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

Edited by

Cristina H. Mandrini
David F. Webb

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Mandrini
Webb

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COMPARATIVE MAGNETIC MINIMA: CHARACTERIZING QUIET TIMES IN THE SUN AND STARS

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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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P. ROMING, *Southwest Research Institute, Space Science & Engineering Division, P.O. Drawer 28510, San Antonio, TX 78228-0510, USA*

IAUS 280
The Molecular Universe
J. CERNICHARO, *Depto. de Astrofísica, Centro de Astrobiología, Crta. Torrejón Km 4, 28850 Torrejón de Ardoz, Madrid, Spain*

IAUS 281
Binary Paths to the Explosions of type Ia Supernovae
R. DI STEFANO, *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA*

IAUS 282
From Interacting Binaries to Exoplanets: Essential Modeling Tools
M. RICHARDS, *Pennsylvania State University, Dept. of Astronomy & Astrophysics, 525 Davey Lab, University Park, PA 16802, USA*

IAUS 283
Planetary Nebulae: an Eye to the Future
A. MANCHADO, *Instituto de Astrofísica de Canarias, Calle Vía Láctea s/n, 38200 La Laguna, Tenerife, Spain*

IAUS 284
The Spectral Energy Distribution of Galaxies (SED2011)
R. J. TUFFS, *MPI für Kernphysik, Astrophysics Dept, Saupfercheckweg 1, 69117 Heidelberg, Germany*

IAUS 285
New Horizons in Time-Domain Astronomy
R. E. M. GRIFFIN, *NRC Dominion Astrophysical Observatory, 5071 W Saanich Rd, Victoria, BC, V9E 2E7, Canada*

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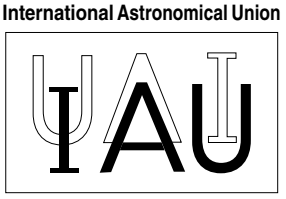

COMPARATIVE MAGNETIC MINIMA: CHARACTERIZING QUIET TIMES IN THE SUN AND STARS

PROCEEDINGS OF THE 286th SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION HELD IN THE CITY OF MENDOZA, MENDOZA, ARGENTINA OCTOBER 3–7, 2011

Edited by

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Table of Contents

https://doi.org/10.1017/S1743921312006461 Published online by Cambridge University Press

Session 4: Stellar Cycles

Chairs: C. H. Mandrini & A. Valio

https://doi.org/10.1017/S1743921312006461 Published online by Cambridge University Press

Session 5: Grand Minima and Historical Records

Chairs: A. Dal Lago & I. Usoskin

Session 6: General Topics

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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.

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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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The symposium was coordinated through IAU Division II (Sun and Heliosphere) and sponsored and supported by IAU Divisions III (Planetary System Sciences) and IV (Stars), including several of their associated Commissions: 10 (Solar Activity), 12 (Solar Radiation and Structure), 49 (Interplanetary Plasma and Heliosphere), and 36 (Theory of Stellar Atmospheres).

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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1. Lela Taliashvili
2. Blanca Mendoza
3. Inez Batista
4. Werner Schmutz
5. Madhulika Guhathakurta
6. Caius Selhorst
7. Eric Priest
8. Adriana Valio
9. Cristina Mandrini
10. Hebe Cremades
11. Cesar Bertucci
12. María Luisa Luoni
13. Lidia van Driel-Gesztelyi
14. Ximena Abrevaya
15. Mariela Vieytes
16. Bernardo Vargas Cárdenas
17. Sarah Gibson
18. Romina García
19. Nadezhda Zolotova
20. Maximiliano Crescitelli
21. Deysi Cornejo Espinoza
22. Lurdes Martínez Meneses
23. Lois Linsky
24. Accompanying person (Raphael Steinitz)
25. Raphael Steinitz
26. Jaime Osorio Rosales
27. Jeffrey Linsky
28. Mariano Poisson
29. Marlos Rockenbach da Silva
30. Carolina Salas Matamoros
31. Andrey Tlatov
32. Ilya Usoskin
33. Francesco Zuccarello
34. Sasha Brun
35. Michael Thompson
36. Kate Thompson
37. Ivonne Elsworth
38. Hiroko Miyahara
39. David Webb
40. Heidi Korhonen
41. Marcelo López-Fuentes
42. Katja Poppenhaeger
43. Dibyendu Nandi
44. Volker Bothmer
45. Romina Petrucci
46. Eugene Rozanov
47. Alisson Dal Lago
48. Pablo Mauas
49. Ezequiel Echer
50. Margit Haberreiter
51. Carlene Skeffington
52. Ed Cliver
53. Joern Warnecke
54. John Linker
55. Dmitry Sokoloff
56. Matthias Rheinhardt
57. Marc DeRosa
58. Andres Muñoz Jaramillo
59. Leif Svalgaard
60. Laura Balmaceda
61. Pedro Corona Romero
62. Matthew Browning
63. Karel Schrijver
64. Bidya B. Karak
65. Raul Terrazas Ramos
66. Giuliana de Toma
67. Cristian Ferradas Alva
68. Emre Isik
69. Alberto Vásquez
70. Germán Cristiani
71. Steven Saar
72. Jurgen Schmitt
73. Abraham Chian
74. Mark Giampappa
75. Arnab Choudhuri
76. Axel Brandenburg
77. Federico Nuevo
78. Simon Candelaresi
79. José Vaquero
80. Gustavo Guerrero
81. Jenny Rodríguez Gómez
82. Marialejandra Luna Cardozo
83. Fabio del Sordo
84. Fernando López
85. Daniel Gómez
86. María Emilia Ruiz
87. Ramon Lopez
88. Paulo Batista
89. Sergio Dasso
90. Francisco Iglesias
91. Janet Luhman
92. Vera Hurlburt
93. Neal Hurlburt
94. Kazuoki Munakata

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