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# Editorial: Generation-to-Generation Communications in space physics

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Editorial on the Research Topic
Generation-to-Generation Communications in space physics

Space physics has been an active area of international research for more than 60 years. Spacecraft measurements require enormous resources: space research is a community effort. Generation after generation of researchers enter the field and their careers evolve shaped by personal experience, mentors, and collaborators. The senior generations of scientists retire and their decades of irreplaceable human wisdom become difficult to access.

One goal of this Frontiers Research Topic (Research Topic) was to document some of the lifetime wisdom of the senior and mid-career leaders in the field of space physics and to reveal it to the generations that follow: advice, mistakes, proud moments, lessons learned, mentors, influential colleagues, concerns for the future. A second goal of this Research Topic was to hear the voices of early career scientists and glimpse their visions for the future of space physics.

This unique Frontiers Research Topic, collected into a Frontiers Research Topic, contains a lot of wisdom, advice, history, and stories of experience (cf. Figure 1). The editors hope these published open-access papers will provide entertaining, enlightening, and valuable advice to both young and experienced researchers in space physics. This editorial contains brief summaries of the 26 papers of this Frontiers Research Topic, plus 17 other papers.

The authors of this editorial (who were also the editors of the Frontiers Research Topic) would like to inform the readers that a number of manuscripts submitted to this Research Topic, although compliant with the goals of the Research Topic, did not pass the initial-validation screening of Frontiers, typically failing because they were deemed too personal or not focused on a specific scientific Research Topic. Seventeen of these manuscripts are published in the open-access AGU journal Perspectives of Earth and Space Scientists https://agupubs.onlinelibrary.wiley.com/journal/26376989. These 17 additional articles also contain a great deal of wisdom, history, personal lessons, humor, and advice. We consider those articles in the Perspectives journal to be part of this "Generation-to-Generation" Research


FIGURE 1
Accoutrements of space physics.

Topic and we highly recommend that the readers of this Frontiers Research Topic examine those Perspectives articles which are in the spirit of this Frontiers Research Topic. After this editorial overviews (alphabetically by author) the 26 articles in this Frontiers Research Topic, this editorial overviews (alphabetically by author) the 17 articles in Perspectives.

Akasofu describes his methodology for solving scientific problems. In particular, focuses on his approach and experience to correct well-accepted theories that contradict observations.

Andre (2022) discusses the need for a "wider perspective" for space sciences wherein results in space science should be presented in a way that makes those results useful to other fields of research such as astrophysics, plasma physics, and astrobiology. Mats Andre also elaborates on the importance of diversity on a research team.

Antonova overviews for the younger generations of space-physics researchers the development of her career and her views about auroral processes. argues that understanding these aurora processes could be a key to understanding other magnetospheric processes.

Clauer advises young scientists to pick something for a vocation that is fun and exciting, advice he himself received from his mentors. highlights the importance of intuition over equations and he tells of the great scientific satisfaction of friendships in research.

Gonzalez-Esparza discusses the opportunities and challenges of developing space-research programs and facilities in developing countries. argues that observational infrastructure is crucial to creating a local scientific community and advises us that this infrastructure should be pursued as a national priority.

Haerendel reviews the development of the field of research focusing on the plasma physics of the aurora, particularly focusing on discrete auroral arcs. looks at the present state of the understanding of the aurora and points out that there are many open questions, particularly involving auroral generation mechanisms.

Hysell discusses several examples of unexpected discoveries in equatorial aeronomy made when experiments did not go according to plan. tells us that it is important to be able to "pivot" when plans fail and to make discoveries from the plan failures.

Kahler compares the advantages of solar imaging with the disadvantages of SEP *in situ* single-point measurements and the lack of synoptic measurements of SEP events, leading to SEP science being "second class" in heliophysics. puts forth the hope for future SEP imaging techniques.

Kronberg discusses lessons learned from improving particle data analysis focusing on the importance of calibration, statistics, and machine learning. also addresses future directions for space research (such as combining data and models, and looking in three dimensions) and Elena summarizes for us best practices in data analysis.

Lockwood discusses, using personal examples and famous cases, how mistakes can be an important driver for scientific progress. One wise lesson that puts forth is to not be overly fearful of mistakes or

failures: in a subsection "Learning How to Handle and Exploit Mistakes" Mike says to avoid them but also learn from them.

