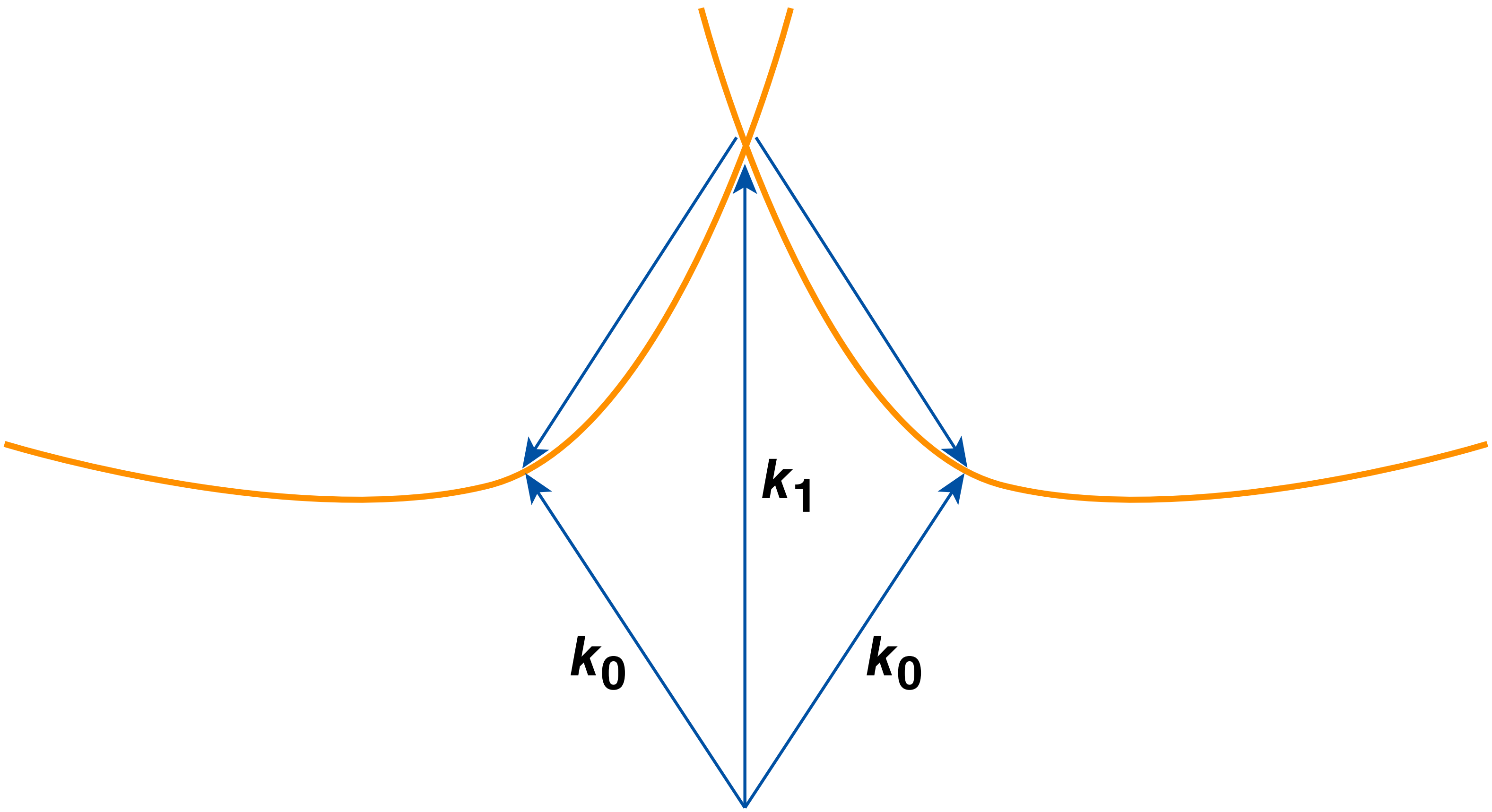
Anisotropy of Two-Plasmon Decay (TPD) for Multiple Obliquely Incident Laser Beams



