# Comparison with Experiments

The real and imaginary parts of $\kappa$ as defined by equation (Nmc12) lead respectively to a sound speed and an attenuation that are both functions of the frequency of the perturbations. A number of experimental investigations have been carried out (primarily at very small $\alpha$) to measure the sound speed and attenuation in bubbly gas/liquid mixtures. This data is reviewed by van Wijngaarden (1972) who concentrated on the experiments of Fox, Curley, and Lawson (1955), Macpherson (1957), and Silberman (1957), in which the bubble size distribution was more accurately measured and controlled. In general, the comparison between the experimental and theoretical propagation speeds is good, as illustrated by figure 1, section (Nmc). One of the primary experimental difficulties illustrated in both figures 1 and 2, section (Nmc), is that the results are quite sensitive to the distribution of bubble sizes present in the mixture. This is caused by the fact that the bubble natural frequency is quite sensitive to the mean radius (see equation (Nmc10)). Hence a distribution in the size of the bubbles yields broadening of the peaks in the data of figures 1 and 2, section (Nmc).

Though the propagation speed is fairly well predicted by the theory, the same cannot be said of the attenuation, and there remain a number of unanswered questions in this regard. Using equation (Nmc12) the theoretical estimate of the damping coefficient, $\delta_d$, pertinent to the experiments of Fox, Curley, and Lawson (1955) is 0.093. But a much greater value of $\delta_d = 0.5$ had to be used in order to produce an analytical line close to the experimental data on attenuation; it is important to note that the empirical value, $\delta_d = 0.5$, has been used for the theoretical results in figure 2, section (Nmc). On the other hand, Macpherson (1957) found good agreement between a measured attenuation corresponding to $\delta_d \approx 0.08$ and the estimated analytical value of 0.079 relevant to his experiments. Similar good agreement was obtained for both the propagation and attenuation by Silberman (1957). Consequently, there appear to be some unresolved issues insofar as the attenuation is concerned. Among the effects that were omitted in the above analysis and that might contribute to the attenuation is the effect of the relative motion of the bubbles. However, Batchelor (1969) has concluded that the viscous effects of translational motion would make a negligible contribution to the total damping.

Finally, it is important to emphasize that virtually all of the reported data on attenuation is confined to very small void fractions of the order of 0.0005 or less. The reason for this is clear when one evaluates the imaginary part of $\kappa$ from equation (Nmc12). At these small void fractions the damping is proportional to $\alpha$. Consequently, at large void fraction of the order, say, of 0.05, the damping is 100 times greater and therefore more difficult to measure accurately.