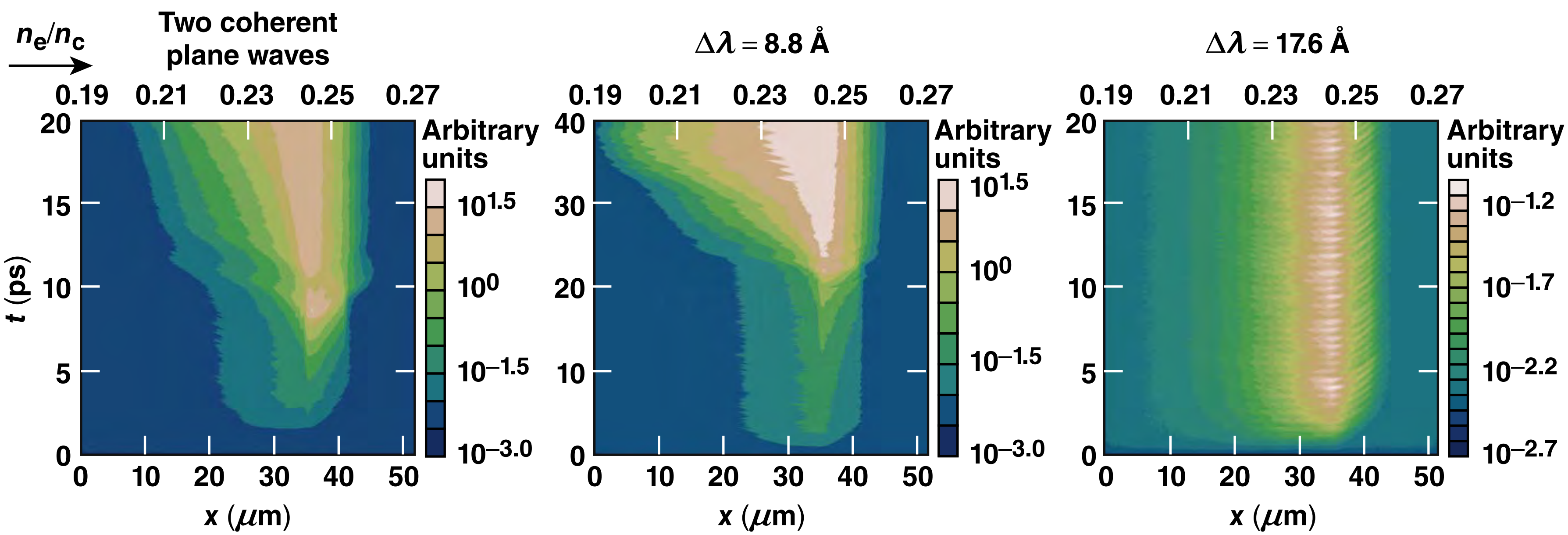
Two-Plasmon Decay Driven by Multiple Incoherent Laser Beams

$$\int |E(x,y,t)|^2 dy \Big/ \int dy \text{ (arbitrary units)}$$



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Summary

Two-plasmon decay (TPD) driven by multiple incoherent beams in inhomogeneous plasma is investigated

- Multiple coherent laser beams can share plasma waves in both large[†]-and small*-*k* regions
- TPD driven by laser beams with finite temporal bandwidth and spatial incoherence give a higher absolute threshold
- A more-realistic model including both distributed phase plates (DPP's) and smoothing by spectral dispersion (SSD) is in development

[†]C. Stoeckl *et al*., Phys. Rev. Lett. 90, 235002 (2003); D. T. Michel *et al*., Phys. Rev. Lett. 109, 155007 (2012).
*J. F. Myatt *et al*., Bull. Am. Phys. Soc. 57, 299 (2012); J. Zhang *et al*., ibid. R. W. Short *et al*., Bull. Am. Phys. Soc. 57, 300 (2012).

