Transactions IAU, Volume XXVIIIA
Reports on Astronomy 2009–2012
Ian Corbett, ed.

doi:10.1017/S1743921312002669

DIVISION II SUN and HELIOSPHERE
SOLEIL et HELIOSPHERE

Division II of the IAU provides a forum for astronomers and astrophysicists studying a wide range of phenomena related to the structure, radiation and activity of the Sun, and its interaction with the Earth and the rest of the solar system. Division II encompasses three Commissions, 10, 12 and 49, and four Working Groups.

PRESIDENT	**Valentín Martínez Pillet**
VICE-PRESIDENT	**James A. Klimchuk**
PAST PRESIDENT	**Donald B. Melrose**
BOARD	**Gianna Cauzzi, Lidia van Driel-Gesztelyi, Natchimuthuk Gopalswamy, Alexander Kosovichev, Ingrid Mann and Carolus J. Schrijver**

DIVISION II COMMISSIONS

Commission 10	**Solar Activity**
Commission 12	**Solar Radiation & Structure**
Commission 49	**Interplanetary Plasma & Heliosphere**

DIVISION II WORKING GROUPS

Division II WG	**Solar Eclipses**
Division II WG	**Comparative Solar Minima**
Division II WG	**International Collaboration on Space Weather**
Division II WG	**Communicating Heliophysics to the Public**

TRIENNIAL REPORT 2009-2012

1. Introduction. The status of ground and space based solar and heliospheric astronomy

The solar activity cycle entered a prolonged quiet phase that started in 2008 and ended in 2010. This minimum lasted for a year longer than expected and all activity proxies, as measured from Earth and from Space, reached minimum values never observed before (de Toma, 2012). The number of spotless days from 2006 to 2009 totals 800, the largest ever recorded in modern times. Solar irradiance was at historic minimums. The interplanetary magnetic field was measured at values as low as 2.9 nT and the cosmic rays were observed at records-high. While rumors spread that the Sun could be entering a grand minimum quiet phase (such as the Maunder minimum of the XVII century), activity took over in 2010 and we are now well into Solar Cycle 24 (albeit, probably, a low intensity cycle), approaching towards a maximum due by mid 2013. In addition to bringing us the possibility to observe a quiet state of the Sun and of the Heliosphere that was previously not recorded with modern instruments, the Sun has also shown us how little we know about the dynamo mechanism that drives its activity as all solar cycle predictions failed to see this extended minimum coming.

While the most veteran solar missions are being slowly decommissioned (such as the ESA/NASA SOHO mission) or have been completely switched off (such as the NASA SMEX TRACE mission), others are continuing to observe the Sun and the Heliosphere and new ones have been launched. SOHO spacecraft is functioning at the moment with the irreplaceable LASCO coronagraphs that still provides unique images of Coronal Mass Ejections (CMEs) at distances of several solar radii. It is unclear for how long will ESA and NASA provide support to this landmark mission. The Japanese-led Hinode mission (launched in 2006) is still observing the Sun at a resolution, continuity and sensitivity never achieved before. The database built up by this mission will provide unparalleled insights about the solar magnetic field in years to come. The twin-spacecraft STEREO mission has finally benefited from an active Sun after its first cruise years where the Sun was sitting in a deep activity minimum with a strongly reduced CME production. We have now crucial 3D information about these events that represent the most energetic processes that shape the Heliosphere. Finally, in 2010 NASA launched the SDO mission that provides full Sun coverage in white-light and UV wavelengths together with high temporal cadences. While the outstanding images provided by this mission have already impressed scientists and laymen, their quantitative aspects (vector magnetic fields, perfect alignment between visible and UV frames, etc.) are of an importance that we are barely starting to fully appreciate. Last, but not least, the SUNRISE stratospheric balloon flight (launched during the activity minimum of June 2009, Solanki *et al.* 2010) has shown the enormous potential of these platforms half-way in between ground based telescopes and space observatories. The SUNRISE mission has provided half an hour long time series of Doppler velocities and vector magnetic fields with a sensitivity, cadence and spatial resolution (0.15 arcsec) that will be difficult to match any time soon. A second flight of this balloon-based platform with the Sun in maximum activity conditions promises a scientific return as large as that from the first one.

