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Comparative Magnetic Minima: Characterizing Quiet Times in the Sun and Stars

Edited by

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Mandrini
Webb

Cristina H. Mandrini
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COMPARATIVE MAGNETIC MINIMA:
CHARACTERIZING QUIET TIMES IN THE SUN AND STARS

IAU SYMPOSIUM No. 286

COVER ILLUSTRATION:

Mendocinean landscape showing a typical vineyard plantation with the Andes mountains in the background. Surrounded by a mixture of arid and semiarid landscapes, the city of Mendoza and its rural outskirts have been turned into a fertile oasis, sustained by the melting of glaciers and snow and manmade dams, channels, and drains. Also called “The land of Sun and good wine”, its diaphanous skies and wine-producing fields attract over a million tourists every year.

Our Mendoza IAU Symposium on “Comparative Magnetic Minima” brought together scientists who studied the Sun, stars, and effects of magnetic activity on planetary space environments. One such “space weather” effect is that of beautiful aurorae, as illustrated here on a star field background courtesy of NASA and The Hubble Heritage Team (STScI/AURA). The solar disc image is courtesy of SDO (NASA) and the AIA consortium, while the solar corona is courtesy of Williams College Eclipse Expedition (Jay M. Pasachoff, Muzhou Lu, and Craig Malamut), captured on July 11, 2010.

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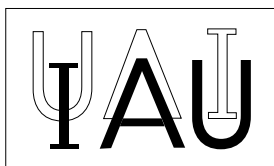
IAUS 286

Comparative Magnetic Minima: Characterizing Quiet Times in the Sun and Stars

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INTERNATIONAL ASTRONOMICAL UNION
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Edited by

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Table of Contents

Preface	x
Organizing committee	xii
Conference photograph	xiii
Conference participants	xvi
Session 1: Solar and Stellar Minima	
<i>Chairs: H. Cremades & S. Gibson</i>	
The nature and significance of solar minima	3
<i>E. Priest (Keynote)</i>	
Solar and stellar activity: diagnostics and indices	15
<i>P. G. Judge & M. J. Thompson (Invited)</i>	
How well do we know the sunspot number?	27
<i>L. Svalgaard (Solicited)</i>	
Session 2: Dynamos and Cycle Variability	
<i>Chairs: D. Gómez & G. Guerrero</i>	
Cycles and cycle modulations	37
<i>A. Brandenburg & G. Guerrero (Invited)</i>	
Magnetic helicity fluxes and their effect on stellar dynamos	49
<i>S. Candelaresi & A. Brandenburg (Contributed)</i>	
Modeling the solar cycle: what the future holds	54
<i>D. Nandy (Invited)</i>	
Spontaneous chiral symmetry breaking in the Tayler instability	65
<i>F. Del Sordo, A. Bonanno, A. Brandenburg & D. Mitra (Contributed)</i>	
Magnetic feature tracking, what determines the speed?	70
<i>G. Guerrero, M. Rheinhardt & M. Dikpati (Poster)</i>	
Session 3: Comparative Solar Minima from Sun to Earth	
<i>Chairs: M. Haberreiter, A. Tatlov & D. Webb</i>	
Helioseismology - a clear view of the interior.	77
<i>Y. Elsworth, A.-M. Broomhall & W. Chaplin (Invited)</i>	
Reconstruction of magnetic field surges to the poles from sunspot impulses	88
<i>N. Zolotova & D. Ponyavin (Contributed)</i>	
The Ni I lines in the solar spectrum.	93
<i>M. C. Vieytes, P. J. D. Mauas & J. M. Fontenla (Contributed)</i>	
Towards the reconstruction of the EUV irradiance for solar Cycle 23.	97
<i>M. Haberreiter (Contributed)</i>	

