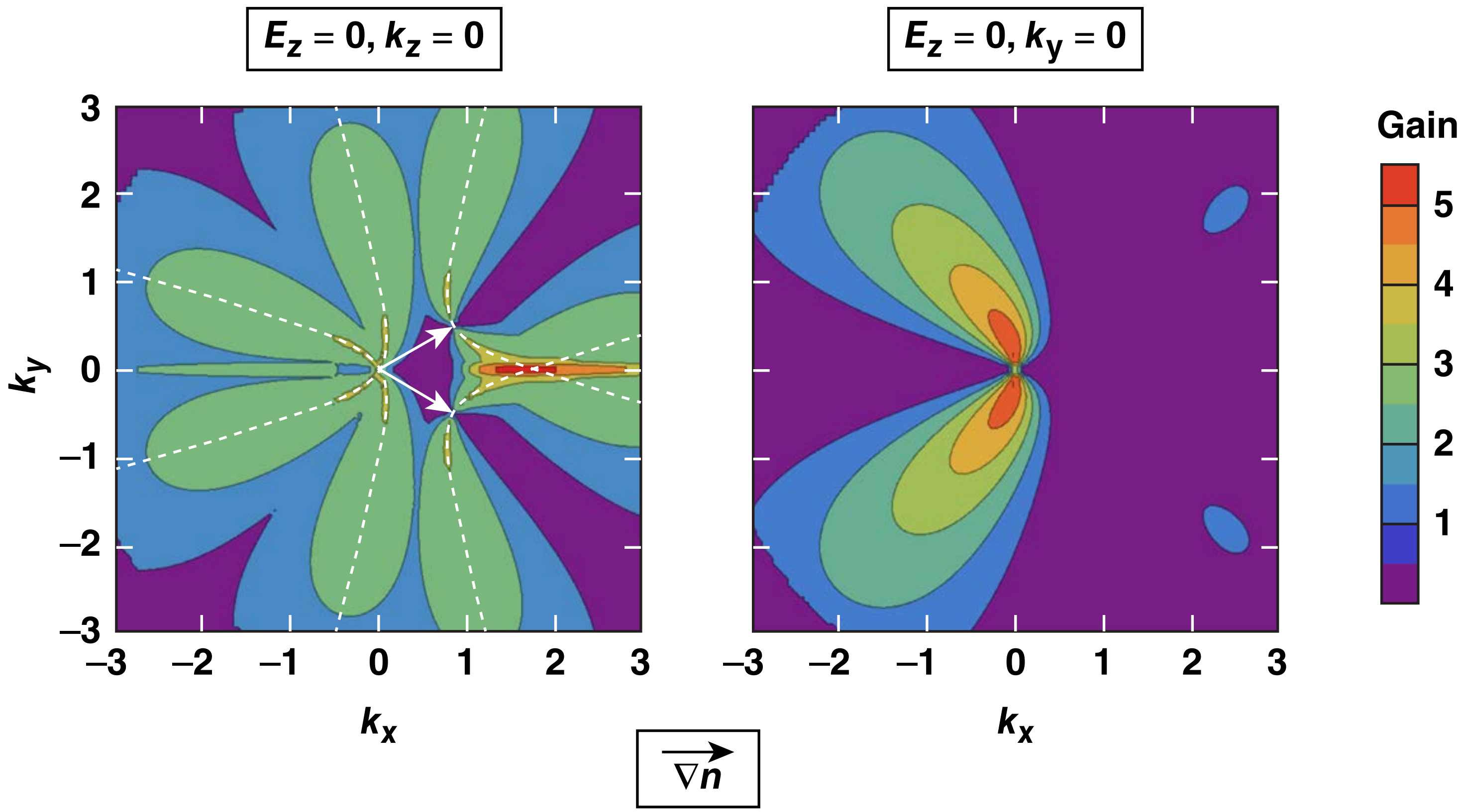
Absolute and Convective Two-Plasmon Decay Driven by Multiple Laser Beams



