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EDITORIAL
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Editorial: Towards a Full Understanding of Magnetic Storms and Substorms

A. T. Y. Lui[1]*, *S.-I. Akasofu*[2]*, *Q. Zong*[3]*, *P. H. Yoon*[4]*, *R. Nakamura*[5]* and *G. Parks*[6]*

[1]Space Exploration Sector, Applied Physics Laboratory the Johns Hopkins University, Laurel, MD, United States, [2]International Arctic Research Center, University of Alaska Fairbanks, AK, United States, [3]Center for Planetary and Space Science, Beijing University, Beijing, China, [4]Institute for Physical Science and Technology, University of Maryland College Park, College Park, MD, United States, [5]Academy of Sciences, Austrian Academy of Sciences, Graz, Austria, [6]Geophysics Program, University of California Berkeley, Berkeley, CA, United States

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Editorial on the Research Topic

Towards a Full Understanding of Magnetic Storms and Substorms

In order to focus on the near-Earth space as an invaluable asset to our societal function, a special research topic was proposed to the Frontiers in Astronomy and Space Sciences journal with the title "Towards a full understanding of magnetic storms and substorms." A description to introduce the topic is written as follows:

'For the Space Physics discipline, two outstanding topics that evade resolution in spite of decades/centuries of dedicated research are magnetic storms and substorms.

The space phenomenon called magnetic storm, alternatively known as geomagnetic storm, was first reported in the early 19th century by Alexander von Humboldt. He made recordings on the bearing of a magnetic compass in Berlin from May 1806 to June 1807. With this effort, he revealed a notable erratic deflection of the compass bearing on 21 December 1806. Later scientific investigation using the magnetic disturbances on the ground led to the introduction of three phases of a geomagnetic storm: initial, main, and recovery one. The three phases are generally marked by worldwide systematic variations of the horizontal component of the Earth's magnetic field. However, deviations from this systematic variation can occur for some geomagnetic storms with apparent absence of the initial phase.

Geomagnetic storms generally last for 2–3 days. Embedded within a geomagnetic storm are shorter-duration geomagnetic disturbances that are most evident at high-latitude region. Nature reveals this association even with the first awareness of geomagnetic storm as Alexander von Humbolt noted bright auroral displays accompanying the erratic deflection of compass bearing. Through the establishment of global networks of all-sky-cameras to monitor the worldwide distribution of auroras, Akasofu in 1964 recognized a unique and identifiable sequence of auroral displays called auroral substorms. The latter indicates that each one of these disturbances constitute an elementary building block of a geomagnetic storm. Subsequent research revealed that auroral substorms are merely one of the facets of disturbances that span over a vast volume of space.

The rather simplistic view of activities in space is now challenged in many ways. Progress in space research equipped with highly-sophisticated instrumentations on the ground and in space has blossomed into a discipline that has close ties with daily human activities as witnessed by space weather development and significant implications on the physical processes responsible for explosive phenomena in our Universe. Although there are many theories proposed for both geomagnetic storms and substorms, there is yet no consensus on their underlying physical processes. This

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Joseph E. Borovsky,
Space Science Institute, United States

***Correspondence:**
A. T. Y. Lui
Tony.Lui@jhuapl.edu
S.-I. Akasofu
sakasofu@alaska.edu
Q. Zong
qgzong@pku.edu.cn
P. H. Yoon
yoonp@umd.edu
R. Nakamura
Rumi.Nakamura@oeaw.ac.at
G. Parks
parks@ssl.berkeley.edu

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Research Topic aims to reflect on the present status of space research and contemplate on how to achieve a full understanding for these natural phenomena.

Six articles are included in this issue. Two are contributed by the discoverer of the geomagnetic substorm, with one on the relationship between geomagnetic storms and substorms and the other on the electric current approach to understand both space disturbances. In contrast to the electric current approach is the utilization of magnetohydrodynamic simulation to investigate the substorm dynamics in one article. A topic that has not caught much attention is the coupling between the magnetosphere and ionosphere. This topic is discussed in an article with a new insight into this coupling. A more traditional view on substorm initiation is covered by an article using the potential association of meso-scale auroral structures and energetic particle injections at geosynchronous orbit with the underlying physical process. The sixth article deals with two main theories of substorm origin being examined by the characteristics of oxygen ion energization and transport in the plasma sheet. Overall, these six articles offer a brief glimpse at the various hot research areas that can constitute a better understanding of both geomagnetic storm and substorm.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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