Collaborators

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The Zakharov model is a time-enveloped fluid moment model that describes the coupling between Langmuir and ion-acoustic fluctuations

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Extended Zakharov model equations[†]

Collisional plus Landau damping; Density gradient

$$\nabla\cdot\left[2i\omega_{p0}\left(\partial_t+\underbrace{\nu_e}\circ\right)+3v_e^2\nabla^2-\omega_{p0}^2\left(\delta n+\overbrace{\delta N}\right)/n_0\right]E$$

$$=\underbrace{(e/4m_e)\nabla\cdot\left[\nabla\sum_{m=1}^{N}\left(E_{0,m}\cdot E^*\right)-\sum_{m=1}^{N}E_{0,m}\nabla\cdot E^*\right]e^{-i(\omega_0-2\omega_{pe})t}}_{\text{Laser source}}+\underbrace{S_E}_{\text{Noise source}}$$

$$\left[\partial_t^2+2\underbrace{\nu_i}\circ\partial_t-c_s^2\nabla^2\right]\delta n=\underbrace{\frac{1}{16\pi m_i}\left(\nabla^2|E|^2+\frac{1}{4}\nabla^2\sum_{m=1}^{N}|E_{0,m}|^2\right)}_{\text{Ponderomotive force}},$$

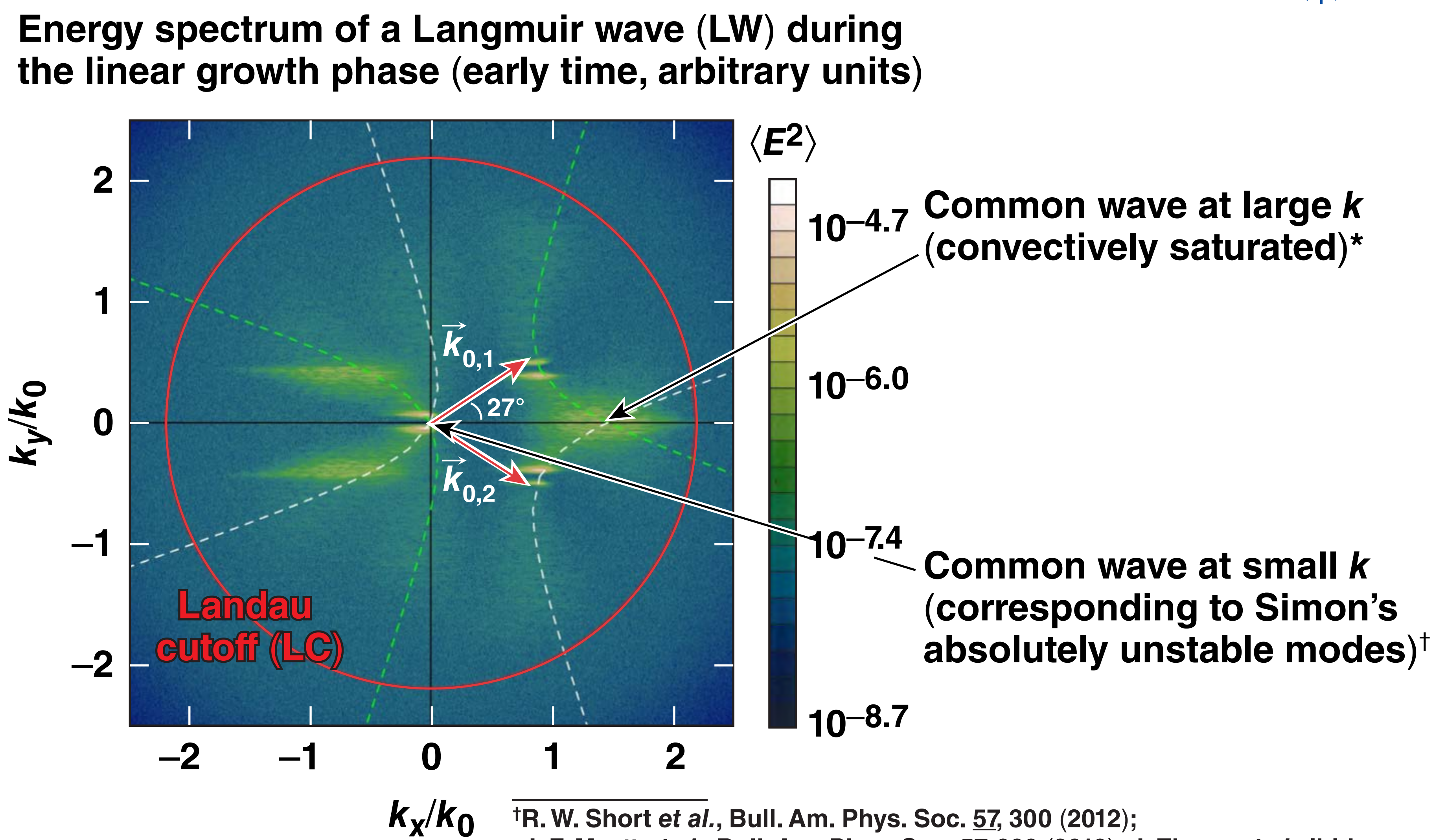
Landau damping for ion-acoustic waves

