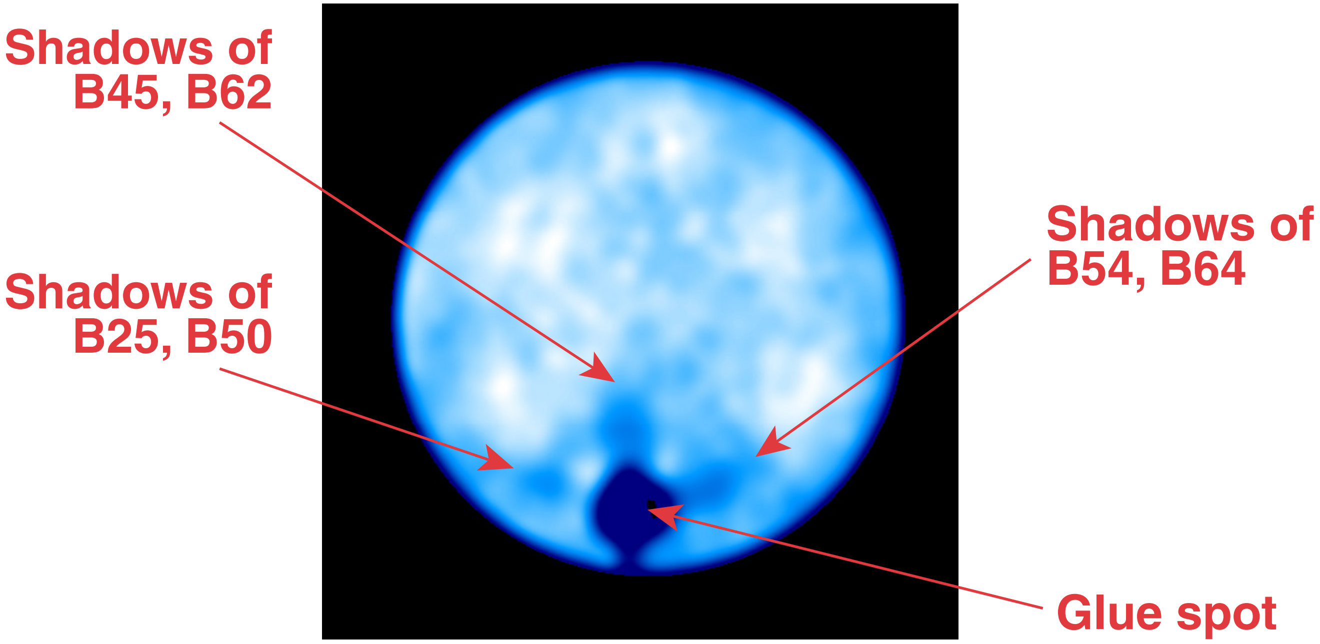
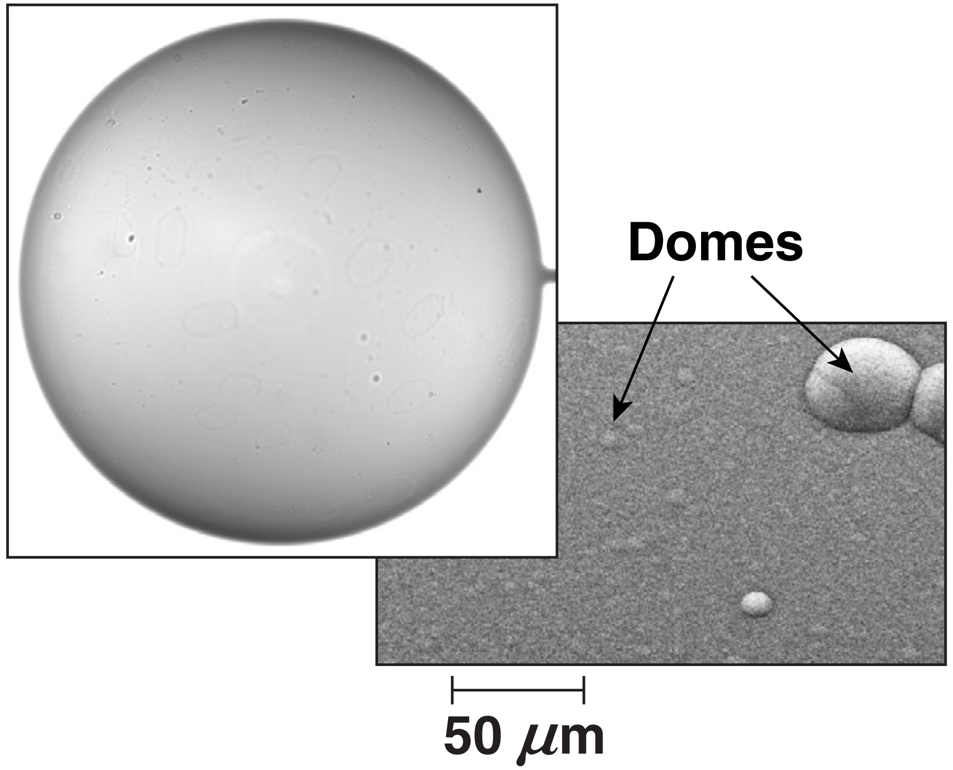
A Model for the Growth of Localized Shell Features in Inertial Confinement Fusion Implosions

