**Zagorodnov Conformal Particle In Cell Simulations**

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We describe a range of conformal algorithms that have been developed to enable high accuracy (and numerically stable) Particle In Cell (PIC) simulations of devices with curved metal surfaces, such as relativistic magnetrons. In particular we have upgraded from the Dey-Mittra FDTD field method in ICEPIC to Zagorodnov's 2003 Uniformly Stable Conformal FDTD method. The area-borrowing Zagorodnov method is preferable as it is both faster and more accurate than the Dey-Mittra technique (including second order electromagnetic field convergence, less numerical dispersion, and improved field emission for PIC simulations), although at the cost of additional algorithmic complexity.

The Zagorodnov method can give rise to a number of numerical instabilities when integrated into a PIC code and these must be addressed. In particular a high frequency "nearly-trapped-mode" instability can grow in conformal cells that have both small areas and are either undergoing field emission or are subject to incoming wave boundary conditions. Small violations of Gauss's law can also accumulate near conformal boundaries during field emission (even when the new particles are transported from interior metal edges) and these must be corrected as well.

We have developed a combination of field and particle emission algorithms that work together to remove these instabilities and allow for fast and accurate Zagorodnov conformal simulations. We demonstrate these new conformal techniques on relativistic space charge limited emission test cases, and on a modified version of the Michigan magnetron. The rapid convergence of the measured current, emitted power and resonant frequency allow for accurate simulations to be performed at lower resolution, thus substantially reducing their computational cost.