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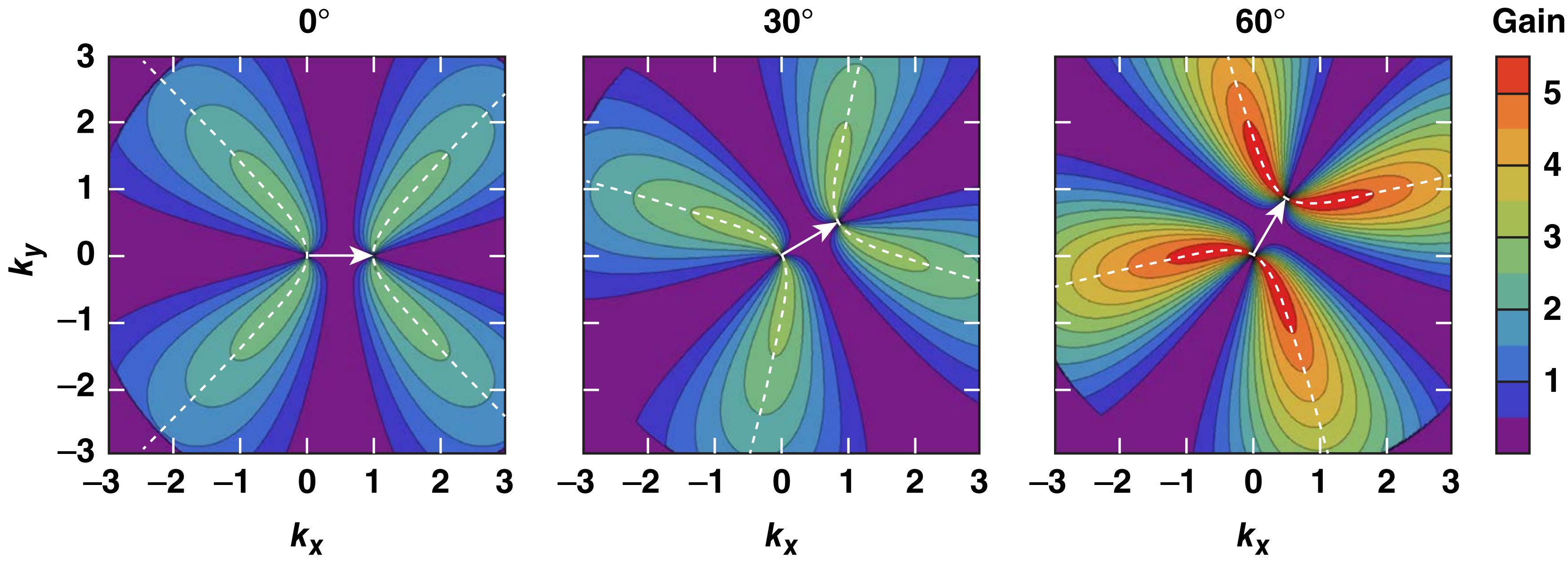
Summary

Multibeam two-plasmon decay (TPD) depends on the number, orientation, and polarization of the beams; in general it requires 3-D analysis

- With increasing angles of incidence, TPD convective gains increase and absolute thresholds decrease
- The location and magnitude of the spatial TPD gain and the onset of absolute instability is sensitive to the relative orientations and polarizations of the beams in 3-D
- The analysis presented here is linear; however, there is evidence that the absolute TPD it describes persists well into the nonlinear regime