X-ray emission from a gold sphere





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An analytic model describing the growth of localized engineering features has been developed

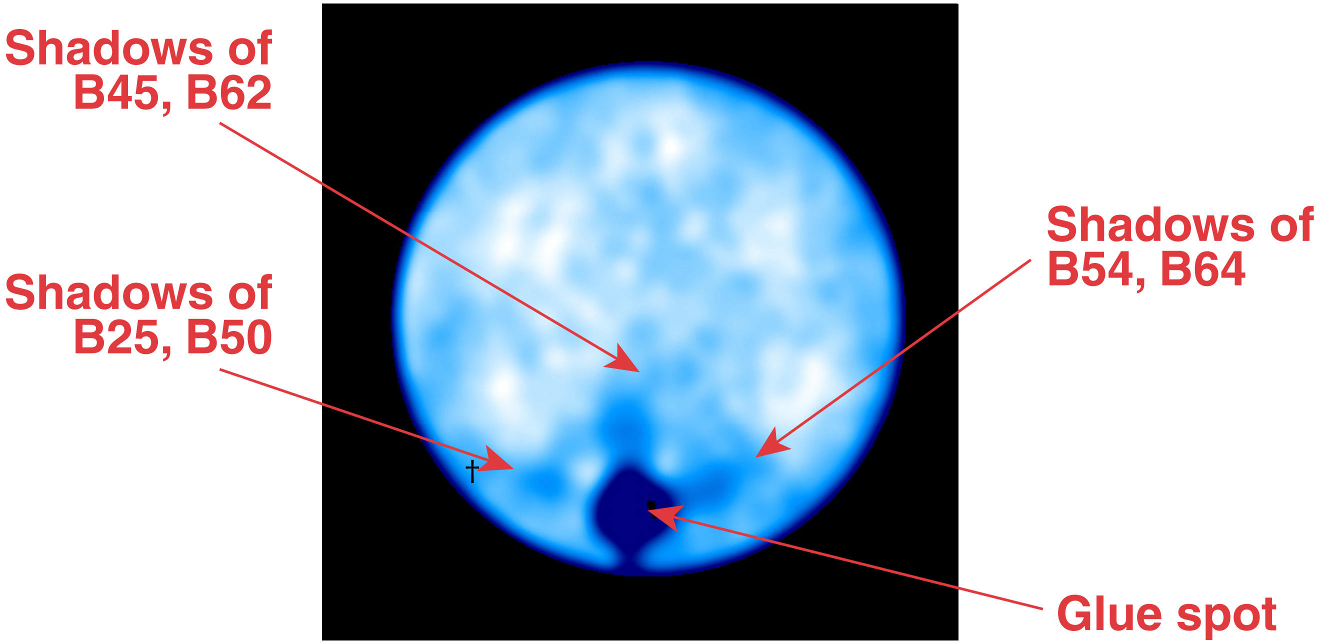
- The contact points of engineering features with the target's surface, as well as shadowing effects,* produce localized shell nonuniformities
- Rayleigh–Taylor (RT) growth of such nonuniformity leads to significant mass modulation in the shell and injection of the ablator and cold-fuel material into the target vapor region
- The model is based on a Layzer-type approach**

*A. G. MacPhee *et al.*, Phys. Rev. E 95, 031204(R) (2017).
**V. N. Goncharov and D. Li, Phys. Rev. E 71, 046306 (2005).

