frontiers | Frontiers in Astronomy and Space Sciences

TYPE Editorial
PUBLISHED 15 July 2024
DOI 10.3389/fspas.2024.1431804

OPEN ACCESS

EDITED AND REVIEWED BY
Julio Navarro,
University of Victoria, Canada

*CORRESPONDENCE
Joseph E. Borovsky,
jborovsky@spacescience.org

RECEIVED 12 May 2024
ACCEPTED 17 June 2024
PUBLISHED 15 July 2024

CITATION
Borovsky JE (2024), Editorial: Editor's challenge in space physics: solved and unsolved problems in space physics. *Front. Astron. Space Sci.* 11:1431804. doi: 10.3389/fspas.2024.1431804

Editorial: Editor's challenge in space physics: solved and unsolved problems in space physics

Joseph E. Borovsky*

Space Science Institute, Boulder, CO, United States

KEYWORDS

space physics, ionosphere, magnetosphere, solar wind, solar physics, heliosphere, aurora, substorms

Editorial on the Research Topic
Editor's challenge in space physics: solved and unsolved problems in space physics

Starting with the first spaceflight explorations in the 1960s, the space environment has driven a high interest in the scientific community [cf. Ness, 1996; Neugebauer, 1997; Obridko and Vaisberg, 2017; Stepanova et al., 2024]. From the study of planetary magnetospheres to the solar environment and the local interstellar medium, scientists have produced an enormous quantity of interesting research that has given us a clearer picture of Space and its mechanisms. Nevertheless, there are still open questions in the field even if our technology is developing faster than in the past. This Research Topic strives to assess the state of space physics, to guide researchers to address outstanding questions, and to open dialog about what might and might not be solved issues.

This Research Topic contins 17 papers (reviews, perspectives, etc.) on a great diversity of space-physics issues. The author teams of the 17 papers rose to the challenge to address the following questions:

- Are there any solved problems in space physics?
- Are there problems that the community thinks are solved, but are not?
- What are the outstanding issues in space physics?
- In particular, what are the neglected outstanding issues in space physics?

In the following 17 paragraphs these 17 papers are briefly described, alphabetically by the first author of each paper.

Allanson et al. (2024) explore whether quasilinear theories of wave-particle interactions apply in space plasmas. They explore techniques that go beyond quasilinear theory and they highlight new ideas about calculating wave-particle interactions.

In a perspective article Baumjohann and Treumann examine the diagnostic power of examining the emission of AKR (auroral kilometric radiation) production from the Earth's magnetosphere and they examine open questions about the standard theory of AKR (i.e., the electron-cyclotron maser mechanism).

Borovsky and Lao use a system-science mathematical methodology (vector-vector correlations) to derive a new geomagnetic index that has a number of advantages: (1) describing the global reaction of the magnetospheric system, (2) high predictability from solar-wind parameters, and (3) linearity and robustness.

In a perspective article Borovsky and Partamies point out that the whistler-mode chorus waves that produce pulsating aurora are the waves that energize the electron radiation belt, and since the wave behavior giving rise to the spatial-temporal pulsating-aurora precipitation is not understood, the wave behavior accelerating the electron radiation belt is not understood.

Chau et al. review the long-standing riddles of ionospheric irregularities at altitudes of about 150 km and they review and catalog the many solved and unsolved issues associated with these irregularities.

In a very thorough review, Georgieva and Veretenenko (2023) discuss the coupling of the Sun to the Earth's atmosphere, how this interaction is not fully understood, and what might be occurring by discussing multiple possible mechanisms. They lay out a system-science picture involving solar irradiance, energetic particles, and the subtle reactions of the Earth's atmosphere.

Green et al. examine some implicationsof the facts that (1) the Earth's moon at one time had its own magnetosphere and (2) that the Moon was much closer to the Earth in the past. They examine the implications for the transfer of plasma between the Earth and the Moon and the potential evidence that could be found for this in future moon missions.

In a perspective article Huba discusses unresolved issues about equatorial spread-F that need to be addressed. He recommends that exploration is needed for a unified theory of turbulence, for an understanding of the impact of storms, and for more-accurate thermospheric-wind measurements and models.

Kim et al. examine the direct injection by substorms of MeV electrons into the outer electron radiation belt in the dipolar magnetosphere and they discuss the role of direct injections in comparison with the standard picture of electron-radiation-belt production by chorus-wave acceleration.