Clearly, the status of space based solar physics shows a wealth of missions providing state-of-the-art data that ensures substantial quantitative and qualitative progress in our understanding of the Sun and its surrounding Heliosphere. The longer-term future is also bright given the recent selection by ESA of the Solar Orbiter mission (launch 2017) with its unique suite of in-situ and remote sensing observations filling the gap left by the highly successful Ulysses mission. Solar Orbiter will be flown in combination with the NASA Solar Probe+ mission that, thanks to their proximity to the Sun, will provide a step forward in our predicting capability of solar storms and other Space Weather phenomena.

Ground-based solar physics is also moving forward. The Advanced Technology Solar Telescope is near its construction phase with a firm funding line and a very competitive set of first-light instruments (Keil *et al.* 2010). In Europe, a telescope with a slightly different scientific scope (European Solar Telescope, Collados *et al.* 2010), but also in the 4m aperture class, is being studied and its feasibility phase was successfully completed in 2011. As this 4m-class era of solar telescopes approaches, successful first-light images are being obtained from the 1.5m aperture telescopes that are starting operations both in the USA and Europe. The NST (Big Bear Observatory, Goode *et al.* 2010) has obtained astonishing images of the Sun in white-light that make the comparison between MHD simulations and these observations straightforward. The Gregor telescope (Volkmer *et al.* 2010) has received its 1.5m mirror and its near its commissioning phase. Both Gregor and NST represent a much needed intermediate step while the solar community approaches the exciting era of a less photon-starved telescopes of the 4m class later this decade.

https://doi.org/10.1017/S1743921312002669 Published online by Cambridge University Press

2. Structure of the Division

Division II includes three Commissions, 10, 12 and 49, and four Working Groups. The current Commission presidents, elected at the Rio de Janiero General Assembly, are Lidia van Driel-Gesztelyi, Commission 10, Alexander Kosovichev, Commission 12, and Natchimuthuk Gopalswamy, Commission 49. Also at the IAU XXVII General Assembly, in Rio, 2009, Lidia van Driel-Gesztelyi was asked to continue as the Division's first secretary. Commission 10 Solar Activity, focuses on transient aspects of the Sun, including flares, prominence eruptions, CMEs, particle acceleration, magnetic reconnection and topology, coronal loop heating, and shocks in the corona. Commission 12 Solar Radiation and Structure, emphasizes steady-state aspects of the Sun, including long-term irradiance, helioseismology, magnetic field generation, active regions, photosphere, and chromosphere. Commission 49 Interplanetary Plasma and Heliosphere, studies the solar wind, shocks and particle acceleration, both transient and steady-state, e.g., corotating, structures within the Heliosphere, and the termination shock and boundary of the Heliosphere. There can be considerable overlap among the Commissions, such as in the areas of magnetic activity, solar evolution, particle acceleration, and space weather.

The four Division Working Groups are explained in the next section.

The organizing committee of Division II includes the president, vice-president, secretary and immediate past president of the Division, together with the presidents and vice-presidents of the three Commissions. The position of Divisional secretary had been discussed and agreed in principle at the Sydney General Assembly, but it was only at the Prague General Assembly that it was decided to elect a secretary from among the vice-presidents of the Commissions. This structure was agreed to be maintained in the Rio General Assembly.

Communication with the members of the Division has been relatively fluent by using the e-mail system announced in the Rio GA (<iaudivii@iac.es>). This e-mail system has been mostly used to remind Division II members about the various deadlines, in particular for Symposium proposals. This has indeed had a considerable impact in terms of the number of Division II proposals received in the various calls.

2.1. *Working Groups*

The four current Working Groups of the Division are, from the oldest to the newest, Solar Eclipses, International Collaboration on Space Weather, Comparative Solar Minima and Communicating Heliophysics to the Public.

It is worth mentioning that the Division II Organizing Committee (OC) has proposed to the IAU Executive that all members of the WG on Solar Eclipses that belong to the WG-OC but are non-professional astronomers should be nominated for IAU membership in the XXVIII GA in Beijing.