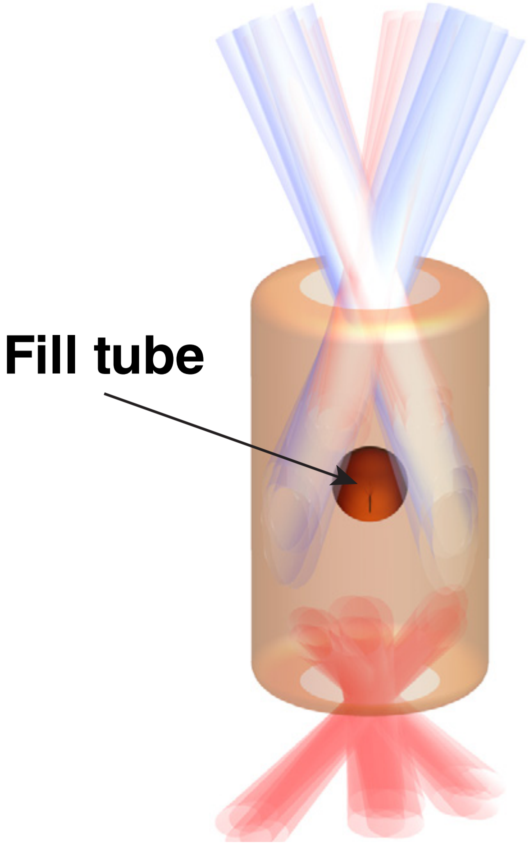
Engineering features produce localized mass modulations on the target

Direct drive

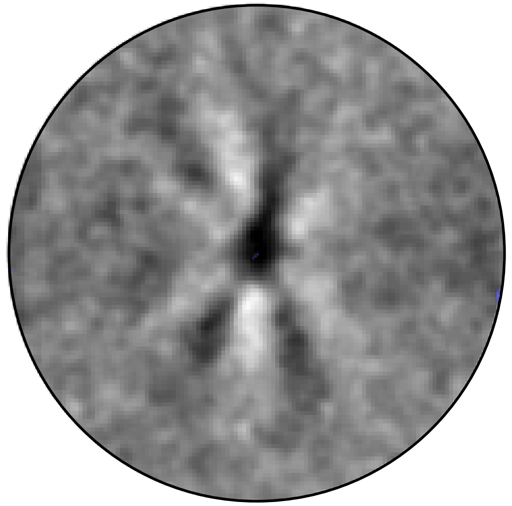
Image from TIM*-3 XRPC**
X-ray emission from a gold sphere



