Children's Hospital Visit	The Royal Belfast Hospital for Sick Children, 247 Grosvenor Road, Belfast, BT12 6BA	N. Parke	Outreach
06-Jul-18	Castleblaney Science Festival	Castleblaney, Co. Monaghan, Ireland	N. Parke	Outreach
07-Jul-18	Force Academy Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
27-Jul-18	An Evening with the Planets at Armagh Observatory	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	M. Burton, Staff and Students	Event
28-Jul-18	Talk: Astronomical Events Impacting Our Earth	Sunflowerfest, Tubby's Farm, 31 Cabra Road, Legacurry Road, Hillsborough, Co. Down, BT26 6NB	J. Vink	Outreach
28-Jul-18	Talk: The Role and Future of Women in Astronomy	Sunflowerfest, Tubby's Farm, 31 Cabra Road, Legacurry Road, Hillsborough, Co. Down, BT26 6NB	H. Preece	Outreach
28-Jul-18 to 29-Jul-18	50 Years of Sci-Fi Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
03-Aug-18	Engineering Week Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
18-Aug-18	Force Academy Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
21-Jul-18	Children's Hospital Visit	The Royal Belfast Hospital for Sick Children, 247 Grosvenor Road, Belfast, BT12 6BA	N. Parke	Outreach
24-Aug-18 to 25-Aug-18	Minecraft at AOP	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event

Date	Event Description	Location	Personnel	Category
27-Aug-18	Family Fun Day	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
31-Aug-18	Talk: Scope of Citizen Science and Public Outreach Projects in the Developing World	XXXth General Assembly of the IAU, Symposium 346, Vienna, Austria	A. Sekhar	Outreach Policy
08-Sep-18	Tour: Guided Tours of the Armagh Observatory and Planetarium in association with European Heritage Open Days	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	Staff	Outreach
08-Sep-18	Talk: 50 Years of the Armagh Planetarium	British Association of Planetaria Annual Meeting, Thinktank, Birmingham	M. Burton, S. Mackle	Outreach
12-Sep-18	Public Lecture as part of the Hydrogen Deficient Stars Conference - Heavy Metals from Giant Stars by Amanda Karakas	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	C.S. Jeffery	Outreach
17-Sep-18	Talk: The Connacht Schools Planetary Radio Telescopes Network	2018 European Planetary Science Congress, Berlin, Germany	A. Golden	Outreach
25-Sep-18	Toddler Takeover Tuesday Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	H. McLoughlin	Event
28-Sep-18	Talk: CERN Travelling Exhibition to India	Department of Atomic Energy HQ, Mumbai, India	A. Sekhar	Science Policy/ Planning
04-Oct-18	Facebook Live Q&A, World Science Week Event	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	H. Alexander, G. Ramsay	Outreach
05-Oct-18	Space Selfie, World Science Week Event	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	Staff	Outreach
08-Oct-18	Talk: A History of Armagh Observatory	Astronomy Ireland, School of Physics, Trinity College, Dublin	M. Burton	Outreach
09-Oct-18	Space Engineering, Engineering and Space Careers Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
10-Oct-18	School Skype Q&A	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	H. Alexander, T. Watts	Education
12-Oct-18	Talk: CERN India Mega Science Exhibition	National Council of Science Museums HQ, Kolkata, India	A. Sekhar	Science Policy/ Planning
17-Oct-18	Talk: The Probability of a Doomsday Solar Superflare: Fact or Fiction?	Irish Astronomical Association, Bell Lecture Theatre, Queen's University, Belfast, Co. Antrim	J. G. Doyle	Outreach
19-Oct-18	The Juggling Scientist, Maths Week Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
23-Oct-18	Toddler Takeover Tuesday Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	H. McLoughlin	Event
23-Oct-18	Talk: Meteorites (or Rocks That Fall From the Sky)	Newtownabbey Rotary Club, Corr's Corner Hotel, 35 Ballyclare Road, Newtownabbey, BT36 4TQ	A. Christou	Outreach
30-Oct-18	Murder at Armagh Observatory Event	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	Staff	Event
31-Oct-18	Supermassive Black Holes, the DNA of Galaxies	Irish Astronomical Association, Bell Lecture Theatre, Queen's University, Belfast, Co. Antrim	M. Sarzi	Outreach
01-Nov-18 to 02-Nov-18	Potions and Explosions Live Science Show	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
05-Nov-18	Talk: The Origin of Comets: A Riddle Wrapped in an Enigma	Causeway U3A, Agherton Parish Centre, Portstewart, Co Antrim, BT55 7AH (Invited)	M.E. Bailey	Outreach
08-Nov-18	Schools Education Outreach Programme	St. Ronan's Primary and Nursery School, 34-36 Nutfield Road, Lisnaskea, Enniskillen, BT92 0LA	H. McLoughlin R. Mee	Education

