Institution: Aberystwyth University

Unit of Assessment: 9 Physics

Title of case study: Impact of physics and astronomy research on the work of the Urdd National Eisteddfod

1. Summary of the impact

Recognising a national shortage of young people adopting careers in physics, particularly in Wales, we used our experience in engaging the public with physics research to have an impact on the work of the young people's organisation Urdd Gobaith Cymru at its National Eisteddfod, one of the largest cultural youth festivals in Europe. At the heart of the pavilion, Aberystwyth researchers presented an exhibition of our research on the Sun and the Solar System, supported by the STFC Science in Society scheme. This core activity convinced the organisation to reintroduce a prominent science pavilion (the Gwyddon*Le*), having originally planned not to host a science event. Since 2010, this has grown to be one of the largest and most popular events at the Eisteddfod, attracting external funding and allowing DMAP researchers to have a further impact on society by demonstrating physics to tens of thousands of school children and their parents.

2. Underpinning research

The research of the Solar System Physics group of the Department of Mathematics and Physics focuses on understanding and predicting the physical processes that lead to the flow of solar material into interplanetary space, and studying the evolution of this material from the Sun to the planetary and lunar surfaces. The group has a long and successful history of analysing data from many space missions and ground-based facilities and developing novel methods and models to interpret the observations.

The energy that drives space weather throughout the heliosphere ultimately comes from the solar interior. It is therefore essential to investigate the processes for energy and mass transport between the Sun's interior, photosphere and atmosphere. The group has researched this environment by analysing observations from missions such as the Solar Dynamic Observatory and Hinode and by developing new analytical and numerical models and simulations. Novel image processing and analysis have led to new discoveries of the corona including the unexpected expansion of active regions into the solar wind, and the first direct measurements of coronal rotation rates. A recent highlight was our discovery of a huge solar tornado [3.1] which captured the imagination of the science media.

Further from the Sun, the research included the development of novel automated methods to study large solar eruptions in the extended corona, and analysis of satellite and radio observations of the solar wind and planetary ionospheres. This breadth of expertise enabled a unique picture of the influence of space weather on the planetary environments [3.2 – 3.4]. The structure and composition of planetary and lunar surfaces have also featured prominently in our research [3.5].

With the launch of the STEREO NASA spacecraft in 2006, members of the research group took the opportunity to produce a 3D movie of the first solar images sent by the two STEREO cameras viewing from two different angles. The stereo images were generated at Aberystwyth even before NASA had processed the data. Animating the data in this way, using advanced visualisation techniques, aids the scientist's understanding of the complicated structures which form the dynamic solar atmosphere. For public outreach the visualisation is extremely useful, particularly with a target audience of adults and young people. Interactive exhibits and presentations at schools and festivals have included the National Eisteddfod of Wales in 2009 with funding obtained from the RAS [3.6] and the Urdd National Eisteddfod in 2010 with funding from the STFC [3.7].

3. References to the research

[3.1] Li, X., Morgan, H., Leonard, D., Jeska, L., A solar tornado observed by AIA/SDO: Rotational flow and evolution of magnetic helicity in a prominence and cavity, Astrophysical Journal, 752, L22 (2012). DOI: 10.1088/2041-8205/752/2/L22. REF2 submitted.
http://users.aber.ac.uk/xxl/tornado.htm.

[3.2] Lugaz, Vourlidas, Roussev, and Morgan, Solar-Terrestrial Simulation in the STEREO Era: The 24-25 January 2007 Eruptions, Solar Physics, 256, 269-284 (2009), DOI: 10.1007/s11207-009-9339-4. REF2 submitted.

[3.3] Breen et al., The solar eruption of 2005 May 13 and its effects: Long-baseline interplanetary scintillation observations of the earth-directed coronal mass ejection, Astrophysical Journal Letters 683, L79-L82 (2008). DOI: 10.1086/591520.

[3.4] Pryse et al., Multi-instrument probing of the polar ionosphere under steady northward IMF, Annales Geophysicae-Atmospheres Hydrospheres And Space Sciences 18, 90-98 (2000). DOI: 10.1007/s00585-000-1118-3.

[3.5] The D-CIXS X-ray spectrometer on the SMART-1 mission to the moon - First results, Planetary And Space Science, 55, 494-502 (2007). DOI: 10.1016/j.pss.2006.08.004.

[3.6] Pryse and Wheldon Williams, National Eisteddfod of Wales Astronomy Competition & Activities (Bala), RAS grant (2009).

[3.7] James, Pryse, Hardy, Morgan, Astronomy at the Urdd National Eisteddfod 2010, STFC Science in Society Small Award Scheme (H504838/1) http://www.stfc.ac.uk/2062.aspx.