Indirect drive



Hydro-growth radiography†

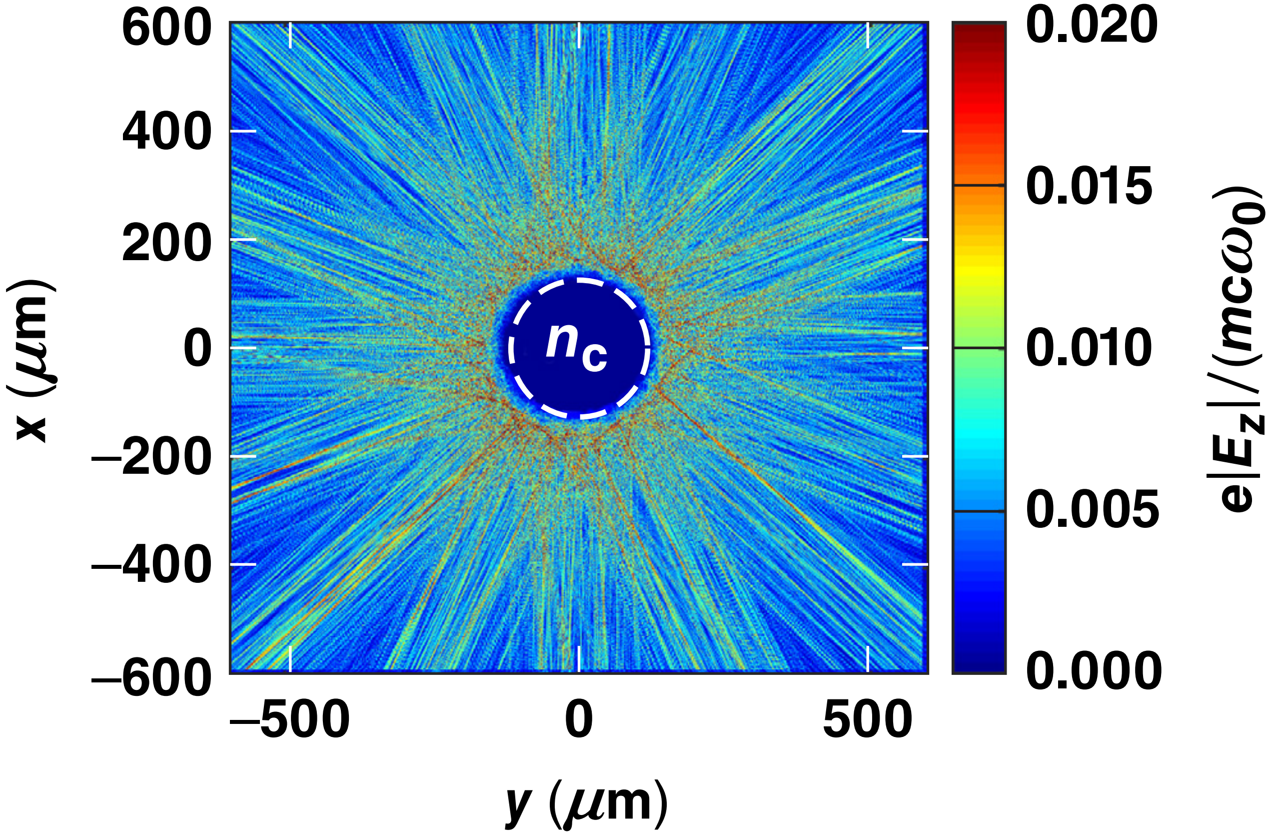


*TIM: ten-inch manipulator
**XRPC: x-ray pinhole camera
†A. MacPhee, presented at the 10th International Conference on Fusion Sciences and Applications, Saint Malo, France, 11–15 September 2017.