Date	Event Description	Location	Personnel	Category
13-Nov-18	Star Tracker Evening (included talk on Massive Stars by E. Rojas Montes)	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
14-Nov-18	Schools Education Outreach Programme	Bellarena Primary School, 260 Sea Coast Road, Limavady, Co. Londonderry, BT49 0JB	H. McLoughlin R. Mee	Education
20-Nov-18	Talk: Remarks on the ancient Chinese Astronomer Luo Xiahong	Luo Xiahong Conference, Langzhong, Sichuan, China	C.S. Jeffery	Outreach
24-Nov-18	Tour: Georgian Day Tours at Armagh Observatory and Planetarium in association with ACBCBC	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	M. Burton, H. Alexander	Outreach
27-Nov-18	Toddler Takeover Tuesday Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	H. Mcloughlin	Event
29-Nov-18	Talk: General Astronomy	Cub Scout Group, Armagh Planetarium, Armagh, Co. Armagh	T. Watts	Outreach
04-Dec-18	Mystery of the Christmas Star Evening Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
11-Dec-18	Star Tracker Evening (included talk "The Best of Hubble" by T. Watts)	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
11-Dec-18	AOP World Meteorological Organization Centennial Award Event Panel Event "Past, Present and Future of Air Quality" (included talk "Armagh Observatory's Weather Records: More than 220 Years Recording the Weather at Armagh" by M.E. Bailey)	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	Staff	Education
18-Dec-18	Mystery of the Christmas Star Evening Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
10-Jan-19	Star Tracker Evening	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
10-Jan-19	Facebook Live Q&A for 100 Hours of Astronomy	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	H. Alexander, G. Ramsay	Outreach
15-Jan-19	Schools Education Outreach Programme	Mount St. Michael's Primary School, 3 Craigstown Road, Randalstown, Co. Antrim, BT41 2AF	H. Alexander, R. Mee	Education
15-Jan-19	Talk: Robert Jarvis's aroundNorth: A New Tool for Communicating Astronomy to People Who Cannot See the Stars	Communicating Physics and Astronomy to a Visually Impaired Audience, University of Manchester	M.E. Bailey	Outreach
21-Jan-19	Total Lunar Eclipse at Armagh Observatory Event (included talk "The Total Lunar Eclipse of 21 January 2019" by M. Burton with A. Christou)	Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG	Staff	Outreach
22-Jan-19	Talk: The Armagh Orrery: Ground-Based Astronomy for All!	Portadown Probus, Seagoe Hotel, Craigavon, Co. Armagh, BT63 5JE	M.E. Bailey	Outreach
23-Jan-19	Schools Education Outreach Programme	Tullyallen National School, Drogheda, Co. Louth, Ireland	R. Mee, H. McLoughlin	Education
24-Jan-19	Schools Education Outreach Programme	Tullyallen National School, Drogheda, Co. Louth, Ireland	R. Mee, H. McLoughlin	Education
25-Jan-19	Schools Education Outreach Programme	Tullyallen National School, Drogheda, Co. Louth, Ireland	R. Mee, H. McLoughlin	Education
26-Jan-19	Talk: Stellar Coronal Mass Ejections & Implications for Life on Exoplanetary Systems	Galway Astrofest 2019, Galway, Ireland	A. Golden	Outreach
29-Jan-19	Toddler Takeover Tuesday Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	H. Mcloughlin	Event
01-Feb-19	Science Fiction: Facts Vs Myths	Assumption Grammar School Group, Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	M. Sarzi	Education
04-Feb-19	Tour of Observatory for Cycling Club	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Outreach

Date	Event Description	Location	Personnel	Category
12-Feb-19	Armagh Observatory's Weather Records: More than 220 Years Recording the Weather at Armagh	Armagh Probus, Armagh City Golf Club, Armagh Co. Armagh, BT60 1EN	M.E. Bailey	Outreach
14-Feb-19	International Book Giving Day	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
18-Feb-19	Little Professors Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	H. Mcloughlin	Event
18-Feb-19	Girls Takeover at AOP	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
19-Feb-19	Finding Planet B Workshop: Geological Event at the Planetarium	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
19-Feb-19	Star Tracker Evening (includes talk "Galaxies" by B. Nedelchev)	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
20-Feb-19	Hands on Science Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
20-Feb-19	Talk: Women in Astronomy: from the Maunder Minimum, to Leavitt and Hubble's expanding Universe"	Irish Astronomical Association, Bell Lecture Theatre, Queen's University, Belfast, Co. Antrim	J. Vink	Outreach
21-Feb-19	Dome Show Mystery Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
22-Feb-19	Planetarium After Dark Event (included talk "Weird Science" by M. Burton with H. Alexander)	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
26-Feb-19	Toddler Takeover Tuesday Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
27-Feb-19	Talk: Light Pollution and Its Impact: Inspiring Astronomy and Sustainable Development	Broughderg Community Centre, Broughderg, Co. Tyrone, BT79 8JN	M.E. Bailey	Outreach
06-Mar-19	Talk: A History of Armagh Observatory / The Human Orrery	The Geographies of Outer Space, Geography Class, Queen's University Belfast Visit to Armagh Observatory and Planetarium, Armagh, Co. Armagh, BT61 9DB	M. Burton	Education
08-Mar-19	Talk: The Heavens Declare the Glory of God (with Archbishop Richard Clarke, Archbishop Eamon Martin and Professor Monica Grady)	Ballyclog Church, Coagh Road, Stewartstown, Co Tyrone, BT71 5LL	M. Burton	Outreach
11-Mar-19	Launch of Summer Programme - One Giant Leap	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
12-Mar-19	Star Tracker Evening (includes talk "Women in Astronomy" by J. Vink)	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event
16-Mar-19	St. Patrick's Day Parade - Part of the Home of St. Patrick Festival March 2019	Armagh City Centre, Co Armagh	Staff	Outreach
16-Mar-19	St. Patrick's Day Lecture, The Moon @ 50: Rediscovering Our Moon Half a Century on from the Apollo 11 Landing - Part of the Home of St. Patrick Festival March 2019	Market Place Theatre and Arts Centre, Armagh, Co Armagh, BT61 7BW	M. Sarzi	Outreach
20-Mar-19 27-Mar-19	2018/19 A-Level Physics Course in association with Armagh Area Learning Community	Royal School, Armagh, BT61 9DH	M. Burton, Staff and Students	Education
25-Mar-19	Talk: Armagh Observatory's Weather Records: More than 220 Years Recording the Weather at Armagh (2 talks given)	Hart Memorial Primary School, Portadown, Co. Armagh, BT62 4BD	M.E. Bailey	Outreach
26-Mar-19	Toddler Takeover Tuesday Event	Armagh Planetarium, Armagh, Co. Armagh, BT61 9DB	Staff	Event