Polar magnetic fields and coronal holes during the recent solar minima	101
<i>G. de Toma (Invited)</i>	
Global magnetic fields: variation of solar minima	113
<i>A. Tlatov & V. Obridko (Invited)</i>	
The 3D solar minimum with differential emission measure tomography	123
<i>A. M. Vásquez, R. A. Frazin, Z. Huang, W. B. Manchester IV & P. Shearer (Invited)</i>	
The role of streamers in the deflection of coronal mass ejections	134
<i>F. P. Zuccarello, A. Bemporad, C. Jacobs, M. Mierla, S. Poedts & F. Zuccarello (Contributed)</i>	
Magnetic clouds along the solar cycle: expansion and magnetic helicity	139
<i>S. Dasso, P. Démoulin & A. M. Gulisano (Invited)</i>	
Coronal transients during two solar minima: their source regions and interplanetary counterparts	149
<i>H. Cremades, C. H. Mandrini & S. Dasso (Contributed)</i>	
Coronal ejections from convective spherical shell dynamos	154
<i>J. Warnecke, P. J. Käpylä, M. J. Mantere & A. Brandenburg (Contributed)</i>	
Dynamic evolution of interplanetary shock waves driven by CMEs	159
<i>P. Corona-Romero & J. A. Gonzalez-Esparza (Contributed)</i>	
Dynamical evolution of anisotropies of the solar wind magnetic turbulent outer scale	164
<i>M. E. Ruiz, S. Dasso, W. H. Matthaeus, E. Marsch & J. M. Weygand (Contributed)</i>	
Interplanetary conditions: lessons from this minimum	168
<i>J. Luhmann, C. O. Lee, P. Riley, L. K. Jian, C. T. Russell & G. Petrie (Invited)</i>	
The floor in the solar wind: status report	179
<i>E. W. Cliver (Solicited)</i>	
Probing the heliosphere with the directional anisotropy of galactic cosmic-ray intensity	185
<i>K. Munakata (Invited)</i>	
Search for solar energetic particle signals in the Mexico City neutron monitor database	195
<i>B. Vargas-Cárdenas & J. F. Valdés-Galicia (Contributed)</i>	
Extremely low geomagnetic activity during the recent deep solar cycle minimum	200
<i>E. Echer, B. T. Tsurutani & W. D. Gonzalez (Invited)</i>	
A porcupine Sun? Implications for the solar wind and Earth	210
<i>S. E. Gibson & L. Zhao (Contributed)</i>	
Modeling of the atmospheric response to a strong decrease of the solar activity .	215
<i>E. Rozanov, T. Egorova, A. Shapiro & W. Schmutz (Invited)</i>	

Coronal Mass Ejection deflection in the corona during the two last solar minima <i>F. M. López, H. Cremades & L. Balmaceda (Poster)</i>	225
High-speed streams in the solar wind during the last solar minimum <i>G. Maris, O. Maris, C. Oprea & M. Mierla (Poster)</i>	229
Geomagnetic effects on cosmic ray propagation for different conditions <i>J. J. Masías-Meza, X. Bertou & S. Dasso (Poster)</i>	234
The 3D solar corona Cycle 24 rising phase from SDO/AIA tomography <i>F. A. Nuevo, A. M. Vázquez, R. A. Frazin, Z. Huang & W. B. Manchester IV (Poster)</i>	238
Earth-directed coronal mass ejections and their geoeffectiveness during the 2007–2010 interval <i>C. Oprea, M. Mierla & G. Maris (Poster)</i>	242
Evolution of a very complex active region during the decay phase of Cycle 23 . . . <i>M. Poisson, M. López-Fuentes, C. H. Mandrini, P. Démoulin & E. Pariat (Poster)</i>	246
Very intense geomagnetic storms: solar sources, characteristics and cycle distribution <i>N. S. Szajko, G. Cristiani, C. H. Mandrini & A. Dal Lago (Poster)</i>	250
Session 4: Stellar Cycles	
<i>Chairs: C. H. Mandrini & A. Valio</i>	
Stellar cycles: general properties and future directions <i>M. Giampapa (Invited)</i>	257
Investigating stellar surface rotation using observations of starspots <i>H. Korhonen (Invited)</i>	268
Modulated stellar and solar cycles: parallels and differences <i>K. Oláh, L. van Driel-Gesztelyi & K. G. Strassmeier (Solicited)</i>	279
The solar wind in time. <i>J. L. Linsky, B. E. Wood & S. Redfield (Contributed)</i>	286
Stellar activity cycles in a model for magnetic flux generation and transport . . . <i>E. Işık (Contributed)</i>	291
Magnetic activity of cool stars in the Hertzsprung-Russell diagram <i>J. H. M. M. Schmitt (Invited)</i>	296
Semi-empirical modelling of stellar magnetic activity <i>A. Valio (Invited)</i>	307
12 years of stellar activity observations in Argentina <i>P. J. D. Mauas, A. Buccino, R. Díaz, M. Vieytes, R. Petrucci, E. Jofre, X. Abrevaya, M. L. Luoni & P. Valenzuela (Solicited)</i>	317
A statistical analysis of H α -Ca II relation for solar-type stars of different activity levels <i>A. P. Buccino, M. C. Vieytes & P. J. D. Mauas (Poster)</i>	324

