Solar Phys (2013) 285:1–7
DOI 10.1007/s11207-013-0267-y

Observations and Modelling of the Inner Heliosphere: Preface and Tribute to the Late Dr. Andy Breen

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Published online: 20 March 2013

This Topical Issue (TI) of *Solar Physics* is dedicated to (the memory of) Dr. Andrew (Andy) Robert Breen – 1964 – 2011 – Aberystwyth University.

Observations and Modelling of the Inner Heliosphere
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Keywords Remote-sensing · Space weather · Solar wind · Solar wind, disturbances · Velocity fields, solar wind · Coronal mass ejections · Coronal mass ejections, interplanetary · Coronal holes

1. Introduction

This topical issue (TI) of *Solar Physics* presents papers given at or associated with the Second International Workshop on "Remote Sensing of the Inner Heliosphere", which was held at the same venue as the first workshop (of the same name) at Yr Hen Coleg (The Old College) of Aberystwyth University in Wales (UK) from 06 to 11 June 2011. The Old College is a majestic building overlooking the seafront and only a two-minute walk from the main centre of town. Founded in 1872, Aberystwyth University is situated in this truly outstanding location on the Mid-Wales coast overlooking Cardigan Bay.

A study of the inner heliosphere, defined here as the region between the solar corona and Mars, demands a wide range of interdisciplinary instruments and methods, so the Workshop was specifically aimed at bringing together experts from the different fields. Remote-sensing observations available for probing the extended solar atmosphere (the inner heliosphere) range from direct observations of non-thermal solar radio emissions, through observations of extreme-ultraviolet (EUV) and X-ray low-coronal emissions, observations of photospheric white light scattered by electrons (Thomson scattering), observations of radio waves from distant astronomical sources scattered by density irregularities in the solar wind (interplanetary scintillation – IPS), and radio emissions from particles accelerated on interplanetary shocks, to direct imaging of the impact of solar disturbances in planetary atmospheres – auroras –, particularly at the Earth. These observations can be combined with *in-situ* measurements at or near Earth, at other terrestrial planets, or in the inner heliosphere, and with numerical magneto-hydrodynamics (MHD) simulations. Outstanding physical issues and questions, which can be tackled with this multi-disciplinary approach, include the propagation and interaction of coronal mass ejections (CMEs), the formation of co-rotating and stream interaction regions (CIRs/SIRs), the acceleration of the solar wind, and the propagation of energetic particles, as well as space-weather forecasting – *i.e.* the prediction of the conditions in the near-Earth environment using observations and models. While observations and measurements of the inner heliosphere have historically been sparse, a better understanding of this region is required to advance all subfields of solar-terrestrial physics – this at least is being built upon with each new deep-space and near-Earth solar-terrestrial type mission.

2. The Workshop

The broad aims of the Workshop were to gather experts from the various fields of remote-sensing observations of the inner heliosphere, including white-light, EUV, and radio observations, together with modellers to tackle key outstanding science issues, establish closer working relations, and devise the best ways to move the field forward. This workshop built on the previous successful first workshop in 2009 (05 – 08 May – "Remote Sensing of the Inner Heliosphere") and also on a series of IPS/radio-astronomy workshops held in Toyokawa, Japan in 2007 (30 – 31 October – "Toyokawa IPS Workshop") and in Cambridge, MA, USA earlier in 2007 (29 June – 02 July – " 'MWA Kick-off', International meeting for the Murchison Widefield Array, Low Frequency Demonstrator for the Square Kilometre Array"). In

addition, there were earlier similarly related workshops in Pushchino, Russia in 2006 (19 – 23 June – International Colloquium "Scattering and Scintillation in Radio Astronomy") as well as the workshop in San Diego, CA, USA in 2004 (27 – 28 January – "The Application of IPS and Faraday Rotation Techniques to Space Weather using LOFAR").

For the 2011 meeting, following the many successes of IPS with various radio-telescope systems around the world and of white-light imaging using the *Solar Mass Ejection Imager* (SMEI) on the *Coriolis* satellite and the *Solar TErrestrial RElations Observatory* (STEREO) *Heliospheric Imagers* (HIs), the decision was made to widen the remit further to embrace all methods of remote-sensing observations and modelling covering the inner heliosphere including that of space weather (and its forecasting) and of future remote-sensing instrument design considerations.

