Numerical Study of Temporal Density Variation on Nonlinear Evolution of Classical Rayleigh–Taylor Instability

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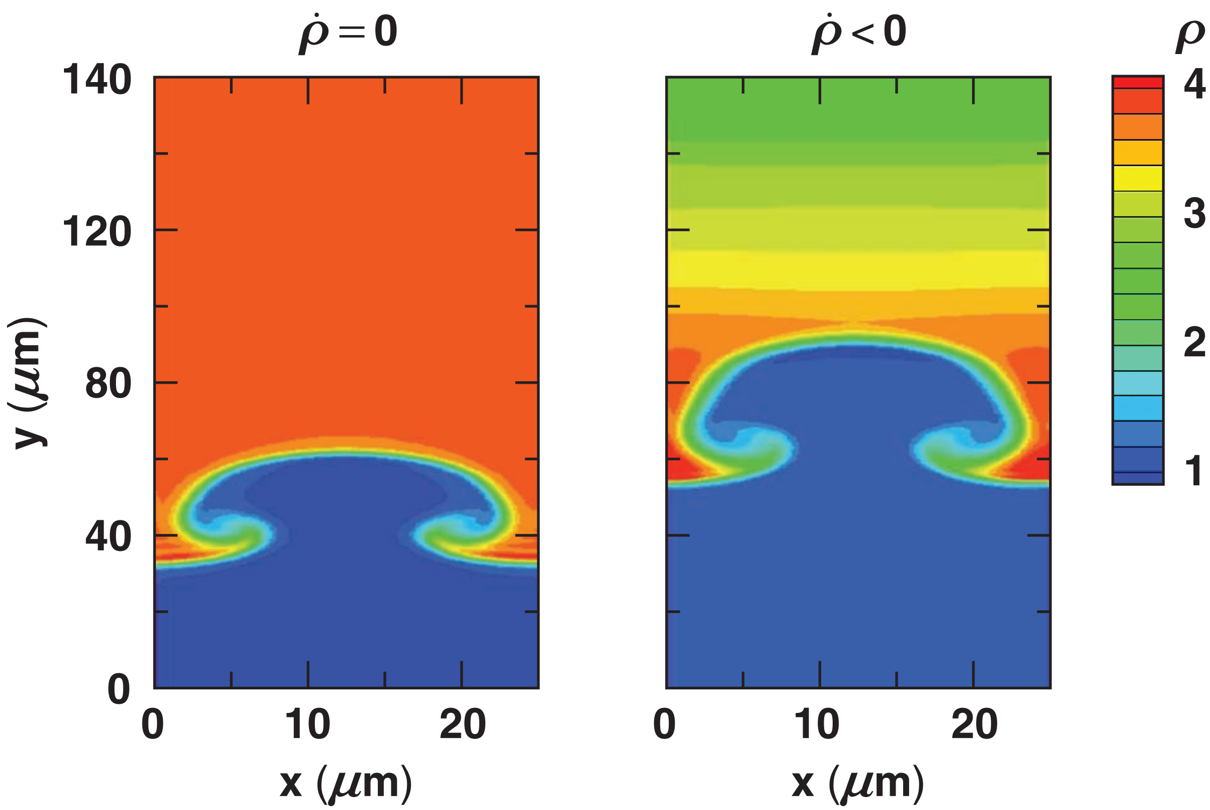

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47th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Denver, CO
24–28 October 2005

Summary

The results of the Layzer-type model with time-dependent density have been validated with a 2-D simulation

