DISCUSSION

F. G. Hammitt[1]

This paper concerning the analysis of the collapse of nonspherical bubbles near solid walls, using a method of matched asymptotic expansions rather than a full numerical treatment of the problem, which is very expensive in machine time, is most welcome, and I believe a highly important contribution to this extremely complex, and also important problem. As the authors suggest, I hope they will have the opportunity to carry further this valuable approach to the cases of several bubbles in close proximity to each other, and also to an elastic rather than rigid wall. Both cases are certainly highly important to the understanding of the actual cavitation damage process, and also to the use of elastomeric coatings for alleviating damage.

It is encouraging that they find that their method produces reasonably valid results when bubble wall distance is only 1.5 × original bubble radius, by comparing with more exact past numerical treatments (authors' [5–7]). I wonder what is the minimum distance ratio for which they feel their method could be applied?

I am happy they they have resolved a previous disagreement between our previous treatment (authors' reference [6]) and another earlier work (authors' reference [13]), which had appeared to disagree. They now conclude that the pressure near the wall can be very large indeed under certain conditions, which we had not previously predicted (reference [6]).

Their conclusion that initial gas pressure and its law of compression can be more important than wall proximity is interesting, and I believe unexpected, since the volume collapse ratio is usually not enormous before the generation of a microjet.

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[2] Ivany, R. D., and Hammitt, F. G., "Cavitation Bubble Collapse in Viscous, Compressible Liquids," *Journal of Basic Engineering*, Vol. 87, No. 4, 1965, pp. 977–985.

Authors' Closure

We very much appreciate Professor Hammitt's comments and would like to thank him for giving us the opportunity to present an update on the progress made using the method described here. We first presented this paper at the ASME Symposium on Cavitation Erosion in Fluid Systems, Boulder, Colo., June 1981. Since then, the method has proven successful in studying the nonspherical behavior near a free surface [1], and more importantly, has been extended to the study of the interaction of a cloud of bubbles [2, 3]. A major influence of the collective behavior on the bubble dynamics and on the generated pressure field has been shown. We share Professor Hammitt's view on the importance of the study of elastomeric coatings. Unfortunately, we have not yet had the chance to pursue our initial approach [4] of that problem and hope to do it soon.

The matched asymptotic method we have used in this paper is valid as long as the bubble radius to wall distance ratio, ϵ, is small compared to one. We have pushed the method a little too far by applying it to a value of ϵ, of 2/3. The last phase of the collapse is the hardest to describe, and depending on the bubble gas content and on ϵ, the method fails earlier or later in the bubble history. Here we address the last comment of the discussant. We believe that the volume collapse ratio before the generation of a microjet is a function of both the wall proximity and gas content; for a given bubble wall configuration, the less noncondensible gas the bubble contains, the earlier the microjet forms. Thus, the formation of a microjet and of large bubble deformations (limit of application of the method) is function as much of gas content as of bubble wall proximity.

Additional References

1 Bovis, A., and Chahine, G. L., "Etude Asymptotique de l' Interaction d' une Bulle Oscillante avec une Surface Libre Voisine," *Journal de Mécanique*, Vol. 20, No. 3, 1981, pp. 537–556.

2 Chahine, G. L., "Pressures Generated by a Bubble Cloud Collapse," ASME *Cavitation and Polyphase Flow Forum*, St. Louis, Mo. 1982, pp. 27–31.

3 Chahine, G. L., "Cloud Cavitation: Theory," *Proceedings 14th Symposium on Naval Hydrodynamics*, Ann Arbor, Mich. 1982, pp. 165–195.

4 Chahine, G. L., Cohen D., Ducasse, P. and Ligneul, L., "Influence d' un Revêtement Elastique sur le Collapse d' une Bulle au Voisinage d' une Paroi Solide," *Proceedings 4th Int.* Meeting on Water Column Separation, Cagliari, Italy, Sept. 1982.