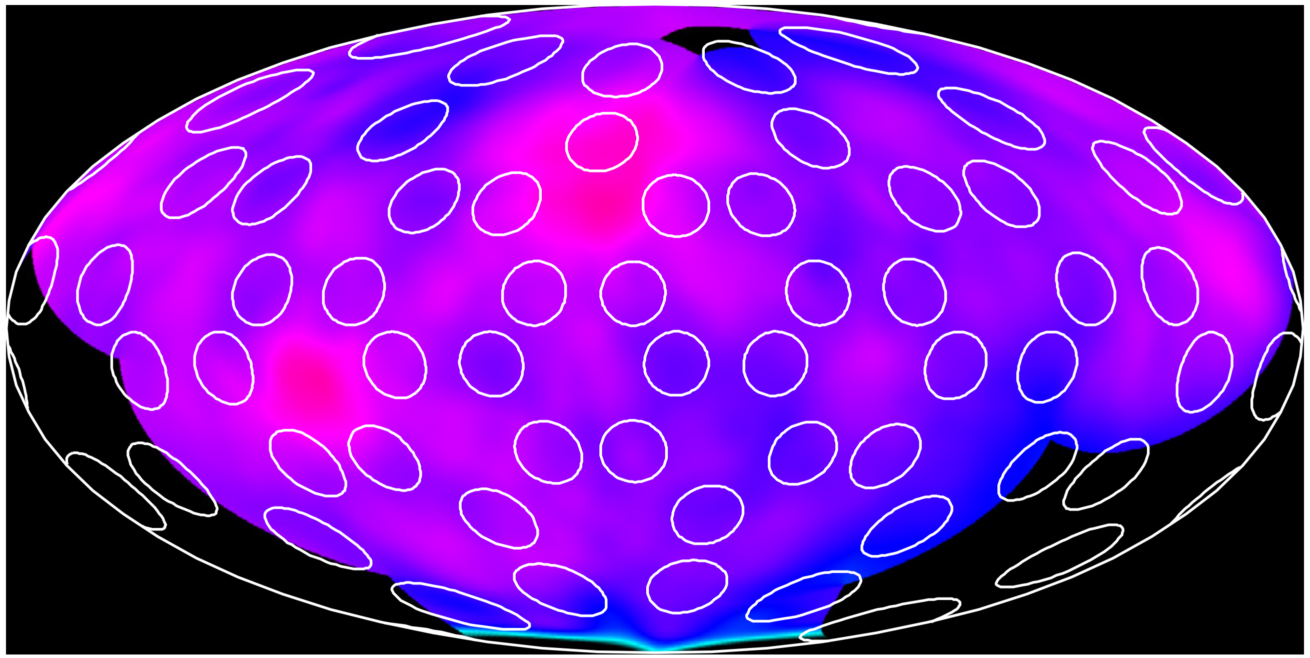
TC13798

Intensity modulations caused by beam overlap also produce localized features on target

Map of normalized laser electric field



X-ray emission from gold-coated sphere



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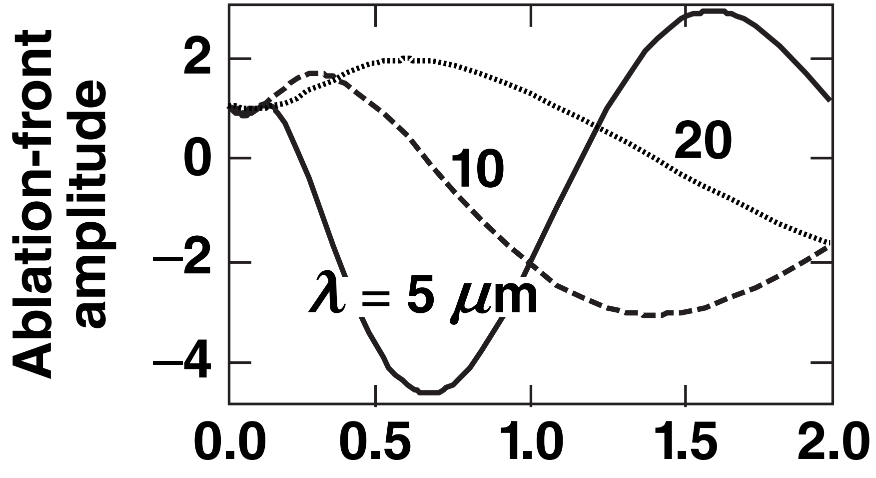
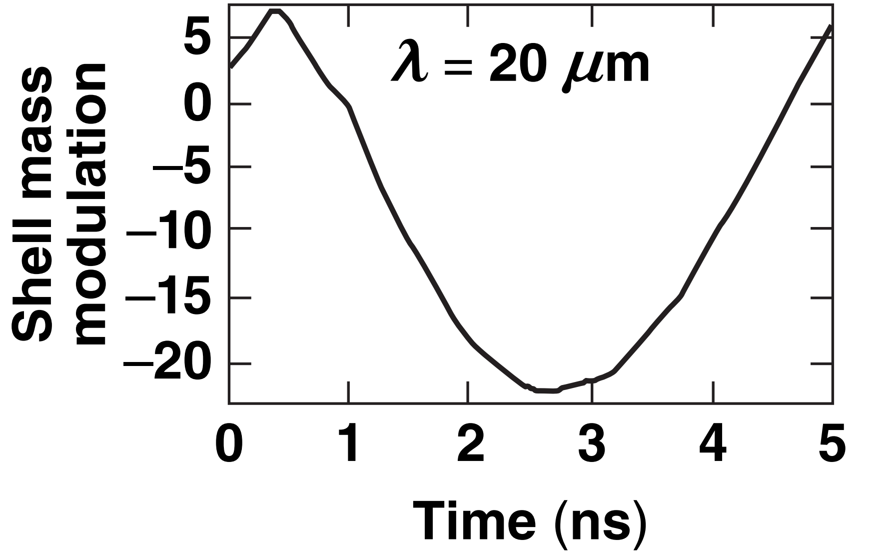
Accurate modeling and high-resolution growth measurements are required to better understand the effect of local features on target performance