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 2019 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. I have also audited the information in the Remuneration and Staff Report that is described in that report as having been audited.

In my opinion the financial statements:

- give a true and fair view of the state of Armagh Observatory and Planetarium 's affairs as at 31 March 2019 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.

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 of opinions

I conducted my audit in accordance with International Standards on Auditing (UK) (ISAs) 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 Armagh Observatory and Planetarium in accordance with the ethical requirements of the Financial Reporting Council's Revised Ethical Standard 2016, 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.

Other Information

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

In connection with my audit of the financial statements, 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, 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:

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

Responsibilities of the Governors and Accounting Officer for the financial statements

As explained more fully in the Statement of the Responsibilities of the Governors and Accounting Officer, the Governors and the Accounting Officer are responsible for the preparation of the financial statements and for being satisfied that they give a true and fair view.

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 evidence about the amounts and disclosures in the financial statements sufficient to give reasonable assurance that the financial statements are free from material misstatement, whether caused by fraud or error. 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.

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.

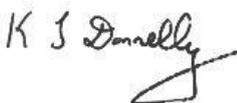
Matters on which I report by exception

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
- 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.

Report

I have no observations to make on these financial statements.



KJ Donnelly
Comptroller and Auditor General
Northern Ireland Audit Office
106 University Street
Belfast
BT7 1EU

9th January 2020

Armagh Observatory and Planetarium

Statement of Financial Activities for the year ended 31 March 2019

	Note	Unrestricted Funds 2019 £	Restricted Funds 2019 £	Total Funds 2019 £	Unrestricted Funds 2018 (restated) £	Restricted Funds 2018 £	Total Funds 2018 (restated) £
Income from:							
Charitable activities	2	1,824,764	659,634	2,484,398	1,881,102	481,590	2,362,692
Other trading activities	4	90,346	-	90,346	88,322	-	88,322
Total incoming resources		1,915,110	659,634	2,574,744	1,969,424	481,590	2,451,014
Expenditure on:							
Charitable activities	5	2,527,179	324,261	2,851,440	2,400,811	225,326	2,626,137
Other trading activities	7	46,223	-	46,223	36,626	-	36,626
Total outgoing expenditure		2,573,402	324,261	2,897,663	2,437,437	225,326	2,662,763
Net income / (expenditure)		(658,292)	335,373	(322,919)	(468,013)	256,264	(211,749)
Transfers between funds	14	447,932	(447,932)	-	199,152	(199,152)	-
Other recognised gains/(losses):							
(Losses)/gains on the revaluation of fixed assets	9	(71,033)	-	(71,033)	366,699	-	366,699
Gains on the revaluation of heritage assets	10	-	-	-	50,000	-	50,000
Actuarial gains less provisions on defined benefit pension scheme	16	281,000	-	281,000	213,000	-	213,000
Net Movement in Funds		(393)	(112,559)	(112,952)	360,838	57,112	417,950
Reconciliation of funds							
Total funds brought forward at 1 April 2018 (restated)		9,172,391	229,019	9,401,410	8,811,553	171,907	8,983,460
Total funds carried forward at 31 March 2019		9,171,998	116,460	9,288,458	9,172,391	229,019	9,401,410

All amounts above relate to continuing operations of the organisation.
The notes on pages 52 to 64 form part of the financial statements.

