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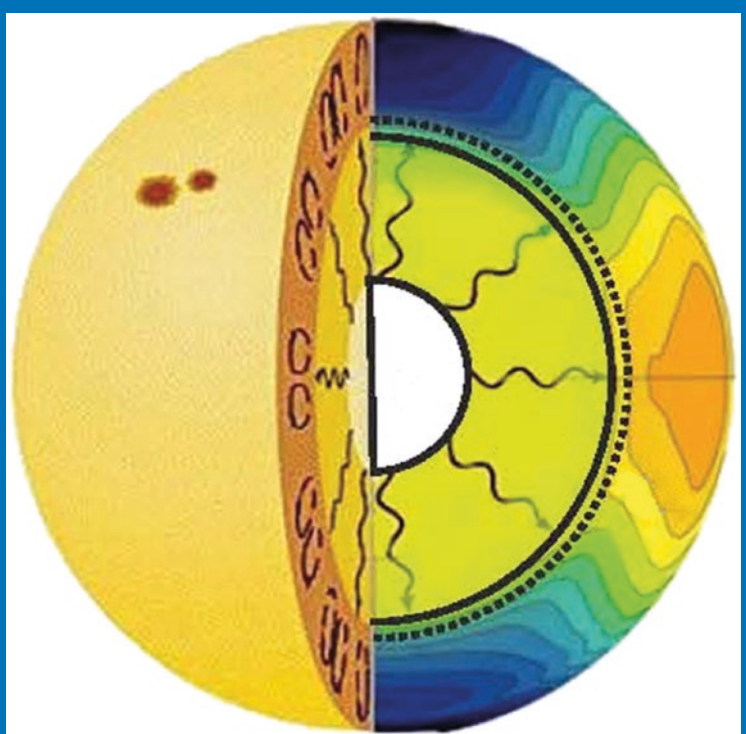
Dynamics of Solar and Stellar Convection Zones and Atmospheres

Edited by

Alexander V. Getling
Leonid L. Kitchatinov



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DYNAMICS OF SOLAR AND STELLAR CONVECTION ZONES AND ATMOSPHERES

IAU SYMPOSIUM 365

COVER ILLUSTRATION: INTERNAL STRUCTURE OF THE SUN

This illustration is adapted from Figure 1 (A) of "A simple but powerful model of the solar cycle" by Dário Passos, CSEI2012 – Conferência Nacional sobre Computação Simbólica no Ensino e na Investigação, Lisbon, 2012.

The white central sphere is the core of the Sun, the yellow spherical shell surrounding the core is the radiative zone and the outermost shell is the convection zone. In the latter, helioseismologically mapped constant-rotation-rate contours are shown, with the fastest rotation in the equatorial areas (warm colours) and slower rotation at higher latitudes (cold dark colours). Closed curves in the other meridional section of the convection zone (light brown) conventionally represent convective circulation of the solar plasma. The radiative zone rotates as a solid body.

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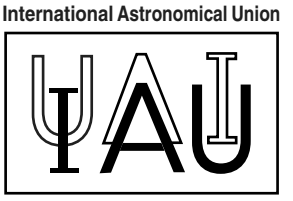

DYNAMICS OF SOLAR AND STELLAR CONVECTION ZONES AND ATMOSPHERES

PROCEEDINGS OF THE 365th SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION YEREVAN, REPUBLIC OF ARMENIA 21–25 AUGUST 2023

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Table of Contents

Section 5. Local Processes of Magnetic-Flux Emergence. Sunspot and Starspot Formation

Invited talks

Contributed papers

Section 6. Miscellaneous

Contributed papers

Preface

Impressive events of magnetic-energy release, such as solar and stellar flares or coronal mass ejections, take place in the atmospheric layers above the solar/stellar photosphere. The magnetic-activity events are closely related to the dynamics of subsurface convection zones inside the stars. The last few decades have been marked by substantial progress in understanding the physics of internal and external processes in the Sun and solar-type stars, but the scientific communities making this progress have not worked closely together. The idea to bring together specialists in the physics of convection zones and atmospheres materialised in a proposal to organise a symposium on the dynamics of solar and stellar convection zones and atmospheres, which was approved by the IAU Executive Committee in May 2019.