2.2. *WG on Solar Eclipses (Jay M. Pasachoff)*

The Working Group on Solar Eclipses is chaired by Jay M. Pasachoff (USA) and for the 2009-2012 triennium also included Iraida S. Kim (Russia), Hiroki Kurokawa (Japan), Jagdev Singh (India), Vojtech Rusin (Slovakia), Atila Ozguc (Turkey), Yihua Yan (China), Fred Espenak (USA), Jay Anderson (Canada, consultant on meteorology), Glenn Schneider (USA), and Michael Gill (UK, maintainer of Solar Eclipse Mailing List). For the 2012-2015 triennium, the Working Group will again include Jay M. Pasachoff (USA, chair), Iraida S. Kim (Russia), Hiroki Kurokawa (Japan), Jagdev Singh (India), Vojtech Rusin (Slovakia), Fred Espenak (USA), Minde Ding (China), Jay Anderson (Canada, consultant on meteorology), Glenn Schneider (USA), and Michael Gill (UK, maintainer of Solar Eclipse Mailing List). New members will include Nick Lomb (Australia), Haisheng

https://doi.org/10.1017/S1743921312002669 Published online by Cambridge University Press

Ji (China), Bill Kramer (www.eclipse-chasers.com), Xavier Jubier (online maps), and Michael Zeiler (www.eclipse-maps.com, maps).

The WG has web sites www.eclipses.info and www.totalsolareclipse.net. The WG has as its task the coordination of solar eclipse efforts, particularly making liaisons with customs and other officials of countries through which the path of totality passes and providing educational information about the safe observation of eclipses for the wide areas of the Earth in which total or partial eclipses are visible. The work is coordinated with that of the Program Group on Public Information at the Times of Eclipses of IAU Commission 46 on Education and Development. Two members, Espenak and Anderson, have produced the widely used NASA Technical Publications with eclipse paths and detailed information, available as hard copies or online, linked through www.eclipses.info or via the NASA Eclipse Web Site at eclipse.gsfc.nasa.gov. The bulletins are directly at URL eclipse.gsfc.nasa.gov/SEpubs/bulletin.html; at this writing, bulletins are in preparation for ASE2012 and TSE2012.

Eclipse maps, with the paths marked in Google Maps or in Google Earth, and local circumstances presented for wherever the user clicks, are provided by Xavier Jubier as the first entries at www.eclipses.info, or directly, for the Google maps, to xjubier.free.fr/en/site_pages/SolarEclipsesGoogleMaps.html. See also xjubier.free.fr/en/site_pages/Solar_Eclipses.html. Fred Espenak's World Atlas of Solar Eclipse Paths is at eclipse.gsfc.nasa.gov/SEatlas/SEatlas.html.

Two review articles by the WG chair in Nature (freely available in Pasachoff, 2009a) and in Research in Astronomy and Astrophysics (Pasachoff, 2009b) describe the scientific value of eclipse observations.

During the past triennium, we had total solar eclipses of 11 July 2010, visible across the Pacific Ocean, including some islands in French Polynesia and, later, Easter Island.

A comparison of the observations from the two sites separated by 93 minutes appeared in Pasachoff *et al.* (2011). The thermodynamics of the corona and the observed evolution of the magnetic field during this same eclipse was described in Habbal *et al.* (2011).

There were no central eclipses in 2011. Partial eclipses were visible on 4 January 2011 over a wide area of Europe, Africa, and Asia; on 1 June 2011 in Iceland and northern Scandinavia, as well as northenmost Canada, Alaska, and Siberia; on 1 July 2011 in a small area of the ocean off the coast of Antarctica, barely touching the coast (so was, for all practical purposes, invisible; most unusually, probably nobody on Earth viewed this solar eclipse); and on 25 November 2011, in southern New Zealand, Tasmania, and southern South Africa. See maps at eclipse.gsfc.nasa.gov/OH/OH2011.html. 2012 boasts of two central solar eclipses. The 20 May 2012 annular eclipse will be visible from sites in Japan and then across the Pacific to the western United States. The 13/14 November 2012 total solar eclipse's path of totality will cross northerneasternmost Australia, principally Cairns and Port Douglas, before heading entirely over the ocean. Partial phases will be visible throughout Australia, New Zealand, eastern Indonesian islands, and Papua New Guinea. See xjubier.free.fr/en/site_pages/solar_eclipses/TSE_2012_GoogleMapFull.html. Discussions of the 2012 eclipses and maps appeared online at the minus-first anniversary of the next total solar eclipse at www.365daysofastronomy.org for 13 and 14 November 2011.