Armagh Observatory and Planetarium

Balance Sheet as at 31 March 2019

	Note	2019 £	2018 (restated) £
Fixed Assets			
Tangible assets	9	8,091,188	8,099,582
Heritage Assets	10	2,598,595	2,533,434
Total fixed assets		10,689,783	10,633,016
Current assets			
Stocks	11	17,920	11,503
Debtors	12	105,352	128,848
Cash at bank and in hand	17	599,322	673,851
Total current assets		722,594	814,202
Creditors: amounts falling due within one year	13	(875,919)	(597,808)
Net current assets		(153,325)	216,394
Total assets less current liabilities		10,536,458	10,849,410
Creditors: amounts falling due after more than one year		-	-
Net assets excluding pension liability		10,536,458	10,849,410
Defined benefit pension scheme liability	18	(1,248,000)	(1,448,000)
Net assets		9,288,458	9,401,410
Funds			
Restricted funds	14	116,460	229,019
Unrestricted funds	14	2,714,190	2,648,633
Revaluation Reserves	14	7,705,808	7,971,758
Pension Reserve	14	(1,248,000)	(1,448,000)
Total Charity Funds		9,288,458	9,401,410

The financial statements on pages 49 to 64 were approved by the Board of Trustees of Armagh Observatory and Planetarium on 17 December 2019 and were signed on its behalf by:



Chair of the Board of Trustees
Archbishop Richard Clarke



Accounting Officer
Professor Michael Burton

Armagh Observatory and Planetarium

Statement of cash flows for the year ended 31 March 2019

	Note	2019 £	2018 £
Net cash provided by operating activities	16	236,649	394,499
Cash flows from investing activities:			
Interest received		666	137
Proceeds from sale of tangible fixed assets		216	1,159
Purchase of tangible fixed assets		(312,060)	(208,748)
		(311,178)	(207,452)
Increase / (decrease) in cash and cash equivalents		(74,529)	187,047

Further detail is reported in Notes 16 - 17.

Reconciliation of net cashflow to movement in net cash funds

		2019 £	2018 £
Increase in cash and cash equivalents in the year		(74,529)	187,047
Cash and cash equivalents at 1 April 2018		673,851	486,804
Cash and cash equivalents at 31 March 2019	17	599,322	673,851

The notes on pages 52 to 64 form part of the financial statements.

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019

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 2019.

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 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 received.

(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 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) 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 - 25%
Office equipment	15 - 25%
Scientific equipment	10 - 25%
Astropark	2%
Exhibits and grounds equipment	6 - 25%
Motor Vehicles	25%

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 2019. Revaluation gains (losses) are transferred to a revaluation reserve. Land and buildings in years where no revaluation occurs are restated using indices.

Land and Buildings were revalued by Land and Property Services in accordance with the RICS Valuation Standards, insofar as these are consistent with the requirements of the client. The valuations were 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 Valuation – Professional Standards.

Other fixed assets (non Land & Buildings) with a life estimated over 5 years have a net book value of £165,218 at 31st March 2019. This accounts for 2% of the net book value of fixed assets. The Trustees do not consider it appropriate to carry out an annual indexation of such assets on grounds of immateriality.

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

(f) 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.

These assets were revalued by the valuers listed above at 31 March 2019 at £2,533,434, an uplift of £1,291,474 on the valuation originally recorded in the balance sheet at 31 March 2018 of £1,241,160 which was based upon a 2010 insurance valuation. The valuers have further confirmed that had their valuations been carried out as at 31 March 2018 they would not have been materially different than the March 2019 valuations. Consequently, in accordance with IAS 8 Accounting policies, Changes in Accounting Estimates and Errors, the prior year comparative figure at 31 March 2018 has been restated in light of these new valuations.

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.

(g) 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.

(h) Debtors

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

(i) Cash at bank and in hand

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

(j) Creditors

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

(k) 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.

(l) 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 2019 was £271,248 (£3,093 at 31 March 2018).

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.

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

2 Income from charitable activities

	Note	Unrestricted Funds 2019 £	Restricted Funds 2019 £	Total Funds 2019 £	Total Funds 2018 £
Grant Income					
DfC Recurrent grant-in-aid		1,661,180	-	1,661,180	1,731,000
DfC VES grant-in-aid		-	92,500	92,500	-
DfC In-year capital grant-in-aid		-	292,600	292,600	196,000
Total grant-in-aid from the DfC		1,661,180	385,100	2,046,280	1,927,000
Income from other grants and receipts	3	1,107	255,175	256,282	285,590
Total Grant Income		1,662,287	640,275	2,302,562	2,212,590
Operating Income					
Admissions		160,190	-	160,190	148,420
Miscellaneous income		2,287	19,359	21,646	1,682
Total Operating Income		162,477	19,359	181,836	150,102
Total Income from Charitable Activities		1,824,764	659,634	2,484,398	2,362,692

3 Income from other grants and receipts

	Note	Unrestricted Funds 2019 £	Restricted Funds 2019 £	Total Funds 2019 £	Total Funds 2018 £
STFC Research, Visitor and Travel grants		-	254,275	254,275	278,838
Space Awareness Project		-	-	-	5,166
IAESTE		-	-	-	1,586
Royal Society		-	900	900	-
Sundry donations		1,107	-	1,107	-
Total other grants and receipts	2	1,107	255,175	256,282	285,590

