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A regularized version of the Kuwabara-Kono force scheme for 2nd order convergence in DEM simulations of granular materials

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Abstract

The Discrete Element Method is a technique widely used to simulate multi-particle systems, in particular granular materials. For conservative systems, the integration of the equations of motion is often performed via a Verlet-type method of order two, due to its second order accuracy and near energy conservation properties. However, when dissipative forces are included, such as in simulations of granular materials, the Verlet method no longer behaves as a second order method. For instance, when using the popular Kuwabara-Kono force scheme, the order of the Verlet method decreases to 1.5, due to the singular behavior of the damping force during particle collisions. In this work, we propose a regularization of the Kuwabara-Kono force model via mollification. We show numerically that the Verlet method combined with this regularized force model can integrate collisions with second order accuracy and that the coefficient of restitution of the system increases as a function of the regularization parameter