The single-beam convective spatial gain increases with angle of incidence

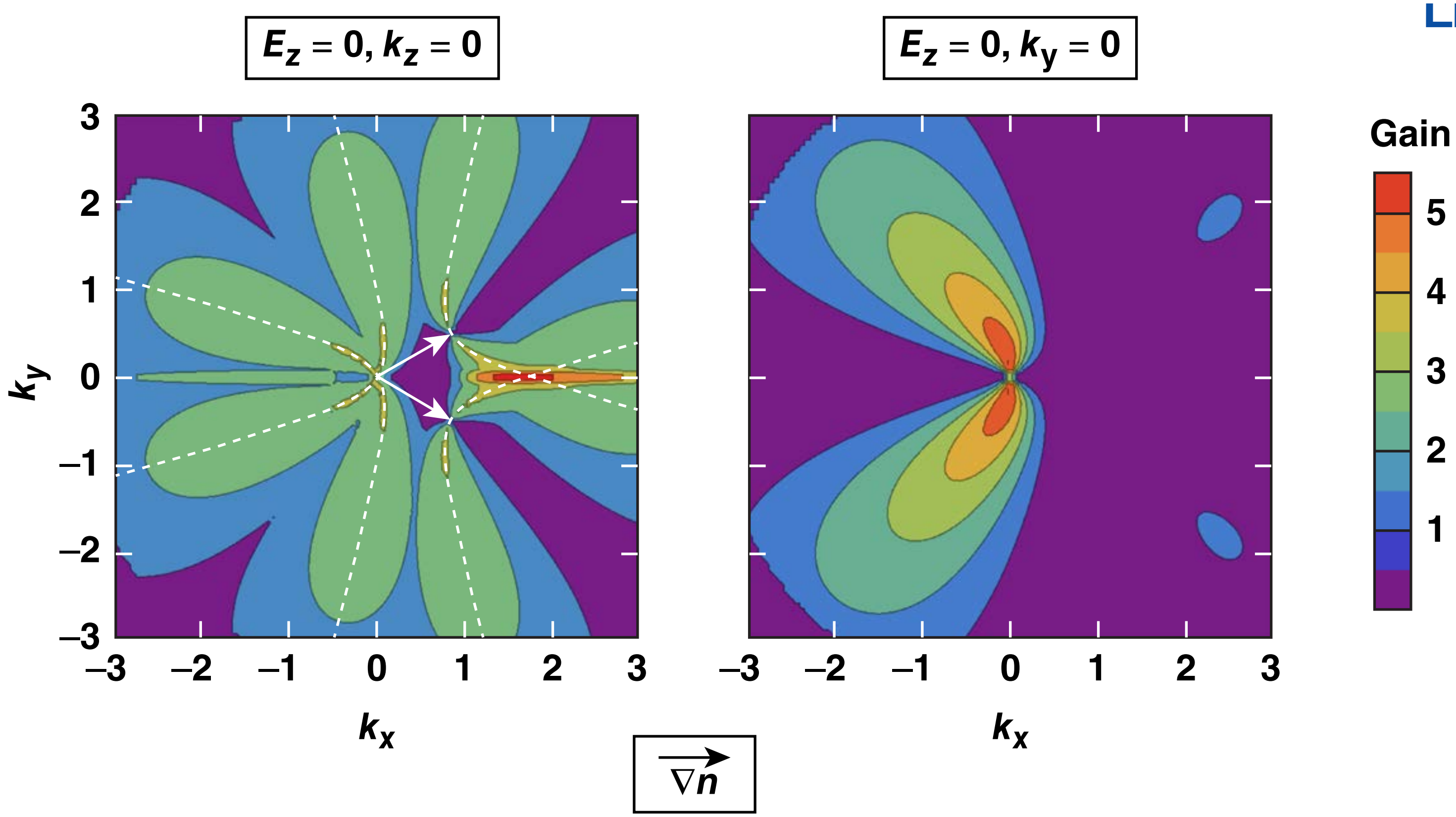
$I_{14} = 1.0$, $T_{keV} = 2.0$, $L = 300\ \mu m$, $\nabla n_0 \parallel \hat{x}$



- The *p*-polarized case is shown here; this is also true for the *s*-polarized case
- Consequence of longer effective scale length for oblique incidence
- For the same reason, the absolute threshold decreases at larger angles of incidence

