Shear viscosity of granular mixtures: Assessment of kinetic theories

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The determination of the transport coefficients of granular mixtures (namely, mixtures constituted by smooth hard spheres of different masses, diameters, and coefficients of restitution) is still a challenging target. This is due not only to the large number of parameters involved in the description of the system but also by the array of intricacies and uncontrolled approximations needed to achieve explicit results. Due to the above difficulties, most of the previous attempts for computing transport in polydisperse granular systems were restricted to nearly elastic spheres. In this limiting situation, the partial temperatures of each species (measuring their mean kinetic energies) were assumed to be equal to the global granular temperature. On the other hand, the departure of energy equipartition increases with increasing inelasticity and hence, some recent kinetic theories [1] have taken into account not only the breakdown of kinetic energy in granular mixtures but also its impact on the transport properties.

In this talk, I consider two different kinetic theories for determining the shear viscosity for moderately dense granular mixtures. These theories have been independently proposed by Solsvik and Manger [1] (hereafter referred to as the SM-theory) and by Garzó, Dufty and Hrenya [2] (hereafter referred to as the GDH-theory). The set of Enskog kinetic equations is the starting point to obtain the shear viscosity in terms of the parameters of the mixture. While the SM-theory [3] assumes that the distribution functions of each species are Maxwellian distributions defined at the partial temperatures, the GDH-theory solves the Enskog equation by means of the Chapman-Enskog method conveniently adapted to account for the inelastic character of collisions. To assess the reliability of both theories, the Enskog equation for granular mixtures is numerically solved by means of the direct simulation Monte Carlo method. The mixture is assumed to be under simple shear flow and driven by the action of an external force that exactly compensates the energy dissipated by collisions. Under these conditions, the system achieves a linear hydrodynamic regime where the Navier-Stokes shear viscosity can be identified and measured in the simulations. The results clearly show that the GDH-theory compares with simulations much better than the SM-theory over a wide range of values of the coefficients of restitution, the volume fraction, and the parameters of the mixture (masses, diameters, and concentration).

References

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