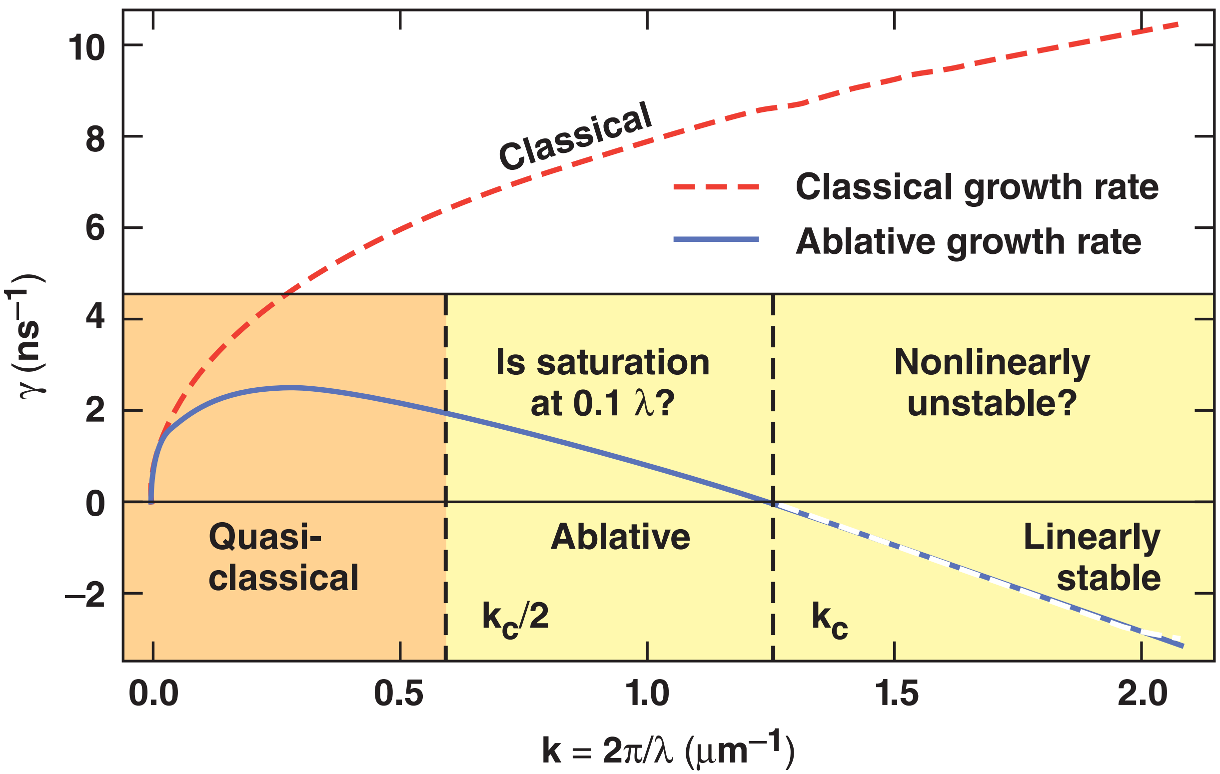
Nonlinear Ablative Rayleigh–Taylor Instability

Ablative RT growth rate $\gamma_{DT} = 0.94\sqrt{kg} - 2.7\,kV_A$



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Summary

While stabilizing in the linear phase, mass ablation is destabilizing in the nonlinear regime

UR LLE

- **The nonlinear evolution is studied using the theory of Sanz, Ramirez, Ramis, Betti, Town, Phys. Rev. Lett. 89, 195002 (2002) and detailed 2-D simulations.**