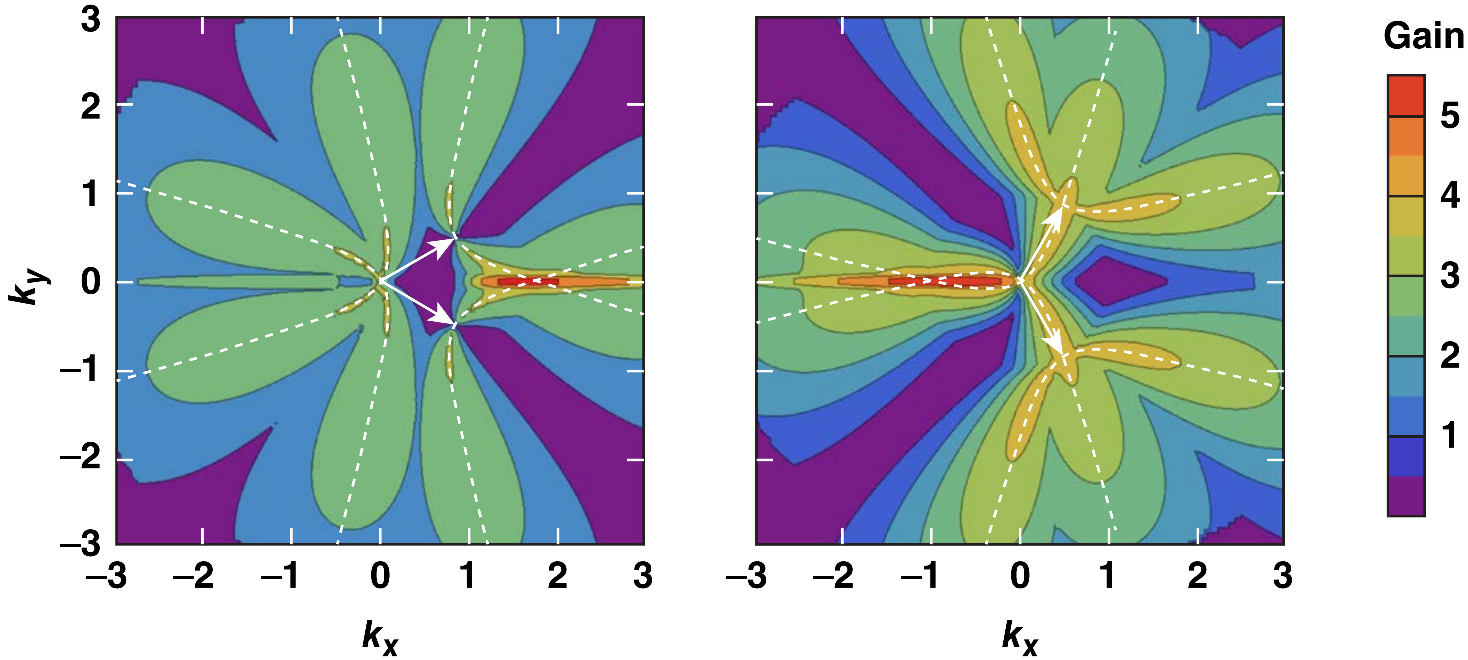
TC11291

The nature of multibeam TPD is sensitive to the relative orientations and polarizations of the beams in 3-D



- On the left, the two pump-wave vectors and polarization vectors lie in the *x*–*y* plane; this can be treated as a 2-D problem
- On the right, the two pump-wave vectors lie in the *x*–*z* plane but the maximum gain is in the *x*–*y* plane; this requires 3-D analysis/simulation

Larger angles between beams give rise to a new regime of small-*k* (potentially absolute) TPD



- **At large angles the two "backward" branches of the hyperbolas nearly intersect, leading to enhanced gain**
- **This becomes the dominant form of the absolute instability**

For a single beam, the absolute TPD threshold* is lower than the Rosenbluth convective threshold

- The Simon threshold (adjusted for *s*-polarized oblique incidence) is

$$\eta \equiv \frac{I_{14} L_{\mu}}{233\, T_{\text{keV}} \cos\theta} > 1$$

- The Rosenbluth convective gain is $G_R = \frac{2\pi\gamma_0^2}{\kappa' V_1 V_2} = \frac{I_{14} L_{\mu}}{53.6\, T_{\text{keV}} \cos\theta} \cong 4.35\,\eta$

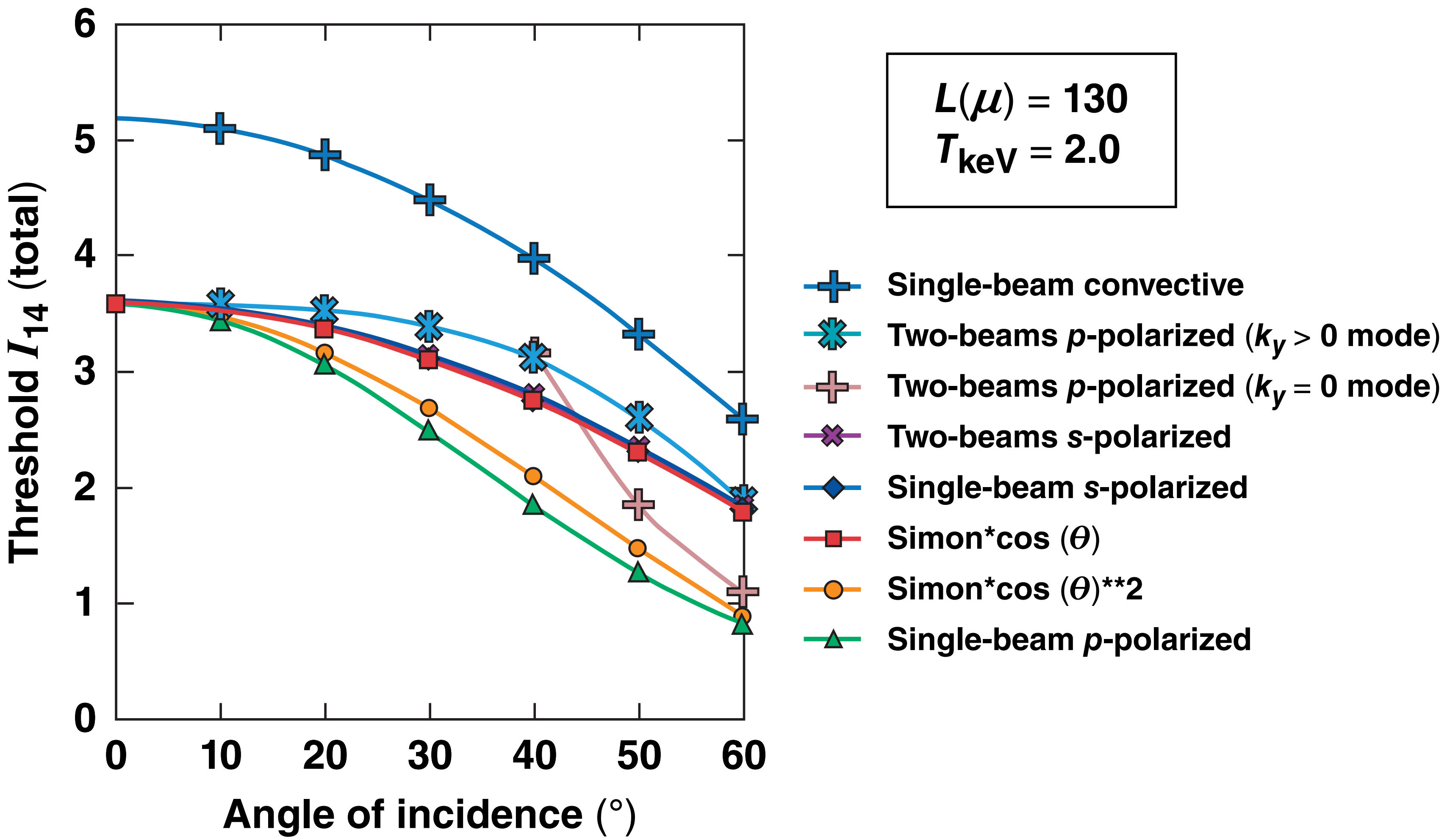
- The nominal convective threshold is $G_R > 2\pi$ or $\eta > \frac{2\pi}{4.35} \cong 1.44$

