

# Progress and Challenges in Kinetic Plasma Modeling for High Power Microwave Devices

**Abstract:** We review progress and challenges in kinetic plasma modeling by electromagnetic particle-in-cell (EMPIC) algorithms on unstructured grids. These algorithms are implemented in modular CONPIC and BORPIC C++ codes which integrate a matrix-free explicit finite-element (FE) Maxwell solver based on a parallel sparse-approximate inverse algorithm and a first-principles charge-conserving scatter algorithm to transfer charged particle information into dynamic variables on the grid. The Maxwell field solver of the EMPIC algorithm utilizes a mixed FE basis and discretizes the time-dependent coupled first-order Maxwell's system explicitly. The explicit solver approximates the inverse FE system matrix ("mass" matrix) using hierarchical sparsity patterns based on the sparsity pattern of the original matrix. The resulting algorithm effectively accounts for multiscale plasma phenomena. We discuss the application of the developed EMPIC algorithm to the analysis of laboratory plasmas, vacuum electronic devices for generation of high power microwave signals, and RF electronics multipactor effects in harsh space environments.

**Bio:** Fernando L. Teixeira received the Ph.D. degree in electrical engineering from the University of Illinois at Urbana–Champaign, Champaign, IL, USA, in 1999. He was a Post-Doctoral Associate with the Massachusetts Institute of Technology, Cambridge, MA, USA, from 1999 to 2000. He joined The Ohio State University, Columbus, OH, USA, in 2000, where he is currently a Professor in the ElectroScience Laboratory and the Department of Electrical and Computer Engineering. His current research interests include computational electromagnetics and sensor physics. Since joining Ohio State, Dr. Teixeira has served as a Principal Investigator (PI) or co-PI on projects sponsored by the Department of Defense, Department of Energy, National Science Foundation, NASA, and a number of industrial organizations. Dr. Teixeira has published over 180 journal papers in the aforementioned areas and is co-author of the textbook *Radiowave Propagation: Physics and Applications* (Wiley, 2010). Dr. Teixeira is a Fellow of IEEE and was a recipient of the Career Award from the National Science Foundation, the triennial Booker Fellowship from the International Union of Radio Science, and the Outstanding Young Engineer Award from the IEEE Microwave Society (MTT-S). He served as an Associate Editor and a Guest Editor for *IEEE Antennas and Wireless Propagation Letters*, and a Guest Editor for the journals *Progress In Electromagnetics Research* and *Remote Sensing*. He currently serves as an Associate Editor for *IET Microwaves, Antennas, and Propagation*.