Lockwood reminds us that we should be developing a system science perspective of the Earth's magnetosphere. points out that even with a full understanding of how a system works, a complex system (such as the Earth's magnetosphere or a flock of starlings) may not be predictable.

Lübken reflects on his own work and the work of others on the Earth's mesosphere/lower thermosphere. describes physical processes acting in the mesosphere/lower thermosphere (MLT) and discusses open questions dealing with that region. He makes the point that young scientists in MLT can achieve visibility in the science community more quickly than in many other fields of physics.

McGranaghan recommends that the space-physics community embrace complexity and systems science. discusses the importance in overcoming the disconnects between different scientific communities and describes cultural and scientific grand challenges for space physics such as the need to construct "participatory ecosystems of knowledge sharing, governance, and trust".

Mobius describes how multiple diverse observations have provided information about the interstellar wind in the vicinity of our Sun. describes the picture assembled from the synergy of (a) *in situ* measurements of interstellar pickup ions and (b) remote neutral-particle imaging to provide us knowledge about the environment of the Milky Way galaxy that our heliosphere resides in.

Palmroth recounts the story of the development of Vlasiator, the first global hybrid-Vlasov code for simulating the solar-wind-driven magnetosphere-ionosphere system. shares with us the advice that long-term code development should target the development to the computer resources of the future, not the present, an argument validated by the success of Vlasiator.

Pedatella overviews the need for and development of whole-atmosphere models. points out how these whole-atmosphere models help us to understand the role of terrestrial weather on the variability of the ionosphere-thermosphere and Nick discusses future whole-atmosphere modeling and the science that those future models will yield.

Reames overviews the evolution of the field of solar-energetic-particle research (SEP) of which he was a key participant. recounts our progress in the understanding of SEPs, leading past outdated models of SEP origins to the current knowledge of particle events driven by shock waves and solar jets.

Richards discusses two problems: 1) the model-data discrepancies in the ionospheric photoelectron-flux spectra and 2) the lack of thermospheric neutral-wind data. presents a personal account of the solutions to these two problems, which sometimes involved "being in the right place at the right time".

Roederer reviews the history of the "climate revolution" of the 1980s, discussing the split of the research community into those favoring an Earth system science approach and those focusing on whatever has the greatest impact on society. also discusses the early history of "space weather" and he puts forth a number of insightful lessons learned.

Rostoker presents his lessons from a career in space physics, particularly lessons gleaned from his work to understand magnetospheric substorms. points out that frameworks for the understanding of substorms are only as good as the existing data, and the relevant magnetospheric data is notoriously sparse.

Sanchez-Cano discusses the solar-wind, magnetosphere, ionosphere, atmosphere system for Mars. argues that understanding the ionosphere as a natural sink of energy from both the solar wind and the atmosphere may be a key to understanding this system. To that end she describes several proposed new Mars missions.

Shiokawa recounts the development of the idea of Earthward flow braking in the near-Earth plasma sheet and its relationship to substorm phenomena. addresses the colleagues who helped to develop this idea and discusses a number of lessons learned that would be valuable for early-career scientists.

Sivadas hypothesizes that working to maximize our number of publications and our number of citations can inhibit scientific discovery. Using a simple mathematical toy model explores and demonstrates this undesirable possibility.

Sonnerup recounts his experiences in graduate school, what he learned and did not learn, and discusses some of the research topics that he has worked on through the years. recalls some of the people with whom he has worked, particularly the people who were most influential.

Tsyganenko discusses the modeling of the Earth's magnetospheric magnetic field from measurements from multiple spacecraft taken at different times and under different conditions. overviews the lessons learned in his half-century-long efforts in building the well-known magnetospheric models.

Wang argues that solar physics has a great advantage over other fields of astrophysics because of the enormous amounts of high-quality solar data, claiming also that much of that solar data is underutilized. wonders why solar physicists are not more skeptical of theoretical models, particularly the "fashionable ones".

Borovsky (2022) recounts his pathway into a science career and discusses the three favorite papers that he wrote, each paper focused on one hypothesis *versus* another hypothesis. Even as a senior scientist, Joe Borovsky has a hidden argument that he is still just a kid from Detroit.

