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Validation Studies: Are Particle-in-Cell Simulations in Good Agreement with Experiments?

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Recent benchmarking activity shows that modern particle-in-cell simulations give results consistent with each other. This result suggests, but does not prove, that the results of these calculations are also correct, in some useful sense, and should be expected to be in agreement with relevant experiments. For the rare gases helium and argon, this expectation is strengthened by the good agreement that is found with experimental measurements of transport coefficients for both electron and ions. Of course, comparison with experiments involves complications such as the possible effect of charged particle emission from surfaces, multi-step ionization and geometrical factors. Some of these involve appreciably uncertain parameters, and the consequences of such uncertainty must be taken into account. In this paper, we will investigate whether there is, in light of these considerations, satisfactory agreement between particle-in-cell computer simulations and various now classical experimental studies. We will show that, in at least some cases, there apparently is not, and we will offer speculations as to why this might be the case.