4 Income from other trading activities

	Unrestricted Funds 2019 £	Restricted Funds 2019 £	Total Funds 2019 £	Total Funds 2018 £
Shop income	74,625	-	74,625	70,624
Rental income	15,721	-	15,721	17,698
Total Income from other trading	90,346	-	90,346	88,322

5 Expenditure on charitable activities

	Note	Unrestricted Funds 2019 £	Restricted Funds 2019 £	Total Funds 2019 £	Total Funds 2018 £
Research	6	869,808	324,261	1,194,069	1,152,083
Education	6	751,416	-	751,416	740,692
Governance and Support	6	905,955	-	905,955	733,362
		2,527,179	324,261	2,851,440	2,626,137

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

6 Expenditure on charitable activities

	Note	Unrestricted Funds 2019 £	Restricted Funds 2019 £	Total Funds 2019 £	Total Funds 2018 £
Research					
Staff costs		470,878	187,328	658,206	564,663
Direct costs		127,771	135,597	263,368	269,458
Support costs		115,036	1,336	116,372	180,585
Depreciation		156,123	-	156,123	137,377
	5	869,808	324,261	1,194,069	1,152,083
Education					
Staff costs		238,462	-	238,462	279,233
Direct costs		120,025	-	120,025	11,230
Support costs		127,939	-	127,939	136,622
Depreciation		264,990	-	264,990	213,607
	5	751,416	-	751,416	640,692
Governance and Support					
Staff costs		707,272	-	707,272	597,675
Direct costs		9,917	-	9,917	97,345
Support costs		174,741	-	174,741	38,342
Depreciation		14,025	-	14,025	-
	5	905,955	-	905,955	733,362

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

	Unrestricted Funds 2019 £	Restricted Funds 2019 £	Total Funds 2019 £	Total Funds 2018 £
Management Committee expenses	2,608	-	2,608	2,261
Audit	27,651	-	27,651	29,706
	30,259	-	30,259	31,967

7 Expenditure on trading activities

	Unrestricted Funds 2019 £	Restricted Funds 2019 £	Total Funds 2019 £	Total Funds 2018 £
Trading				
Direct costs	46,223	-	46,223	36,626
	46,223	-	46,223	36,626

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

8 Average staff numbers and related costs

	Permanent staff	Others	2019 Number	2018 Number
Average staff numbers	21.0	9.6	30.6	27.1

Staff costs comprise:	Permanent staff £	Others £	2019 £	2018 £
Wages and salaries	868,798	314,626	1,183,424	1,117,032
Social security costs	96,201	-	96,201	78,406
Employer's pension contributions	185,815	-	185,815	144,832
Defined benefit pension additional service cost	46,000	-	46,000	95,000
Termination costs	92,500	-	92,500	6,301
	1,289,314	314,626	1,603,940	1,441,571

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

	2019 Number	2018 Number
£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 £97,603 (2018: £85,623).

One employee opted to avail of the NICS Voluntary Exit Scheme (VES) during the year, with leaving date of 30 June 2019. As such, the VES cost of £92,500 has been accrued in the current year but paid in June 2019.

There was no remuneration paid to trustees during the year (2018: nil). Travel and subsistence expenses totalling £159 was reimbursed to 2 trustees (2018: £1,667 to 7 trustees).

Average student numbers and related costs (not included above)

	2019 Number	2018 Number
PhD students	8	8

	2019 £	2018 (restated) £
Student maintenance grants & stipends	137,153	143,816

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

9 Tangible fixed assets

	Freehold Land & buildings £	Exhibits grounds and Astropark £	Digistar Projection System £	Observatory Equipment & Historic telescopes £	Other Equipment & Vehicles £	Total £
Cost or valuation						
At 1 April 2018	7,578,437	550,185	1,200,332	931,666	533,237	10,793,857
Asset revaluation	(265,950)	-	-	-	-	(265,950)
Additions	280,281	59,170	-	-	224,149	563,600
Transfer to Heritage Assets	-	(5,100)	-	(81,775)	-	(86,875)
Disposals	-	(28,877)	-	(43,470)	(71,112)	(143,459)
At 31 March 2019	7,592,768	575,378	1,200,332	806,421	686,274	10,861,173
Depreciation						
At 1 April 2018	-	513,300	1,104,873	672,668	403,434	2,694,275
Adjustment for asset revaluation	(194,917)	-	-	-	-	(194,917)
Charge for year	194,917	26,484	58,856	47,684	107,196	435,137
Transfer to Heritage Assets	-	-	-	(21,714)	-	(21,714)
Disposals	-	(28,627)	-	(43,470)	(70,699)	(142,796)
At 31 March 2019	-	511,157	1,163,729	655,168	439,931	2,769,985
Net book value						
At 31 March 2019	7,592,768	64,221	36,603	151,253	246,343	8,091,188
At 31 March 2018	7,578,437	36,885	95,459	258,998	129,803	8,099,582

Tangible fixed asset additions of £563,600 as shown above were funded by £292,600 DfC in-year capital grant-in-aid with a further £271,000 accrued at year end.

