Energy decay of freely cooling granular gases in three dimensions

ZAHERA JABEEN, Department of Physics, University of Michigan, Ann Arbor, MI 48109-1040, SUDHIR N. PATHAK, RAJESH R., Institute of Mathematical Sciences, CIT Campus, Taramani Chennai-600 113, India — Freely cooling granular gases, wherein a dilute system of macroscopic particles with uncorrelated initial velocities lose energy through inelastic collisions, have been extensively studied both as a simple model for granular systems as well as a nonequilibrium system showing nontrivial coarsening at late times. As the system cools, inelasticity induces clustering, making the system inhomogeneous. While the form of energy decay ($E(t) \sim t^{-\theta}$) in the initial homogeneous regime is well established by Haff’s law (\(\theta = 2\)), the energy decay in the clustered regime is still unresolved in higher dimensions. Within mean field theory, \(\theta = 2d/(d+2)\) (where \(d\) is the spatial dimension), while a correspondence to Burgers equation implies an exponent \(\theta = 2/3(d = 1), d/2(d > 1)\). In one and two dimensions, the two formulae predict the same exponents. By performing extensive event driven molecular dynamics simulations, we show that in three dimensions, the energy decays asymptotically with a power \(\approx 1.2\), for all coefficients of restitution \(r < 1\), consistent with the mean field exponent. However, we argue that the mean field arguments fail due to non local interactions between mass clusters.