In the spirit of this, a significant portion of the workshop was devoted to the multi-instrument analysis and interpretation of the events of early August 2010. This was a particularly fruitful period of observation during the first major active period of the new solar cycle (Solar Cycle 24), allowing a unique opportunity for collaborative studies; the workshop allowed wide discussion of the progress of several investigations that have since come to fruition in this and other journals, including some contributions in this TI.

The workshop also looked into ways in which we can more easily and efficiently share and access the various types of data between individual groups and sub-communities, ways in which we model the inner heliosphere looking at the advantages and disadvantages of the available modelling, updates on present and future remote-sensing capabilities – including those on the STEREO, *Solar Dynamics Observatory* (SDO), *Solar Orbiter*, and *Solar Probe* + Missions, as well as progress on the use of the *LOw Frequency ARray* (LOFAR) and *Murchison Widefield Array* (MWA) (originally called the Mileura Widefield Array) radio arrays – pathfinders/precursors for the *Square Kilometre Array* (SKA) – linking remote-sensing observations of the inner heliosphere with those closer-in to the Sun as well as with *in-situ* measurements, and investigating further the ways in which these data sets all complement each other and are necessary to gain knowledge and understanding of the fundamental physical processes that occur within the inner heliosphere.

The Workshop covered a range of topics but provided a facility to focus on some key areas of research. Highlights from this included the following:

- The events of late July into early August 2010 involved the first major active region complex of the new solar cycle, releasing at least four coronal mass ejections on 01 of August 2010 alone. The timing and location of these events, which were mostly Earth-directed, ensured that key observations could be made, and compared from missions such as SDO, STEREO, the *Advanced Composition Explorer* (ACE), *Wind*, the *Solar Mass Ejection Imager* (SMEI) instrument onboard *Coriolis*, *Venus Express* (VEX), *Mars Express* (MEX), and the analyses and interpretation of these datasets was a major element of the Workshop. At the heart of these studies were issues such as the impact of these events at Earth and their predicted arrival times, the interaction of CMEs with one another, methods for tracking and modelling the propagation of the CMEs, and studies of their onsets. A number of papers have been published as a result of this work, which was a collaborative effort from more than a dozen institutes.
- Another key discussion at the Workshop was the debate on the nomenclature related to CMEs. Should we call a CME in the heliosphere an interplanetary CME (ICME), or is the term confusing? Does it imply different physical drivers and differences in nature between CMEs and ICMEs? Should "stealth" CMEs, where no specific source region on the solar "surface" is detected, be considered as a different class of CMEs? The workshop

attendees agreed unanimously to drop the term ICME and encourage the use of the abbreviation CME for both coronal and heliospheric (or interplanetary) events. Additionally, the general thoughts of the attendees were that all CMEs (three-part, halo, stealth) have the same physical driver and should not be treated differently from one another.

- Much discussion also took place with regard to IPS, its capabilities, and its use in solar/heliosphere/space-weather studies. A key point from this discussion was that of single-site observing information *versus* that of cross-correlated multi-site observing information and similarities/differences as well as advantages/disadvantages to both. The IPS community were to take this on board with investigations comparing the various techniques of IPS analyses already underway.

The Local Organising Committee (LOC) for the workshop were Drs. Mario M. Bisi (Lead Organiser – University of California, San Diego, CA, USA/Aberystwyth University, Wales, UK – now Aberystwyth University), Andrew R. Breen (Chair – Aberystwyth University), Richard A. Fallows (Co-organiser – Aberystwyth University – now at ASTRON, The Netherlands), and Miss Sarah Spring (Secretarial Support – Aberystwyth University). The Scientific Organising Committee (SOC) for the Workshop were Drs. Ernesto Aguilar-Rodriguez (Universidad Nacional Autónoma de México, México), Mario M. Bisi (Co-Chair), Andrew R. Breen (Co-Chair), Prof. Richard A. Harrison (Rutherford-Appleton Laboratory, England, UK), and Drs. Xing Li (Aberystwyth University), Noé Lugaz (now at the University of New Hampshire, NH, USA), and Dusan Odstrcil (NASA/George Mason University, VA, USA). The workshop venue, conference facilities and support were provided by the Institute of Mathematics and Physics (IMAPS) at Aberystwyth University (AU, UK) as well as central conference services for catering, overall providing an excellent – and architecturally unique – setting for the meeting. The archived meeting website can be found on the Aberystwyth University WebPages and is accessed here: http://heliosphere2011.dph.aber.ac.uk/.