Precise effective temperatures of solar analog stars.	328
<i>D. Cornejo-Espinoza, I. Ramírez, P. S. Barklem & W. Guevara-Day (Poster)</i>	
Session 5: Grand Minima and Historical Records	
<i>Chairs: A. Dal Lago & I. Usoskin</i>	
Stars in magnetic grand minima: where are they and what are they like?	335
<i>S. H. Saar & P. Testa (Invited)</i>	
Soft X-ray emission as diagnostics for Maunder minimum stars	346
<i>K. Poppenhaeger & J. H. M. M. Schmitt (Contributed)</i>	
Dynamo models of grand minima	350
<i>A. R. Choudhuri (Invited)</i>	
A model for grand minima and geomagnetic reversals	360
<i>D. D. Sokoloff, G. S. Sobko, V. I. Trukhin & V. N. Zadkov (Solicited)</i>	
Is meridional circulation important in modelling irregularities of the solar cycle?	367
<i>B. B. Karak & A. R. Choudhuri (Contributed)</i>	
Grand minima of solar activity during the last millennia.	372
<i>I. G. Usoskin, S. K. Solanki & G. A. Kovaltsov (Invited)</i>	
Historical records of solar grand minima: a review	383
<i>J. M. Vaquero (Invited)</i>	
Effects of solar variability on planetary plasma environments and habitability . .	393
<i>C. Bertucci (Invited)</i>	
Flares and habitability.	405
<i>X. C. Abrevaya, E. Cortón & P. J. D. Mauas (Contributed)</i>	
Potential energy stored by planets and grand minima events	410
<i>R. G. Cionco (Poster)</i>	
A new imminent grand minimum?	414
<i>R. G. Cionco & R. H. Compagnucci (Poster)</i>	
Long term relation between solar activity and surface temperature at different geographical regions.	418
<i>M. P. Souza-Echer, W. D. Gonzalez, E. Echer, D. J. R. Nordemann & N. R. Rigozo (Poster)</i>	
Parallels among the “music scores” of solar cycles, space weather and Earth’s climate.	423
<i>Z. Kolláth, K. Oláh & L. van Driel-Gesztelyi (Poster)</i>	
Climate interaction mechanism between solar activity and terrestrial biota.	427
<i>J. Osorio-Rosales & B. Mendoza (Poster)</i>	
Session 6: General Topics	
A cellular automaton model for coronal heating	433
<i>M. C. López-Fuentes & J. A. Klimchuk (Poster)</i>	

Magneto-seismology of solar atmospheric loops by means of longitudinal oscillations <i>M. Luna-Cardozo, G. Verth & R. Erdélyi (Poster)</i>	437
TTVs study in southern stars <i>R. Petrucci, E. Jofré, M. Schwartz, A. Buccino & P. J. D. Mauas (Poster)</i>	441
The LAGO (Large Aperture GRB Observatory) in Perú <i>E. Tueros-Cuadros, L. Otiniano, J. Chirinos, C. Soncco & W. Guevara-Day (Poster)</i>	445
Seeing measurement on Sasahuine mountain, Moquegua, Perú <i>C. Ferradas-Alva, G. Ferrero, M. Huamán, W. Guevara-Day, E. Meza, J. Samanes & P. Becerra (Poster)</i>	448
Creating a sunspot database at the Solar Observatory of Ica National University in Perú <i>L. Martínez-Meneses (Poster)</i>	452
A solar station in Ica - Mutsumi Ishitsuka: a research center to improve education at the university and schools <i>R. Terrazas-Ramos (Poster)</i>	454
Author index	457
Subject index	459

Preface

IAU Symposium 286, “Comparative Magnetic Minima: Characterizing Quiet Times in the Sun and Stars”, was coordinated through Division II, with the strong support of Division IV, including several of their associated commissions. It was held in Mendoza, Argentina, from 3 to 7 October 2011, and attracted nearly 100 scientists expert on various pertinent topics from 23 countries. The goal of the symposium was to consider solar and stellar minima, from generative dynamo mechanisms to in-depth analyses from Sun to Earth for recent well-observed and modeled minima, to a range of stellar cyclic activity, to outlier “grand minima”. Solar, heliospheric, geospace, atmospheric, stellar, and planetary sciences were included in the meeting’s scope.

Solar and stellar minima represent times of low magnetic activity and simple helio/asterospheres. They are, thus, excellent targets for interdisciplinary, system-wide studies of the origins of stellar variability and consequent impacts on planetary systems. The recent solar minimum extended longer and was “quieter” than any we have observed in the Space Age, inspiring both scientific and public interest. A rich variety of satellite and ground-based observations, in conjunction with theoretical and numerical modeling advances, have allowed us to probe the peculiarities of this minimum as never before. The implications are far-reaching, connecting Earth to Sun to stars, radio to X-rays to cosmic rays, and the plethora of observations of recent minima to the Sun’s past behavior as preserved in cosmogenic isotopes and historical sunspot and auroral records.