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

	2019 £	2018 £
Cost	2,346,853	2,066,573
Aggregate depreciation	(920,084)	(873,424)
Net book value based on historic cost	1,426,769	1,193,149

Depreciation on fixed assets for the year was £435,137 (2018: £350,984).

Land and buildings include grounds and buildings with a net book value of £1,872,759 at 31 March 2019 which were donated to the organisation in 1790 by Archbishop Richard Robinson, the founder of the organisation (31 March 2018: £1,877,922).

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.

10 Heritage assets

	Books £	Clocks & Watches £	Scientific Equipment £	Furniture, Artworks, etc £	Total £
At Valuation					
Carrying Amount at 1 April 2018 (restated)	546,975	572,600	1,238,839	175,020	2,533,434
Transfers	-	-	60,061	5,100	65,161
Disposals	-	-	-	-	-
Depreciation / impairment	-	-	-	-	-
Carrying Amount at 31 March 2019	546,975	572,600	1,298,900	180,120	2,598,595

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.

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 2019. £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. The carrying amount at 1 April 2018 has been restated as outlined in note 1(f).

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

11 Stocks

	2019 £	2018 £
Goods for resale	17,920	11,503

12 Debtors

	2019 £	2018 £
Trade debtors	4,237	2,853
Prepayments and accrued income	54,243	96,977
Other debtors	46,872	29,018
	105,352	128,848

13 Creditors: amounts falling due within one year

	2019 £	2018 £
Trade creditors	316,685	180,528
Accruals and deferred income	526,279	398,160
Taxation and social security	32,955	19,120
	875,919	597,808

14 Statement of Funds

	At 1 April 2018 (restated) £	Income £	Expenditure £	Revaluation £	Transfers £	At 31 March 2019 £
Restricted Funds						
Government grant for assets	-	292,600	-	-	(292,600)	-
Restricted resource grants	229,019	367,034	(324,261)	-	(155,332)	116,460
Total restricted funds	229,019	659,634	(324,261)	-	(447,932)	116,460
Unrestricted Funds						
Designated Funds						
Donated assets reserve	1,712,591	-	-	-	-	1,712,591
Government grant for assets	932,949	-	-	-	(202,598)	730,351
General fund	3,093	1,915,110	(2,573,402)	-	926,447	271,248
	2,648,633	1,915,110	(2,573,402)	-	723,849	2,714,190
Undesignated Funds						
Revaluation reserve - Land & Buildings	6,680,284	-	-	(71,033)	(194,917)	6,414,334
Revaluation reserve - Heritage Assets	1,291,474	-	-	-	-	1,291,474
Pension reserve	(1,448,000)	-	-	281,000	(81,000)	(1,248,000)
	6,523,758	-	-	209,967	(275,917)	6,457,808
Total Unrestricted Funds	9,172,391	1,915,110	(2,573,402)	209,967	447,932	9,171,998
Total Funds	9,401,410	2,574,744	(2,897,663)	209,967	-	9,288,458

Details of Transfers between funds

	£
Release of restricted resource grant available to offset overheads	(155,332)
Release of deferred capital grant	(495,198)
Transfer of defined benefit pension service and interest cost	(81,000)
Transfer of depreciation adjustment on asset revaluation to general fund	(194,917)
General fund	926,447

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

15 Analysis of net assets between funds

	Pension Reserve	Revaluation Reserve	Unrestricted Funds	Restricted Funds	Total Funds
	£	£	£	£	£
Tangible fixed assets	-	6,414,334	1,676,854	-	8,091,188
Heritage assets	-	1,291,474	1,307,121	-	2,598,595
Current assets	-	-	606,134	116,460	722,594
Creditors: amounts falling due within one year	-	-	(875,919)	-	(875,919)
Pension scheme liability	(1,248,000)	-	-	-	(1,248,000)
Net assets/(liabilities)	(1,248,000)	7,705,808	2,714,190	116,460	9,288,458

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

	2019	2018
	£	£
Net expenditure for the year per statement of financial activities	(322,919)	(211,749)
Adjustments for:		
Depreciation	435,137	350,984
Interest received	(666)	(137)
Loss/(profit) on sale of assets	447	(1,159)
Defined benefit pension scheme service and interest cost less contributions payable	81,000	95,000
Increase in stock	(6,417)	(3,557)
Decrease/(increase) in debtors	23,496	(25,220)
Increase in creditors	26,571	190,336
Net cash provided by operating activities	236,649	394,499

17 Analysis of cash and cash equivalents

	31 March 2019	1 April 2018
	£	£
Cash at bank and in hand	599,322	673,851
Total cash and cash equivalents	599,322	673,851

18 Pension scheme

The disclosures below relate to the funded liabilities within the Local Government Pension Scheme for Northern Ireland (the "LGPS"), administered by NILGOSC, 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. The unfunded pension arrangements relate to termination benefits made on a discretionary basis upon early retirement in respect of members of the LGPS under the Local Government (Early Termination of Employment) Regulations (Northern Ireland) 2007.