Fairfield (2022) overviews his science career spanning the entire history of magnetospheric physics. Don Fairfield emphasizes the importance of understanding yourself and praises the influence of fortunate circumstances.

Fisk (2023) was originally invited to the Frontiers Research Topic "Generation-to-Generation" but instead under the guidance of the editors was directly submitted to the "Perspectives of Earth and Space Scientists" journal. In this article Len Fisk argues that there is a need for "enhanced vitality" in heliophysics, i.e., a need for paradigm shifts. With three examples of shifts that were not accepted, Len warns that complacency will limit the respect that is given to heliophysics and coronal physics.

Fuselier (2022) uses personal examples to make a case about the importance of mentoring in space physics. Stephen Fuselier's key advice is to "identify and rely on your mentors". Stephen also points out that great advancements in space physics have been enabled by open access to spacecraft data.

Gombosi (2022) recounts his scientific and professional career and the important influences of the people he worked with. Tamas Gombosi tells of his personal experiences (sometimes behind the scenes) bringing together the space communities of the East and the West during the Cold War.

Huba (2023) was originally invited to the Frontiers Research Topic "Generation-to-Generation" but instead under the guidance of the editors was directly submitted to the "Perspectives of Earth and Space Scientists" journal. In this article Joe Huba recounts the story of how he and Glenn Joyce developed the SAMI2 numerical model, bending the rules to attain success.

Kennel (2022) reviews his career of 50 years of serving on NASA advisory panels, recounting influential personalities on those panels and the accomplishments they made. Charlie Kennel describes how those panels led to the Voyager mission to the outer planets, to the Hubble Space Telescope, to the space shuttle, to the space station, and to the James Webb Space Telescope.

Kessel (2022) recounts her research career from graduate student to NASA scientist to NASA Program Manager and Program Scientist. Mona Kessel's research spanned diverse Research Topic such as shock physics, ULF waves, magnetospheric reconnection, ion measurements, and creating standardized formats for spacecraft data.

Koskinen (2022) argues that, as in a nonlinear dynamical system, a small perturbation to a scientific career can completely change its evolution. After recounting several examples from his own career, Hannu Koskinen gives the advice to young scientists: "watch your opportunities and be well-prepared".

Liemohn (2023) provides a great deal of wisdom to the space-physics community. Mike Liemohn's perspectives involve advice on conducting research, on improving research leadership, and on becoming involved in diversity, equity, and inclusion improvements. On the personal level Mike asks us to "work hard and be kind".

Mitchell (2022) recounts his science career from lowly manual labor to designing and flying space-flight scientific instrumentation. Don Mitchell talks about the advantages of "playing to your strengths," which appears as "taking the easy route": easy for Don but probably difficult for others.

Mozer (2022) tells the story of his career from undergraduate student to senior researcher and talks about some of the influential people that he met. Forrest Mozer emphasizes the importance of viewing other researchers as collaborators and not as competitors, looking forward to their advancements.

Pellinen-Wannberg (2023) describes her multifaceted career path and how taking risks repeatedly paid off. Asta Pellinen-Wannberg has particular advice for female scientists, and she has a warning to us all to keep the space environment clean.

Sibeck (2022) recounts the development of his research career, focusing on his history of interaction with scientists from Eastern Europe after the end of the cold war. discusses the international cooperation in space physics and in particular the integration of the Russian-Czech Interball-Magion project into the International Solar-Terrestrial Physics (ISTP) project.

Smith (2022) talks about the importance of mentoring, opening the article with a brief history of his training and about mistakes he made. Throughout the article, Chuck Smith lays out the clear lessons he learned in the development of his scientific career: lessons for the apprentice and lessons for the mentor. He ends with an encouraging message: "Do not ever forget that we got into this career for the joy of the work".

Thomsen (2022) recounts her launch into a scientific career in space physics, overcoming discouragement which almost prevented the career from happening. offers lessons she has learned, which include "a commitment to scientific significance, integrity, communication, and humility".

Wolf (2023) yields advice for a young scientist and a description of the development of the Rice Convection Model for the Earth's magnetosphere. Dick Wolf gives the advice "do not be afraid to be different" and "do not hide your problems". Describing his interactions with Nobel-Prize winners, he points out that even famous professors can be wrong.

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

## Publisher's note

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