Other total eclipses in the triennium are 3 November 2013 across Africa from Gabon to northern Kenya, xjubier.free.fr/en/site_pages/solar_eclipses/HSE_2013_GoogleMapFull.html; and 20 March 2015 in Svalbard or the Faroe Islands, up to the north pole, xjubier.free.fr/en/site_pages/solar_eclipses/TSE_2015_GoogleMapFull.html. Partial phases will be visible throughout Europe, northern Africa, and north-central Asia. Annular eclipses will be visible on 10 May 2013 in

https://doi.org/10.1017/S1743921312002669 Published online by Cambridge University Press

northern Australia, including the outback and the Cape York peninsula, and Kiribati xjubier.free.fr/en/site_pages/solar_eclipses/ASE_2013_GoogleMapFull.html; and, undoubtedly unobserved, on 29 April 2014 in Antarctica xjubier.free.fr/en/site_pages/solar_eclipses/ASE_2014_GoogleMapFull.html. See xjubier.free.fr/en/site_pages/SolarEclipsesGoogleMaps.html.

A new set of eclipse maps, from Michael Zeiler, is available at www.eclipse-maps.com. Jay Anderson has maps, cloud statistics, and weather discussions at home.cc.umanitoba.ca/∼jander/=http://eclipser.ca.

Additional online resources that have become available in the past three years include an enhanced local circumstances calculator at www.eclipse-chasers.com/tseCalculator.php with Baily's Beads simulations using either the US Naval Observatory's charts by Watts showing the lunar profile or the JAXA Kaguya lunar data reduced by International Occultation Timing Association (IOTA) Australia member David Herald. Charts showing an exaggerated lunar profile with predicted bead placements can be created for one-tenth second intervals. Advanced local circumstance calculations incorporate the dip of the horizon and refraction estimates for more accurate timing predictions.

Eclipse chasers can log their eclipse experiences and upload pictures to Kramer's log at www.eclipse-chasers.com/tseChaserLogSums.php. Google maps showing the eclipse paths as pins or weather icons (based on submitted observations) can be displayed for those eclipses with log data. Over 100 observers with an average of six total solar eclipses each have logged their eclipse observations thus far. Eclipse-observer statistics are also logged at Sheridan Williams' site at www.clock-tower.com.

2.3. *WG on Communicating Heliophysics to the Public (C. Briand)*

The Working Group on Solar Eclipses is chaired by Carine Briand (France) and includes Francesco Berilli (Italy), Maria-Cristina Rabello-Soares (USA), Jean-Pierre Raulin (France), Deborah Scherrer (USA), Yihua Yan (China).

Communication to and with the public takes an increasing place in the researcher activities. If for a long time it was felt as a time consuming obligation, the scientists now consider it as part of their professional work and a way to increase the impact of scientific results and indeed recognize the benefit of such activity. Most of scientific disciplines develop outreach activities. Of course, astrophysicists are also deeply implicated in many public outreach activities. In fact, it results that the astronomical community is one the best organized community for Education/Public Outreach (E/PO).

Images of galaxies, deep space and planets have been largely spread in the public. But heliophysicists also have numerous original assets to communicate. The high spatial resolution of the telescopes provide amazing details of the Sun, unachievable on other stars. Many solar structures have lifetime from a few minutes to a few hours, allowing the production of fascinating movies. Last but not least, sonification of radio dynamic spectra offer an original way to "look" at our environment. These media provide exciting means to catch the public's attention and to help delivering more complex messages about physics.

Owing to the space age and the development of large international instruments, the heliophysical community is particularly well organized compare to other fields of physics. The International Heliophysical Year 2007 has demonstrated the capability of our community to mobilize the researchers all over the world to participate to E/PO activities (see IAU report 2006-2009 for details). Now, the link with the other fields of astrophysics needed to be reinforced in particular through a strongest participation to the activities of the Commission 55 of the IAU. The aim of this working group is twofold. We first aim to join the IAU-C55 efforts to provide information from the heliophysics community, and

second to discuss the best practices to share experience and documents within our own community.

The working group was proposed during the General Assembly of IAU in 2009. It is composed of six persons representing most of the regions of the world: two from Europe, two from the United States, one from China and one from Brazil. When possible, we also invited other scientists to participate to our works. For example, Jean-Pierre Lebreton (ESA) joined a discussion of the WG during the AGU 2009 in San Francisco.

