Institution: University of Central Lancashire

Unit of Assessment: 09: Physics

Title of case study: ***Transforming Perceptions of Astrophysics and Astronomy: the Jeremiah Horrocks Institute's regional programmes of outreach and public engagement***

Period when the underpinning research was undertaken:
The underpinning research began in 2013 and is ongoing**.**

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Robert W. Walsh	Professor (Solar Physics); Uni Dir of Research (2008-2017)	2000 – present
Victor Debattista	Professor (Astrophysics)	2007 – present
Joanne Pledger	Snr Lecturer (Astrophysics); Ogden Science Officer	2012 – present
Megan Argo	Lecturer (Astrophysics)	2016 – present
Mark Norris	Snr Lecturer (Observational Astronomy)	2015 – present
Aimilia Smyrli	Lecturer (Astrophysics); Ogden Outreach Officer	2014 – present

Period when the claimed impact occurred: 2013-2020

Is this case study continued from a case study submitted in 2014? No.

1. Summary of the impact (indicative maximum 100 words)

The high-profile research across the Jeremiah Horrocks Institute (JHI) forms the basis for extensive outreach and public engagement programmes across communities in Preston and the wider region of Lancashire. Through a growing public lecture series, observatory evenings, schools outreach and media appearances alongside University's Lancashire Science Festival, JHI researchers have engaged with hundreds of thousands of people through large scale set piece events, regional media coverage and national and international media appearances. Relations have been deepened with the Harris Museum, Preston and the local amateur astronomy society with these collaborations leading to enhanced new visitor numbers and increased memberships respectively. The externally supported interventions at local schools have led to increases in the uptake of science subjects, have improved how physics is taught at a college and have helped young people to pursue physics as their route into further and higher education.

2. Underpinning research (indicative maximum 500 words)

The research areas of the JHI are of interest to society as together we explore and define our place in the Universe. Each of the staff indicated are active researchers across a number of specialisms.

Walsh's research focuses on examining potential heating mechanisms for the Sun's corona through both space-based observations and magnetohydrodynamical modelling of the plasma environment [1]. Research into very high-mass stars, which are believed to be the progenitors of core-collapse supernovae [2], is carried out by Pledger. Her large survey of eleven nearby star-forming galaxies utilises world-leading telescopes to produce one of the most focused and detailed studies in the field.

Debattista uses state-of-the-art computer simulations to study the formation and evolution of galaxies on scales from atomic nuclei to galactic bulges, from spiral discs to mysterious dark matter halos [3]. His visualisations are the inspiration for the interactive virtual reality (VR) "GalaxyFlyer". The main research area of Norris involves observations of those compact stellar systems which lie in the transition region between globular clusters and true galaxies. Exploring this population fully provides many important clues to the nature of the galaxy formation process [4]. Norris manages all teaching and outreach activity at Alston Observatory.

Argo's interest is in radio astronomy, including investigations into radio supernovae in nearby starbursts and masers in the nearby starburst galaxy M82. Her public and school talks include "The Kaleidoscopic Universe" which looks at how different parts of the electromagnetic spectrum can help us build a complete picture of the universe [5]. Smyrli's work in solar spectroscopy focuses on determining basic plasma properties in different part of the Sun's atmosphere. [6]

The JHI believes that astronomy and astrophysics are inspirational disciplines and each academic brings relevant elements of their research into the expansive outreach and public engagement work undertaken.

3. References to the research (indicative maximum of six references)

All outputs are peer reviewed.

[1] Cirtain, J. plus 11 co-authors including **Walsh, R.W**. (2013) Energy release in the solar corona from spatially resolved magnetic braids. *Nature*, 493 (7433). pp. 501-503. ISSN 0028-0836 DOI:10.1038/nature11772

[2] **Pledger, J**, Moffat, A F J et al (2018) The First Optical Spectra of Wolf Rayet Stars in M101 Revealed with Gemini/GMOS. *Monthly Notices of the Royal Astronomical Society*, 473 (1). pp. 148-164.DOI: 10.1093/mnras/stx2190

[3] **Debattista, V**, Ness, M., Gonzalez, O.A., et al (2017) Separation of stellar populations by an evolving bar: implications for the bulge of the Milky Way, *Monthly Notices of the Royal Astronomical Society*, 469 (2), pp. 1587–1611, DOI: 10.1093/mnras/stx947