- **A finite amplitude instability develops for modes with $k > k_{cutoff}$.**

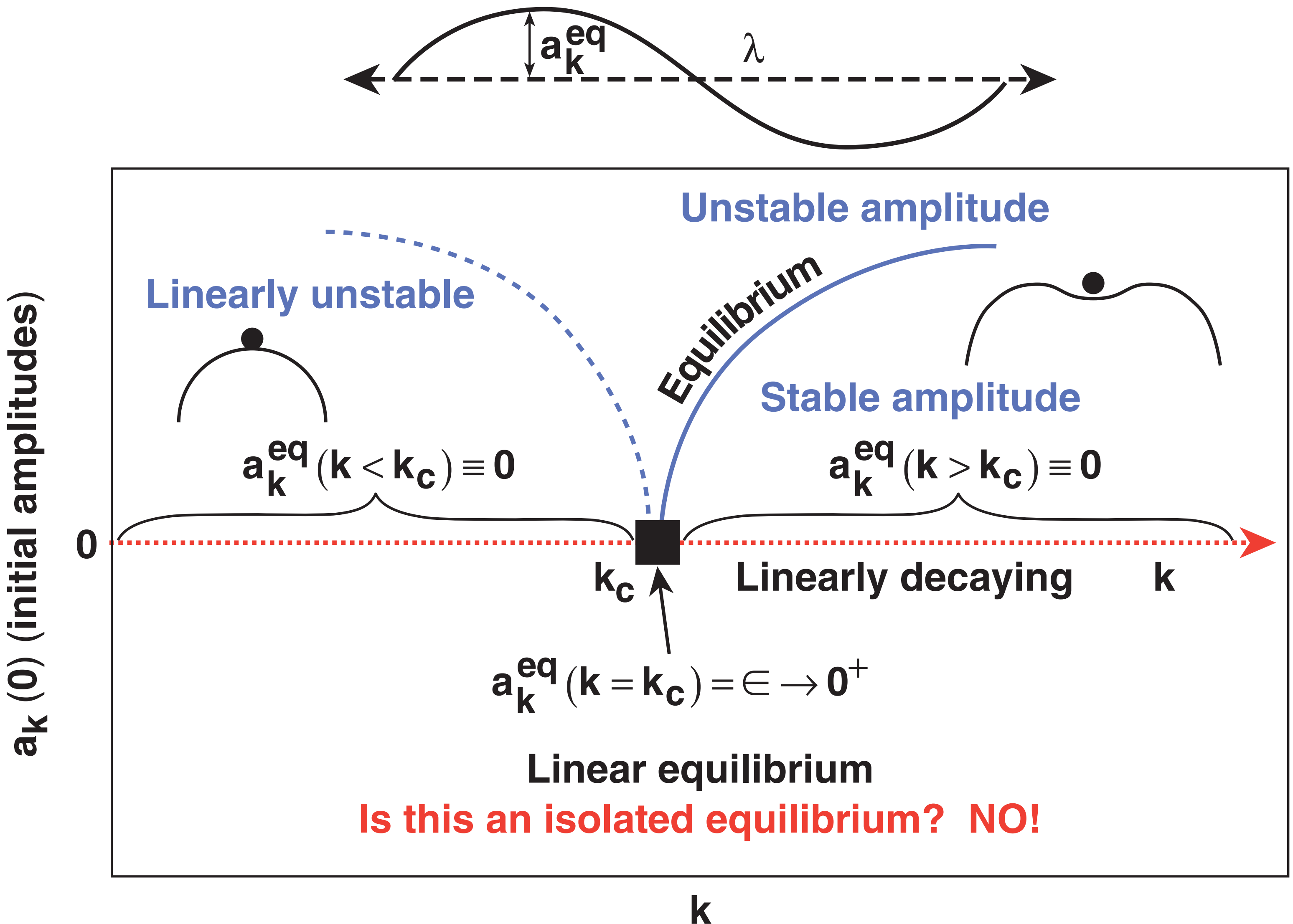
- **Unstable modes with $1/2\ k_{cutoff}\ k < k_{cutoff}$ exhibit a nonlinear growth faster than linear.**

- **The saturation amplitudes of modes with $1/2\ k_{cutoff}\ k < k_{cutoff}$ is larger than $0.1\ \lambda$.**

- **The generation of long-wavelength modes by coupling of short wavelengths is much greater than predicted by the classical theory.**