RM* phase

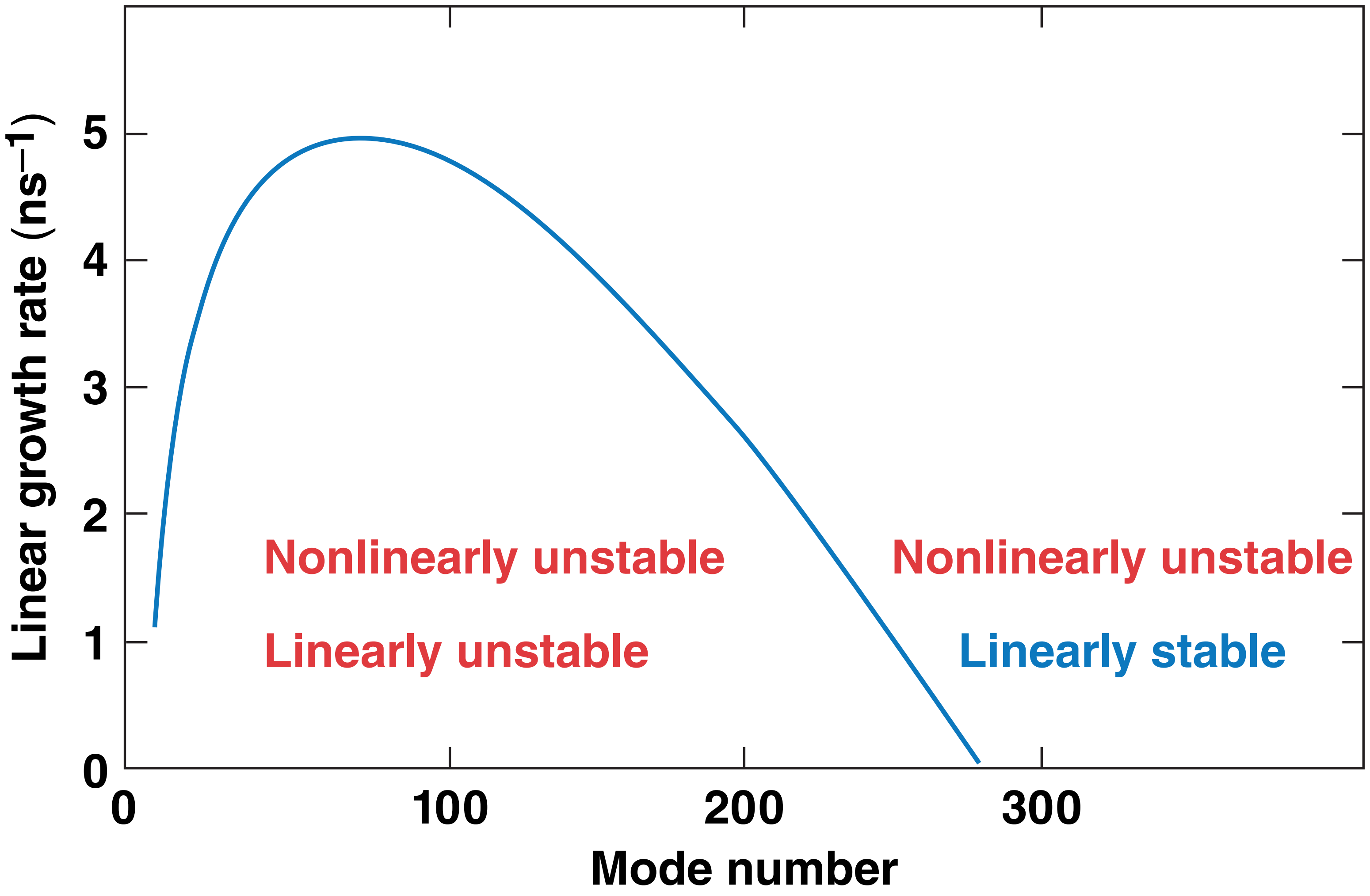
Growth depends on L_n, conduction zone





RT phase

Nonlinear bubble growth is faster than the classical limit



TC13800

*RM: Richtmyer–Meshkov

A Layzer-type model was developed and applied to study the growth of local features in spherical geometry

