

A Joint Colloquium

Nuclear Engineering and Radiological Sciences
Michigan Institute for Plasma Science and Engineering

Recent Advances in Theory of Multipactor Discharges



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4pm-5pm

White Auditorium, Cooley Building
Refreshments served at 3:45pm

Multipactor is an electron avalanche occurring when stray electrons are trapped and accelerated by radiofrequency (rf) waves in a vacuum, hitting walls and ejecting other electrons by secondary electron emission (SEE). The rapid multiplication in the number of electrons ultimately creates noise, heat and possibly damage in a wide range of environments from space communication systems to accelerators and microwave tubes. Modern design standards use “susceptibility diagrams” for multipactor based on theory developed in the 1950s by Hatch and Williams, which considers multipactor as a resonant discharge. Observed discrepancies with experiment are accounted for by the addition of arbitrary margins that have no theoretical basis. Modern theories acknowledge that multipactor does not necessarily have a single resonance, but can exhibit higher periodicity, or even non-resonant forms. These theories, however, rarely depart from the conventional paradigm of presuming a multipactor mode, then deriving the conditions for that mode, an exercise that can be exceedingly difficult for more complex trajectories.

A novel approach based on the methodology of nonlinear dynamics and chaos is presented, in which all possible modes are recovered with no *a priori* assumptions. The new methodology systematically applies iterative maps to identify multipacting region boundaries and stability more reliably and comprehensively than existing models. It does so by globally analyzing the structure of dynamical space, resulting in bifurcation diagrams that summarize all possible multipactor

modes over a wide range of parameters. This information is combined with secondary electron emission properties of the surface material to predict multipactor growth rates and identify parameter regions that are multipactor free. Three-dimensional simulations with the WARP PIC code successfully validate the model under more realistic conditions of random emission velocities of secondaries and more realistic rf field profiles.

Rami A. Kishkek is a Research Professor at the Institute for Research in Electronics and Applied Physics at the University of Maryland (UMD), where he leads the effort on the University of Maryland Electron Ring Laboratory, a small research accelerator investigating space charge dynamics. He received his B.S.E. (1993) in Electrical Engineering, M.S.E. (1995) and Ph.D. (1997) in Nuclear Engineering, all from the University of Michigan, Ann Arbor. Professor Kishkek has over 20 years’ experience in charged particle dynamics and is an expert on space charge effects, computation, and multipactor, where he made groundbreaking contributions to its theoretical modeling. He is a scientific consultant for multiple companies and has advised or co-advised 15 PhD students and guided the research of dozens more graduate, undergraduate, and high school students, and regularly teaches at the US Particle Accelerator School. Kishkek is a fellow of APS and the 2015 recipient of the USPAS Prize for Achievement in Accelerator Physics and Technology.