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Averaging processes in granular flows driven by gravity

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One of the more promising theoretical frames to analyse the two-phase granular flows is offered by the similarity of their rheology with the kinetic theory of gases [1]. Granular flows can be considered a macroscopic equivalent of the molecular case: the collisions among molecules are compared to the collisions among grains at a macroscopic scale [2,3].

However there are important statistical differences in dealing with the two applications. In the two-phase fluid mechanics, there are two main types of average: the phasic average and the mass weighed average [4]. The kinetic theories assume that the size of atoms is so small, that the number of molecules in a control volume is infinite. With this assumption, the concentration (number of particles n) doesn't change during the averaging process and the two definitions of average coincide. This hypothesis is no more true in granular flows: contrary to gases, the dimension of a single particle becomes comparable to that of the control volume. For this reason, in a single realization the number of grain is constant and the two averages coincide; on the contrary, for more than one realization, n is no more constant and the two types of average lead to different results. Therefore, the ensamble average used in the standard kinetic theory (which usually is the phasic average) is suitable for the single realization, but not for several realization, as already pointed out in [5,6].

In the literature, three main length scales have been identified [7]: the smallest is the particles size, the intermediate consists in the local averaging (in order to describe some instability phenomena or secondary circulation) and the largest arises from phenomena such as large eddies in turbulence.

Our aim is to solve the intermediate scale, by applying the mass weighted average, when dealing with more than one realizations. This statistical approach leads to additional diffusive terms in the continuity equation: starting from experimental results, we aim to define the scales governing the diffusive phenomenon, introducing the diffusive terms following the Boussinesq model. The diffusive coefficient will be experimentally defined; it will be probably proportional to the square root of the granular temperature θ and the diameter of the particles d or, alternatively, the flow height h.

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