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Fast and rigorous grid-based verification for particle-in-cell methods in multiple dimensions PAUL TRANQUILLI, LEE RICKETSON, Lawrence Livermore Natl Lab, LUIS CHACN, Los Alamos Natl Lab — Particle-in-cell (PIC) methods are a critical tool for the computer simulation of plasmas. As important as obtaining a solution is to assess confidence in the solution's accuracy. Historically, PIC schemes have been validated via analytical solutions for very simple problems, code-to-code comparisons, or the identification of specific solution features. However, as the size and complexity of both the PIC implementation and the hardware on which they run increases, a more rigorous framework is necessary. The method of manufactured solutions (MMS) is a standard, and well understood, approach for verifying codes for the solution of partial differential equations, which appears to have limited applicability to PIC codes due to the use of particles to represent a continuous probability distribution function (PDF). Here, we present a mathematically rigorous MMS-based verification approach for PIC methods. Unlike earlier proposed MMS approaches [1], which required estimating errors on the PDF, our approach only requires errors computed from grid quantities, avoiding the need to estimate errors in the PDF entirely. We also find – both analytically and empirically – that the particle sampling error scales differently for different field quantities in the manufactured solution context. This observation guides our choice of convergence metric. The new method has the advantage of being relatively low cost, avoiding unnecessary implementation overhead and unwieldy statistical metrics. We will demonstrate the approach with numerical experiments. [1] Riva et al, Phys. Plasmas (2017)

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