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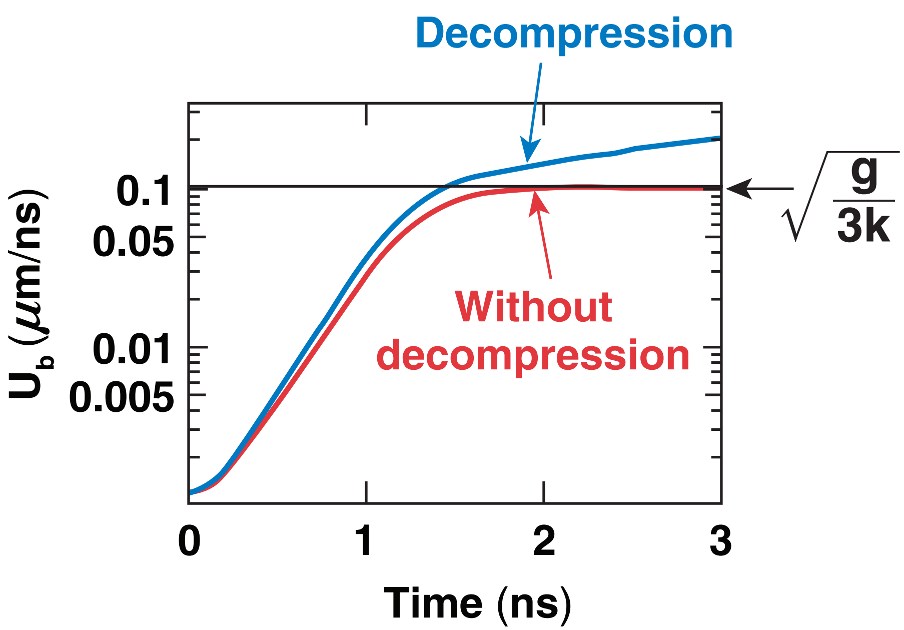
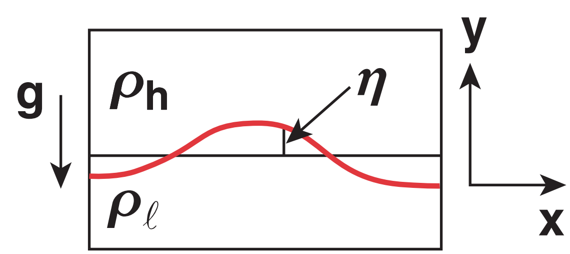
- Temporal density variation is important in ICF implosion.
- Layzer's model is extended to include the density variation in planar and spherical geometry.
- A 2-D Eulerian code has been developed to test the results of the model.
- Decompression increases asymptotic bubble velocity.
- The saturated bubble curvature is independent of the Atwood number.

Density variation can be easily included in Layzer's model*





$$\mathbf{U} = \nabla \Phi$$

$$\nabla^2 \Phi = -\frac{\dot{\rho}}{\rho}$$

$$\Phi = a(t)\cos(kx)\, e^{-k(y-\eta_0)} - \frac{\dot{\rho}}{\rho}\frac{y^2}{2}$$

$$\eta = \eta_0 + \eta_2 x^2$$

$$\eta_0 \xrightarrow{t \to \infty} \sqrt{\frac{g}{3k}} \frac{\int \rho(t')\,dt'}{\rho(t)}$$

