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Solar and Stellar Magnetic Fields: Origins and Manifestations

Edited by

Alexander Kosovichev
Klaus Strassmeier
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SOLAR AND STELLAR MAGNETIC FIELDS:
ORIGINS AND MANIFESTATIONS

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The solar eclipse image was obtained on 2 July 2019 near Tres Cruces, Chile, and processed to visualize coronal structures by Miloslav Druckmüller and Peter Aniol.

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**SOLAR AND STELLAR
MAGNETIC FIELDS: ORIGINS
AND MANIFESTATIONS**

**PROCEEDINGS OF THE 354th SYMPOSIUM OF
THE INTERNATIONAL ASTRONOMICAL UNION
HELD IN COPIAPO, CHILE
30 June–6 July, 2019**

Edited by

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Table of Contents

Preface	xi
Editor	xiii
Conference Photograph	xiv
Participants	xv

Chapter 1. Total Solar Eclipse of 2019

Early results from the solar-minimum 2019 total solar eclipse	3
<i>Jay M. Pasachoff, Christian A. Lockwood, John L. Inoue, Erin N. Meadors, Aristeidis Voulgaris, David Sliski, Alan Sliski, Kevin P. Reardon, Daniel B. Seaton, Ronald M. Caplan, Cooper Downs, Jon A. Linker, Glenn Schneider, Patricio Rojo and Alphonse C. Sterling</i>	

Chapter 2. New observational diagnostics of solar, stellar and interstellar magnetic fields

Diagnosing coronal magnetic fields with radio imaging-spectroscopy technique	17
<i>Yihua Yan, Baolin Tan, V. Melnikov, Xingyao Chen, Wei Wang, Linjie Chen, Fei Liu and MUSER Team</i>	
Observing the Sun with the Atacama Large Millimeter/submillimeter Array – from continuum to magnetic fields	24
<i>Sven Wedemeyer, Mikolaj Szydlarski, Jaime de la Cruz Rodriguez and Shahin Jafarzadeh</i>	
Revisiting the building blocks of solar magnetic fields by GREGOR	38
<i>Dominik Utz, Christoph Kuckein, Jose Iván Campos Rozo, Sergio Javier González Manrique, Horst Balthasar, Peter Gömöry, Judith Palacios Hernández, Carsten Denker, Meetu Verma, Ioannis Kontogiannis, Kilian Krikova, Stefan Hofmeister and Andrea Diercke</i>	
Ca II 854.2 nm spectropolarimetry compared with ALMA and with scattering polarization theory	42
<i>J. W. Harvey and SOLIS Team</i>	
Diagnosing chromospheric magnetic field through simultaneous spectropolarimetry in H α and Ca II 854.2 nm	46
<i>K. Nagaraju, K. Sankarasubramanian and K. E. Rangarajan</i>	
The magnetic structure and dynamics of a decaying active region	53
<i>Ioannis Kontogiannis, Christoph Kuckein, Sergio Javier González Manrique, Tobias Felipe, Meetu Verma, Horst Balthasar and Carsten Denker</i>	

Coordinated observations between China and Europe to follow active region 12709	58
<i>S. J. González Manrique, C. Kuckein, P. Gömöry, S. Yuan, Z. Xu, J. Rybák, H. Balthasar and P. Schwartz</i>	

Chapter 3. Progress in understanding the solar/stellar interior dynamics and dynamos

Global simulations of stellar dynamos	65
<i>G. Guerrero</i>	
3D Modeling of the Structure and Dynamics of a Main-Sequence F-type Star	86
<i>Irina N. Kitiashvili and Alan A. Wray</i>	
Helioseismic insights into the generation and evolution of the Sun's internal magnetic field	94
<i>Anne-Marie Broomhall and René Kiefer</i>	
Resolving Power of Asteroseismic Inversion of the Kepler Legacy Sample	107
<i>Alexander G. Kosovichev and Irina N. Kitiashvili</i>	
Cycle times of early M dwarf stars: mean field models versus observations	116
<i>Manfred Küker, Günther Rüdiger, Katalin Oláh and Klaus Strassmeier</i>	
Searching for the cycle period in chromospherically active stars	120
<i>F. Villegas, R. E. Mennickent and J. Garcés</i>	
Are there local dynamo in solar polar region?	123
<i>Chunlan Jin</i>	
A Clock in the Sun?	127
<i>C. T. Russell, J. G. Luhmann and L. K. Jian</i>	
Various scenarios for the equatorward migration of sunspots	134
<i>Detlef Elstner, Yori Fournier and Rainer Arlt</i>	
A solar cycle 25 prediction based on 4D-var data assimilation approach	138
<i>Allan Sacha Brun, Ching Pui Hung, Alexandre Fournier, Laurène Jouve, Olivier Talagrand, Antoine Strugarek and Soumitra Hazra</i>	
Global Evolution of Solar Magnetic Fields and Prediction of Activity Cycles	147
<i>Irina N. Kitiashvili</i>	
Solar Open Magnetic Flux Migration Pattern over Solar Cycles	157
<i>Chia-Hsien Lin, Guan-Han Huang and Lou-Chuang Lee</i>	
Probing solar-cycle variations of magnetic fields in the convection zone using meridional flows	160
<i>Chia-Hsien Lin and Dean-Yi Chou</i>	

