Multi-Workgroup Tiling to Improve the Locality of Explicit One-Step Methods for ODE Systems with Limited Access Distance on GPUs

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Solving an initial value problem of a large system of ordinary differential equations (ODEs) on a GPU is often memory bound, which makes optimizing the locality of memory references important. We exploit the limited access distance, which is a property of a large class of right-hand-side functions, to enable hexagonal or trapezoidal tiling across the stages of the ODE method. Since previous work showed that the traditional approach of launching one workgroup per tile is worthwhile only for small limited access distances, we introduce an approach where several workgroups cooperate on a tile (multi-workgroup tiling) and investigate several optimizations and variations. Finally, we show the superiority of the multi-workgroup tiling over the traditional single-workgroup tiling for large access distances by a detailed experimental evaluation using two different Runge-Kutta (RK) methods.