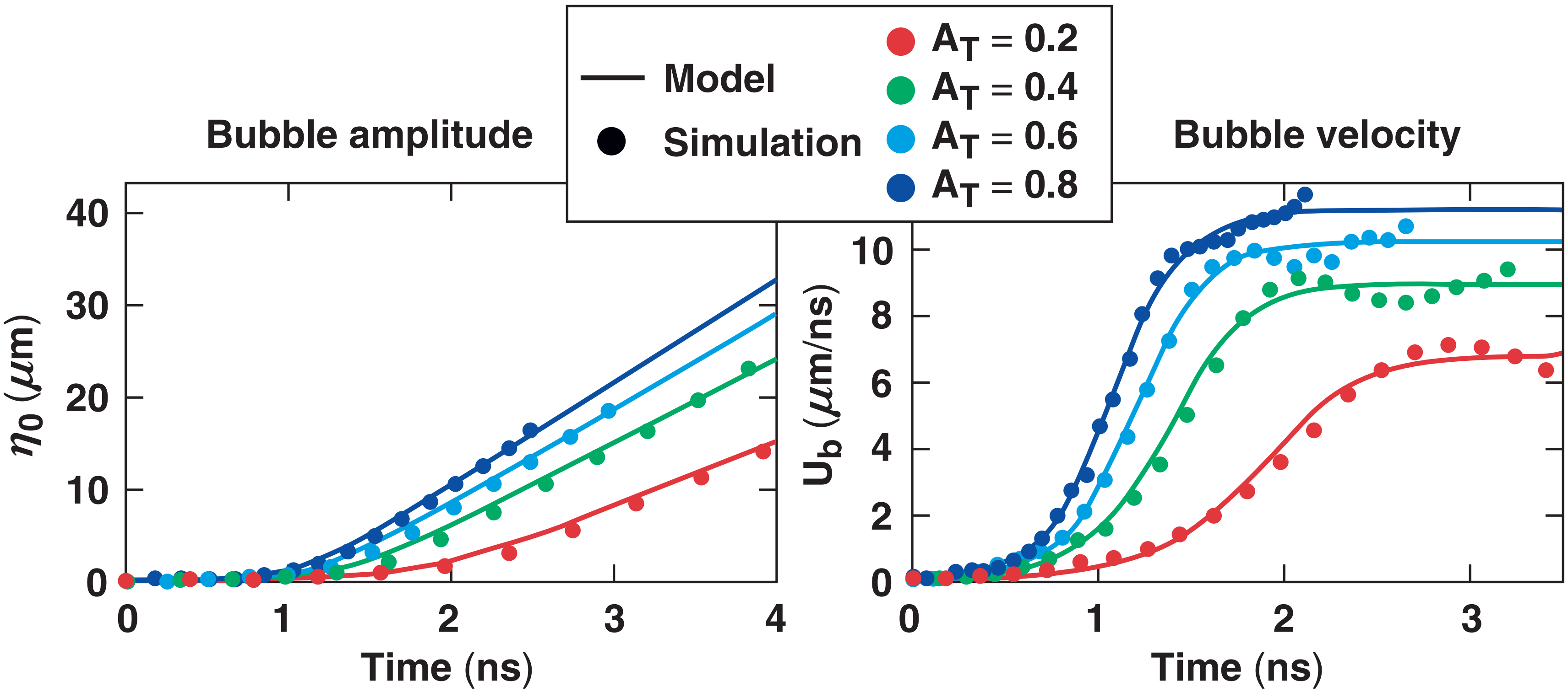
TC7097

*V. N. Goncharov and D. Li, Phys. Rev. E 71, 046306 (2005).

A 2-D Eulerian code was developed to test the decompression effects

- A two-dimensional MacCormack's method is used to solve Euler equations.
- Artificial viscosity is introduced in momentum equations and artificial heat flux in the energy equation.
- Periodic boundary conditions are applied on the left and right sides.
- Continuous boundary conditions are applied on the upper and lower borders.

The code was tested against a Layzer-type solution with constant density*



η_0 (0) = 0.0 μm
$\dot{\eta}_0$ (0) = 0.2 μm/ns
g = 100 μm/ns^2
λ = 25 μm

$$A_T = \frac{\rho_h - \rho_\ell}{\rho_h + \rho_\ell} \qquad U_b \rightarrow \sqrt{\frac{2A_T}{1+A_T}\frac{g}{3k}}$$

