Comment on "Role of liquid compressional viscosity in the dynamics of a sonoluminescing bubble"

Tao Lu and Yu An
Department of Physics, Tsinghua University, Beijing 100084, China
(Received 22 October 2004; published 7 October 2005)

Moshaii and Bonabi found a new viscous term to the traditional bubble boundary equation and declared it greatly affects the motion of the sonoluminescing bubble. However, the simple analysis and recomputation show it is incorrect.

DOI: 10.1103/PhysRevE.72.048301 PACS number(s): 78.60.Mq, 47.55.Dz, 43.25.+y

Moshaii and Sadighi-Bonabi [1] derived a new bubble boundary equation in their paper,

$$P_l+\alpha\frac{dP_l}{dt}=P_g-\frac{4\mu\dot{R}}{R}-\frac{2\sigma}{R}, \tag{1}$$

where R is the bubble radius, P_l is the liquid side pressure at the bubble wall, P_g is the gas pressure in the bubble, μ is the first coefficient of viscosity, σ is the coefficient of surface tension. $\alpha(dP_l/dt)$ is the new term of viscous correction, $\alpha=(\lambda+2\mu)/\rho C^2$, where ρ is the liquid density, λ is the second coefficient of viscosity, C is the sound speed in the liquid. They declared that this corrected term has the damping role in the bubble motion at the end of collapse and during the rebounds which raises observable changes to the maximum temperature and lowers the afterbounces radius. However, the simple analysis of this term will show this is impossible. As they quoted in their paper $\rho=998.0\ \mathrm{kg/m^3}$, $C=1483\ \mathrm{m/s}$, $\lambda=3.43\times10^{-3}\ \mathrm{kg/m/s}$ and $\mu=1.01\times10^{-3}\ \mathrm{kg/m/s}$, by which α can be estimated $\sim10^{-12}$ in SI. For general cases of the single bubble sonoluminescence, the time duration at the end of compression phase of the bubble is so short that the process at this interval can be treated as the adiabatic approximately, i.e., $P_g(V-b)^\gamma=\text{const}$, where V is the bubble volume, b is the van der Waals hard core volume, γ is the ratio of the molar specific heats, and we find that $P_l\sim P_g$. Then, the new term is

$$\alpha\frac{dP_l}{dt}\sim\alpha\frac{dP_g}{dt}=-3\alpha\gamma\frac{\dot{R}}{R}\frac{1}{1-\frac{b}{V}}P_g. \tag{2}$$

In general, we have $R_{\min}\sim0.6\ \mu\mathrm{m}$, $\dot{R}_{\max}\sim2000\ \mathrm{m/s}$, $\gamma\sim1.67$, $b/V\sim0.5$, when the new term reaches its maximum value of $\sim10^{-2}\ P_g$. From Eq. (1) we see the new term is too small to affect the result.

In addition, we use the uniform model [2] which Moshaii and Sadighi-Bonabi used in their calculation [1] and the parameters therein to calculate the variations of the bubble radius, the molecules number and temperature in the bubble. Figure 1 compares the two calculated radius-time curves, one with and another without the new viscous term. It is seen that there is no distinguishable difference between the two curves. In fact, the calculation shows that the new viscous term almost has no influence to the results. We also calculate the case ignoring the chemical reactions [3,4], the results show again that the new viscous term is negligible. It turns out that the new viscous term is too small to affect the calculation. Our calculation programs are available on request.

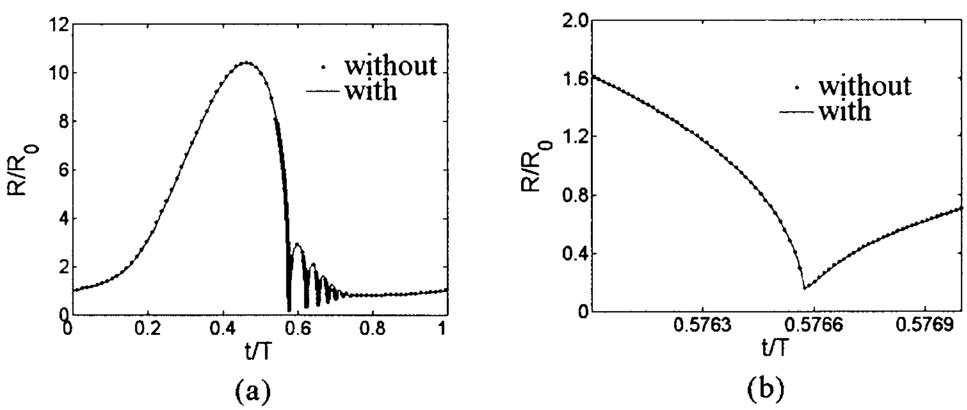

FIG. 1. Time variations of the bubble radius for the same case illustrated in Fig. 1 in Ref. [1], with (solid lines) and without (dotted lines) the new viscous term. (a) shows a complete oscillation of the bubble and (b) the radius variation during the end of the bubble collapse, where T is the oscillation period and R_0 is the ambient radius.

[1] A. Moshaii and R. Sadighi-Bonabi, Phys. Rev. E **70**, 016304 (2004).
[2] Xiaozhen Lu, Andrea Prosperetti, Ruediger Toegel, and Detlef Lohse, Phys. Rev. E **67**, 056310 (2004).
[3] Ruediger Toegel, Bruno Gompf, Rainer Pecha, and Detlef Lohse, Phys. Rev. Lett. **85**, 3165 (2000).
[4] http://arxiv.org/abs/physics/0309080