The last actuarial valuation of the LGPS funded benefits was carried out at 31 March 2016 and the contributions to be paid until 31 March 2020 are set out in the Fund's Rates and Adjustment Certificate. The funding level (ratio of assets to past service liabilities) at 31 March 2016 was 96% compared to 91% at 31 March 2013 corresponding to a funding deficit of £262.6 million (£467m at 31 March 2013).

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 2019.

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

18 Pension scheme (continued)

Key assumptions used by the actuary were:

	31/03/2019	31/03/2018	31/03/2017
	%	%	%
Discount rate	2.40	2.60	2.50
RPI inflation	3.30	3.20	3.10
CPI inflation	2.20	2.10	2.00
Pension increases	2.20	2.10	2.00
Pension accounts revaluation rate	2.20	2.10	2.00
Rate of increase in salaries	3.70	3.60	3.50

Mortality assumptions

	2019	2018
	Years	Years
Males		
Member aged 65 at accounting date	22.6	23.3
Member aged 45 at accounting date	24.3	25.5
Females		
Member aged 65 at accounting date	24.9	25.9
Member aged 45 at accounting date	26.7	28.2

Asset Allocation

	Value at	Value at
	31/03/2019	31/03/2018
	%	%
Equities	59.5	71.4
Property	11.2	10.0
Government bonds	16.5	5.2
Corporate bonds	7.0	7.2
Cash	2.7	4.5
Other	3.1	1.7
Total	100.0	100.0

Reconciliation to balance sheet

	2019	2018
	£'000	£'000
Fair value of assets	10,731	9,831
Present value of funded defined benefit obligation	11,769	11,276
Funded status (deficit)	(1,038)	(1,445)
Present value of unfunded defined benefit obligation	(2)	(3)
McCloud judgement provision	(173)	-
GMP Indexation and Equalisation provision	(35)	-
Liability recognised on the balance sheet	(1,248)	(1,448)

Amounts recognised in statement of financial activities

	Year to	Year to
	31/03/2019	31/03/2018
	£'000	£'000
Operating cost		
Current service costs	(239)	(205)
Past service cost	-	(31)
Net assets/ liabilities gain/(loss) in period	489	213
Additional provisions		
McCloud judgement provision	(173)	-
GMP Indexation and Equalisation provision	(35)	-
Financing cost		
Interest on net defined benefit liability	(35)	(36)
Pension expense recognised in statement of financial activity	7	(59)
Allowance for administrative expenses included in Current Service Cost	3	3

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

18 Pension scheme (continued)

Asset gains recognised in statement of funds

	Year to 31/03/2019 £'000	Year to 31/03/2018 £'000
Asset gains/(losses) arising during the period	626	255
Liability gains/(losses) arising during the period	(137)	(42)
Total	489	213

Changes to the present value of defined benefit obligation

	Year to 31/03/2019 £'000	Year to 31/03/2018 £'000
Opening defined benefit obligation	11,276	10,903
Current service cost	239	205
Interest expense on defined benefit obligation	291	270
Contributions by participants	64	56
Actuarial (gains)/ losses on liabilities	137	42
Net benefits paid out	(238)	(231)
Past service costs	-	31
Closing defined benefit obligation	11,769	11,276

Changes to the fair value of assets

	Year to 31/03/2019 £'000	Year to 31/03/2018 £'000
Opening fair value of assets	9,831	9,340
Interest income on assets	256	234
Remeasurement gains/(losses) on assets	626	255
Contributions by the employer	192	177
Contributions by participants	64	56
Net benefits paid out	(238)	(231)
Closing fair value of assets	10,731	9,831

Liability of Members

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

Active members	46%
Deferred pensioners	18%
Pensioners	36%

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)	11.567	11.769	11.974
% change in present value of total obligation	-1.7%		1.7%
Projected service cost (£m)	0.246	0.252	0.252
Approximate % change in projected service cost	0.0%		0.0%

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)	11.812	11.769	11.726
% change in present value of total obligation	0.4%		-0.4%
Projected service cost (£m)	0.252	0.252	0.252
Approximate % change in projected service cost	0.0%		0.0%

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

18 Pension scheme (continued)

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)	11.931	11.769	11.610
% change in present value of total obligation	1.4%		-1.4%
Projected service cost (£m)	0.258	0.252	0.246
Approximate % change in projected service cost	2.6%		-2.5%

Post retirement mortality assumption

Adjustment to mortality age rating assumption	-1 year	Base Figure	+1 year
Present value of total obligation (£m)	12.144	11.769	11.397
% change in present value of total obligation	3.2%		-3.2%
Projected service cost (£m)	0.262	0.252	0.242
Approximate % change in projected service cost	4.0%		-4.0%

McCloud Judgement

In December 2018 the Court of Appeal ruled in the 'McCloud / Sargeant' judgement that the transitional protection arrangements put in place when the Firefighters' and Judges' pension schemes were reformed were age discriminatory. The Government applied to the Supreme Court for permission to appeal this judgement, however the Supreme Court rejected the government's request on 27 June 2019. The next stage is for the case to be referred to the Employment Tribunal to agree the remedy, following appropriate consultation.