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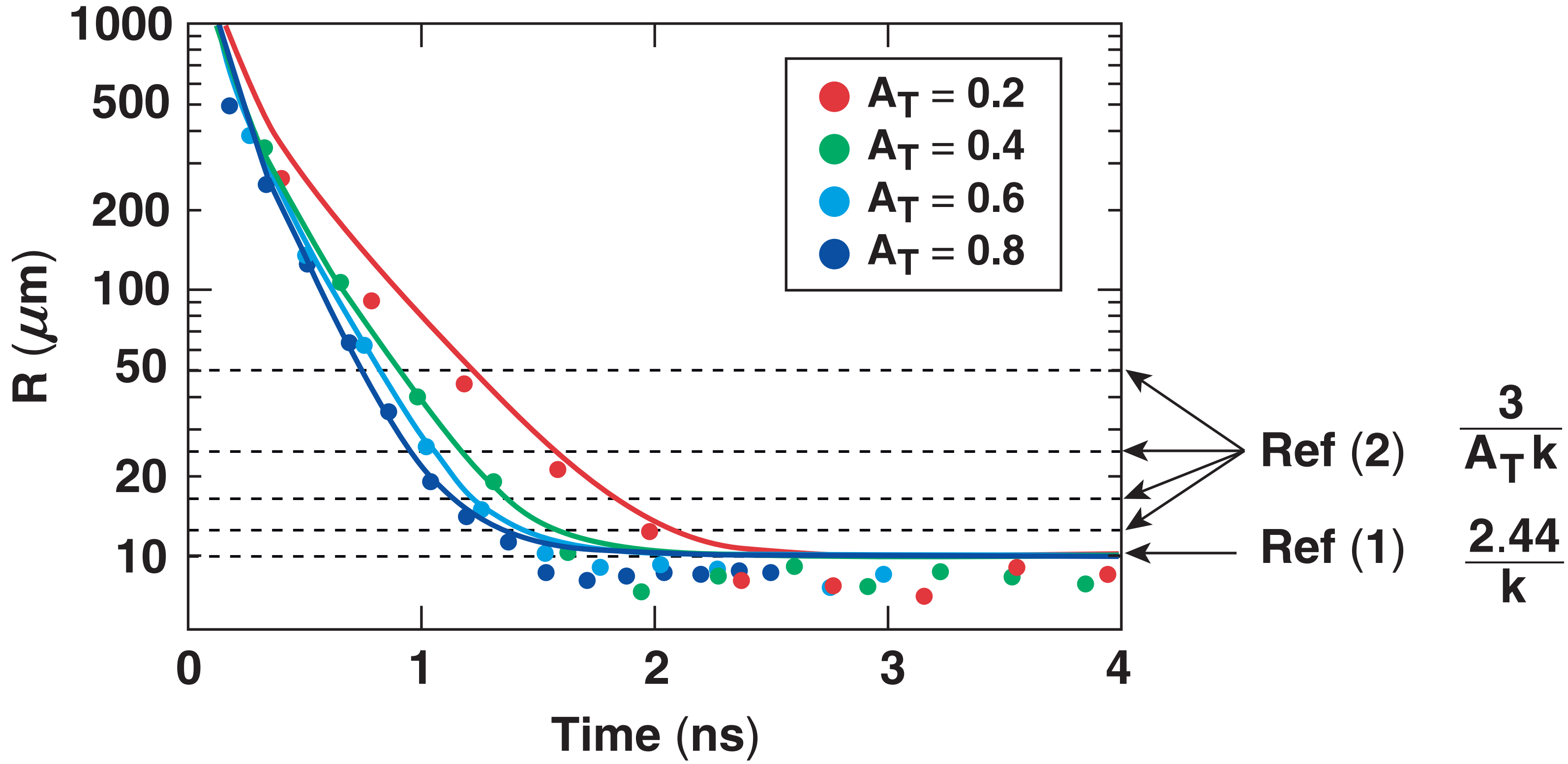
* V.N. Goncharov, Phys. Rev. Lett. 88, 4502 (2002).

The saturated bubble curvature is independent of Atwood numbers[1]

$$R = \frac{1}{2\eta_2}$$



[1] V.N. Goncharov, Phys. Rev. Lett. 88, 4502 (2002).
[2] S. I. Abarzhi *et al*., Phys. Lett. A 317, 470 (2003).