- Therefore, the absolute instability appears below the convective instability threshold; this, in general, remains true for multiple beams

TC10637a

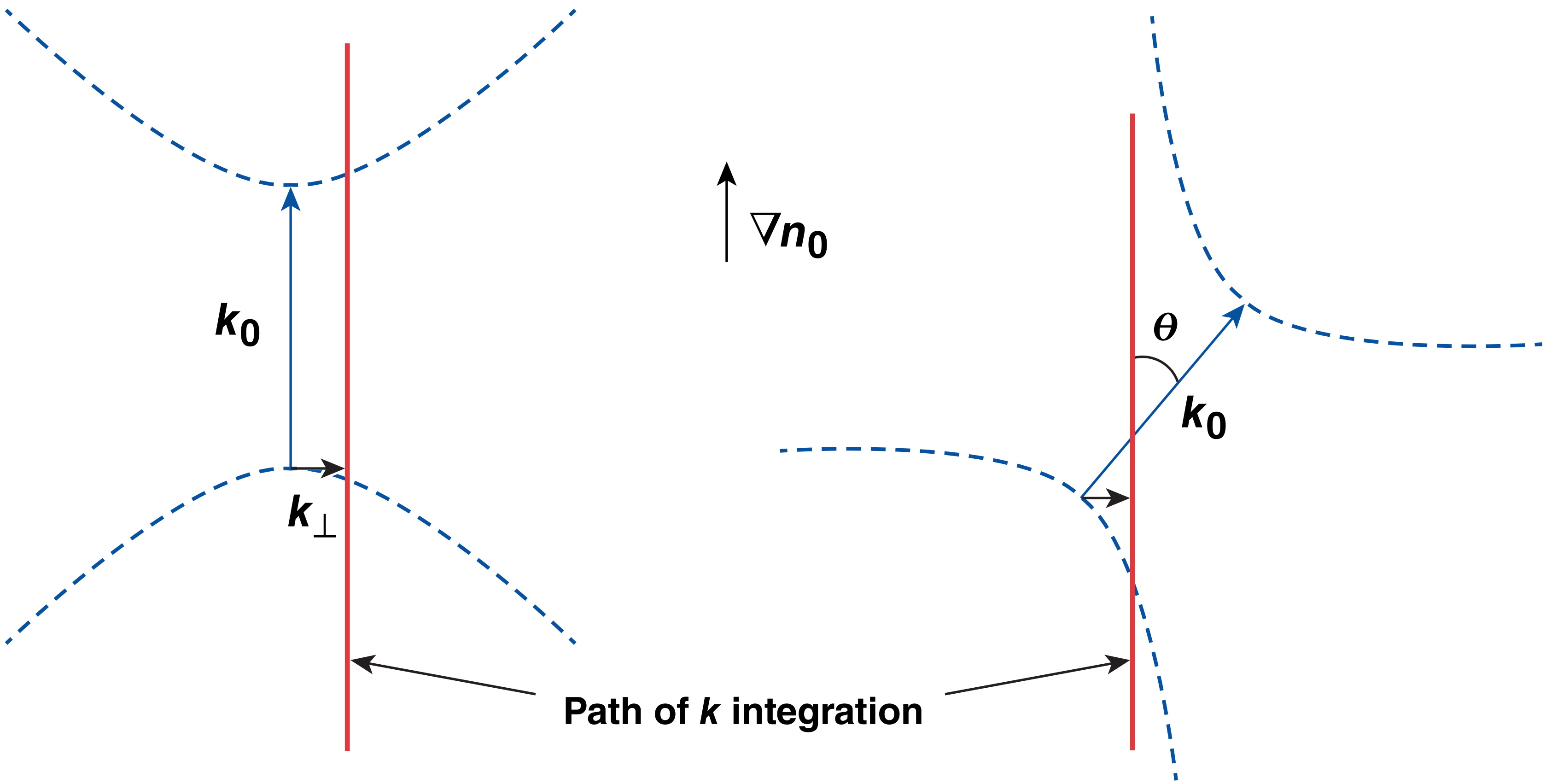
*A. Simon *et al*., Phys. Fluids 26, 3107 (1983).

