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GPU implementation of an SPH model for lava flow simulation

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Simulation of lava flow poses a number of challenges ranging from non-newtonian free boundary fluid dynamics to complex thermal effects such as temperature-dependent physical properties and liquid/solid phase transition. Traditional Eulerian (implicit) methods such as finite elements, finite volumes or finite differences incur in considerable penalties when handling these issues, due to the complexity of properly tracking boundaries and solidification fronts. We propose a Lagrangian (explicit) model based on SPH (Smoothed Particle Hydrodynamics), with the addition of non-newtonian rheology, exploring both the Bingham model traditionally used for lava, and the power-law rheology more recently taken into consideration. The model is implemented taking advantage of the cheap high-performance parallel computational power provided by the GPU (Graphical Processing Unit) found in modern 3D-accelerated video cards. GPUs are SIMD (Single Instruction, Multiple Data) processors and are therefore particularly suited for the large-scale parallel data processing required for efficient simulation of particle methods.