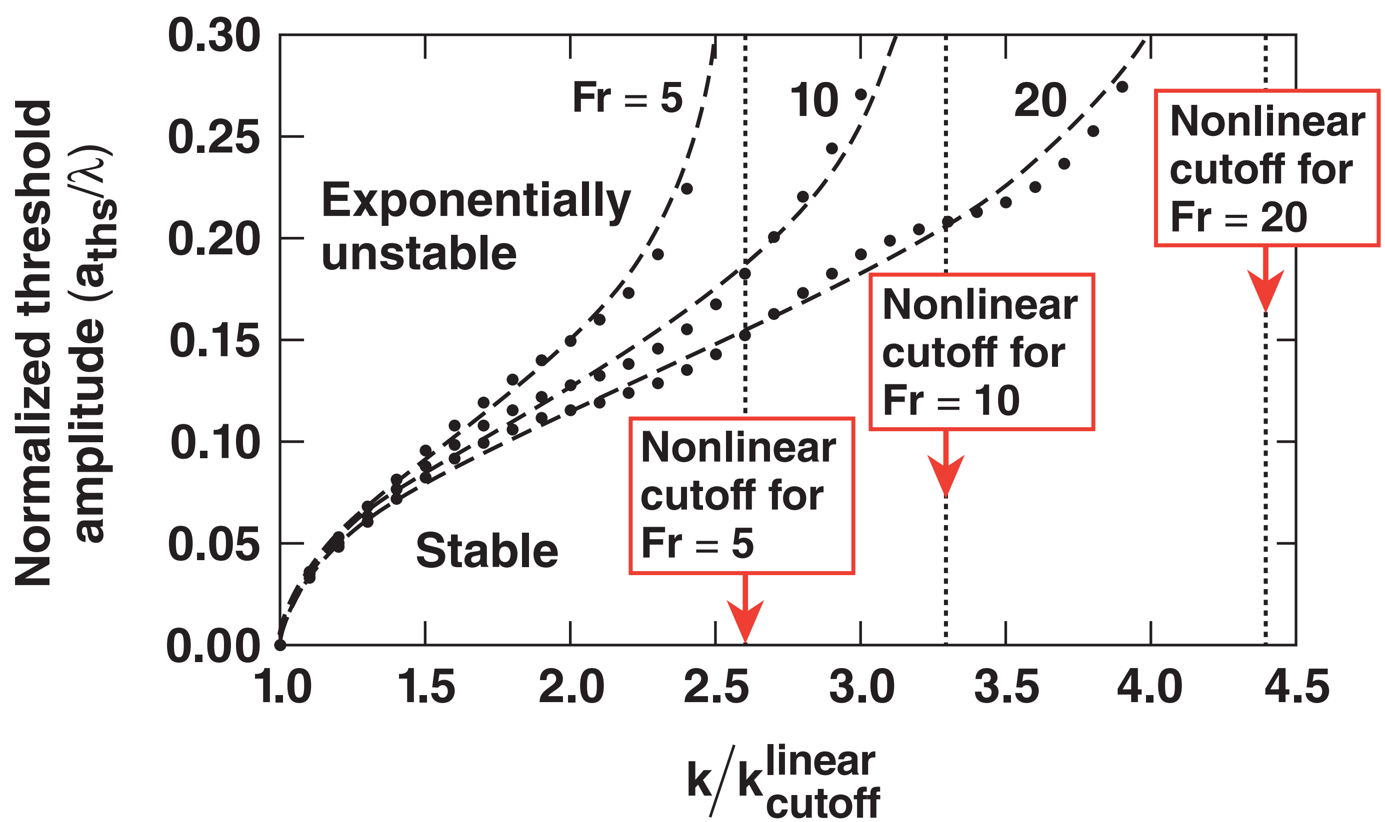
- **The asymptotic bubble velocity is larger than classical (upcoming talk by C. Zhou, JO1.003).**

Linearly stable modes with $k > k_c$ can be unstable for finite initial amplitudes



TC6741

The theory predicts full nonlinear stability only for wave numbers exceeding a nonlinear cutoff beyond the linear cutoff



$$Fr = \frac{V_a^2}{gL_0}$$

$$k_{cutoff}^{nonlinear} = \frac{g}{3V_a^2}\left(\frac{2A}{1+A}\right)$$

TC6742

For 1/2 $k_c < k < k_c$ the theory predicts a nonlinear exponential instability and a saturation amplitude larger than 0.1 λ