We took advantage of the presence of Jean-Louis Bougeret (former chair of the Commission 49) at the CAP2010 to take the first formal contacts with the Commission 55. Strongest bounds were created during the CAP2011 meeting in Beijing. The organizers of the meeting provided us a time slot to present our community and highlight some specific activities. Most of the activities fully correspond to the CAP conferences and journal but also to the "Best Practices" working group of C-55. We will thus encourage all heliophysicists to present their works and to participate to the discussions of C55 during the next IAU-GA.

If space agencies provide numerous resources, the researchers also developed their own activities and documents, in particular in their own language. The second goal of the WG is to promote these public outreach activities and to exchange experiences. The best way to share the documents and to highlight unusual or impressive actions is through a web page. It is dedicated to the heliophysics community but also to the other astronomical communities. At the time of writing those lines, the website is under development. However, it should be opened for the next IAU-GA. Different sections are already written like "Exhibits", "Movies", "Books" and specific E/PO meetings. All researchers will be invited to provide information to appear on this web site.

The working group should evolve by including more heliophysicists to discuss the best practice to share experience. The web we are developing is one option but other media can be used also (in particular social media). The implication of the people specialized in E/PO must increase and the link between them and the scientists should be reinforced. This may be a line of thought for the next period.

2.4. *WG on Comparative Solar Minima (S. Gibson)*

The Working Group on Comparative Solar Minima is chaired by Sarah Gibson (USA) and includes Ed Cliver (USA), Hebe Cremades (Argentina), Peter Fox (USA), Nat Gopalswamy (USA), Gustavo Guerrero (Sweden), Margit Haberreiter (Switzerland), Joanna Haigh (UK), Janet Kozyra (USA), Kanya Kusano (Japan), Cristina Mandrini (Argentina), Georgeta Maris (Romania), Valentin Martinez Pillet (Spain), Pete Riley (USA), Barbara Thompson (USA), Andrey Tlatov (Russia), Ilya Usoskin (Finland) and David Webb (USA).

The mission of the WG is to facilitate international and interdisciplinary research that focusses on the coupled Sun-Earth system during solar minimum periods. Such research seeks to characterize the system at its most basic, "ground state", but also to understand the degree and nature of variations within and between solar minima.

The WG has a web site `ihy2007.org/IAUWG/WEBPAGES/IAUWG.shtml` which includes a listing of meetings and workshops organized by working group members and also a bibliography of multi-disciplinary papers relevant to the WG. In addition, there is a project page summarizing research comparing the last two solar minimum.

One of the main activities of the WG pertained to the Whole Heliosphere Interval - an international coordinated observing and modeling effort to characterize the three-dimensional interconnected solar-heliospheric-planetary system during the last minimum

https://doi.org/10.1017/S1743921312002669 Published online by Cambridge University Press

ihy2007.org/WHI/WHI.shtml. A WHI workshop was held in Boulder, Colorado in November 2009, and an AGU special session in August 2010 in Iguazu, Brazil.

Moreover, at the WHI workshop a topical issue of Solar Physics was successfully proposed to gather papers regarding the Sun-Earth Connection near Solar Minimum, with emphasis on the WHI period. The Issue will be published in December 2011, in a double issue of Solar Physics (Vol. 274).

2.5. *WG on International Collaboration on Space Weather (D. Webb)*

The Working Group for International Collaboration on Space Weather has as its main goal to help coordinate the many activities related to space weather at an international level. It is chaired by David Webb and its website is at www.iac.es/proyecto/iau_divii/IAU-DivII/main/spaceweather.php. The site currently includes the international activities of the International Heliospheric Year (IHY), the International Living with a Star (ILWS) program, the CAWSES (Climate and Weather of the Sun-Earth System) Working Group on Sources of Geomagnetic Activity, and Space Weather studies in China.

The International Heliospheric Year was an international program of scientific collaboration during the time period 2007-2009. The IHY has officially closed, and has been superseded under UN auspices as the International Space Weather Initiative. The website is at: www.iswi-secretariat.org. David Webb is the IAU scientific representative for ISWI. ISWI is a program of international cooperation to advance the space weather science by a combination of instrument deployment, analysis and interpretation of space weather data from the deployed instruments in conjunction with space data, and communicate the results to the public and students. Although ISWI follows-on to the successful IHY, it focuses exclusively on space weather. The goal of the ISWI is to develop the scientific insight necessary to understand the science, and to reconstruct and forecast near-Earth space weather.

