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Solar and Stellar Flares and their Effects on Planets

Edited by

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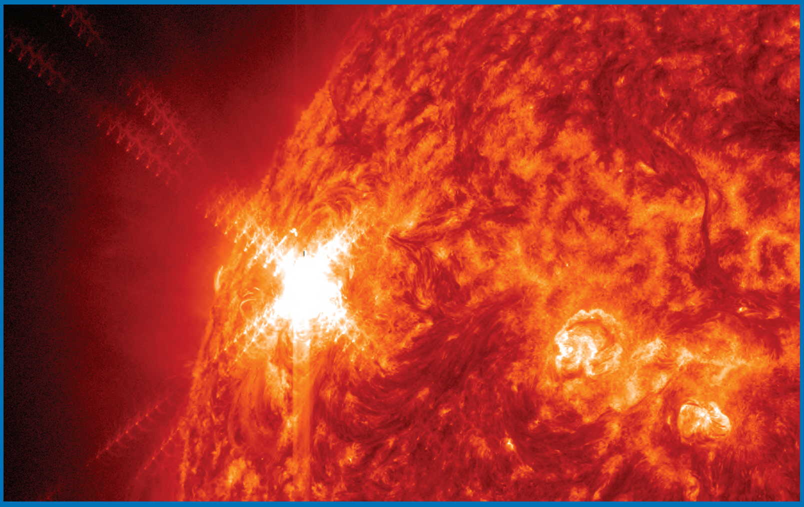

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COVER ILLUSTRATION:

Image of a massive X1.9 class solar flare on the Sun on Nov. 3, 2011 at 20:27 UT, taken by the NASA's Solar Dynamics Observatory. The flare erupted from an extremely active region on the Sun called AR11339.

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Preface

Recent advances in observations and modelling of solar and stellar flares have opened new perspectives for understanding of the fundamental physical mechanisms of magnetic energy storage and release, particle acceleration, and radiative and dynamical processes in solar and stellar flares. The new interest in this topic is stimulated by Kepler observations which have led to the discovery that stellar flares occur not only in M-type dwarfs (UV Ceti-type variables) but also in a wide range of A-F type stars. Previously, it was believed that the F- and A-type stars do not have flaring activity. The discovery of super-flares on solar-type stars has raised questions about the possibility of such flares on the Sun, and led to hot debates about the potential effects of such superflares on terrestrial and extra-terrestrial planets, including their impact on the origin and evolution of life. These results triggered new interest in the physical mechanism of solar and stellar flares, and their connection with the dynamo mechanism and stellar properties.

Recent observations of solar flares from the Solar Dynamics Observatory (SDO), IRIS, RHESSI, STEREO, Hinode and Fermi space observatories and large ground-based telescopes have revealed details of the magnetic topology of flaring active regions, obtained important insight into the processes of magnetic reconnection and particle acceleration, and led to new understanding of the importance of local response and global-scale coupling of the flare dynamics. Among the new observations, the Fermi detection of extremely long gamma-ray emission in many solar flares is particularly surprising. These and other new results challenge the current theories of solar and stellar flares, and even cause to reconsider the whole, once well-established, paradigm about the common physical origin and properties of the solar and stellar flares.

Previously, stellar flares associated with active M-type stars were thought to be similar to solar flares representing a sudden release of magnetic energy accumulated in the coronal part of sunspot region, in the form of high-energy particles which heat the atmosphere and corona. Stellar flares can be four orders of magnitude more powerful, which is thought be due to bigger starspot regions generated by a more efficient dynamo process, because many of the flaring stars rotate faster than the Sun. However, the new observations have raised an alternative point of view that such powerful flares may be due to the interaction with close companions - ‘hot Jupiters’. The discovery of flares on hot A-type stars with a very shallow outer convection zone and without strong magnetic field causes additional problems with the dynamo origin of the flare energy on these stars.

The IAU Symposium 320 had been a forum for discussing the recent advances in observations and theories of solar and stellar flares, focused on the understanding of their phenomenological and physical aspects, as well as consequences for terrestrial planets and exoplanets. It covered a broad range of phenomena, from the magnetic topology of flares and mechanisms of impulsive energy release to high-energy flare emission and potential impacts on planets.

The papers presented in the Proceedings are focused on recent advances in multi-wavelength observations with new space and ground-based telescopes, as well as in theory and numerical simulations. This includes discussions of similarity and differences in magnetism of the Sun and flaring stars, links to the interior dynamics and surface magnetism, physical mechanisms of magnetic energy storage and release, particle acceleration, properties of impulsive radio, optical, EUV, X-ray and gamma-ray emissions, shocks and mass ejections, origin of superflares on solar-types stars, and impact of flares

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on planetary atmospheres. We hope that this volume will be useful to senior and new researchers in this fascinating and rapidly developing field of astronomy.

Alexander G. Kosovichev, Suzanne Hawley, and Petr Heinzel, co-chairs SOC