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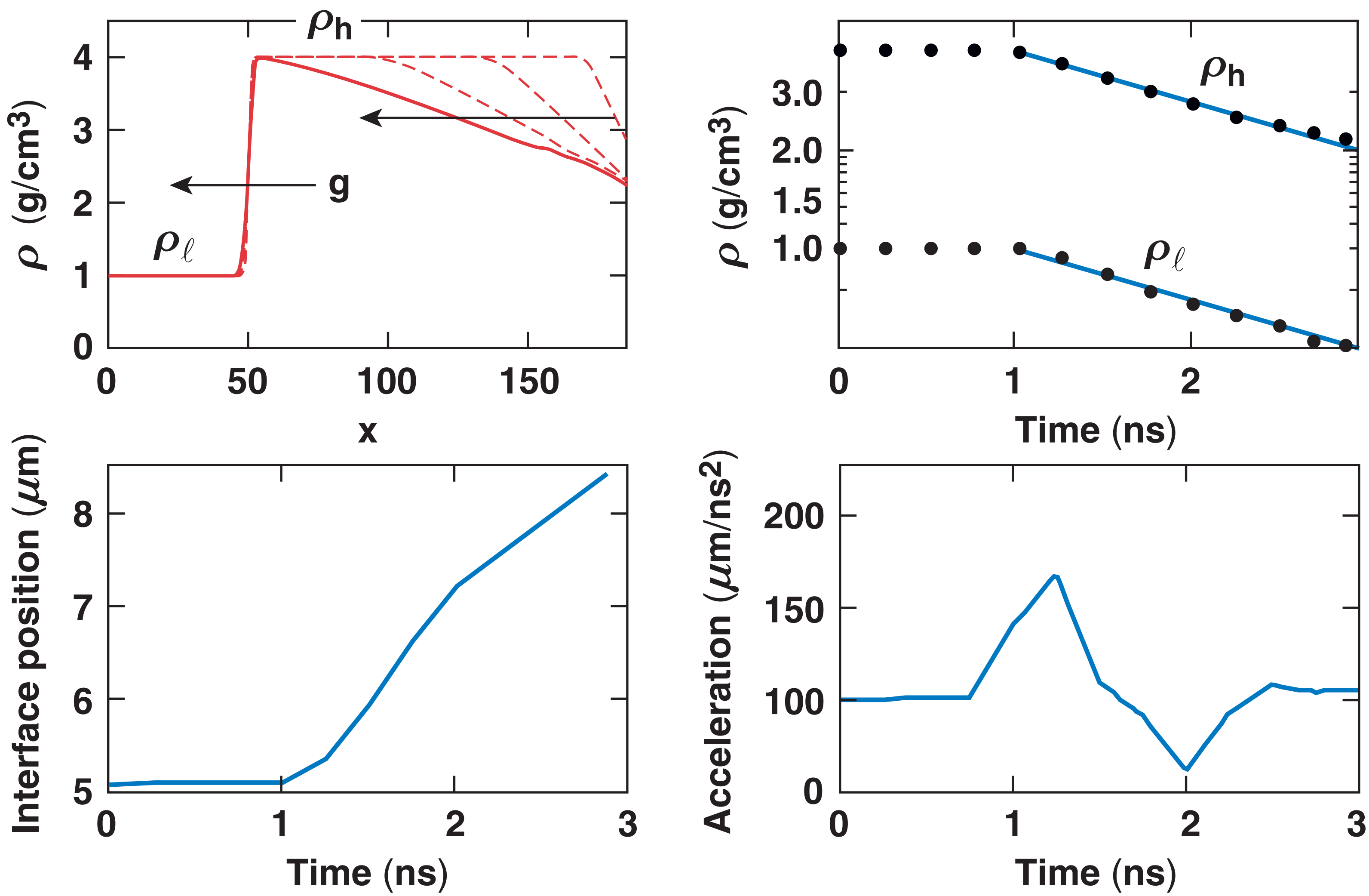
Decompression is imposed by launching a rarefaction wave