where the laser field $E_L=\sum_{m}^{N}E_{0,m}(\vec{x},t)\exp(-i\omega_0 t)+\text{c.c.}$

[†]D. F. DuBois, D. A. Russell, and H. A. Rose, Phys. Rev. Lett. 74, 3983 (1995); D. A. Russel and D. F. DuBois, Phys. Rev. Lett. 86, 428 (2001).

TC10648b

Multiple laser beams can share plasma waves in both large- and small-*k* regions



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J. F. Myatt *et al.*, Bull. Am. Phys. Soc. 57, 299 (2012); J. Zhang *et al.*, ibid.
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TC10651b

The investigation of TPD in incoherent laser beams is broken into three parts

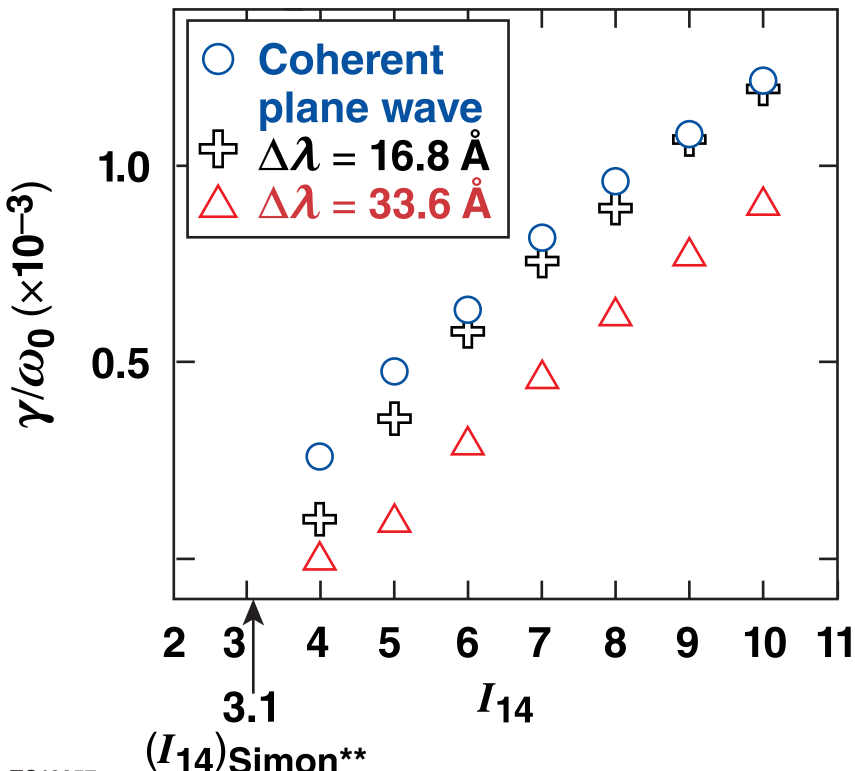
- Temporal bandwidth is introduced in a way that is similar to SSD*
  - a large bandwidth ($\Delta\lambda \approx 10$ Å) is required to modify absolute growth
- Spatial incoherence is introduced using a DPP model**
  - the first investigations have looked at a single DPP speckle
- A model that includes both temporal and spatial bandwidth is under development

*S.Skupsky *et al.,* J. Appl. Phys. 66, 3456 (1989).
**H. A. Rose *et al.,* Phys. Fluids B 5, 590 (1993).