One of the Workshop organisers was Dr. Andrew (Andy) R. Breen (to the memory of whom this TI is dedicated) and it was his enthusiasm that partly fuelled the desire for such a workshop. Indeed, he did attend the Workshop, despite his continuing ill health, and this TI comes to publication more than a year after the sad loss of Andy. He was a pioneer of radio remote-sensing observations of the inner heliosphere using the technique of IPS with the *European Incoherent SCATter* (EISCAT) radar and EISCAT Svalbard Radar (ESR) systems across northern Scandinavia, as well as with the *Multi-Element Radio-Linked Interferometer Network* (MERLIN) system based across the United Kingdom.

3. Dr. Andy Breen

Dr. Andrew (Andy) Robert Breen was born in Sunderland in 1964 and sadly passed away after a long period of increasing ill health, his constant battle since early adulthood with Myasthenia Gravis, and a major heart operation in December of 2011. He started out his professional career as a young Ph.D. student working with the late Prof. Philip (Phil) J.S. Williams at what was then the University of Wales, Aberystwyth, in the late 1980s. Initially, they carried out the kind of research that had been expected from the EISCAT radar system in northern Scandinavia in ionospheric studies investigating the detailed physics and chemistry of the upper atmosphere when bombarded with kilovolt electrons in the auroral oval. Following some years at Southampton University, England, UK, and also at the Max-Planck-Institut für Aeronomie, Lindau, Germany, he returned to Aberystwyth in 1998 as a then Particle Physics and Astronomy Research Council (PPARC) Advanced Research

Fellow (now merged with other facilities to become the Science & Technology Facilities Council – STFC). In 2001, Andy moved fully onto the Academic staff at Aberystwyth as a Lecturer. Reunited with Phil during the late 1990s, together they built up an alternative and new research programme using EISCAT, one that had not been thought of previously and perhaps not realised until this time as being possible with the system. They took advantage of the separation distances of the three mainland antennas to investigate observations of the twinkling of distant astronomical radio sources in the far Universe, otherwise known as radio scintillation, or more-specifically, IPS.

Observations of IPS are obtained by recording the amplitude (or phase) modulation of radio signals from distant, compact, astronomical radio sources on the sky which are due to the density irregularities and turbulence in interplanetary space (the non-uniform solar wind coming out from the Sun). Andy and Phil soon realised that the EISCAT observing frequencies ($\sim$930 MHz and later expanded to include $\sim$1420 MHz) allowed them to make measurements closer to the Sun than the IPS systems around at the time allowed (which were observing at lower frequencies of 327 MHz or below). This was real cutting-edge, exciting, world-leading science of the time. Phil may have supplied the initial idea (and his usual enthusiasm as he did for many things in his life), but it was Andy who worked through the details and made the method actually work: so much so, that by the time Phil moved on to being a member of the Welsh Assembly in Cardiff and pursued his political career, Andy had become a world leader in his field. Andy worked with, and was respected by, solar/heliospheric scientists from all around the world. He became a Co-Investigator on the *Heliospheric Imager* (HI) instruments onboard the twin NASA STEREO spacecraft and also a Member of the Solar and Space Weather Key Science Project for LOFAR. During 2007 and 2008 he was one of the leading organisers for the International Heliophysical Year. Andy also achieved his final academic position of Senior Lecturer at Aberystwyth University in 2006 (although popular opinion suggests that he surely should have been made a professor in more recent years prior to his death).