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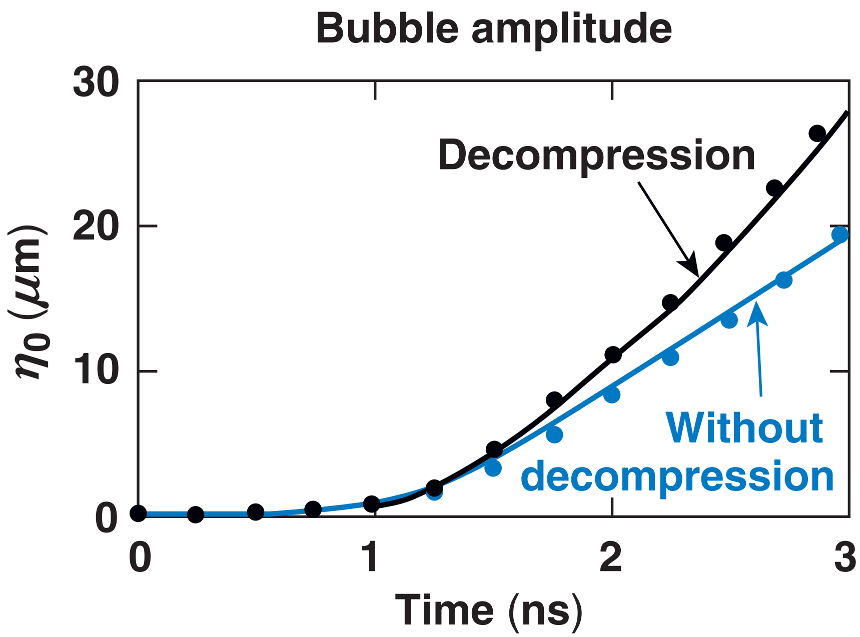
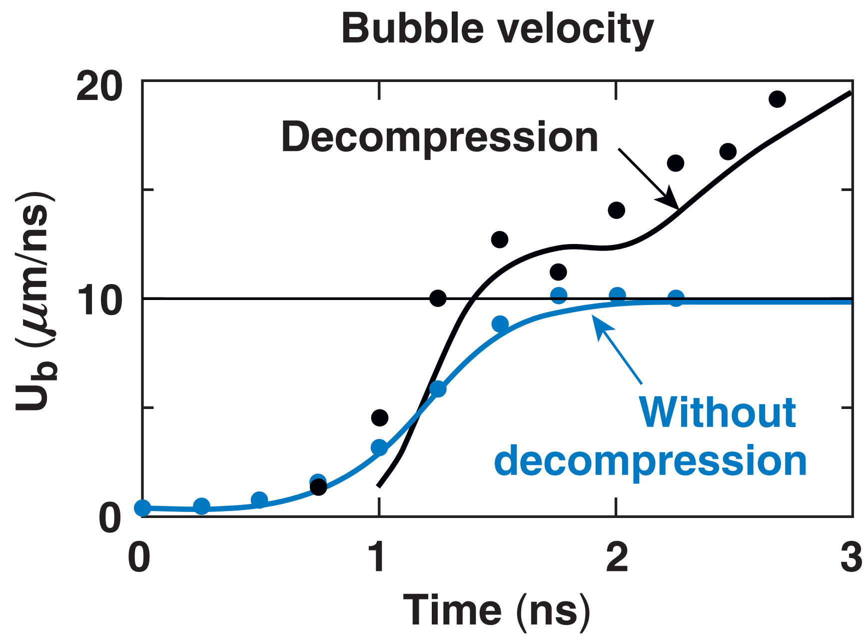
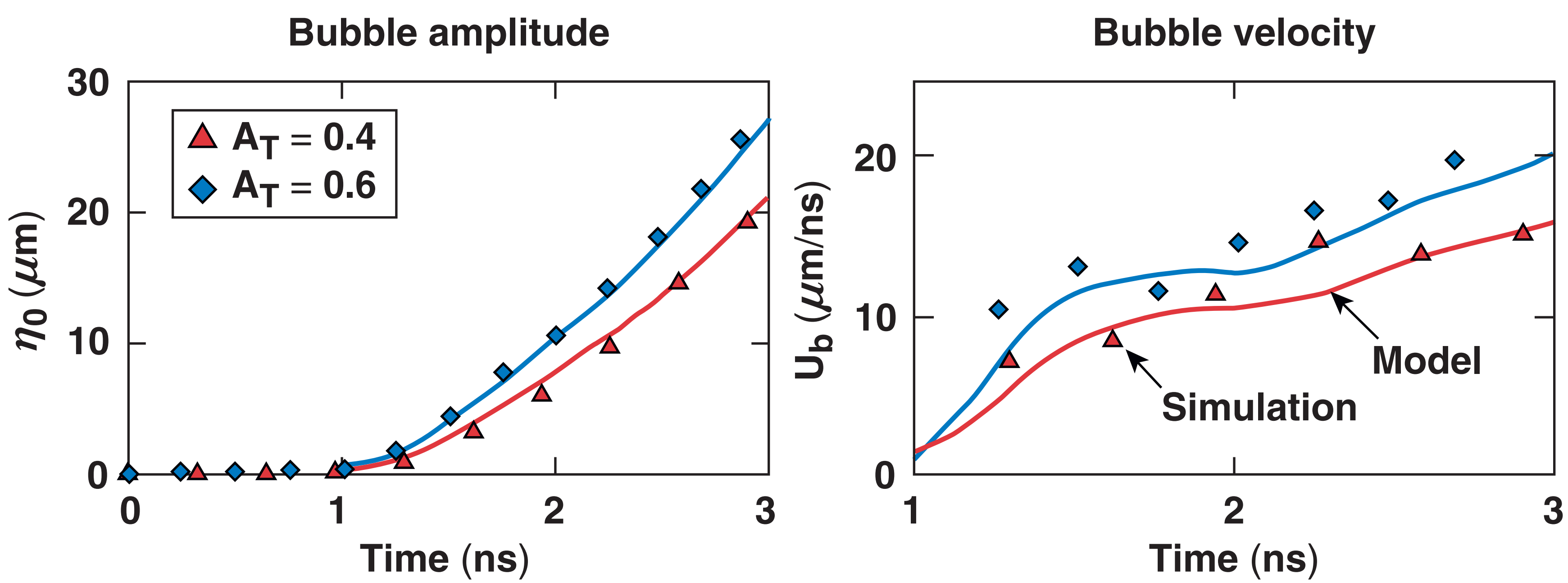
Decompression increases the asymptotic bubble velocity

