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Projection and Tree Based Reduced Order Modeling for Vortex Particle Simulations.[1] STEVEN RODRIGUEZ, ATHANASIOS ILIOPOULOS, United States Naval Research Laboratory, STEVEN BRUNTON, KEVIN CARLBERG, University of Washington, JOHN MICHOPOULOS, JOHN STEUBEN, United States Naval Research Laboratory — Vortex particle methods are ubiquitous in modeling vorticity transport phenomena. Example applications include the modeling of a helicopter rotor wake, or wake-body interactions in a school of fish. Unfortunately, these vortex particle methods exhibit poor quadratic $O(N^2)$ operation-count complexity (OCC), with respect to the number of N particles in the domain. Acceleration techniques, such as the fast-multipole method or other tree-methods, can be used to reduce the OCC. However, these techniques have at best reduced computations to an *N-dependent* linear OCC, i.e. $O(N)$. The presented work addresses the N-dependent OCC bottleneck by introducing a framework that combines hierarchical decomposition and projection-based hyper-reduction to enable *N-independent* OCC. Specifically, the presented framework combines the Barnes-Hut tree method with GNAT hyper-reduction to reduce the pairwise interactions of an N-body problem. The presented method will be showcased on the Biot-Savart kernel to demonstrate fast computations of the induced velocity field for parametric fluid-dynamic example problems.

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