Effect of Concentration on Added Mass

Though most multiphase flow effects are delayed until later chapters it is convenient at this point to address the issue of the effect on the added mass of the particles in the surrounding mixture. It is to be expected that the added mass coefficient for an individual particle would depend on the void fraction of the surrounding medium. Zuber (1964) first addressed this issue using a *cell method* and found that the added mass, M_{ii}, for spherical bubbles increased with volume fraction, α, like

$$\frac{M_{ii}(\alpha)}{M_{ii}(0)} = \frac{(1+2\alpha)}{(1-\alpha)} = 1 + 3\alpha + O(\alpha^2) \tag{Nef1}$$

The simplistic geometry assumed in the cell method (a concentric spherical shell of fluid surrounding each spherical particle) caused later researchers to attempt improvements to Zuber's analysis; for example, van Wijngaarden (1976) used an improved geometry (and the assumption of potential flow) to study the $O(\alpha)$ term and found that

$$\frac{M_{ii}(\alpha)}{M_{ii}(0)} = 1 + 2.76\alpha + O(\alpha^2) \tag{Nef2}$$

which is close to Zuber's result. However, even more accurate and more recent analyses by Sangani *et al.* (1991) have shown that Zuber's original result is, in fact, remarkably accurate even up to volume fractions as large as 50% (see also Zhang and Prosperetti 1994).