IAU Symposium 365 was originally planned to be held at the Lomonosov Moscow State University in 2020. However, the COVID pandemic and unfortunate political developments led to a long postponement and finally to a search for an alternative venue. Eventually, the Byurakan Astrophysical Observatory, National Academy of Sciences of the Republic of Armenia, kindly agreed to host the Symposium in the city of Yerevan in August 2023.

The Sun as a complex hydrodynamic and magnetohydrodynamic object has attracted much researchers' attention over the past few decades. Modern observational instrumentation aboard orbiting observatories, such as the Solar Dynamics Observatory (SDO), have provided an invaluable wealth of diverse data. Substantial progress has been achieved in theoretical studies of solar convection, differential rotation, meridional circulation, the global solar dynamo, and local processes of interaction between plasma flows and magnetic fields in the upper convection zone and photosphere, which are responsible for the local phenomena of solar activity. On the other hand, the progress in the development of observational techniques has stimulated investigations aimed at understanding the dynamics of stellar plasmas. Hydrodynamic and magnetohydrodynamic studies of the Sun and stars show a remarkable convergence, approaching a unified description of all these objects. In the numerical simulations of convection and magnetoconvection, which have now greatly increased their coverage in the parameter space, the solar convection regime plays the role of a 'reference point' for the set of models. The theories of differential rotation and the global dynamo have now reached a level that allows these two components of the global dynamics to be considered in a single model. Helioseismology offers a previously unattainable insight into the dynamics of layers hidden from our eyes. The ideas of helioseismology are now being extended to stellar physics, leading to the successful development of asteroseismology.

A particular point of importance is related to magnetic-flux-emergence processes producing active regions and to the link between global and local magnetohydrodynamic phenomena. The extensive data from, e.g., SDO can be used for detailed analyses and investigations of the underlying physics on the basis of an adequate magnetohydrodynamic description, which is of paramount importance for the elaboration of techniques of active-phenomena predictions.

An important application of the study of global solar processes is the prediction of solar activity cycles. Such predictions will be all the more reliable the more complete our understanding of the global solar dynamics is, and the study of stellar dynamics can contribute significantly to the completeness of the general view of the physical processes.

Further progress in the study of this multifaceted complex of phenomena requires co-ordination of the efforts of researchers working on different problems, and extensive discussion and exchange of views. Particular attention must be paid to processes in

the dense plasmas of the solar and stellar convection zones and photospheres, where the complex of active phenomena originates. At the same time, since the atmosphere is strongly dynamically coupled to the underlying photosphere and convection zone, a strict separation between the photosphere and the layers above it would not be justified. For this reason, although the scope of the Symposium was mainly focused on the dynamics of the convection zones and photospheres, it was also intended to encompass those processes in the lower atmospheres that can be regarded as a direct continuation of the processes in the underlying layers.

The Symposium was devoted to observational and theoretical aspects of solar and stellar hydrodynamics and magnetohydrodynamics, both global and local, including numerical studies as a special branch of theoretical research. With this scope, the meeting stimulated the emergence of new ideas and the development of new techniques in this field of active research.

It is our great pleasure to acknowledge the enormous role of the LOC chair Areg Mickaelian and the members of the LOC team in the realisation of the Symposium.

Alexander V. Getling and Leonid L. Kitchatinov, co-chairs SOC,
Yerevan, 25 August 2023

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National Academy of Sciences of the Republic of Armenia

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Conference Photographs

Figure 1. A group of participants after the closing ceremony.

Figure 2. A group of participants visiting the Byurakan Astrophysical Observatory, in the tower of the 2.6-m telescope.

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