IMPROVED SPACE CHARGE MODELING IN CYLINDRICAL COORDINATES *

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Many electromagnetic and charged-particle beam devices are primarily cylindrical in nature. In such cases, simulation codes employing cylindrical coordinates are extremely efficient, yielding high space/time resolution while minimizing computational costs. However, it has long been known that the curvature of (r,z) and (r,φ,z) coordinates requires adjustment of solution coefficients and particle/current weights as functions of distance from the axis to reduce effects of numerical noise. Recent progress on charge interpolation[1] and solution coefficients[2] has provided a consistent methodology for improved simulation in cylindrical coordinates. In this paper, the improved techniques will be presented, along with their implementation in a widely used 2D particle-in-cell code, XOOPIC[3], and comparisons to standard solution methods. Comparisons are also made with finite element models using the BOA[4] code.

The local Taylor polynomial (LTP) process expresses the field and space charge locally as general polynomials. Requiring these polynomials to satisfy the partial differential equation (PDE) produces a *truncated analytic solution to the continuum PDE* with unknown coefficients. Discrete numerical algorithms are constructed by computing the LTP at stencil points, multiplying each point by an appropriate weight and summing the results. A method for computing optimum weights will be given. The LTP technique can generate 2nd order accuracy in cases with non-conformal boundaries, non-uniform grids and/or high space-charge gradients.

1 J. P. Verboncoeur, J. Comput. Phys. vol. 174 (2001) pp. 421-427.
2. R. Jackson, M. McLay and R. Joshi, final report, Air Force Office of Scientific Research STTR No. FA9550-05-C-0080 (2007).
3. J. Verboncoeur, A. Langdon and N. Gladd, Comput. Phys. Comm. 87, 199-211 (1995).
4. T. Bui et. al., Paper 2A02, ICOPS, Banff, Alberta, Canada, 2002.

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