Effect of Concentration on Particle Equation of Motion

When the concentration of the disperse phase in a multiphase flow is small (less than, say, 0.01% by volume) the particles have little effect on the motion of the continuous phase and analytical or computational methods are much simpler. Quite accurate solutions are then obtained by solving a single phase flow for the continuous phase (perhaps with some slightly modified density) and inputting those fluid velocities into equations of motion for the particles. This is known as *one-way coupling*.

As the concentration of the disperse phase is increased a whole spectrum of complications can arise. These may effect both the continuous phase flow and the disperse phase motions and flows with this *two-way coupling* pose many modeling challenges. A few examples are appropriate. The particle motions may initiate or alter the turbulence in the continuous phase flow; this particularly challenging issue is briefly addressed in section (Nc). Moreover, particles may begin to collide with one another, altering their effective equation of motion and introducing random particle motions that may need to be accounted for; section (Np) is devoted to flows dominated by such collisions. These collisions and random motions may generate additional turbulent motions in the continuous phase. Often the interactions of particles become important even if they do not actually collide. Fortes *et al.* (1987) have shown that in flows with high relative Reynolds numbers there are several important mechanisms of particle-particle interactions that occur when a particle encounters the wake of another particle. The following particle drafts the leading particle, impacts it when it catches up with it and the pair then begin tumbling. In packed beds these interactions result in the development of lateral bands of higher concentration separated by regions of low, almost zero volume fraction. How these complicated interactions could be incorporated into a two-fluid model (short of complete and direct numerical simulation) is unclear.

At concentrations that are sufficiently small so that the complications of the preceding paragraph do not arise, there are still effects upon the coefficients in the particle equation of motion that may need to be accounted for. For example, the drag on a particle or the added mass of a particle may be altered by the presence of neighboring particles. These issues are somewhat simpler to deal with than those of the preceding paragraph and we cover them in this chapter. The effect on the added mass was addressed earlier in section (Nef). In the next section we address the issue of the effect of concentration on the particle drag.