The goal of the ILWS program is to stimulate, strengthen, and coordinate space research to understand the governing processes of the connected Sun-Earth System as an integrated entity. The website is at: ilwsonline.org. The kickoff meeting was held in 2002 and since then several Steering Committee and science meetings have been held. The latest was the 2011 ILWS Science Workshop "Towards the Next Solar Maximum" held August 28-September 1, 2011 in Beijing, China.

The CAWSES Working Group has as its objective to understand how solar events impact geospace by investigating the underlying science and developing prediction models and tools. CAWSES has been extended as CAWSES II for 2009-2013. The website is at: www.cawses.org/CAWSES/Home.html. CAWSES-II supports a framework for sustaining international and interdisciplinary collaborations by leveraging the full potential for scientific discovery and learning inherent in past investments in instrumentation and facilities. CAWSES-II focuses on "grand challenge" questions that can only be addressed through interdisciplinary research and international collaboration. It supports development of a virtual community to produce the scientific breakthroughs enabled by advances in cyber infrastructure and to help revolutionize the way in which collaborative scientific research is done. CAWSES-II has 6 task groups that address science and integrative activities to focus its activities.

The working group on Space Weather Studies in China is chaired by Jingxiu Wang and is involved with many new initiatives on space weather. In the near future we plan to add information and website links to recent and active space weather studies in other countries, such as in India, Russia and the Americas.

https://doi.org/10.1017/S1743921312002669 Published online by Cambridge University Press

3. IAU Meetings

The Division has played a leading role in the following IAU meetings, that have been held since the last triennial report by Melrose *et al.* (2009):

• IAUS 273 on the Physics of Sun and star spots (Debi Prasad Choudhary, Klaus G. Strassmeier, eds.), August 23 - 26 2010, Los Angeles, USA

• IAUS 286 on the Comparative magnetic minima: characterizing quiet times in the Sun and stars (Cristina Mandrini, David Webb, eds.), October 3 - 7, 2011, Mendoza, Argentina

At the XXVII IAU General Assembly in Rio de Janeiro, the following Division II leaded events took place

• IAUS 264 on Solar and Stellar Variability - Imapct on Earth and Planets (Alexander Kosovichev, ed.), August 3 - 7, 2009

• JD16 International Heliospheric Year Global Campaign - Whole Heliosphere Interval (Barbara J. Thompson), August 12 - 14, 2009

• JD11 New Advances in Helio- and Astero-Seismology (Junwei Zhao, ed.), August 10 - 11, 2009

Valentín Martínez Pillet
president of the Division

References

Collados, M., Bettonvil, F., Cavaller, L. *et al.* 2010, *AN* 331, 615
Goode, P. R., Coulter, R., Gorceix, N., *et al.* 2010, *AN* 331, 620
Habbal, S. R., Druckümuller, M., Morgan, H. *et al.* 2011, *ApJ*, 734, 88
Keil, S. L., Rimmele, T. R., & Wagner, J., ATST team 2010, *AN* 331, 609
Melrose, D. B., Martínez Pillet, V., Webb, D. F. *et al.* 2009, *Transactions IAU* 4, 27A, 73
Pasachoff, J. 2009a, *Nature*, 459, 789
Pasacoff, J. 2009ib, *Research in Astronomy and Astrophysics*, 9, 613
Pasachoff, J., Rušin, V., Druckmüllerová, H. *et al.* 2011, *ApJ*, 734, 114
Solanki, S. K., Barthol, P., Danilovic, S. *et al.* 2010, *ApJ* 723, L127
de Toma, G. 2012, in: C. H. Mandrini, J., & D. Webb (eds.), *Comparative Magnetic Minima: characterizing quiet times in the Sun and stars*, Proc. IAU Symp. No. 286, Mendoza, Argentina, 3-7 October 2011 (Cambridge: University Press), in press
Volkmer, R., von der Lühe, O., Denker, C. *et al.* 2010, *AN* 331, 624

https://doi.org/10.1017/S1743921312002669 Published online by Cambridge University Press