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Corresponding author: Ott, Tobias
e-mail of corresponding author: ottt@irs.uni-stuttgart.de
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Title
PIC schemes for multi-scale plasma simulations

Authors
Tobias Ott [1], Marcel Pfeiffer [2],*

** Corresponding author*
[1] Institute of Space Systems, Pfaffenwaldring 29, 70569 Stuttgart, Germany, ottt@irs.uni-stuttgart.de
[2] Institute of Space Systems, Pfaffenwaldring 29, 70569 Stuttgart, Germany, mpfeiffer@irs.uni-stuttgart.de

Abstract
Simulating the behavior of charged particles in electromagnetic fields is a complex task that requires significant computational resources. One of the major difficulties in plasma simulation is the high velocity of electrons, which is a result of their low mass. To accurately resolve the trajectory of these electrons, very small time steps are necessary in most time discretization methods. However, in many simulations, the trajectory of slow ions is the primary focus of interest. To accommodate this issue, implicit time integration can be used instead of explicit time integration, as it does not impose any restrictions on the time step size for stability [1, 2].
In this study, we present an energy-conserving implicit particle-in-cell method that is stable for arbitrary time steps. The energy-conserving properties of this method eliminate the common problem of grid heating in many simulations. The study also compares the efficiency and energy conservation of two methods for solving the electrostatic field in the simulation: the continuous Galerkin (CG) method and the hybridized discontinuous Galerkin (HDG) method [3, 4]. While the HDG method is more computationally efficient, it is easier to achieve energy conservation with the CG method.
The simulations are performed using the solver PICLas [5, 6], which incorporates highly parallel concepts to reduce computation time and also allows for complex, unstructured mesh geometries. We will use this solver to show the favorable energy-conserving properties in a three dimensional test case.

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