The absolute threshold for TPD depends on the angle of incidence and polarization



TC10640k

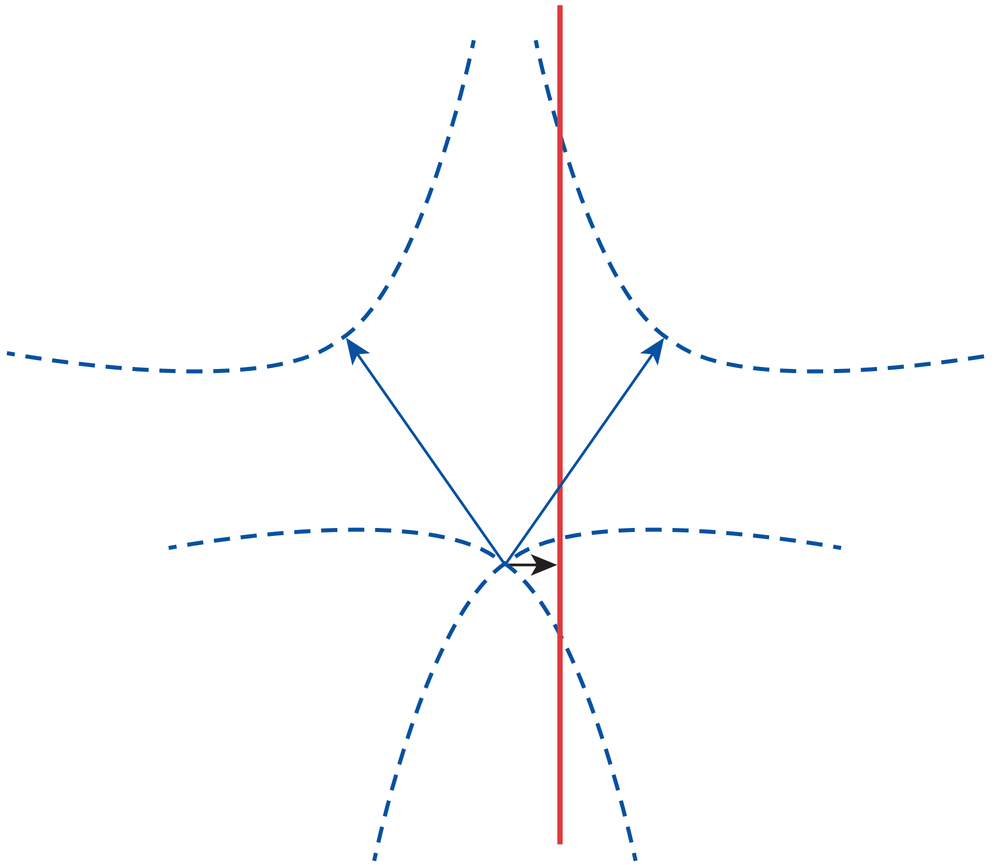
For a single *p*-polarized beam, the interaction lengths in both *k* space and real space are increased by ~1/cosθ



As a result, the threshold is reduced by ~cos$^2\theta$.

