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Are Nanoparticles Sticky or Bouncy?

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Introduction

The purpose of our research is to understand how nanoparticles behave individually and as a group. For this particular set of experiments we focused on how nanoparticles interact in a collision by investigating the size and the collision velocity dependence of the coefficient of restitution. From that simple guiding notion, our research expanded in several directions.

What are Nanoparticles?

Nanoparticles are extremely tiny clusters of atoms. They can consist of hundreds to several million atoms, and have a diameter between one and one hundred nanometers.

Methods

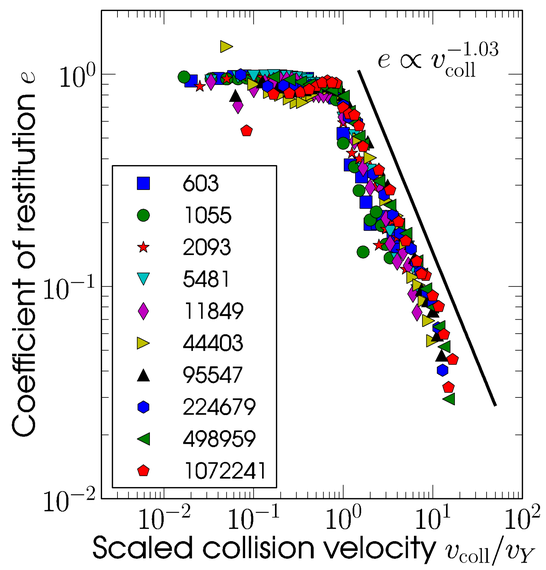
Studying nanoparticles is not easy in the lab or with a computer. Specialized instrumentation and machines are needed. In our research, we studied a seemingly simple problem using high accuracy computer simulations of collisions of nanoparticles made of face-centered cubic lattice of Lennard-Jones atoms. The computer simulations solve lots and lots of Newton's equations, which then allow us to examine the behavior of the nanoparticles before, during, and after collision.

Why is our Research Important?

Knowledge about the interactions of nanoparticles can allow us to make surfaces that are exceedingly strong, data storage devices of unbelievable precision and capacity, deliver targeted drugs to various parts of the body and even help understand how stars form.

Interactions Between Nanoparticles

The nature of interactions between nanoparticles is not well understood. Our research serves as evidence that the interactions between nanoparticles may be different from that for micron sized and larger particles. For nanoparticles, there exists a sharp crossover between elastic collision (bouncy) and plastic collision (sticky), which occurs when the collision velocity approaches the size-dependent yield velocity. However, as the particle size increases, the nanoparticle behaves more like a macroscopic particle.



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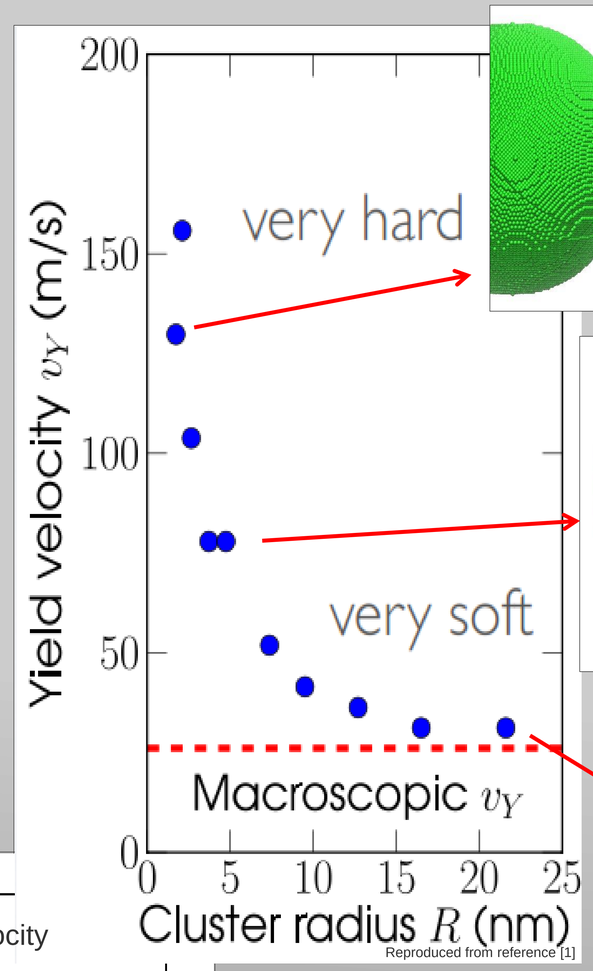