Chapter 4. Stellar rotation and magnetism

Magnetic field evolution in solar-type stars	169
<i>Axel Brandenburg</i>	

Magnetic field and prominences of the young, solar-like, ultra-rapid rotator AP 149	181
<i>Tianqi Cang, Pascal Petit, Colin Folsom and Jean-Francois Donati</i>	
Dipolar stability in spherical simulations: The impact of an inner stable zone	185
<i>Bonnie Zaire and Laurène Jouve</i>	
A large rotating structure around AB Doradus A at VLBI scale	189
<i>J. B. Climent, J. C. Guirado, R. Azulay and J. M. Marcaide</i>	
The impact of magnetism on tidal dynamics in the convective envelope of low-mass stars	195
<i>A. Astoul, S. Mathis, C. Baruteau, F. Gallet, A. Strugarek, K. C. Augustson, A. S. Brun and E. Bolmont</i>	
The rotation of low mass stars at 30 Myr in the cluster NGC 3766	200
<i>Julia Roquette, Jerome Bouvier, Estelle Moraux, Herve Bouy, Jonathan Irwin, Suzanne Aigrain and Régis Lachaume</i>	
Chapter 5. Role of magnetic fields in solar and stellar variability	
Possible evidence for a magnetic dynamo in hot Algols	207
<i>R. E. Mennickent, J. Garcés, G. Djurašević, G. Rojas, D. Schleicher and S. Otero</i>	
New Candidates for Chromospherically Young, Kinematically Old Stars	211
<i>Eduardo Machado Pereira and Helio J. Rocha Pinto</i>	
The dynamo-wind feedback loop : Assessing their non-linear interplay	215
<i>Barbara Perri, Allan Sacha Brun, Antoine Strugarek and Victor Réville</i>	
Statistical analysis of geomagnetic storms and their relation with the solar cycle	224
<i>Paula Reyes, Victor A. Pinto and Pablo S. Moya</i>	
Examining the optical intensity and magnetic field expansion factor in the open magnetic field regions associated with coronal holes	228
<i>Chia-Hsien Lin, Guan-Han Huang and Lou-Chuang Lee</i>	
Solar oblateness & asphericities temporal variations: Outstanding some unsolved issues	232
<i>Jean P. Rozelot, Alexander G. Kosovichev and Ali Kilcik</i>	
Chapter 6. Star-planet relations	
Solar activity influences on planetary atmosphere evolution: Lessons from observations at Venus, Earth, and Mars	241
<i>J. G. Luhmann</i>	
Different types of star-planet interactions	259
<i>A. A. Vidotto</i>	

Influence of the magnetic field of stellar wind on hot jupiter's envelopes	268
<i>Dmitry V. Bisikalo and Andrey G. Zhilkin</i>	
Star-planet interaction through spectral lines	280
<i>C. Villarreal D'Angelo, A. A. Vidotto, A. Esquivel, M. A. Sgró, T. Koskinen and L. Fossati</i>	
From the Sun to solar-type stars: radial velocity, photometry, astrometry and $\log R'_{HK}$ time series for late-F to early-K old stars	286
<i>Nadège Meunier and Anne-Marie Lagrange</i>	
Could star-planet magnetic interactions lead to planet migration and influence stellar rotation ?	295
<i>Jérémy Ahuir, Antoine Strugarek, Allan-Sacha Brun, Stéphane Mathis, Emeline Bolmont, Mansour Benbakoura, Victor Réville and Christophe Le Poncin-Lafitte</i>	
TESS light curves of low-mass detached eclipsing binaries	300
<i>Krzysztof G. Hełminiak, Andrés Jordán, Nestor Espinoza and Rafael Brahm</i>	
Tuning in to the radio environment of HD189733b	305
<i>R. D. Kavanagh, A. A. Vidotto, D. Ó Fionnagáin, V. Bourrier, R. Fares, M. Jardine, Ch. Helling, C. Moutou, J. Llama and P. J. Wheatley</i>	
Chapter 7. Formation, structure and dynamics of solar and stellar coronae and winds	
Observational constraints for solar-type stellar winds	313
<i>Manuel Güdel</i>	
Semi-empirical 2D model of the solar corona and solar wind using solar eclipse images: Progress report	333
<i>Edward C. Sittler Jr. and Linda M. Sittler</i>	
Realistic 3D MHD modeling of self-organized magnetic structuring of the solar corona	346
<i>Irina N. Kitiashvili, Alan A. Wray, Viacheslav Sadykov, Alexander G. Kosovichev and Nagi N. Mansour</i>	
Coherent structures and magnetic reconnection in photospheric and interplanetary magnetic field turbulence	351
<i>Rodrigo A. Miranda, Abraham C.-L. Chian, Erico L. Rempel and Suzana S. A. Silva</i>	
Analysis of the chromosphere and corona of low-activity early-M dwarfs.	355
<i>Gaetano Scandariato, E. González Álvarez, J. Maldonado, A. Suárez Mascareño, M. Perger and the HADES collaboration</i>	
Reversibility of Turbulent and Non-Collisional Plasmas: Solar Wind	363
<i>Belén Acosta, Denisse Pastén and Pablo S. Moya</i>	