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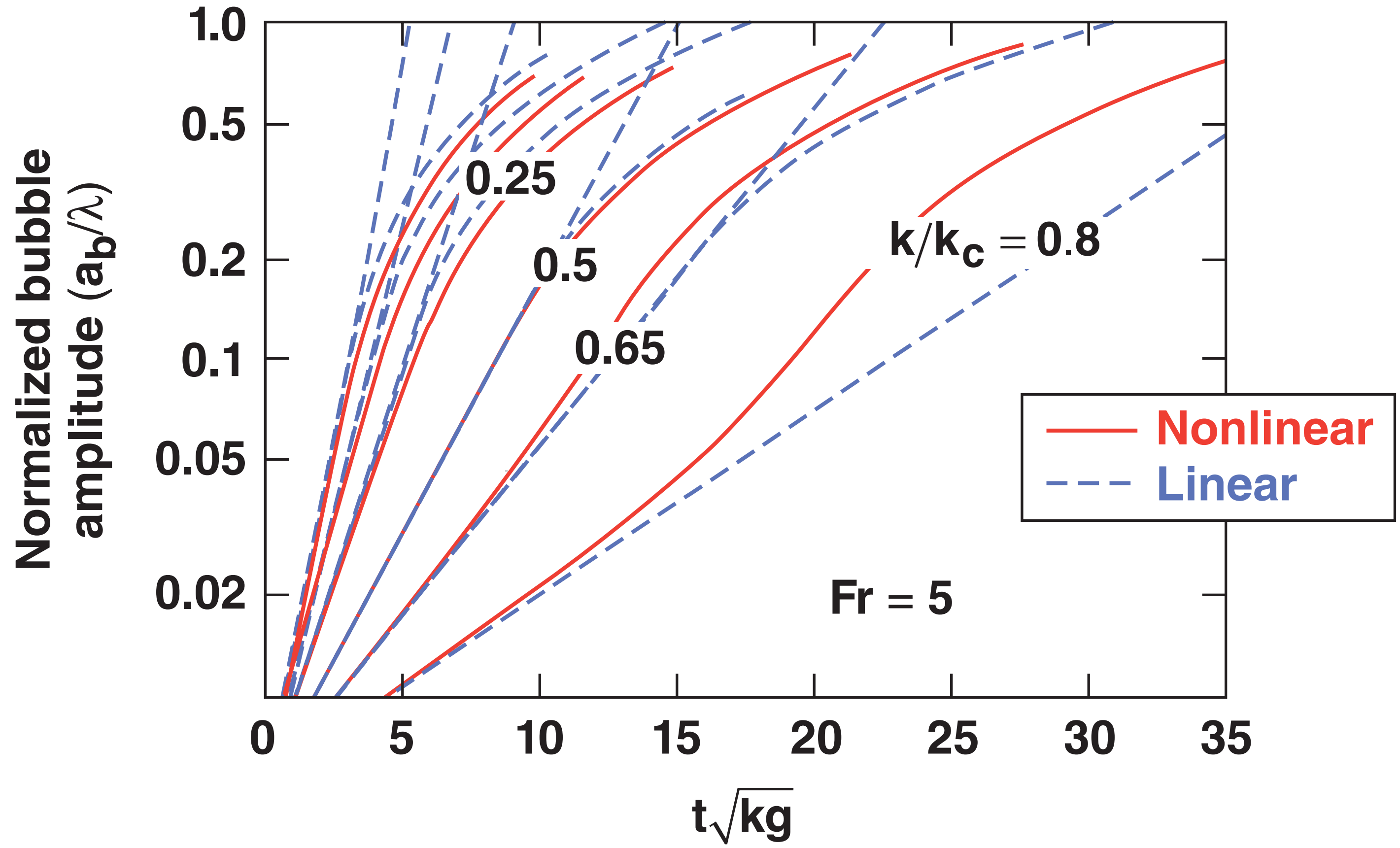
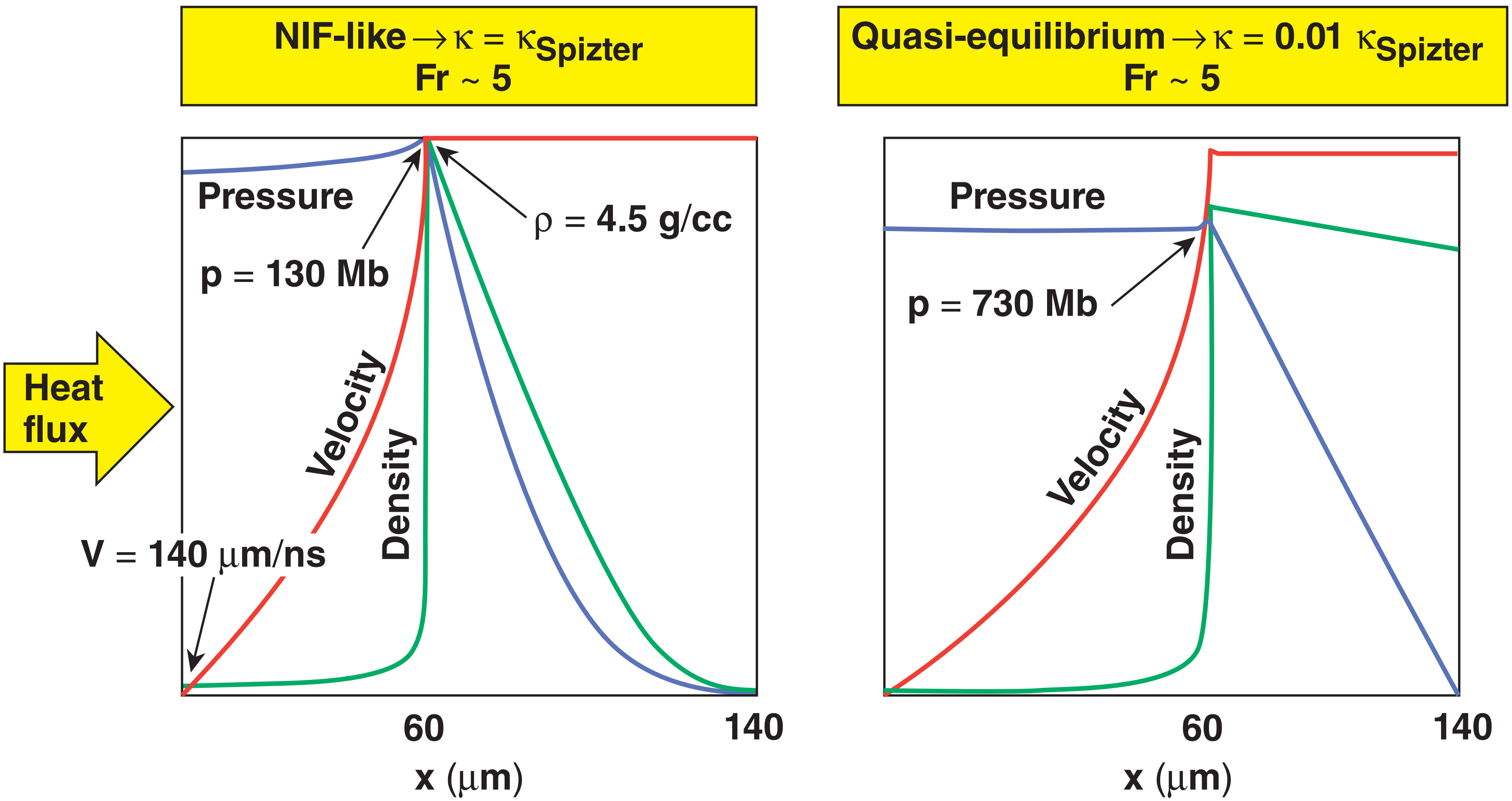


