VORONOI DYNAMIC DOMAIN DECOMPOSITION FOR LOAD-BALANCED PARALLEL SIMULATIONS OF MATERIALS IN EXTREMES WITH PARTICLE METHODS

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A highly efficient adaptive load balancing algorithm for parallel simulations using particle methods on large computational cluster is developed. It is based on dynamic spatial decomposition of simulated samples between Voronoi cells, where each cell with all its particles is handled by a single process. The algorithm shifts the position of the Voronoi cells to reduce the local load imbalance, which leads to the transfer of particles from more loaded processes to less loaded ones. Sequential reiteration of the algorithm leads to equalization of the load between all processes.

The high adaptability of the balancing algorithm is illustrated by atomistic simulation and smoothed particle hydrodynamics (SPH) modeling of dynamic behavior of materials under extreme conditions, which are characterized by large pressure and velocity gradients, as a result of which the spatial distribution of particles varies greatly in time. For all the tests carried out, a comparison with the algorithm of static decomposition of the computational domain is provided. The results of the tests for strong scalability indicate a high parallel efficiency with using several thousand processes.

CSPH&VD^3, the program complex which uses the developed algorithm, provides the means to obtain solutions of many fundamental and applied hydrodynamic problems with free surfaces and continuity losses, produced by material flows with high energy density.