[4] Bianchini, P, van de Ven, G., **Norris, M.A**. et al, (2016) A novel look at energy equipartition in globular clusters, *Monthly Notices of the Royal Astronomical Society*, 458 (4) pp. 3644–3654, DOI: 10.1093/mnras/stw552

[5] Rampadarath, H, Soria, R, Urquhart, R, **Argo, M** et al (2018) Jets, Arcs and Shocks: NGC 5195 at radio wavelengths. *Monthly Notices of the Royal Astronomical Society*, 476 (3). pp. 2876-2889. DOI: 10.1093/mnras/sty390

[6] Pascoe D.J., **Smyrli A.**, Van Doorsselaere T., (2019), Coronal Density and Temperature Profiles Calculated by Forward Modeling EUV Emission Observed by SDO/AIA *The Astrophysics Journal*, 884, 43 DOI: 10.3847/1538-4357/ab3e39

4. Details of the impact (indicative maximum 750 words)

Astronomy research in the Jeremiah Horrocks Institute (JHI) forms the basis of extensive outreach and engagement programmes targeted across the North West of England. The programmes run by the JHI aim to engage directly with groups that have low science capital (the measure of an individual's science-related knowledge, interests, and social contacts) and low socioeconomic status. According to the English Indices of Deprivation 2019 approximately 18% of the Preston's population live in the most deprived 10% of English local authority areas. Neighbouring local authority areas such as Blackpool, are also amongst the ten most deprived local authorities in the country. Low socioeconomic status has an established link with poor educational attainment and there is a demonstratable need for consistent, high quality and impactful engagement in this geographical area.

Since August 2013 the JHI has engaged with hundreds of thousands of people through large scale set piece events, regional media coverage and national and international media appearances by JHI academics. Of this total, over 91,000 individuals were directly engaged with by the JHI through nearly 500 events. These events consisted of a series of complimentary engagement programmes in underserved communities that have stimulated interest in and awareness of astronomy research, including working directly with underserved young people in particular schools to increase their uptake of and success within science topics. Academics from the JHI also made numerous regional, national and international media appearances to talk about their research including the BBC World Service (97,000,000 English language listeners worldwide in 2020), Sky News (3,100,000 viewers in 2020) and BBC Radio Lancashire (148,000 listeners in 2020)[J]. Since 2013 University of Central Lancashire Astronomy and the Alston Observatory have received investments of over GBP530,000 from a number of trusts, societies and funding bodies, including STFC, The Ogden Trust, the Moses Holden family, the Institute of Physics, the National Lottery Heritage Fund and the University itself.

STFC Blackpool PIER (Physics: Inspire, Engage and Research):

In 2017, Walsh successfully obtained a prestigious three-year STFC Leadership Fellowship in Public Engagement focusing on engaging low science capital audiences in Blackpool. The school outreach element, PIER (Physics: Inspire, Engage and Research), involves working intensively with a group of 90 school children for three years across three primary and two secondary schools. Pupils have been followed from Year 6, through the primary school transition and onto Year 8 in high school. Blackpool has some of the most challenging Office for Students participation of local area (POLAR) results in the country with less than 12% of young people entering higher education. The POLAR measure is an indicator of youth participation in HE. The fellowship objectives address directly the need to increase overall science capital in four separate themes; (i) What science (astronomy) they know; (ii) Who they know who is involved in science; (iii) How they think about science; and (iv) What they do that is science-related (out of school, with family etc).

Twenty STFC-funded interventions of face-to-face classroom activities with a range of astronomers, trips to Alston Observatory and the University of Central Lancashire-Royal Institution Young Scientist Centre (YSC) as well as a school-based family science festival have been carried out since 2017. The initial study to understand the Year 6 knowledge baseline of the PIER cohort resulted in a journal paper where it is clear that the group were just as interested in science study and science jobs as their peers nationally. Some of the PIER cohort, particularly boys, demonstrated a concealed "science identity", perceiving themselves as a "science person" but thought others would not. It was clear that their interest in science was not being properly expressed and it was necessary to provide a clearer understanding of possible science career paths [F].