Temporal evolution of the velocity distribution in systems described by the Vlasov equation; Radiation Belts: Analytical and computational results . . . 367
Abiam Tamburrini C, Iván Gallo-Méndez, Sergio Davis and Pablo S. Moya

On the multifractality of plasma turbulence in the solar wind 371
Sebastián Echeverría, Pablo S. Moya and Denisse Pastén

Chapter 8. Mechanisms of flaring and CME activity on the Sun and stars

The UV/X-ray radiation fields and particle (CME) flows of M dwarf exoplanet host stars 377
Alexander Brown

Exploring Flaring Behaviour on Low Mass Stars, Solar-type Stars and the Sun 384
L. Doyle, G. Ramsay, J.G. Doyle, P. F. Wyper, E. Scullion, K. Wu and J. A. McLaughlin

Trigger mechanisms of the major solar flares 392
Shuhong Yang

(Simulating) Coronal Mass Ejections in Active Stars 407
Julián D. Alvarado-Gómez, Jeremy J. Drake, Cecilia Garraffo, Sofia P. Moschou, Ofer Cohen, Rakesh K. Yadav and Federico Fraschetti

Diagnostics of non-thermal-distributions from solar flare EUV line spectra 414
Elena Džifčáková, Alena Zemanová, Jaroslav Dudík, and Juraj Lörinčík

Linking radio flares with spots on the active binary UX Arietis 418
Christian A. Hummel and Anthony Beasley

CME deflections due to magnetic forces from the Sun and Kepler-63 421
F. Menezes, Y. Netto, C. Kay, M. Opher and A. Valio

Coronal dimming as a proxy for stellar coronal mass ejections 426
M. Jin, M. C. M. Cheung, M. L. DeRosa, N. V. Nitta, C. J. Schrijver, K. France, A. Kowalski, J. P. Mason and R. Osten

Chapter 9. Surface magnetic fields of the Sun and stars

On the properties of the magnetic Chemically Peculiar B, A, and F-type stars 435
Kutluay Yüce, Saul J. Adelman, Diane M. Pyper and Robert J. Dukes

Impact of small-scale emerging flux from the photosphere to the corona: a case study from IRIS 439
Salvo L. Guglielmino, Peter R. Young, Francesca Zuccarello, Paolo Romano and Mariarita Murabito

Multi-flux-rope system in solar active regions	443
<i>Yijun Hou, Jun Zhang, Ting Li and Shuhong Yang</i>	
The 3D structure of the penumbra at high resolution from the bottom of the photosphere to the middle chromosphere	448
<i>Mariarita Murabito, Ilaria Ermolli, Fabrizio Giorgi, Marco Stangalini, Salvo L. Guglielmino, Shahin Jafarzadeh, Hector Socas-Navarro, Paolo Romano and Francesca Zuccarello</i>	
On the Role of Magnetic Fields in an Erupting Solar Filament	452
<i>Qiao Song, Shuhong Yang and Jing-Song Wang</i>	
Fast downflows in a chromospheric filament	454
<i>K. Sowmya, A. Lagg, S. K. Solanki and J. S. Castellanos Durán</i>	
Chapter 10. Observations of solar eclipses and exoplanetary transits	
Characterization of stellar activity using transits and its impact on habitability	461
<i>Raissa Estrela, Adriana Valio and Sourav Palit</i>	
Discovering the atmospheres of hot Jupiters	467
<i>P. Wilson Cauley</i>	
Sun-as-a-star observations of the 2017 August 21 solar eclipse	473
<i>Ekaterina Dineva, Carsten Denker, Meetu Verma, Klaus G. Strassmeier, Ilya Ilyin and Ivan Milic</i>	
Solar astrometry with planetary transits	481
<i>Marcelo Emilio, Rock Bush, Jeff Kuhn and Isabelle Scholl</i>	
Author Index	495

