Fast Boundary Element Methods for Plasma Simulation

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In this talk, we present a grid-free method for the numerical treatment of the three-dimensional Vlasov-Poisson system. After the discretisation of the density function with a standard particle method, the solution of the Poisson equation is split into two parts: a particle-particle part and a solution of a Laplace problem. Solving the later with the Boundary Element Method (BEM) leads to a (volume) grid-free method.

The BEM makes use of an equivalent boundary integral formulation of the Laplace problem, which is descretised on a boundary mesh. This reduces the three-dimensional volume problem to a two-dimensional problem on the boundary. Consequently, the number of degrees of freedom of the BEM is typically much smaller than the number of particles.

The electric field is approximated by hierarchical matrices which are computed on the fly. The computational complexity for their evaluation is linear in the number of particles and nearly linear in the number of degrees of freedom of the BEM. The numerical experiments confirm the theoretical complexity estimates.

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