The effect of temporal bandwidth on the absolute threshold for a single beam is investigated

- $E(t) = E_0 \exp(i\delta * \sin\omega_m t)$; similar to SSD*
  - here δ and ω_m are the modulation amplitude and frequency
    $\Delta\omega = 2\delta\omega_m$; $\Delta\lambda/\lambda_0 = \Delta\omega/\omega_0$

Absolute growth rate for different temporal bandwidth



$T_{keV} = 2$; $L_{\mu m} = 150$; normal incidence

Temporal bandwidth used here is one order larger than the growth rate

$\Delta\lambda$ = 33.6 Å increases the threshold intensity by ~30 %.

*S.Skupsky *et al.*, J. Appl. Phys. 66, 3456 (1989).
**Simon *et al.*, Phys. Fluids 26, 3107 (1983).

TC10857

Temporal bandwidth must be large to have an effect on the TPD saturation level

- Nonlinear calculations
  - Two laser beams polarized in the same plane (*p*-polarized) $I_{14} = 4$, $L_n = 150\ \mu m$, $T_e = 2$ keV, $\theta = 27°$ (Laser intensity is 1.2× above absolute threshold)

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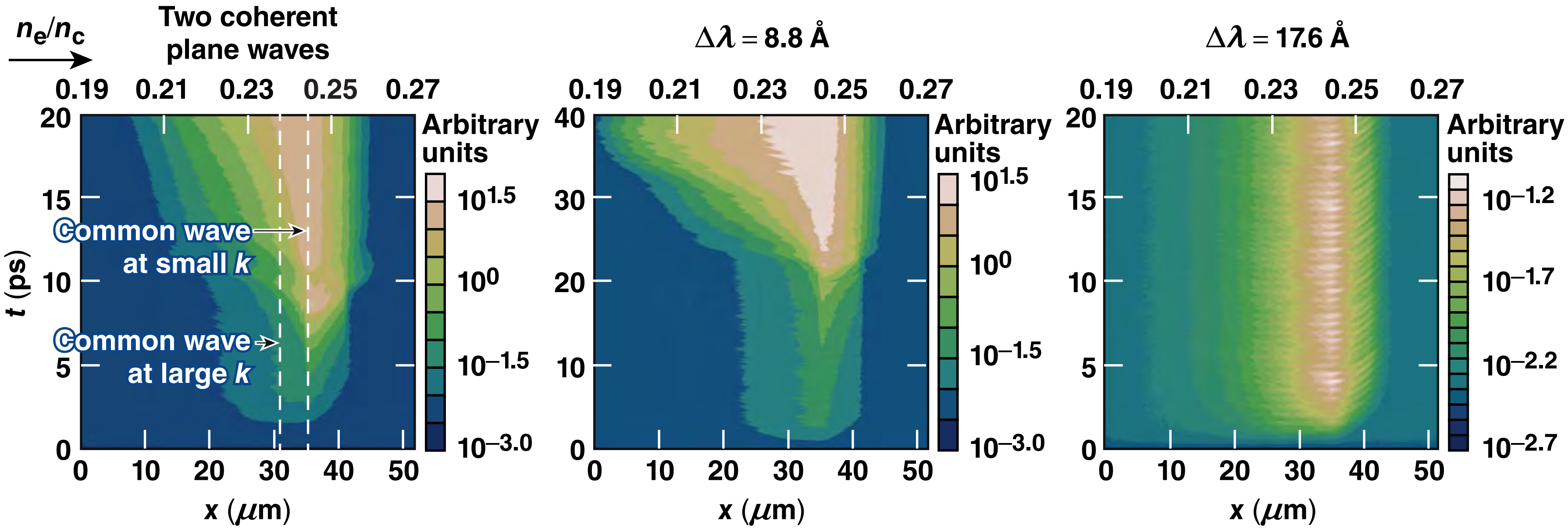

If the temporal bandwidth is large enough to suppress absolute modes, the saturation level is greatly reduced.