Lynn Bilton, Physics specialist teacher from Unity Academy, Blackpool stated: "**With the STFC PIER program we had the opportunity to work with a group of pupils over a longer period of time and from an earlier age, to encourage and support aspirations, to enthuse and improve engagement and ultimately raise achievement. … . The students have returned positive feedback on the program at each stage and as a consequence their feedback on science taught within school has also been more positive than other year groups**." Bilton goes on to say that "**Last year students were given options for a subject career day in sport or fashion /art or science / engineering. For the first time, the science option was oversubscribed and had twice the number of students opting for it as their first choice. The students will choose options this academic year and although science is a core subject, I expect many to prefer to complete triple science, which has not been the case historically at the academy**." [G]

The COVID-19 pandemic stopped all activity in the first half of 2020 and the PIER pupils from low socioeconomic backgrounds have been disproportionately affected. Walsh's STFC fellowship was extended as a result of this disruption, now supporting all Year 9 pupils across PIER schools though a targeted number of online events (three repeated at least twice per secondary school). Walsh worked with teachers to discover which physics topics would best complement and enhance what is being taught. The interventions have consisted of: experiments filmed in the YSC; an experimental box with all necessary equipment and consumables provided to each school and an online live streaming event involving each school year group, with Walsh and a guest astronomer.

Lancashire Science Festival

Instigated by Walsh in June 2013, the annual **Lancashire Science Festival** (LSF) has attracted over 65,000 attendees during the REF period. The festival is a free event and aims to make STEM and HE more accessible to a variety of audiences. Attracting visitors from across the North West of England, the Festival is embedded in local communities with dedicated days set aside for school groups. The Festival helps to overcome misconceptions about and barriers to involvement in science. One attendee commented: **"I never fully understood what science covers. This opened my eyes and made science fascinating to me where before I seen it as boring and geeky."** [C2]

The JHI are stalwarts of the event, presenting numerous public lectures each year as well as providing hands-on activities such as “GalaxyFlyer" – a VR fly-though of galaxy morphology. In 2017 and 2018, an audience analysis conducted by the UK Science Festival Network showed that attendees with limited budgets or living in rented accommodation were overrepresented compared to national averages [C1].

Peer-reviewed research on the LSF shows that it has a positive effect on parents’ and carers’ views of both STEM and HE, particularly parents from disadvantaged backgrounds. The research showed that 44% of families attending the LSF came from more deprived postcodes. Parental views on HE is one of the most significant influencers on young people’s expectations around HE progression. The research on the LSF found that 70% of parents attending the Festival reported a positive impact on their perception of science, with this proportion increasing among parents from more deprived areas [C2].

Public lectures, Alston Observatory and Partnering with Local Astronomy Societies

Since December 2013 the JHI has hosted up to four events annually with high profile speakers from all over the world as part of a targeted public lecture series. In 2018 an additional five talks over five days were delivered as part of the University's 190th anniversary celebrations. The lecture series has demonstrated consistent increases in attendance: doubling from approximately 100 in 2013 to more than 200 in 2019 [A, J]. The anniversary series attracted over 340 attendees. One attendee indicated: **“I wanted to express my sincere gratitude for making this event accessible. I never studied science at school and this was my first encounter with anything astronomy related… At the age of 31 I have been given an opportunity to learn and understand a concept that has always been baffling to me.”** [A] Half of the people who attended one of the Anniversary Lectures came to at least one other, suggesting sustained engagement and an observable heightened interest in learning more. 60% of attendees who answered regular post-lecture questionnaires indicated that they had plans to take their interest in astronomy further. To coincide with the 50th Anniversary of the moon landings in 2019 a special lecture, ‘Rocket to the Moon’, was delivered to over 300 attendees at the University, the Harris Museum and Art Gallery, Preston, and the World Museum, Liverpool. As part of the anniversary commemoration JHI staff worked closely with the Harris Museum and Art Gallery to develop the *Museum of the Moon* exhibition. The University lent historical documents to create an associated exhibition and JHI staff gave over twenty public tours of the exhibit that were attended by more than 500 people. The exhibition brought a whole new audience to the museum and led to unprecedented interest, with over 47,000 visitors over the course of the month-long installation. [D, J]

JHI’s **Alston Observatory** is a purpose-built teaching and outreach facility comprising both modern and historical telescopes, a fixed planetarium and a Royal Astronomical Society funded exhibit on “Telescopes as Time Machines”. The centrepiece is the GBP250,000 Moses Holden Telescope (MHT), a 70 cm diameter state-of-the-art robotic telescope used for both undergraduate teaching and public engagement. As well as nearly daily visits by schools, youth and adult groups, as well as uniformed organisations, every month Alston Observatory is opened to members of the public who are given the opportunity to listen to talks and observe the night sky. In 2014, 507 people visited Alston; this increased year on year to 1,652 in 2019 and, despite COVID restrictions, more than 600 people visited the observatory in 2020 [J]. Public observing nights are always fully booked, and in 2018, 40% of attendees (up from 7% in 2017) were people who had attended before in earlier years. 44% of visitors have indicated that they have an active plan to take their interest further, suggesting an active change in participation in astronomy [B].