Preface

Recent observational results from space and ground-based telescopes have convincingly demonstrated that the progress in our understanding of how magnetic fields are generated, how they emerge from the interior, organize in active regions, and cause powerful eruptions can be achieved only by developing a unified approach from relationships between solar and stellar magnetism. Developing a general synergy of solar and stellar astronomy is essential for solving grand-challenge problems like the primary mechanisms of magnetic activity and its impact on planetary atmospheres. An important key issue is that the same or similar phenomena occur on the Sun and other stars under different conditions (different mass, age, metallicity, rotation rate, etc.). Studying these similarities and differences helps to uncover the underlying physical mechanisms of magnetic activity, its evolution in time, and its impacts on planetary environments.

The Proceedings presents recent results and discussions of new emerging topics that include magnetic field diagnostics using high-resolution observation; initial data from ALMA, Chinese Radio Spectroheliograph and other instruments; detection of stellar magnetospheres; detailed mapping of the magnetic fields on the surface of stars using new unique instrumentation, such as the PEPSI spectrograph that provided first high-resolution spectropolarimetry with a 12m telescope. The new observations stimulate comparisons of solar and stellar results, and advance our understanding of how surface magnetic structures and their evolution are related to the generation of magnetic fields by dynamos in solar and stellar interiors.

In this respect, tremendous progress has been achieved from helioseismology and asteroseismology with data from SDO, Kepler, and TESS, as well as from synoptic observations of solar and stellar variability. Discussions of the current long-term trend of declining solar activity and its initial results on the prediction of the next solar cycles are among the hot topics. The new picture of stellar cycles that is emerging from analysis of the Kepler and supporting ground-based spectroscopic data reveals scaling laws and relations that need to be taken into account in solar magnetism studies. Recent theoretical studies based on advanced supercomputer simulations have demonstrated the key role of magnetism for establishing solar and stellar differential rotation laws, and the importance of observational tests to validate theoretical predictions.

One of the puzzles of solar and stellar magnetism is related to the origin of extreme flare events. During the last weak magnetic cycle, the Sun produced some of the strongest flares in the history of observations. This raises questions on how the flare energetics are related to the magnetism of other stars that produce giant superflares, and what physical mechanism drives such extreme events. Another important topic of joint solar-stellar studies is the influence of solar and stellar variability on planetary space environments which become more and more important.

The interest in understanding the role of stellar magnetism in star-planet relations is driven by the need to determine conditions for habitability. In this aspect, the discussion is focused on properties of solar and stellar coronae and winds, and their interactions with planetary magnetospheres. Compared to the solar system, in many recently discovered planetary systems stellar winds are substantially stronger, and planets are much closer to their parent stars. This creates extreme conditions for magnetic interactions and radiation environments, which depend on the state of stellar magnetic activity. The discussion of this renewed old problem, that is beyond traditional studies, raises interest in understanding the broader impacts of magnetic activity on planetary space weather and habitability.

These Proceedings present recent advances and key problems of solar and stellar magnetic fields and their impact on planetary atmospheres, discussed at the IAU Symposium 354 “Solar and Stellar Magnetic Fields: Origins and Manifestations”, from June 30–July 6, 2019. The Symposium was organized in conjunction with the Total Solar Eclipse of July 2, 2019. The opening paper in Chapter 1 presents the initial observational results of this eclipse. Chapter 2 is focused on new observational diagnostics of solar magnetic fields. The progress in understanding the solar and stellar interior dynamics and dynamos is discussed in Chapter 3. Chapter 4 is devoted to investigations of relationships between stellar rotation and magnetism. The role of magnetic fields in solar and stellar variability is discussed in Chapter 5. Star-planet relations are discussed in Chapter 6. Chapter 7 is focused on the problem of the formation of solar and stellar coronae and winds. The progress in the understanding of solar and stellar flares and coronal mass ejections is presented in Chapter 8. Some key aspects of magnetic field structures and dynamics on the surface of the Sun and other stars are described in Chapter 9. The final Chapter 10 discusses the role of observations of solar eclipses and exoplanetary transits for characterization of solar and stellar activity and its impacts on the habitability of exoplanets.

The Symposium was organized in close cooperation and support of the University of Atacama, other Chilean universities, as well as of local authorities of the city of Copiapo. In particular, we thank Luis Campusano, Natalie Huerta, Pablo Moya, Lorenzo Morelli, Priscilla Guerrero, and Giovanni Leone for their support, enthusiasm, dedication, and hard work that made the IAUS 354 such a success[†].

[†] A previous version of this statement failed to include a number of key individuals. This has been updated to accurately reflect their contribution and a corrigendum published.

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