LaBelle reviews auroral radio emissions, what they do, what they reveal, and how future methodologies can improve our understanding of what they can tell us about the Earth system.

Lockwood and Milan review some universal-time variations in the reaction of the Earth's magnetosphere to the solar wind, variations that are different in the northern *versus* southern hemispheres. One focus is an examination into the interplay between dipole tilt and ionospheric conductivities.

In a perspective article Lyons et al. discuss the connections between polar-cap flow channels and magnetospheric phenomena and dynamics. The authors point out the need to determine what causes these flow channels in the ionosphere, the need to determine their mapping to the magnetosphere and magnetosheath, and the need to determine their effects upon entering the auroral oval.

The status of SAID (subauroral ion drifts) and SAPS (subauroal polarization streams) in the ionosphere is reviewed by Mishin, who points out that recent multi-spacecraft observations call for new ideas about the causes of these subauroral drifts.

Smith and Vasquez (2024) review our understanding of how solar-wind turbulence operates driven in the inner heliosphere by large-scale energy-contai ning structures and driven in the outer heliosphere by interstellar pickup ions. Various pictures of how the turbulence energy cascade works are discussed.

Smith et al. review the gaps in our knowledge of nuclear data that prevent us from understanding the effects of radiation on astronauts as cosmic rays, etc. Interact with spacecraft materials and produce secondary forms of radiation.

Troshichev reviews the information that the polar-cap index PC supplies for magnetospheric physics, particularly on the geoefficiency of the solar wind in driving the magnetosphere.

In a perspective article Voros et al. consider the role of the magnetosheath in solar-wind-magnetosphere coupling, pointing out the important roles of electromagnetic, kinetic, and multi-scale processes acting the magnetosheath.

Author contributions

JB: Writing–original draft, Writing–review and editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. JB was supported at the Space Science Institute by the NSF Magnetospheric Program via grant AGS-2149822, by the NASA LWS Program via grant 80NSSC23, and by the NASA HERMES Interdisciplinary Science Program via grant 80NSSC21K1406.

Acknowledgments

The author of this editorial would like to thank Luke Barnard, Jaroslav Chum, Olga Khabarova, and Thom Moore for their help with editorial duties and the author thanks the many excellent reviewers of these articles Tommaso Alberti, Elizaveta Antonova, Ciaran Beggan, Alex Boyd, Vincenzo Carboni, Marco De Napoli, Alexie Dmitriev, Steve Forsyth, Dennis Gallagher, Mike Henderson, Lauri Holappa, Justin Holmes, David Hysell, Nickolay Ivchenko, Catriona Jackman, Deepak Karan, Larry Kepko, Jun Liang, John Meriwether, Steve Milan, Adnane Osmane, Ashot Chilingarian, Jim Roeder, Danny Summers, Alla Suvorova, Oleg Troshichev, Ivan Vasko, and Peter Yoon.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

References

Allanson, O., Ma, D., Osmane, A., Albert, J. M., Bortnik, J., Watt, C. E. J., et al. (2024). The challenge to understand the zoo of particle transport regimes during resonant wave-particle interactions for given survey-mode wave spectra. *Front. Astron. Space Sci.* 11, 1332931. doi:10.3389/fspas.2024.1332931

Georgieva, K., and Veretenenko, S. (2023). Solar influences on the Earth's atmosphere: solved and unsolved questions. *Front. Astron. Space Sci.* 10, 1244402. doi:10.3389/fspas.2023.1244402

Ness, N. F. (1996). Pioneering the swinging 1960s into the 1970s and 1980s. *J. Geophys. Res.* 101, 10497–10509. doi:10.1029/96ja00138

Neugebauer, M. (1997). Pioneers of space physics: a career in the solar wind. *J. Geophys. Res.* 102, 26887–26894. doi:10.1029/97ja02444

Obridko, V. N., and Vaisberg, O. L. (2017). On the history of the solar wind discovery. *Sol. Syst. Res.* 51, 165–169. doi:10.1134/s0038094617020058

Smith, C. W., and Vasquez, B. (2024). The unsolved problem of solar-wind turbulence. *Front. Astron. Space Sci.* 11, 1371058l. doi:10.3389/fspas.2024.1371058

Stepanova, M., Pinto, V., and Antonova, E. (2024). Regarding the dynamic of relativistic electrons in the outer radiation belt. A historical view. *Rev. Mod. Plasma Phys.*