Since 2014 these outreach activities have also been supported by a long-term collaboration with the Preston and District Astronomy Society (PADAS). A strong partnership has now been formed with PADAS members attending public lectures, engaging with local schools and community groups through the University and assisting with public observing nights at Alston Observatory. In 2014 the University owned Moor Park Observatory, originally opened in 1927, was fully restored as part of a GBP2,350,000 park restoration programme funded by the Heritage Lottery Fund and Preston City Council. Moor Park Observatory is now used

as a regular venue by PADAS for monthly meetings and outreach events with experts from the JHI. In the last four years, PADAS membership numbers have tripled to 50 and they now meet year-round due to the level of interest in astronomy, a direct **"result of a positive relationship between UCLan and PADAS"** [E]. Since August 2013 the JHI have engaged with over 950 members of astronomical societies across the country through public talks.

Cardinal Newman College, Ogden Trust and Isaac Physics

Since 2013, the JHI has fostered close relations with Cardinal Newman College, Preston, which further developed under the College's involvement in the Preston Ogden Partnership, funded by the Ogden Trust [I]. Initially the JHI delivered six talks over three sessions annually, since 2018 the engagements have diversified to include engineering plus three physics masterclasses per year. Cardinal Newman students have also become regular attendees of public lectures as a result. These interventions have provided the teachers there with **"a great source of material to enhance the physics we teach in lessons."**[H1] 85% of the students attending indicated that their interest in pursuing physics and/or engineering at university had increased [H2]. Despite changes to the way students enrol in courses that reduced the number of pupils enrolling in physics in Year 12, the college has shown an overall increase in the cohort size continuing physics into Year 13. Students attending the talks and masterclasses have been inspired to proactively approach teachers to start extra-curricular activities, such as MatLab modelling classes, enhancing the depth of their knowledge about physics and its applications. Several students have credited the talks and masterclasses with changing the degree subjects they aim to take at university or helping to confirm these decisions. One student noted: **"First [I] wanted to do engineering, now deciding whether to do engineering with physics/pure physics."** [H1]

Since 2016, Smyrli has run a dedicated Isaac Physics mentoring scheme with six schools and colleges from across Liverpool, Manchester and Lancashire, funded by the Ogden Trust. Isaac Physics is an Open Platform for Active Learning designed to offer support and activities in physics problem solving to teachers and to students transitioning from GCSE, through to Sixth Form, to university. Initially as a series of one-off workshops for approximately 200 students these developed into repeat interventions with a smaller cohort. Between 2017 and 2020 approximately 100 students have attended and benefitted from more than 60 weekly or fortnightly workshops where nearly 2,000 physics problems from the Isaac Physics website have been tackled [J].

5. Sources to corroborate the impact (indicative maximum of 10 references)

[A] Evaluation of JHI public lectures (including 190th anniversary)
[B] Evaluation of Alston Observatory events
[C] Lancashire Science Festival (2014-2019) data
[C1] Evaluation of Lancashire Science Festival (2014-2019)
[C2] Canovan, C. (2019) Going to these events truly opens your eyes. Perceptions of science and science careers following a family visit to a science festival, *Journal of Science Communication*, 18 (02), DOI: 10.22323/2.18020201.
[D] Attendance figures for Museum of the Moon exhibition, at the Harris Museum & Art Gallery, February 2019
[E] Factual statement: President of Preston and Distract Astronomical Society
[F] Canovan & Walsh (2020) A space to study: expectations and aspirations toward science among a low participation cohort, *Journal of Science Communication*, 19 (6), DOI: 10.22323/2.19060204
[G] Factual statement: Lynn Bilton, Head of Science, Unity Academy Blackpool
[H] Engagement with Cardinal Newman College, Preston
[H1] Factual statement: Head of Physics, Cardinal Newman College, Preston
[H2] Evaluation of Cardinal Newman College seminars and masterclasses
[I] The Ogden Trust (2020) Trustees' report and financial statements for the year ended 31 March 2020
[J] List of JHI Public Engagement Activities 1st August 2013-31st December 2020