TC10641

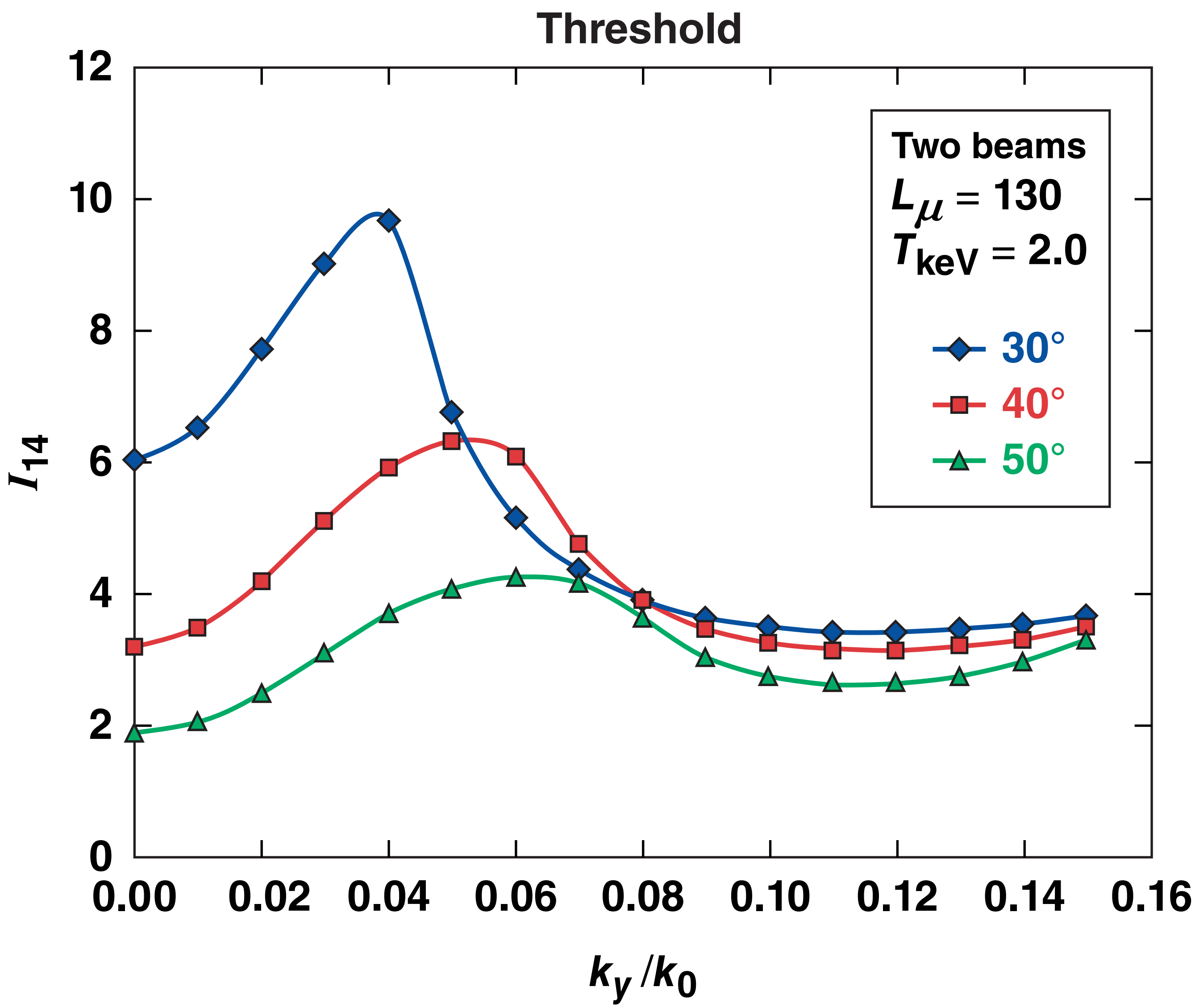
For two *p*-polarized beams, the gain regions separate with increasing angle, reducing synergy