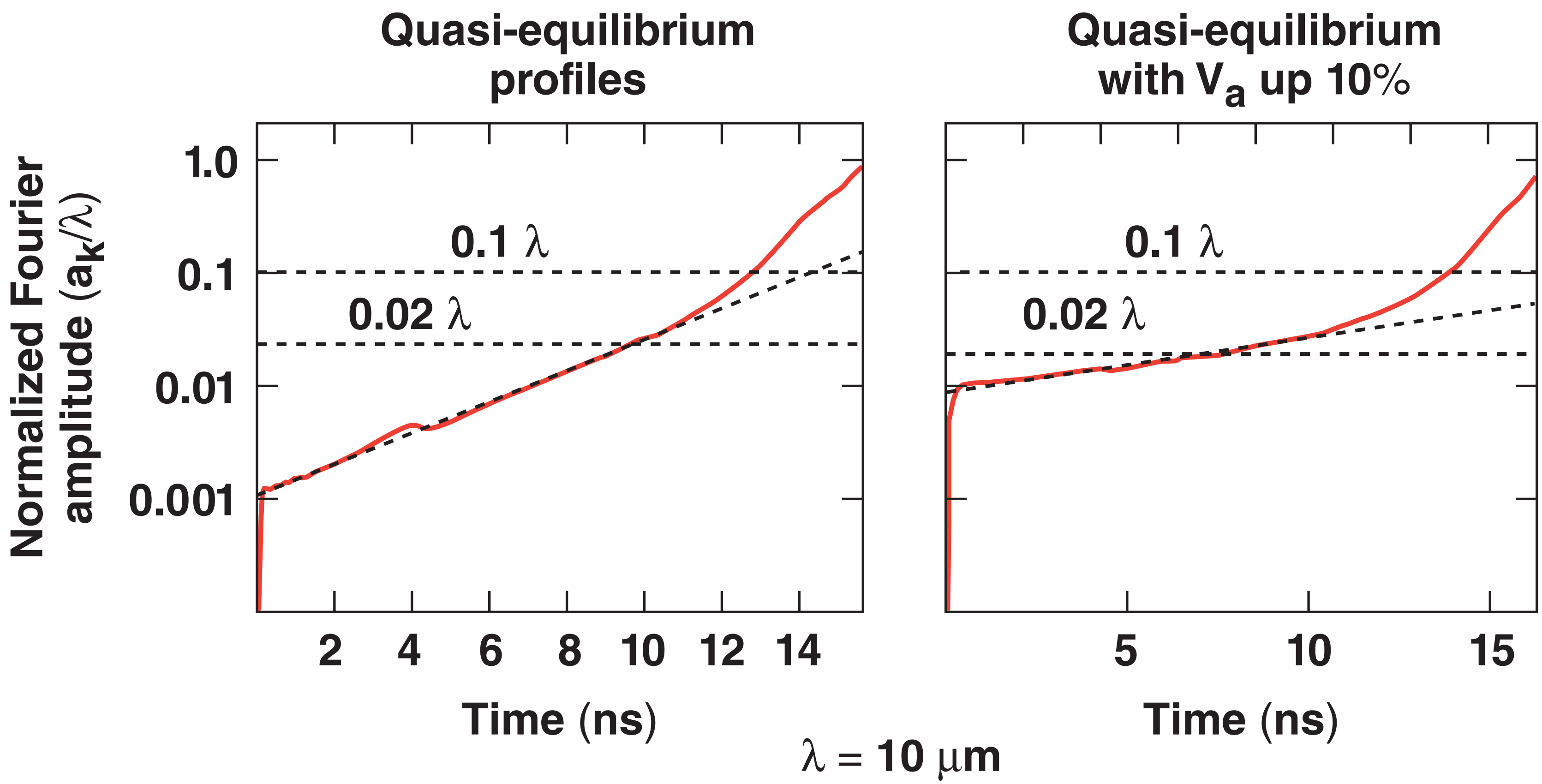
TC6744

The fixed boundary code ART is used to study the detailed evolution of the Rayleigh–Taylor instability



TC6747

The simulations show the development of the nonlinear exponential growth near the linear cutoff in agreement with the nonlinear theory



Nonlinear growth rate ~ 0.1 – 0.2 γ_{clas} ~ max $[\gamma_{abl}]$

TC6749

A linearly stable perturbation ($k > k_{cutoff}$) becomes unstable for a sufficiently large initial amplitude (as predicted by theory)