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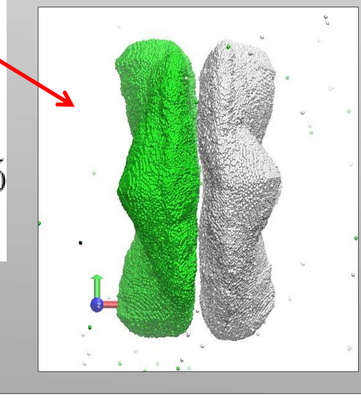

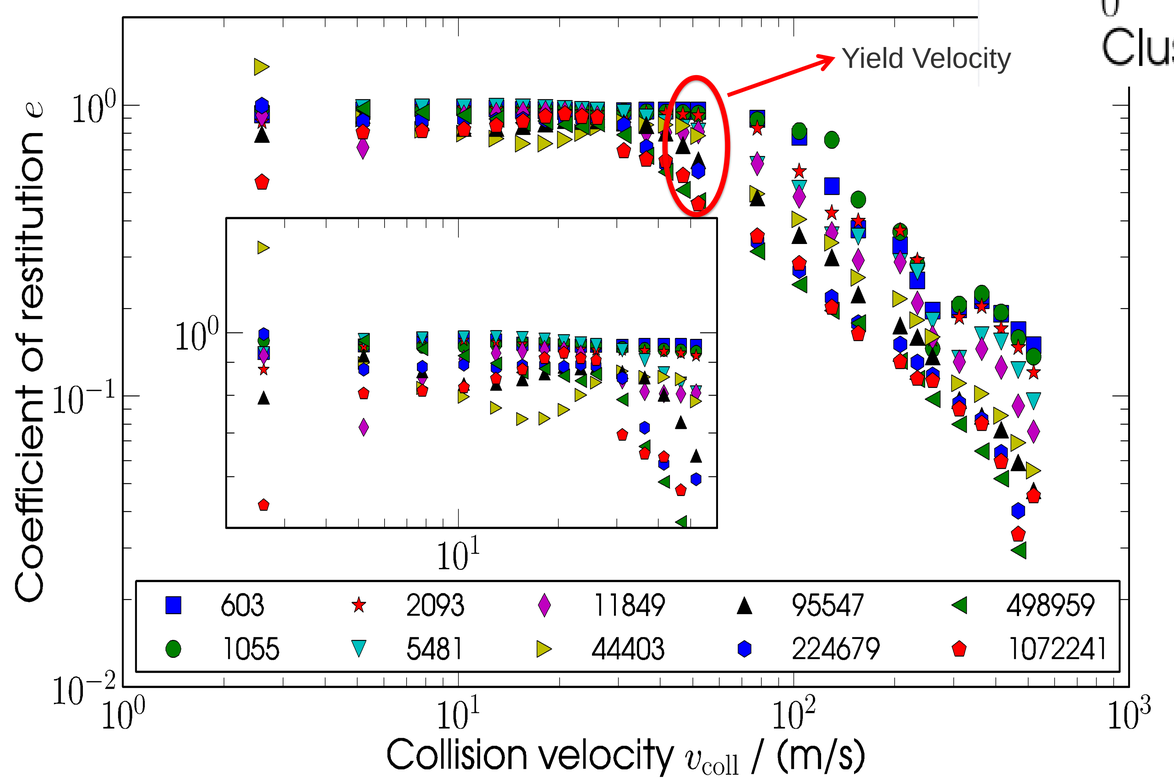

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Conclusion

Nanoparticles show dynamical properties distinctly different than those of bulk materials. We found that slow moving nanoparticles can be firm and bouncy whereas fast moving nanoparticles can be pliable and sticky. The velocity at which the nanoparticle changes from being bouncy to sticky is called the yield velocity, and is dependent upon the size of the nanoparticle. This is in stark contrast to how simple balls behave when they collide; the behavior we observed is counterintuitive.

Literature Cited

[1] Takato, Yoichi, Surajit Sen, and Jeremy B. Lechman. "Strong plastic deformation and softening of fast colliding nanoparticles." Physical Review E 89.3 (2014): 033308.