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Solar and Stellar Magnetic Fields: Origins and Manifestations

Edited by

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SOLAR AND STELLAR MAGNETIC FIELDS:
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IMAGE CREDIT:

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

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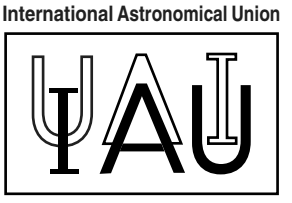

SOLAR AND STELLAR MAGNETIC FIELDS: ORIGINS AND MANIFESTATIONS

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

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Chapter 7. Formation, structure and dynamics of solar and stellar coronae and winds

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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.

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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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