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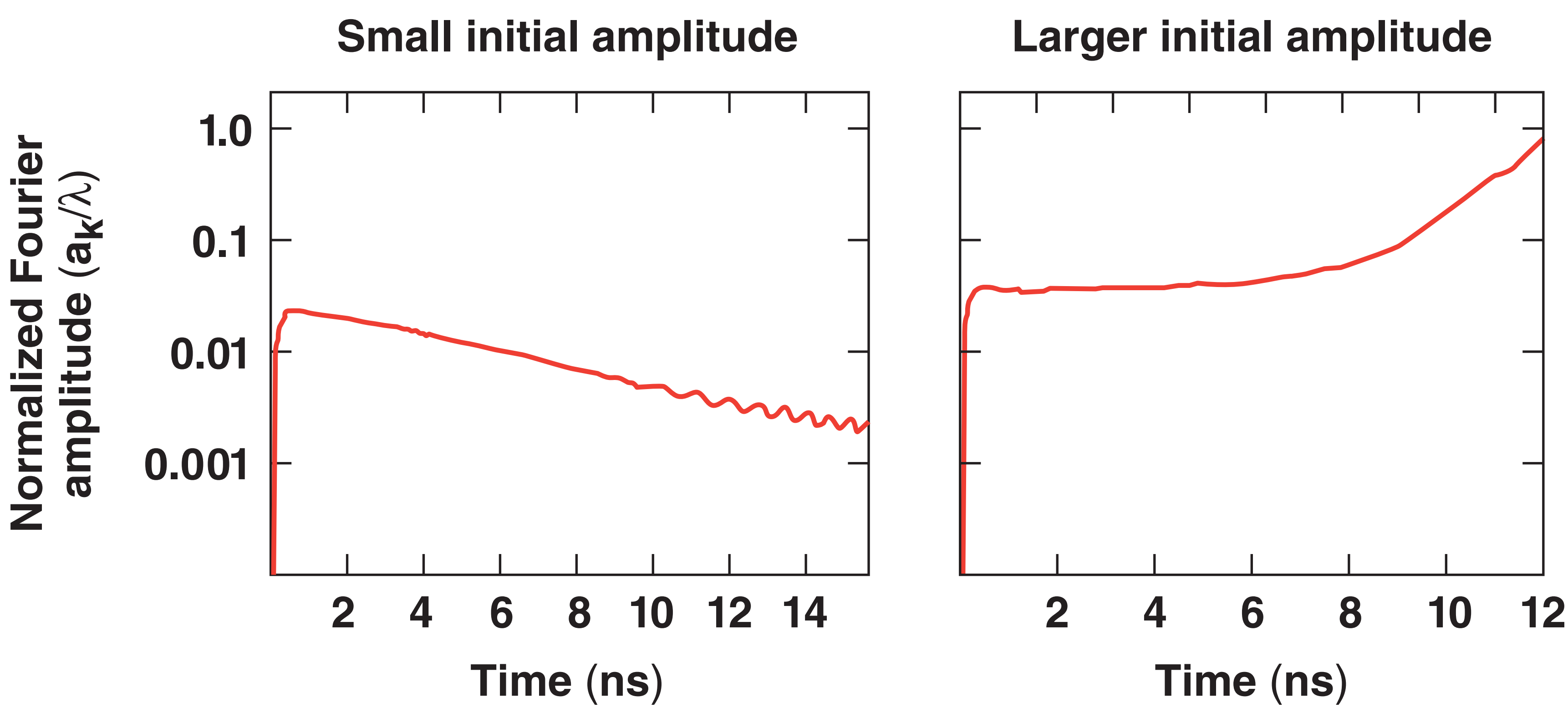
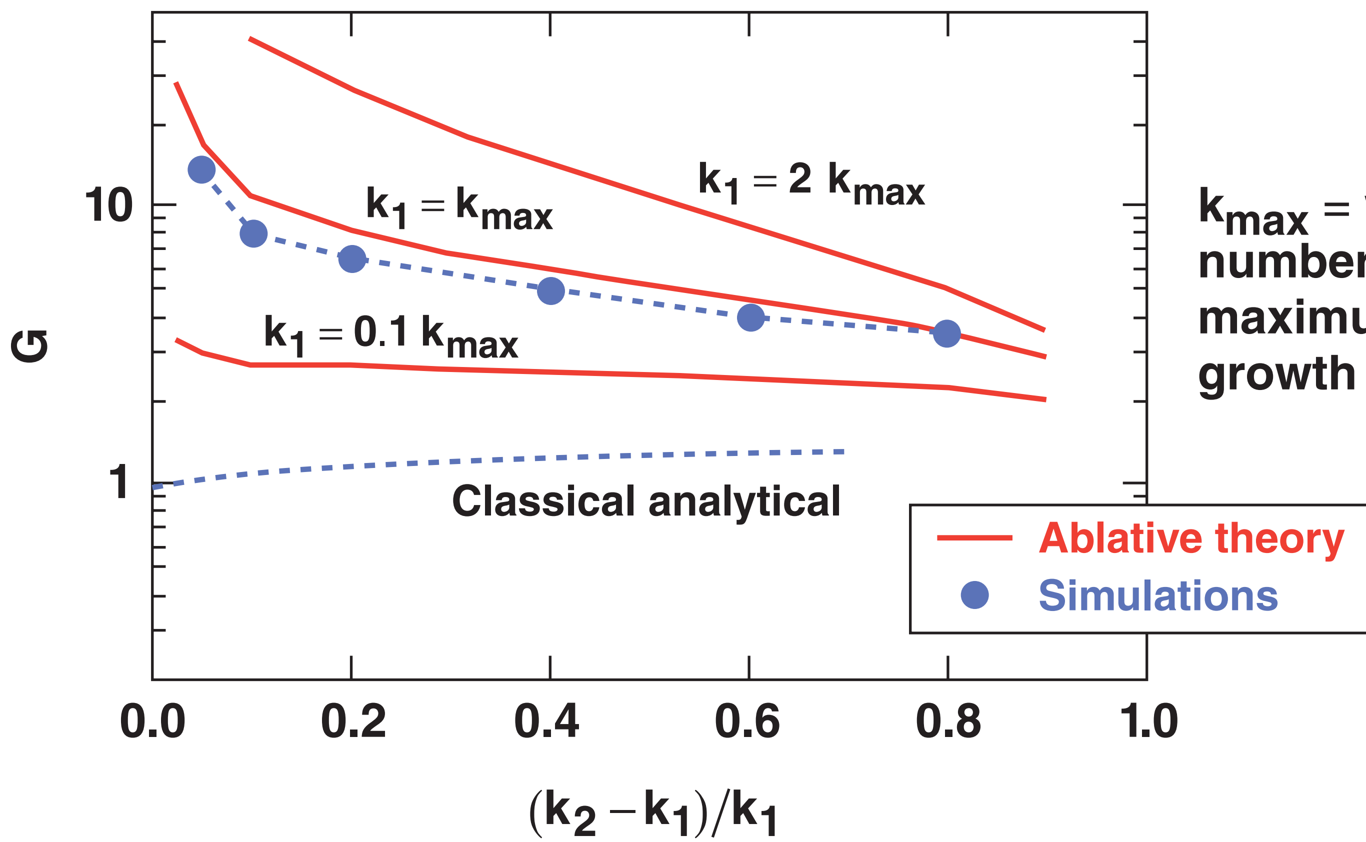
$k > k_{cutoff}$: Linearly stable 10-μm perturbation



TC6750

The quasi-linear generation of long wavelengths is much greater than predicted by the classical theory



k_{max} = wave number of maximum growth rate

$$G = 4\frac{\eta_{k_2 - k_1}}{(k_2 - k_1)\eta_{k_2}\eta_{k_1}} =$$

Long wavelength generation efficiency: G = 1 in classical RT.

TC6754

Summary/Conclusions

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- Unstable modes with 1/2 k_{cutoff} $k < k_{cutoff}$ exhibit a nonlinear growth faster than linear.
- The saturation amplitudes of modes with 1/2 k_{cutoff} $k < k_{cutoff}$ is larger than 0.1 λ.
- The generation of long-wavelength modes by coupling of short wavelengths is much greater than predicted by the classical theory.
- The asymptotic bubble velocity is larger than classical (upcoming talk by C. Zhou, JO1.003).