- Potential flow model* $v = \nabla\Phi, \quad \nabla^2\Phi = -\dot{\rho}/\rho$
- $\Phi = \sum\left[a(t)\left(\frac{r}{r_0}\right)^{\ell} + b(t)\left(\frac{r_0}{r}\right)^{\ell+1}\right]Y_{\ell m}(\theta,\phi) - \left[\frac{d\left(\rho r_0^3\right)}{dt} - \frac{\dot{\rho}r^3}{2}\right]\Big/(3\rho r)$
- Mass conservation at $r = r_i,\ i = 0, b$

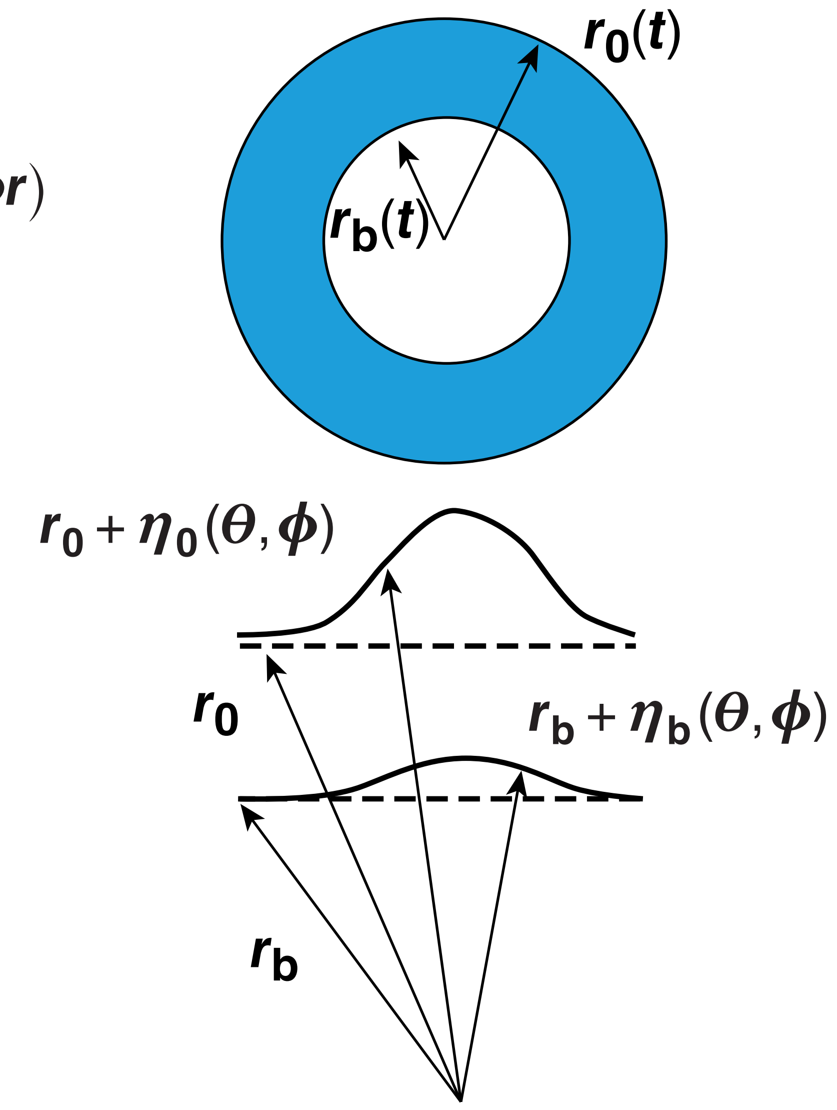
$$\partial_t\eta_i + \frac{v_\theta}{r_i+\eta_i}\partial_\theta\eta_i + \frac{v_\phi}{(r_i+\eta_i)\sin\theta}\partial_\phi\eta_i = v_r - \dot{r}_0$$

- Bernoulli's equation at $r = r_i,\ i = 0, b$

$$\partial_t\Phi + \frac{v^2}{2} = -p/\rho$$

- Local expansion of variables and equations near the tip of the bubble

$$Q = Q_0 + Q_1\theta + Q_2\theta^2 + \ldots$$



TC13867

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