At the meeting, the keynote talk on “The nature and significance of solar minima” was given by Eric Priest. This was followed by 28 invited, 6 solicited talks and 28 contributed presentations spread over five sessions: Solar and Stellar Minima, Dynamos and Cycle Variability, Comparative Solar Minima from Sun to Earth, Stellar Cycles and Grand Minima, and Historical Records. A closing discussion on whether we are entering a grand minimum was led by Karel Schrijver. Thirty one poster presentations were put up and remained during the entire meeting. A public outreach talk on global warming and solar activity was given by Pablo Mauas at the end of the symposium.

The presentations described how magnetic fields can be cyclically generated in solar and stellar interiors via various dynamo processes. Numerical models have increased in complexity to the point where many observed aspects of the cycles in the Sun and stars are captured, although mysteries remain such as the origins of extended, or “grand” minima. Both stellar observations and historical and cosmogenic records at the Earth were presented, forming a basis of understanding of such intervals, and of solar/stellar long-term variability in general. A simple method to reconcile the Zürich Sunspot Number and the Group Sunspot Number was presented, with important and wide ranging implications towards an agreed-upon and vetted single sunspot series for use in the future.

The recent extended minimum was the lowest and longest minimum in about a century, having weak polar magnetic fields, a complex corona and heliosphere, and recurrent high-speed streams. Simultaneously, it was found that solar minima do not all look alike, given that the Sun can have different magnetic flux configurations even during very quiet times, yielding distinct 3D magnetic flux distributions and, therefore, diverse structure of the corona and heliosphere. During this recent minimum, the solar magnetic field achieved a solar maximum-like corona and solar wind source situation, but with weak magnetic fields and associated weak heating. The discussed results point out the need for textbooks and solar physics educators to revise the way they describe the solar wind and its sources.

In addition, the recent minimum provoked discussions on the possibility of a trend in the Sun's current magnetic cycles towards a grand minimum and the potential implications for the Earth's climate. For instance, there is evidence that a strong decrease of solar activity can lead to a delay of ozone recovery, partially compensating greenhouse warming, and that irradiance variability is the most important forcing for global problems. A combination of the bottom-up and top-down models seems appropriate for radiative solar forcing of the atmosphere. Although the forcing due to anthropogenic influences is about seven times larger than the radiative solar forcing, solar activity certainly does affect climate, and all relevant observations need to be maintained or extended.

The question of the origins and implications of cyclic behavior, for the Sun-Earth system and also for other stellar-planetary systems, was the subject of several presentations. For instance, it was shown that induced magnetospheres directly interact with the solar wind and, therefore, are more prone to atmospheric evolution than intrinsic magnetospheres.

This symposium was undoubtedly unique in the sense that it brought together a diverse group of scientists that were able to take part in discussions, appreciate the scientific disciplines of others, and discover the common aspects of the physical processes involved in the different studied environments from Sun to Earth, and stars to planets. The editors take this opportunity to thank Germán Cristiani and Marcelo López-Fuentes for their valuable assistance in preparing this volume. We also are grateful to the following reviewers who assisted us in improving the papers: Drs. Thomas Ayres, Alisson Dal Lago, Sergio Dasso, Marcelo López-Fuentes, Daniel Gómez, Manuel Güdel, Gustavo Guerrero, Jeffrey Hall, Margit Haberreiter, Kanya Kusano, Georgeta Maris, Leif Svalgaard, Andrey Tlatov, Ilya Usoskin, Adriana Valio, and Alberto Vásquez. Please note that many of the papers contain color figures, which are printed here in black and white but which can be viewed online in color.

Sarah Gibson and Hebe Cremades, co-chairs SOC

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Cristina H. Mandrini and David F. Webb, Proceedings Editors

Buenos Aires, Argentina, 29 March 2012

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 Marcelo López-Fuentes
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The Local Organizing Committee operated under the auspices of the Instituto de Astronomía y Física del Espacio (IAFE) and the Universidad Tecnológica Nacional - Facultad Regional Mendoza (UTN-FRM).

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|---|----------------------------|--------------------------------|
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| 15. Mariela Vieytes | 47. Alisson Dal Lago | 79. José Vaquero |
| 16. Bernardo Vargas Cárdenas | 48. Pablo Mauas | 80. Gustavo Guerrero |
| 17. Sarah Gibson | 49. Ezequiel Echer | 81. Jenny Rodríguez Gómez |
| 18. Romina García | 50. Margit Haberreiter | 82. Marialejandra Luna Cardozo |
| 19. Nadezhda Zolotova | 51. Carlene Skeffington | 83. Fabio del Sordo |
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