- For two *s*-polarized beams the separation is much smaller

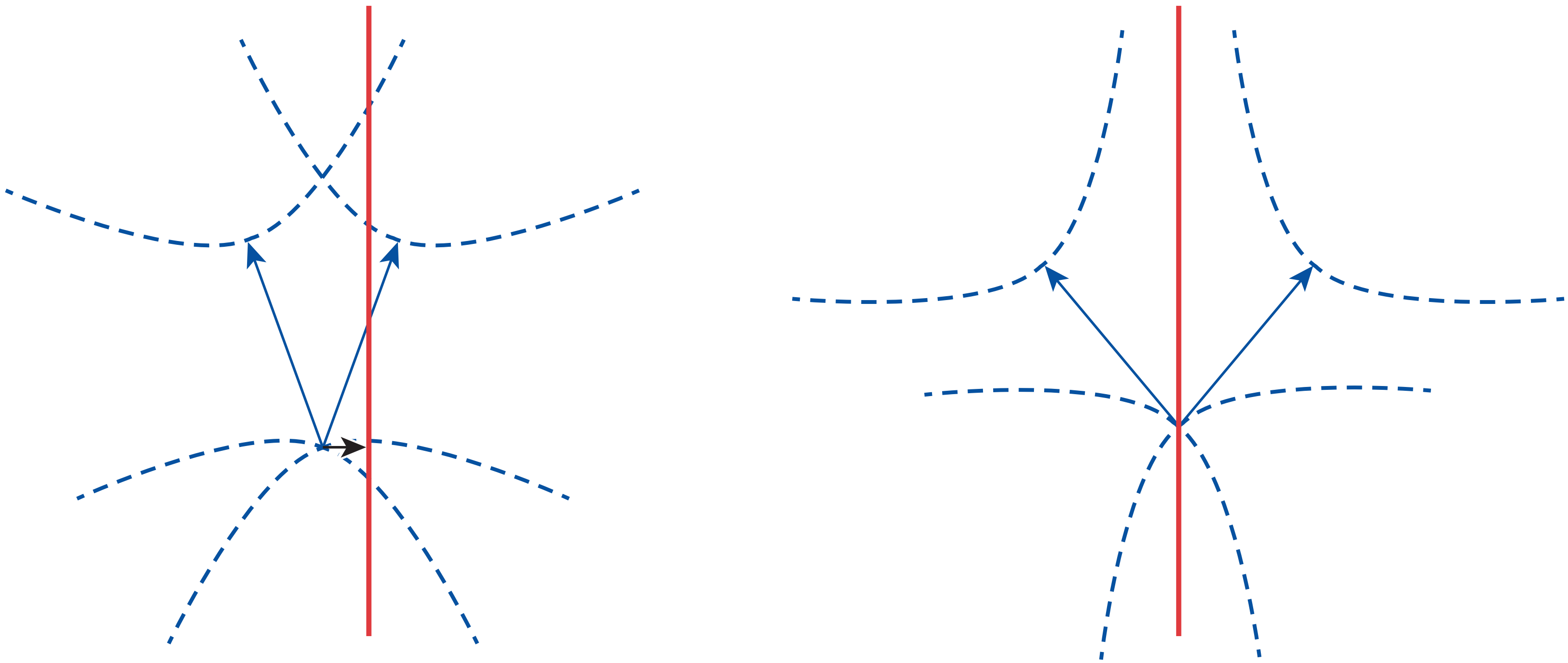
TC10642a

For two *p*-polarized beams, an on-axis absolute mode with $k_y = 0$ has the lowest threshold at larger angles



TC10643

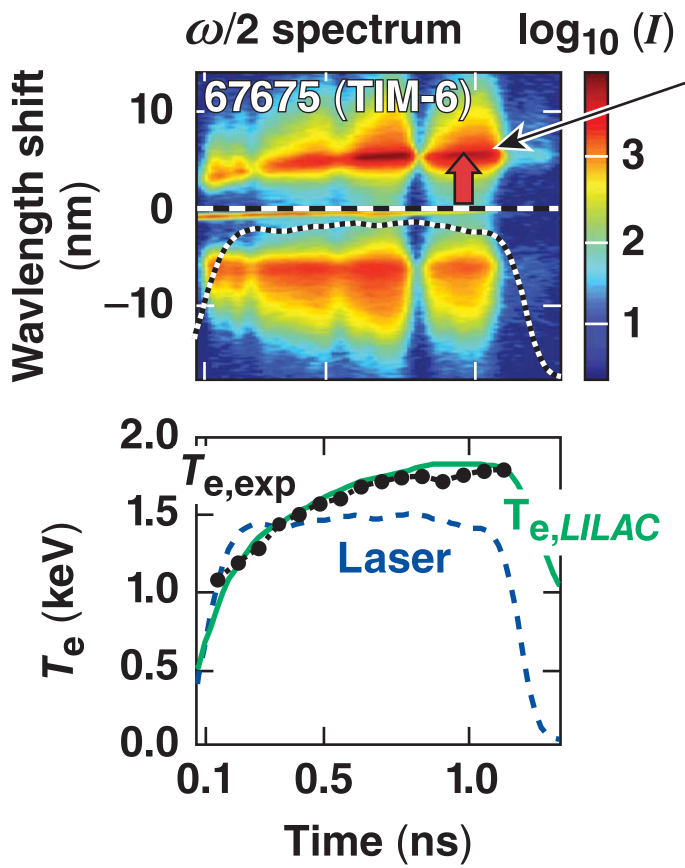
At larger angles, the on-axis mode is closer to the hyperbolas than the off-axis modes



$\theta = 20°$ $\theta = 40°$

TC10644

The spectral signature of the absolute instability near $n_c/4$ is a sharp red-shifted feature that can be used for T_e measurements*



$\Delta\lambda_{nm} = 4.4 \times 10^{-3}\, T_{e,keV}$

At $I \lesssim 5 \times 10^{14}$ $T_{e,keV} \sim T_{e,LILAC}$

$I_{14} = 5.6$

- Although the absolute instability is obtained from linear analysis, it can remain the most-intense TPD mode in the nonlinear regime, persisting throughout the pulse

*W. Seka *et al*., Phys. Rev. Lett. 112, 145001 (2014).

E22225

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