Institution: The University of Manchester

Unit of Assessment: UoA9 Physics

Title of case study: Public engagement with the research of Jodrell Bank

1. Summary of the impact

For decades Jodrell Bank has been a world-leader in both radio astronomy research and public engagement with science. The Lovell Telescope in particular, whilst still remaining one of the world's foremost active research instruments, has become an icon for UK science and engineering. In this case study we show how Jodrell Bank research has had a significant impact on society, culture and creativity, including economic impacts of tourism, educational impacts from engagement with schools, and cultural and creative impacts in television, music and the arts. Our approach to delivering this impact is varied and wide-ranging but a key vehicle is the Jodrell Bank Discovery Centre. The Centre has a significant impact on the regional economy and has attracted 496,000 visitors (including 43,000 school pupils) to engage with our research over the REF period Jan 2008-Jul 2013.

2. Underpinning research

The impact is based on a wide body of research carried out at Jodrell Bank during the past 20 years. Over this time Jodrell Bank astronomers have made a number of seminal contributions to astrophysics, particularly in radio astronomy, and to the technical development of observing techniques. A few selected research highlights are listed below with key staff in each area identified. These few examples are drawn from the wide-ranging research programme carried out by our whole group. The breadth and depth of this programme, coupled with the long-term appeal of Jodrell Bank, enables us to play a leading role in public engagement with astrophysics research.

- The significant volume of ongoing world-leading work on pulsars using the Lovell Telescope (LT), including the discovery and analysis of the double pulsar from 2004 onwards, providing the most stringent test yet of General Relativity (e.g. paper [1]) and resulting in the award of the 2005 Descartes Prize. [Prof. Andrew Lyne(from before 1993 till 2011), Prof. Michael Kramer (1999-2008), Dr Ben Stappers (2005-date), Dr Patrick Weltevrede (2009-date)]
- The development of our radio-linked interferometer MERLIN (which includes the LT) and its upgrade to an optical-fibre linked network e-MERLIN [2], providing high-sensitivity radio images comparable in resolution to those of the Hubble Space Telescope. The application of fibre technologies and signal synchronisation techniques have led to e-MERLIN being designated as a pathfinder for what is planned to be the world's largest radio telescope, the Square Kilometre Array (SKA). [Prof. Simon Garrington (throughout), Prof. Phil Diamond (1999-2010), Dr Tom Muxlow (throughout), Dr Rob Beswick (2002-date), Dr Anita Richards (throughout), Prof. Tim O'Brien (1999-date), Dr Bryan Anderson (to 2006), Prof. Ralph Spencer (to 2010)]
- Observations of the cosmic microwave background over many years, for example developing in collaboration with the University of Cambridge the Very Small Array which made early observations of the power spectrum [3] and recently through building ultra low-noise amplifiers for LFI on the Planck spacecraft and leading on the analysis of "foreground" radio emission in the Planck consortium. [Prof. Rod Davies (to 2004), Prof. Richard Davis (throughout), Prof. Richard Battye (2001-date), Dr Clive Dickinson (2007-date)]
- The work on gravitational lensing following discovery of the first lens by a group led from Jodrell Bank, leading to the significant CLASS survey [4], which provided the majority of known lenses at the time and is continuing in projects such as SuperCLASS with e-MERLIN. [Prof. Ian Browne (to 2012), Prof. Peter Wilkinson (throughout), Dr Neal Jackson (1994-date)]
- The observations of the Hubble Deep Field with MERLIN+LT from 1997 onwards showing that high-redshift galaxies are resolved in the radio, hence providing part of the inspiration for the SKA [5]. [MERLIN group as above]
- The MERLIN observations of radio stars, which were key to linking the Hipparcos Catalogue to the International Celestial Reference System (ICRS) and hence enabling a fundamental astrometric reference frame to be constructed [6]. [MERLIN group as above]