While the judgement was not in relation to members with LGPS (NI) benefits it would be reasonable to assume that Government will now seek a remedy for all public sector schemes, including the LGPS (NI), with the remedy potentially differing by Scheme depending on the transitional protections adopted. Auditors are generally expecting employers to recognise an amount of additional liability to reflect the potential uplift in benefits for those members who were discriminated against.

Any remedy, and hence the amount to recognise, is uncertain. The Government Actuary's Department (GAD), under instruction of the LGPS Advisory Board (England & Wales), were asked to calculate the 'worst-case' scenario impact at LGPS Scheme level on assumptions that are reflective of those that are used for accounting. This was set out in their paper titled 'Local Government Pension Scheme Potential Impact of McCloud/Sargeant ruling on pension accounts disclosures' dated 10 June 2019. The GAD Report presented two 'worst case' figures based on alternative salary increase assumptions. The additional liability was calculated to be 3.2% of the active liabilities using a salary increase assumption of 1.5% above CPI Inflation (as used for employers in the Northern Ireland Local Government Officer's Pension Fund). Whilst their analysis was based on England and Wales data our view is these figures are also appropriate to accounting for benefits in the NILGOSC Pension Fund.

Based on the calculations outlined in GAD's paper, AON Hewitt Ltd have calculated an approximate liability value to include as a provision in respect to the McCloud judgement to be £0.173M (2017/18 - Nil).

The figures in the GAD Report are based on a worst case scenario (as defined by GAD), allowing for the final salary underpin to be extended to all members (including post April 2012 joiners) for those who leave service with immediate benefits only. The underpin is assumed to apply until retirement. The figures are approximate based on an estimate of the LGPS liabilities as a whole, to which we have made approximate adjustment. The actual impact on the Employer's pension liabilities will depend on the proportion of the active liabilities and the active membership profile, with the cost being higher for younger members.

GMP Indexation and Equalisation

The LGPS (NI) is required to pay a Guaranteed Minimum Pension (GMP) to members who accrued benefits in the Scheme between 6 April 1978 and 5 April 1997, when the Scheme was 'contracted-out' of the State Second Pension out on a salary-related basis. The GMP was intended to approximately replace the State Pension which members were giving up, however the payment terms of GMP are different between men and women, which was a consequence of the state pension itself being unequal at that 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 results which is at present produced in relation to GMPs". HM Treasury has gone on record since the Lloyds case to say, "Public sector schemes already have a method to equalise guaranteed minimum pension benefits, which is why we will not have to change our method as a result of this judgement".

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 (NI) 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.

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

18 Pension scheme (continued)

GMP Indexation and Equalisation (continued)

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. This was included in the 2016 valuation of the Fund and was therefore recognised on the balance sheet for years ending in 2017 and recognised in OCI in the same year.

In January 2018 the interim solution was extended to individuals reaching SPA on or before 5 April 2021. The additional liability was not recognised on the balance sheet over 2017/18 - our advice at the time was this was unlikely to be material. 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. The Government's view is that this solution meets equalisation requirements. We understand auditors are generally taking the view that it would be reasonable to include some allowance in the calculations for this additional liability, subject to materiality.

AON Hewitt Ltd have undertaken calculations for a typical LGPS Fund to quantify the value of fully indexing GMPs in line with CPI Inflation for those reaching SPA after 5 December 2018. This was calculated to be 0.3% of the liabilities / defined benefit obligation.

AON Hewitt Ltd have calculated an approximate liability value to include as a provision in respect to the GMP Indexation and Equalisation to be £0.035M (2017/18 Nil).

19 Capital commitments

Capital commitments at 31 March 2019 totalled £50,000 (2018: £nil) in respect of expenditure on projects commenced during the year. DfC has agreed funding for 2019/20.

20 Contingent liabilities

There were no contingent liabilities at the 31st March 2019 (2018: £nil).

21 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.

22 Losses and special payments

There were no losses or special payments during the year.

23 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.

Armagh Observatory and Planetarium

Notes to the financial statements for the year ended 31 March 2019 (continued)

24 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	2019 £	2018 £
Incoming resources			
Incoming resources from research and other non-DfC grants	2	256,282	285,590
Operating income	2	181,836	150,102
Trading income	4	90,346	88,322
Total incoming resources		528,464	524,014
Resources expended			
Direct expenditure of the organisation		2,897,663	2,662,763
Total Resources expended		2,897,663	2,662,763
Net deficit for the year		(2,369,199)	(2,138,749)
Gain on revaluation of Fixed Assets		(71,033)	366,699
Gains on the revaluation of Heritage Assets		-	50,000
Actuarial gain on pension scheme		281,000	213,000
Amount transferred to funds		(2,159,232)	(1,509,050)

Analysis of funds prepared under the FReM

		2019 £	2018 (restated) £
Balance at 1 April 2018		9,401,410	8,983,460
Grant-in-aid received in the year	2	2,046,280	1,927,000
Net operating costs for the year		(2,159,232)	(1,509,050)
Balance at 31 March 2019		9,288,458	9,401,410

25 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 9 January 2020.