$A_T = 0.4, \lambda = 25\ \mu m$





The Layzer-type model with decompression is in good agreement with simulations for different Atwood numbers



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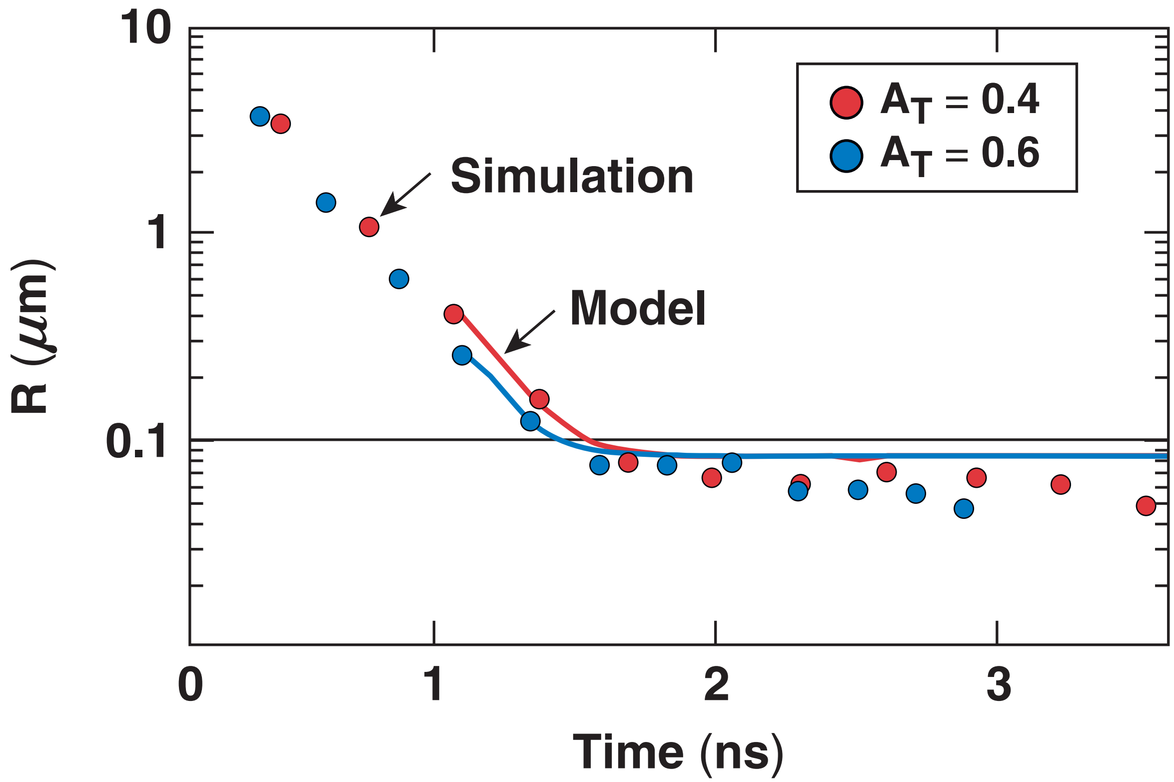
The saturated bubble curvature is independent of the Atwood number for time-dependent density



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Summary/Conclusions

The results of the Layzer-type model with time-dependent density have been validated with a 2-D simulation

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