IPS research today is just as prevalent as at its discovery as detailed in the first IPS paper in 1964, which happened to be the year of Andy's birth – perhaps it was fated in some sense that Andy took up that field with such vigour for most of his research career. There are active research groups around the world taking and using IPS data for scientific research: at the University of California San Diego (UCSD), CA, USA; at the Solar-Terrestrial Environment Laboratory (STELab/STEL), Japan; at Ooty, India; at Aberystwyth University, Wales, UK; at the Pushchino observatory, Russia; at Michoacán, México (*MEXican Array Radio Telescope* – MEXART); and also with LOFAR across northern Europe. In the very near future, the new MWA system will hopefully begin to take data with its full 128-tile (128T) system, making MWA the first southern-hemisphere-based IPS-capable system. Some more recent tests have also been made with the *Kilpisjärvi Atmospheric Imaging Receiver Array* (KAIRA) in northern Finland on the tri-border with Sweden and Norway, which is a pathfinder for the future EISCAT_3D system (primarily for incoherent-scatter-type investigations, but with far wider astrophysical, astronomical, and heliospheric science capabilities) that is envisaged to be built and online by around 2018.

Andy's favourite scientist was Arthur Eddington – the British scientist who, among other things, worked out where the Sun's energy came from. It is said that he was out walking with a friend one night and his friend looked up at the stars and said how beautiful they were. He replied, "Yes, indeed, but tonight I'm the only one who understands how they shine". Andy admired that ability to make a difference, to answer the big questions. He can be justly proud of the scientific contributions that he made throughout his relatively short career of scientific discovery!

Figure 1 An overview mini-collage of photographs of Andy Breen engaged in one of his most often enjoyed hobbies and interests: sailing. These are three photographs of Andy out sailing on Cardigan Bay on his old boat, Mochras, now with a new owner in New Quay South of Aberystwyth and still going out onto Cardigan Bay.

On a personal level, Andy was a very eccentric, lovable, terribly enthusiastic, colourful, caring, brilliant individual – who brought all of those wonderful qualities to the world as an internationally recognised heliospheric physicist. He had a wide variety of interests and hobbies from trains to old aircraft, sailing, reading, and speciality ales, and he always had something interesting to say on any topic or matter. A set of three photographs of Andy engaged in one of his favourite activities, sailing, can be seen in Figure 1. Andy's wit, spirit, humanity, courage, and human decency touched many more people than he ever realised; his early death, at the age of only 47, means he will be hugely missed by his friends, his colleagues (especially those at Aberystwyth), and all in the several scientific communities that were fortunate to count him as one of their own.

4. Summary

The next meeting, the third in this series, will take place in Toyokawa or Nagoya, Japan, in November 2013 around the time of the CAWSES-II meeting. It will be organised by the IPS group at STELab, Nagoya University, Japan.

Finally, we thank the many authors for the influx of extra papers from those not able to attend the Workshop in 2011 as well as the papers from those in attendance. We also convey special thanks to the team of referees, who worked diligently in making sure the papers contained within this TI of *Solar Physics* on "Observations and Modelling of the Inner Heliosphere" are of the highest scientific quality and content. We are very happy with the papers in this TI and are pleased that they collectively cover the many aspects of remote-sensing techniques, observations, modelling, and comparisons with in situ measurements, from near the Sun's "surface" out to beyond 1 Astronomical Unit from the Sun and including space-weather effects on the Earth.

Acknowledgements It is a pleasure to acknowledge the Editors and staff at *Solar Physics* for their work in pulling this Topical Issue (TI) together, and thanks again to the team of referees for their time and effort in making this a very successful TI, covering a broad range of topics and studies related to observing and modelling the inner heliosphere. Special thanks also go to colleagues and friends of the late Andy Breen, but especially to Shelley Upton (a dear and long-time friend of Andy's), Andrew Rawlins (a very close friend

of Andy's) of Aberystwyth University for providing various photographs and stories of Andy, of his various hobbies and interests and other aspects of his personal life, as well as to Michael Lockwood of the University of Reading, who kindly researched and wrote various tributes/obituaries to Andy, on which some of the material here was based. We also like to thank Aberystwyth University (AU) for providing the rooms and internet access for the Workshop as well as the Institute of Mathematics and Physics (IMAPS) at AU for providing funding towards the refreshments in the mornings and at break times throughout the workshop.