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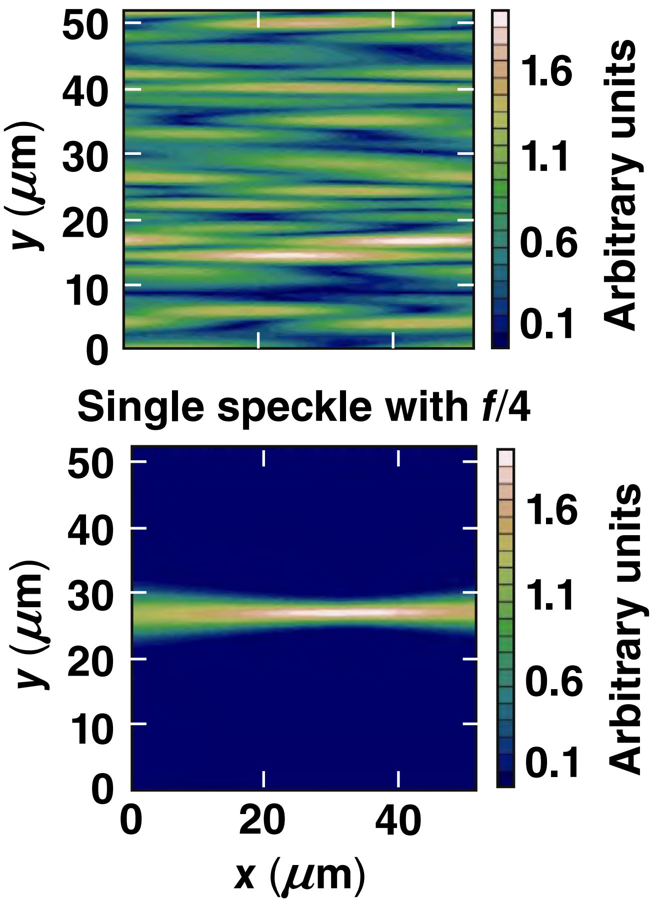
A DPP model* is in development to include spatial incoherence

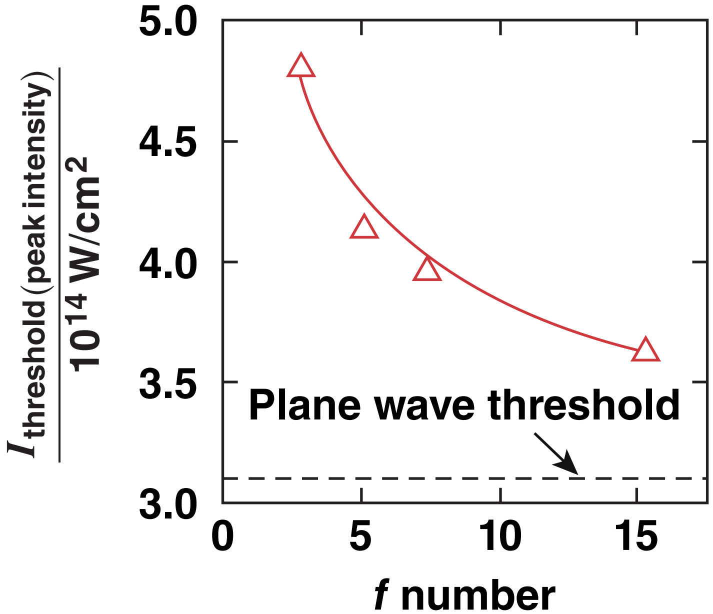
- Comparisons are underway between DPP and single speckle

An example of 2-D DPP laser beam with *f*/4



Single Gaussian laser beam with different *f* number:

$f = \omega_a / \lambda_0; \;\; T_{keV} = 2; \;\; L_{\mu m} = 150$



So far it appears that the threshold is increased as the speckle *f* number (width) decreases.

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Summary/Conclusions

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