IEEE AWPL Special Cluster 2027 on
"AI-Native Metasurfaces: Physics-Aware Learning and Wave-Domain Computing"

Modern wireless and sensing systems must acquire signals, extract digital information, and support timely decisions. Separating electromagnetic acquisition from digital intelligence introduces data-conversion, movement, and processing overhead. AI-native electromagnetic systems offer a complementary approach by co-designing sensing, computation, communication, and learning within the physical signal-processing chain. Metasurfaces extend microwave analogue computing from interconnected networks to radiative apertures. Programmable, stacked, nonlinear, time-varying, and waveform-selective structures provide opportunities to implement transformations, feature extraction, nonlinear activation, and physical memory. Their integration with microwave neural networks (MNNs) and intelligent antennas enables new architectures for processing information directly in the wave domain.

This Special Cluster will highlight metasurface-enabled computing and inference for direct microwave classification, intelligent sensor networks, edge computing, and physical AI. Both guided-wave-radiative integration and hybrid analogue-digital processing are welcome. Applications include adaptive sensing, autonomous platforms, task-oriented communications, and distributed intelligence, with a clear electromagnetic hardware contribution. Both AI-assisted metasurface design and physical or hybrid analogue-digital processing are welcome. Theoretical, numerical, and experimental contributions are encouraged, particularly hardware demonstrations and assessments of accuracy, bandwidth, robustness, latency, energy consumption, and scalability. The Guest Editors invite original theoretical, numerical, and experimental contributions on topics including, but not limited to:

- Physics-informed neural networks and neural operators for scalable metasurface modelling;
- Microwave neural networks and metasurface-based physical computing;
- Programmable and stacked computing meta-surfaces and metasurface-integrated intelligent antennas;
- Nonlinear, time-varying, waveform-selective, and energy-selective metasurfaces;
- Direct microwave classification and RF-native feature extraction;
- Physics-aware learning, physical memory, and hybrid analogue-digital processing;
- In situ training, self-supervised learning, and self-calibration of programmable metasurfaces;
- Reinforcement learning and continual adaptation for autonomous metasurface control;
- Memristive and phase-change metasurfaces for trainable weights and in-memory computing;
- Integrated sensing, communication, and computation for edge intelligence;
- In-sensor computing, edge intelligence, and intelligent sensor networks;
- Metasurface-engineered scattering, physics-aware inverse scattering for sensing, wave-domain inference
- Hardware-algorithm co-design, experimental validation, and benchmarking.

The Guest Editors of this Special Cluster are:

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Prospective authors are encouraged to contact the Guest Editors regarding the suitability of their contributions. Manuscripts should follow the regular IEEE AWPL submission instructions: a maximum of four pages of technical content and one reference page, in double-column IEEE format, as described on the Information for Authors website. Authors should identify this Special Cluster in their cover letter to the Editor-in-Chief. The submission and publication schedule is given below.

Key dates:

- Submission deadline: **March 31, 2027**
- First decision: May 15, 2027
- Revised manuscripts deadline: June 15, 2027
- Final decision: July 30, 2027
- Final manuscripts due by: September 1, 2027
- Online publication: Shortly after final manuscript submission
- Cluster publication: November 2027 issue of AWPL