3. References to the research

Research from the Jodrell Bank group has consistently been rated as of international quality (e.g. RAE 2008). Six examples of underpinning research cited in Section 2 are listed below. All appear in leading journals for the astrophysics community. Three of the references which best exemplify the research quality are:

[1] *A double-pulsar system: A rare laboratory for relativistic gravity and plasma physics*, Lyne et al inc. Kramer, Science, 303, 1153-1157 (2004), DOI: 10.1126/science.1094645 Journal article, 362 citations and leading to a further 173 publications from groups worldwide whose title includes the name of the object.
[2] *e-MERLIN*, Garrington et al inc. , in "Ground-based Telescopes", eds. Oschmann, Jacobus M., Jr., Proceedings of the SPIE, Vol. 5489, pp. 332-343 (2004), DOI: 10.1117/12.553235 Technical journal article, currently 50% of time e-MERLIN is conducting significant legacy programmes, applications for which involved 325 astronomers from over 100 institutes in more than 20 countries.
[3] *High-sensitivity measurements of the cosmic microwave background power spectrum with the extended Very Small Array*, Dickinson et al inc. Battye, Davies, Davis, MNRAS, 353, 732-746 (2004), DOI: 10.1111/j.1365-2966.2004.08206.x Journal article, 194 citations.

A further three references are included to show the breadth of our research and its applications:
[4] *The Hubble constant from the gravitational lens CLASS B0218+357 using the Advanced Camera for Surveys*, York et al inc. Jackson, Browne, MNRAS, 357, 124-134 (2005), DOI: 10.1111/j.1365-2966.2004.08618.x Journal article
[5] *High-resolution studies of radio sources in the Hubble Deep and Flanking Fields*, Muxlow et al inc. Richards, Garrington, Wilkinson, Anderson, Monthly Notices of the Royal Astronomical Society, 358, 1159-1194 (2005), DOI: 10.1111/j.1365-2966.2005.08824.x Journal article
[6] *The HIPPARCOS catalogue as a realisation of the extragalactic reference system*, Kovalevsky et al inc. Garrington, Astronomy & Astrophysics, 323, 620-633 (1997), Journal article

4. Details of the impact

Introduction : Public engagement with our research has led to impacts on the economy and on society, culture and creativity. We have stimulated public interest in science and engineering and inspired thousands of schoolchildren by including our research in their education programmes. We achieve this impact through a strategic approach to developing a high national and international media profile combined with a purpose-built facility at Jodrell Bank to welcome visitors and engage them directly with the actual research going on at the site. This engagement with live science and active researchers at a working observatory is a key element in our delivering impact. Another key element of our approach is that the engagement programme is directed by designated members of staff – currently Prof. Tim O'Brien (1999-date; Associate Director Jodrell Bank Observatory) and Dr Teresa Anderson (2006-date; Director of Jodrell Bank Discovery Centre) and, until 2007, Prof. Ian Morison (retired 2010). Some specific examples of this impact during 2008-13 are listed below.

The Jodrell Bank Discovery Centre : In April 2011 we opened a new £2.9M Discovery Centre (funded by external grants from the Regional Development Agency and the European Regional Development Fund) replacing remaining parts of the public science centre which had been on site since the mid 1960's but reduced in size in 2003. The new Centre has a broad remit of enhancing public engagement with our research combined with providing out-of-classroom education aimed at inspiring the next generation of scientists and engineers. From Jan 2008 to Jul 2013, 496,000 people visited the Centre. From 2008 until it closed for rebuilding in Sep 2010, numbers were around 70-80,000 per year, but since re-opening in 2011 annual visitor numbers have risen to 128,000 (Aug 2012-Jul 2013). (A)

