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Editorial: Frontiers in astronomy and space sciences: a decade of discovery and advancement-10th anniversary conference

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Editorial on the Research Topic
Frontiers in astronomy and space sciences: a decade of discovery and advancement-10th anniversary conference

The Research Topic you are reading highlights the breadth and cross disciplinary nature of Astronomy and Space Physics. The papers contained here feature research efforts spanning the wide range of research topics covered by this Journal, from our Solar System to Relativity theory, and even to ourselves as scientists. Close to home, new research on space weathering and its relation to rubble pile asteroids, geomagnetic storms, and Saturn's magnetosphere is brought into view. Looking outward, the role of dust throughout the universe is examined and related to the current results contributed by the James Webb Space Telescope. Active galaxies are discussed in two contexts; one regarding the modeling of reflections produced by spinning supermassive black holes, the other about how the quasar main sequence is revealed. Relativity is also scrutinized, as the constancy of the speed of light is examined over cosmic time. Finally, we come back home and take a look at the topic of equity in our science practices.

Danehkar's contribution "Relativistic Reflection Modeling in AGN and Related Variability from PCA: A Brief Review" provides a comprehensive yet concise overview and a handy reference of how relativistic reflection signatures—such as broadened iron Kα emission lines and Compton reflection humps—are shaped by the strong gravitational fields of spinning supermassive black holes. One of the most remarkable aspects of this work is the application of principal component analysis (PCA) to analyze X-ray variability in AGNs, which has provided significant insights into the separation of spectral components contributing to the observed variability. The discussion on PCA results from several AGN

X-ray spectra shows that the relativistic reflection component remains nearly constant while the power-law continuum varies significantly, reinforcing the idea that reflection originates from stable inner accretion flows near the event horizon. The review by Danehkar also offers an excellent synthesis of recent developments in relativistic disk models, covering spectral fitting techniques that incorporate the Kerr metric to extract black hole spin parameters.

The Panda mini-review provides a comprehensive synthesis of three decades of research on the quasar main sequence (MS). By drawing an analogy with the Hertzsprung-Russell diagram for stars, the paper presents how the Eigenvector 1 scheme has revolutionized our understanding of the diverse population of Type-1 AGNs, linking key spectral properties such as the full width at half-maximum (FWHM) of the Hβ emission line and the strength of Fe II emission to physical parameters such as Eddington ratio and black hole mass. The author not only revisits the foundational work of Boroson and Green (1992) and Sulentic et al. (2000), but also contextualizes large spectroscopic surveys, such as the Sloan Digital Sky Survey (SDSS), and multi-epoch spectroscopic studies of changing-look AGNs through the MS. The discussion on quasars as potential standard candles for cosmology is particularly thought-provoking, as it underscores the role of MS in refining the radius-luminosity relation and its implications for high-redshift distance measurements. Overall, this paper stands out as a must-read for anyone interested in the physics of AGNs.

The astrochemistry contribution "Nanosilicates and molecular silicate dust species: properties and observational prospects" of Bromley to this Research Topic highlights the importance of molecular silicates and nanosilicates in the formation and processing of larger silicate dust grains. Nucleation processes and growth of silicate dust grains in circumstellar environments are reviewed. When fully formed, silicate grains (~0.1 μm diameter) enter the interstellar medium (ISM), where they are expected to play an important role from both physical and chemical points of view. Then, supernova shockwaves, through collision-induced shattering, redistribute a significant proportion of the silicate dust mass into a huge number of nanosilicates. In this paper, their properties have been reviewed with a particular focus on insights arising from bottom-up atomistic computational modeling, also reviewing the energetic and chemical processing of silicate dust. Attention has also been paid to the unique potential of this modeling in predicting spectral features of nanosilicates that may be detectable using the James Webb Space Telescope. Figure 1 of Bromley provides a good example in this regard, as it shows the structural evolution from molecular silicates containing ~10 atoms (< 1 nm diameter) to small nanosilicates containing hundreds of atoms (~1 nm diameter) and then to systems of thousands of atoms (~3 nm diameter). The representative structures of these silicate species are accompanied by their calculated absorption infrared spectra and microwave emission spectra. To conclude, the contribution of Bromley suggests that the combination of computational modeling and observational data will enable confirmation of the presence of nanosilicates and the assessment of their abundance in the ISM and other astrophysical environments.

The planetary science contribution "Evaluation of simulated space weathering based meteorite alteration and potential influence on mechanical deformation of rubble pile asteroids" by Kereszturi et al to this Research Topic investigates the effects of space weathering on meteorites and the implications of radiation-induced changes in the mineral composition and structure of small rubble-pile asteroids. The authors discuss much of what we know about the infrared spectral characteristics of meteorites induced by laboratory-based artificial irradiation simulating space weathering. Through laboratory simulations of solar wind exposure, the study reveals key mineralogical changes, such as decreasing magnesium content in olivine, water loss-induced mineral transformations, and lattice amorphization. These surface alterations, though limited to a thin layer of asteroid grains, may influence the mechanical behavior of small asteroids by affecting grain migration, surface mixing, and granular cohesion, potentially modulated by the Yarkovsky–O'Keefe–Radzievskii–Paddack (YORP) effect. Understanding the influence of space weathering on the internal properties and joint behavior of grain within rubble pile asteroids, how we have acquired information about it, and its relevance to assessing the mechanical behavior of debris asteroids, is of paramount importance for the future of Planetary Science, with significant implications in planetary defense.

Wing et al reviews an intriguing topic in our understanding of the Saturnian magnetosphere, namely, the radially inward transport of plasma, or plasma injections. This contribution highlights the role played by plasma originating from one of Saturn's moons (Enceladus), and by Saturn's rapid rotation, with an emphasis on how effective gravity and flux tube entropy affect Saturnian plasma injections.

Closer to home, Khabarova and Price report on space weather forecasts of geomagnetic storms, a central research topic of solar-terrestrial studies. These forecasts are important, as even storms of moderate intensity can lead to power outages as severe as those caused by extreme storms. This publication reviews geomagnetic storm statistics and discusses recent advances in storm prediction.

At the other end of the scale, Lee scrutinizes the role that the assumption of a constant speed of light plays in our current paradigm for structure formation in the Universe, the ΛCDM model. It makes the intriguing case that models where the speed of light varies with cosmic time, such as the "minimally extended varying speed of light model" (or meVSL), are also consistent with current data, so it will be up to future observations to come up with tests that could probe one of the basic tenets of our cosmological understanding.

Finally, Liemohn examines steps that may be taken to mitigate issues of inequity, inclusion, and lack of diversity in Space Physics. In particular, this contribution highlights key advice and practical actions, as compiled in a recent Research Topic. Although some are specific to Space Physics, other recommendations are likely to prove useful to other scientific communities dealing with similar issues.

Author contributions

JN: Writing – original draft, Writing – review and editing. AF: Writing – review and editing. DF-B: Writing – review and editing. SH: Writing – review and editing. PM: Writing – review and editing. CP: Writing – review and editing. MR: Writing – review and editing.

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Conflict of interest

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