Guest Editorial: Special Cluster on Recent Advances in Antennas for Earth and Planetary Science

RESEARCH into innovative antenna technologies has been growing rapidly with the invention of emerging techniques to manipulate the electromagnetic (EM) waves and their propagation. These efforts have been supported by the increasing demands in wireless technologies in general, covering a wide application spectrum, from 5G and beyond to Earth and planetary science. Antenna design for Earth and planetary science can be particularly challenging. In fact, it can be argued that the interest in these efforts has not been motivated purely by the antenna performance. Rather, a significant challenge has been to achieve the ideal antenna performance by taking into account the environmental- and mission-specific instrument budget requirements, including but not limited to the ability to work in extreme environments, satisfy the weight, space, and power consumption limits for the mission specific instrument for launch. As a result, the development of low-weight, low-profile, cost-effective, and robust antenna architectures without sacrificing the antenna performance has been the holy grail of research efforts conducted in this field. In light of this, recent advances in this community have gradually evolved to include unusual types of antenna solutions, such as reflectarrays, metasurfaces, photovoltaic antennas, and all-metal antennas for harsh environments with promising results.

The objective of this special cluster is to bring together the antenna community to present the state-of-the-art research conducted in this field and highlight the emerging antenna technologies in addressing the Earth and planetary science instrumentation. This special cluster aims to present some examples of the latest advances in antenna technology for Earth and planetary science. Among these antenna topologies, a particular emphasis should be given to metasurface type of antennas. A metasurface can be considered a 2-D surface synthesized using an array of subwavelength-sized unit-cells. Such surfaces can manipulate the behavior of EM waves to achieve the desired transmission, reflection, polarization, and radiation responses. Particularly, operating in a reflection mode, such surfaces have received substantial interest in the context of reflectrarrays. Pelletier *et al.* present a dual-polarized reflectarray antenna operating at Ku-band frequencies to synthesize a synthetic aperture radar (SAR) for snow mass measurements. The proposed design is also installed on a CubeSat platform to verify its performance in the presence of solar cells. The final prototype of the reflectarray represents a promising solution for remote sensing missions on CubeSat platforms. Another design of a reflecting surface is presented by Leszkowska *et al.*, leveraging a partially reflecting surface (PRS) to synthetize high-gain and circularly polarized radiation characteristics at *X*-band frequencies. The proposed structure uses a circularly polarized single-fed patch exciting a PRS surface as a superstrate layer loaded with unit-cells exhibiting spatially modulated geometrical features to synthesize the desired phase response across the PRS. The low-profile structure of the proposed design makes it a suitable candidate for CubeSat integration as well as for drones and high-altitude pseudo-satellite applications.

An interesting concept is the filtenna structure, involving the combination of a filter topology with an antenna that can be tailored to radiate a specific radiation pattern. Patriotis *et al.* propose an active Ka-band filtenna with a right-hand circularly polarized (RHCP) radiation that can be reconfigured between two center frequencies at Ka-band frequencies. The antenna uses PIN diodes to achieve frequency reconfiguration and exhibits a single-layer architecture, ideal for CubeSat integration.

Three-dimensional (3-D) printing of EM structures has advanced significantly over the last decade, with an increasing amount of research being conducted in this area. Turkmen *et al.* present an omnidirectional and circularly polarized dual-band antenna for telemetry/telecommand (TMTC) applications in satellite communications at Ku-band frequencies. The antenna exhibits a single waveguide feed and no dielectric, making it an excellent candidate to be used as a high-power transceiver on a satellite.

Addamo *et al.* demonstrate a Ku/Ka dual-band feed-horn topology developed for the Copernicus Imaging Microwave Radiometer (CIMR). The presented design, when used as a feed horn, meets several challenging requirements needed for the Copernicus Earth observation program, including exhibiting low footprint, high radiation efficiency, narrow beamwidth, and low cross-polarization levels.

Garcia *et al*. present a hybrid analog/digital SAR beamforming for Earth observation. The developed SAR instrument leverages analog beamforming on transmit and hybrid analog/digital beamforming on receive, while using a feed-array topology to feed a reflector aperture at *L*-band frequencies. The resulting system allows for both dual-polarization (VV–HH) and quad-polarization (VV–HH–VH–HV) operations of the SAR instrument.

Zhong *et al.* present a new beamforming method as an enabling technology to meet the coverage requirement of the

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effective isotropic radiated power (EIRP) and achieve multibeam coverage in Low Earth Orbit (LEO) satellites. The developed subarray multibeamforming method is proven to be an effective solution to achieve optimal coverage in LEO satellites.

Alrushud *et al.* demonstrate a quasi-endfire surface-wave antenna integrated with a CubeSat platform. The antenna exhibits a leaky-wave surface-integrated-waveguide (SIW) launcher with an extremely low profile, making it a suitable candidate for CubeSat integration. In another interesting CubeSat antenna design, Kuznetcov *et al.* present a leaky-wave antenna using a SIW technology to achieve dual-band broadside radiation at *K*-band frequencies. Circularly polarized radiation from the developed leaky-wave antenna is also demonstrated while the effect of CubeSat integration on the antenna performance is studied in detail.

In closing, the guest editors would like to express their gratitude to the reviewers and the authors. Their efforts and contributions have made this special cluster possible. They would also like to sincerely thank the IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS Editor-in-Chief, Prof. C. Fumeaux, and the Editorial Assistant, C. Sideri, for their professionalism, patience, and magnificent support. Finally, we hope that this special cluster will foster new research ideas and generate new frontiers in innovative antenna technologies for Earth and planetary science, and hence, will immensely benefit the IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS community.

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