Current exhibits highlight our research, including the work of the Lovell Telescope, pulsars, e-MERLIN, the CMB, black holes, gravitational lensing, the evolution of stars and the search for life. The latest exhibit on the science & technology of Big Telescopes (including the work of VLT and ALMA, and plans for E-ELT and SKA) will open in Oct 2013. Our researchers work closely with the Centre e.g. in daily "Ask an Expert" talks/Q&A during school holidays (which have attracted 5,500

attendees from July 2011 to April 2013) and in public lectures such as the Lovell Lectures (held every 2-3 months, each attracting sell-out audiences of around 125). (A)

The Centre was awarded Tourism Attraction of the Year by Marketing Cheshire in 2012 (B). Evidence of impact of our activities at the Centre can be found in a consistent appetite for our events and exhibitions throughout the REF period (note visitors paying for entrance provide a current annual income of around £600,000 which is ploughed back into the Centre and its operations), audience growth at the new Centre (from 94,000 visitors in first full year 2011/12 to 128,000 in 2012/13), positive feedback and repeat visits from schools and the general public. For example, 82% of visitors rate the quality of the venue and the content of the exhibition as good or very good; whilst in a Girls Night Out event targeted at young women, 91% said they were more interested after the event whilst 94% said they'd come again; quotes include "My 12 year old loved it, as did I"; "It was extremely exciting and when I go back to school it will help me with my studying". A national online survey carried out by Harris International in 2008 showed that 54% of the UK population recognise Jodrell Bank as a UK science facility – a 'brand' recognition unparalleled amongst active UK science centres and indicative of the impact of our public engagement. Another Harris survey in 2012 found 76% of our visitors are very likely or absolutely certain to recommend a visit to friends (C).

Music & Science – Live from Jodrell Bank : New audiences are engaged with our research in innovative events such as the Live from Jodrell Bank music/science festivals. The first event in July 2011 attracted 5,000 people from the UK and beyond, in 2012 this increased to 12,000. In 2013 we held the event over two weekends in July and August. The first on July 6/7 attracted a total of about 12,000 attendees. Aimed at reaching out to a different audience, postcode analysis of ticket holders showed 65% of the attendees travelled further than 60 miles (including some from overseas), whereas 94% of our usual visitors come from within 60 miles. Alongside the Music Arena with the main stage we also have a Science Arena which showcases Jodrell Bank research with exhibitions and talks from our researchers, as well as others from the UK community, including STFC, IoP, RCUK and the Wellcome Trust. Our research is also delivered from the main stage between bands by Prof. O'Brien. This includes descriptions of scientific results from use of the Jodrell telescopes and, in 2012, a live video link to the telescope platform at the VLT in Chile. For the 2013 event, although 68% of people had primarily come to see the bands, 81% of people surveyed said they had learnt something about science whilst 87% would definitely visit Jodrell Bank again (D).

Live From Jodrell Bank 2011 was awarded Best Outdoor Event at the national Event Awards in 2012; the 2012 event received an award for 'Extreme Creativity' from a panel of industry judges at the 2012 UK Festival Awards for its extra activity of integrating science into the music event (E).

Job creation & economic impact of tourism : As of July 2013, 26 jobs have been directly created in the new Discovery Centre (6 of them specifically for science engagement & education), plus 7 have been safeguarded and more will follow both directly and indirectly. As part of the funding process, the Regional Development Agency commissioned an assessment from EKOS (economic & social development consultants) which found the Centre is likely to provide an additional £27M economic impact to the region over the decade from opening in 2011 i.e. ~£6M over the REF period (F). Although no similar analyses exist, the economic impact of visitors during 2008-11 will also have been significant.

Education & inspiration : During the REF period 2008-2013, 43,000 pupils have visited Jodrell Bank as part of school groups, taking part in workshops relating to our research and targeted at the curriculum. The new programme, launched in Sep 2012, attracted 13,000 pupils in its first year and also includes teacher-training and short courses for adults. 97% of teachers rate these sessions as either good or excellent. We also regularly deliver talks and workshops in schools; targeting disadvantaged schools in particular. For example, we reached around 1500 Cumbrian pupils in an outreach event in 2010 alongside one of our research conferences (A).

