SOLAR AND STELLAR VARIABILITY: IMPACT ON EARTH AND PLANETS

IAU SYMPOSIUM No. 264

COVER IMAGE:

Illustration of the impact of the solar wind on Earth's magnetosphere (source: SOHO/NASA), and the dome of a new heliometer developed at the Observatório Nacional at Rio de Janeiro to perform accurate measurements of the solar diameter (see the paper by V. A. d'Ávila et al. in these Proceedings).

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Preface

The Sun is a variable star. Understanding the physical mechanisms of the variability and its effects on the Earth and planets is one of the central and long-standing problems of astronomy and astrophysics. Variability of a similar type has been observed in other stars. It is essential to investigate the similarities and differences between solar and stellar variability in order to understand the physical mechanisms and impacts on planets.

During the past decade multi-wavelength observations from several solar and stellar space missions and ground-based observatories have provided a tremendous amount of new information about the physical processes associated with magnetic activity and variability on the Sun and solar-type stars. Key observational results, new theoretical ideas, and models discussed at Symposium 264 are presented in this volume.

Solar observations have provided new data about the solar cycle variations of the structure and dynamics from the interior to the corona and heliosphere. Intriguing connections exist between the interior dynamics, surface magnetism and coronal phenomena. However, despite the great amount of new data, it is still unclear where and how magnetic fields are generated in the Sun, and why it has a regular 22-year magnetic cycle. Can observations of other stars help us to understand the solar magnetic cycle, which is so important not only for astrophysics but also for our life and society? What are the essential components of the solar variability?

Recent optical, UV and X-ray observations of other stars with significant subsurface convection zones (lower main sequence stars with masses smaller than 1.5 solar masses and cool post-main-sequence stars) reveal starspots and other surface and atmospheric structures that are similar to solar magnetic features. In many cases, the long-term evolution of these features is similar to the solar cycle. Advances in the Doppler imaging technique have enabled mapping of starspot distributions and the tracking of their evolution. This led to the first accurate measurements of stellar differential rotation, a key property of dynamo mechanisms. In addition, UV and X-ray observations detected stellar coronas similar to the solar corona.

The impacts of solar variability on Earth, particularly on the terrestrial atmosphere and climate, have fueled significant debates in recent years. There is no doubt that solar radiation is the major source of terrestrial energy. The solar activity cycle also causes changes in Earth's atmospheric temperature and density, especially in the thermosphere. Energetic particles, which also vary with the solar cycle, cause geomagnetic storms and deposit energy into the magnetosphere and the polar regions of the atmosphere. Variations of the energy input may trigger changes in the climate. However, the complete chain of the impact of the solar variability is not understood.

The unusually long and deep current minimum of solar activity has significantly increased the interest in the mechanisms of solar and stellar variability and the impact of such long periods of low activity on planets. It is well known that a long interval of low solar activity between 1645 and 1715, the Maunder Minimum, coincided with a significant climate change called the "Little Ice Age". Can this happen again? Observations of other Sun-like stars indicate that long periods of low activity are quite common. Various attempts to predict the next solar cycle indicate that it will be significantly weaker than the previous cycle. Some researchers even go so far as to suggest that the Sun is entering a prolonged period of low activity, similar to the Maunder Minimum.

While the first few magnetic sunspot regions of the new solar cycle have appeared on the surface, the solar minimum still continues. The Sun is still mostly spotless. In 2008, 265 days were without sunspots. In the past 160 years of regular solar observations,

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only 1878, 1901 and 1913 have had more such days. The long solar minimum has had a significant impact on the Earth's space environment and atmosphere. The solar wind pressure is at a 50-year low. This resulted in an increase of the flux of cosmic rays, which are believed to play a significant role in cloud formation. In addition, the total solar irradiance dropped to a 30-year low, the lowest since monitoring from space began. The decrease of UV radiation is particularly significant, about 6%. This caused a reduction of the Earth's atmosphere heating, and decreased its height. Thus, perhaps unexpectedly, investigations of the Sun in a low activity state have become critically important.

Of course, these studies are not only of great practical importance, but are also directly related to some of the most important astronomical problems: what are the basic physical mechanisms of solar and stellar activity, and how does stellar variability affects planetary systems and their habitability?

Perhaps, the most significant highlight of the Symposium, which received coverage in science news, was the presentation of new results showing that newly formed stars spin faster and generate stronger magnetic fields than middle-aged stars like the Sun. These active young stars emit much more intense levels of X rays, ultraviolet light, and charged particles all of which affect the formation and evolution of planetary atmospheres and must have a dramatic effect on the development of emerging life forms.

This highly interdisciplinary Symposium provided an excellent opportunity for astronomers from various fields solar, stellar and planetary physics to establish important connections, discuss mutual ideas and develop partnerships. In particular, this was a unique opportunity to establish collaborations with astronomers from Brazil and other Latin American countries.

The Symposium coincided with the completion of a new heliometer to perform accurate measurements of the solar diameter at the Observatório Nacional in Rio de Janeiro. The LOC organized an excursion to the completion ceremony at the Observatório Nacional. This was one of the most interesting and memorable events of the Symposium.

Alexander G. Kosovichev, Alexandre H. Andrei and Jean-Pierre Rozelot, co-chairs SOC
Rio de Janeiro, August 3, 2009

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Participants of IAUS 264 at the completion ceremony of a new heliometer at the Observatório Nacional in Rio de Janeiro. Professor Paolo Benevides-Soares (right) and Dr. Christian Delmas (left) receive commemorative medals from Dr. Jucira Penna, Chair of the LOC.

The heliometer of the Observatório Nacional and its creators,
Drs Victor d'Ávila (right) and Eugenio Reis (left).

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The LOC members (from left to right): Drs. Eugenio Reis, Jucira Penna and Victor d'Ávila

A group of participants after a discussion (left to right): Victor Matias (sitting), Ricardo Dunna (standing), Carlos Eduardo Portela, Eugenio Reis, Todd Hoeksema, Maria Cristina Rabello-Soares, Jucira Penna, Sergio Lomonaco and Victor d'Ávila.

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