4. Details of the impact

In 2010, DMAP staff successfully influenced working of the young people's organisation, Urdd Gobaith Cymru in relation to science activities at their annual National Eisteddfod festival for young people. This was in the context of the Solar System Physics research group's successful assimilation and visualisation of satellite and terrestrial data on the solar system, including the earth's ionosphere and the solar corona. It allowed us to address HEFCW's strategic aims and needs in STEM subjects, in access to HE and in Welsh-medium delivery. Enthusing the young people of Wales in physics is essential to addressing these strategic aspects, and the solar system captures the imagination of the general public and generates interest in physics.

The Urdd National Eisteddfod [5.1, 5.2] is one of Europe's largest cultural/youth festivals; every year it attracts close to 100,000 Welsh speakers and Welsh learners, 15,000 competitors and over 200 organisations. Having run for almost a century, it has wide media coverage, reaching an additional audience on television and radio.

In 2010 the Urdd Eisteddfod was held on the Llanerchaeron estate in West Wales, close to Aberystwyth. In the preceding years, the movement had decided not to support science activities at the Eisteddfod site and, in response, Pryse and Morgan established a group involving universities, the IoP and local organisations to provide leadership for the local and national campaign to reinstate science into this large and popular event. This is confirmed in a letter from the Urdd Co-ordinator of the Eisteddfod and the Arts, who said "…*there were no plans to hold science activities in the Eisteddfod in Llanerchaeron before discussions were held with Aberystwyth University*" [5.1]). The group grew into a science committee, chaired by Pryse, that was recognised by the movement through senior representation; it was also recognised by the Institute of Physics through membership and significant support of its national co-ordinator for Wales.

The key enabling factor was the establishment of a central exhibition drawing from the research excellence of Aberystwyth researchers in the physics of the Sun and the Solar System. This

excellence, combined with a track record of outreach from the department and our partners, attracted funding from STFC to ensure a professional centre-point to the exhibit. Building on this, further participation was attracted from bodies such as Techniquest, the British Science Association, BBC Breathing Places, Institute of Physics in Wales, and the Royal Society of Chemistry. The scale and variety of the exhibit persuaded the central organising committee of the Urdd to re-introduce science to the festival in the form of the Science Pavilion proposed by the committee. As a result of an on-line poll, the pavilion was named Gwyddon*Le* (the "Place of Science") [5.3]; a name that has been adopted for the event ever since, growing at each Eisteddfod since 2010 ("...*GwyddonLe has gone from strength to strength, and has been established as a permanent feature*…" [5.1])

Attendance at the first Gwyddon*Le* was recorded, totalling almost 10,000 (on average, 10% of the daily attendance at the Urdd Eisteddfod as a whole), which included members of the Welsh Assembly Government and other national organisations, and attracting wide media attention [5.1]. The chief executive of Urdd Gobaith Cymru commented on the pioneering nature of the Gwyddon*Le,* saying "*GwyddonLe is an innovative project and one of the festival's flagship exhibitions*" [5.4].

Following the introduction of the Gwyddon*Le* in 2010, the Urdd has "*succeeded in attracting funding from public and corporate sources in subsequent years to fund the venture*" [5.1]. The event initiated by Aberystwyth physicists has thus been welcomed by the science research community in Wales, and by the Urdd administration; and the result is that tens of thousands of Welsh-speaking young people have been exposed to cutting-edge physics.

The department's promotion of science through its research continued at subsequent events, for example using the discovery of a solar tornado as a vehicle for outreach at the 2012 Urdd Eisteddfod. This discovery also attracted a large online discussion and interaction including more than 60 comments at space.com [5.5], more than 80,000 views of the video posted on youtube by Russia Today [5.6], more than 10,000 likes on facebook, 186 tweets, and 50 public recommendations on google+ for a news article from National Geographic [5.7], and 1,206 tweets and 138 public recommendations on google+, for the article at wired.com [5.8].

5. Sources to corroborate the impact

[5.1] letter from the Eisteddfod and Arts co-ordinator, Urdd Gobaith Cymru

[5.2] http://www.urdd.org/en/eisteddfod/what-eisteddfod

[5.3] http://www.urdd.org/en/eisteddfod/gwyddonle

[5.4] Y Cymro (Welsh National weekly newspaper), 11 Chwefror 2011, page 8;
http://www.abayoflife.com/en/news/urdd-national-eisteddfod-announces-major-new-partnership-with-swansea-university/

[5.5] http://www.space.com/15086-sun-tornado-nasa-sdo-spacecraft.html

[5.6] http://www.youtube.com/watch?v=00abKI-lYFQ

[5.7] http://news.nationalgeographic.com/news/2012/03/120329-sun-solar-tornadoes-biggest-nasa-sdo-space-science/

[5.8] http://www.wired.com/wiredscience/2012/03/gigantic-solar-tornado/