Media impact : Jodrell Bank research has attracted the attention of the media for many years

stimulated in part by our active publicity programme. From 2008, we have produced more than 80 press releases and news items (available on our website) and, from monthly Google News searches, there were over 1,500 mentions of Jodrell Bank in print and web news stories (G).

TV producers in particular have been attracted to our work, resulting in our scientists and facilities appearing many times in a wide range of programmes. The most significant recent example is the incredibly successful BBC2 **"**Stargazing Live**"** series broadcast from Jodrell Bank in Jan 2011, 2012 and 2013.The programme typically attracts over 3 million viewers on each night of 3 consecutive nights, remarkable for a science subject. In 2012, it was the most viewed programme on BBC Two, Channel 4 or Channel 5 during the week of transmission and its audience share was 53% higher than the timeslot average (H). The programme always features our research and technology (e.g. pulsars, starburst galaxies, radio jets, masers, SETI, e-MERLIN and SKA). The impact has been clear: many positive reviews; astronomy equipment was reported as selling out in major retailers; a record-breaking 2.3 million downloads of the BBC Stargazing Guide; in 2011, 3,800 viewer photos and 5,000 questions were submitted; the website had 450,000 views; 13,000 people took part in interactive chat; 40,000 people attended 330 linked events nationwide; and astronomy societies reported significant boosts in membership and website traffic (H).

Podcast : A popular feature of our outreach programme is "The Jodcast", a twice-monthly podcast which has been produced since Jan 2006 by a team primarily composed of research students. The show features news, interviews with our researchers and others, and audience Q&A . There have been more than 170 episodes and special programmes, including reports from National Astronomy Meetings and occasional video episodes (e.g. featuring e-MERLIN and LOFAR). The shows are regularly downloaded by over 4,000 listeners (this is a lower limit as it does not include syndicated outlets such as astronomy.fm). When surveyed in 2010, 95% of 195 respondents said they would recommend it to others, 85% said that it had increased their interest in astronomy, whilst 94% said they had learnt something worthwhile. Quotes include "The interviews are my favourite part because you talk to an expert at length rather than editing them down to short sound bites"; "You always inspire and intrigue". (I).

World Heritage Site : In 2011, Jodrell Bank Observatory was added to the UK Tentative List for World Heritage Site status demonstrating a major societal impact of our research. The panel recognised that the site is "impressive tangible evidence of a major modern scientific development which has greatly enlarged human understanding of the Universe" (J).

Conclusion : Our aim with the programme of public engagement from Jodrell Bank is to harness the strong public interest in curiosity-driven research by directly engaging them with scientific research at a major UK facility, providing a legacy for decades by inspiring a wide audience including the scientists and engineers of the future.

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

[A] Records of visitor numbers, event attendees and feedback from Jodrell Bank Discovery Centre
[B] Marketing Cheshire Visitor Attraction of the Year 2012 – p1 and 6 of PDFs
[C] Harris International nationwide and visitor surveys of 2008 and 2012
[D] Testimonial letter from MD of Ground Control, event organisers of Live from Jodrell Bank confirming event details, attendees etc
[E] Event Awards 2012 – Best Outdoor Event – p5 of PDF; UK Festival Awards 2012 – Extra-Festival Activity Award – p4 of PDF
[F] Independent feasibility assessment of case for funding of Discovery Centre produced for NWDA by EKOS p35, inc. testimonial letters of support from Cheshire East Council, Marketing Cheshire (the regional tourism agency) and the MP for Macclesfield
[G] Monthly analysis of mentions of Jodrell Bank in Google News searches since 2008
[H] Testimonial from BBC Executive Producer inc. Stargazing Live campaign review
[I] Jodcast 2010 listener survey results inc archive of episodes at http://www.jodcast.net
[J] Panel report on Jodrell Bank's successful application for placement on UK Tentative List for World Heritage Site status – p52-53 of PDF