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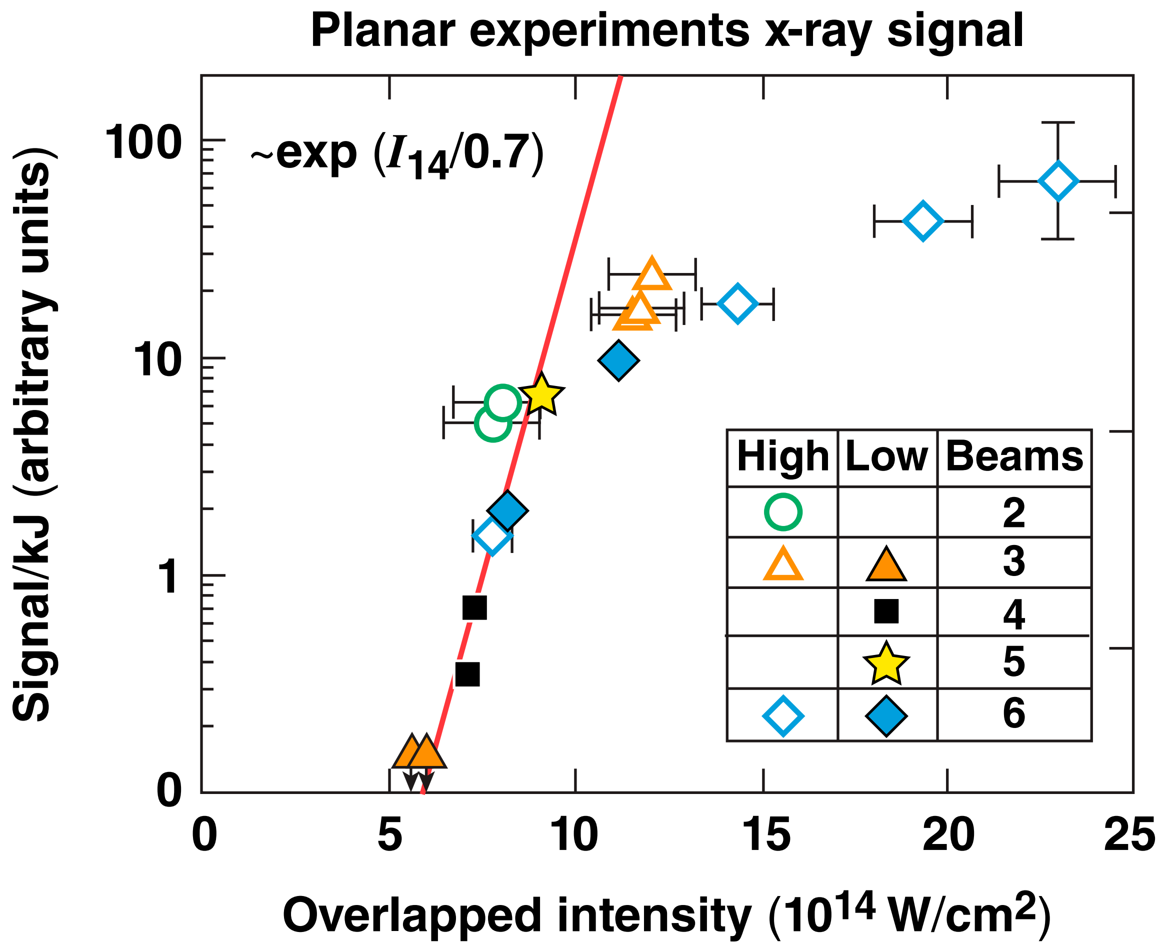
Summary

Collectively driven TPD growth diminishes away from the beam symmetry axis, but increases with angle from the density gradient

- Experiments on OMEGA show that TPD is driven by the collective intensity of several overlapping laser beams.
- Each pump beam drives a common plasma wave and a satellite.
- The common wave is the most strongly driven and is expected to produce most of the hot electrons.
- The angular distribution of this wave will determine the anisotropy of the hot electrons produced and, therefore, their preheating efficiency.
- TPD is strongly suppressed when this wave deviates from the beam symmetry axis, but may be enhanced when the symmetry axis diverges from the density gradient.

TPD is observed to depend on the overlapped intensity for multiple-beam experiments



TC8117

C. Stoeckl *et al.*, Phys. Rev. Lett. 90, 235002 (2003).

The equations describing TPD are difficult to treat in configuration space

- Using the velocity potential defined by $v \equiv \nabla\psi$, the equations governing TPD can be written

$$\frac{\partial\psi}{\partial t} = \frac{e\phi}{m} - \frac{3\upsilon_e^2 n_1}{n_0} - v_0 \cdot \nabla\psi; \quad \frac{\partial n_1}{\partial t} + \nabla\cdot\left(n_0 \nabla\psi\right) + v_0 \cdot \nabla n_1 = 0; \quad \nabla^2\phi = 4\pi e n_1.$$

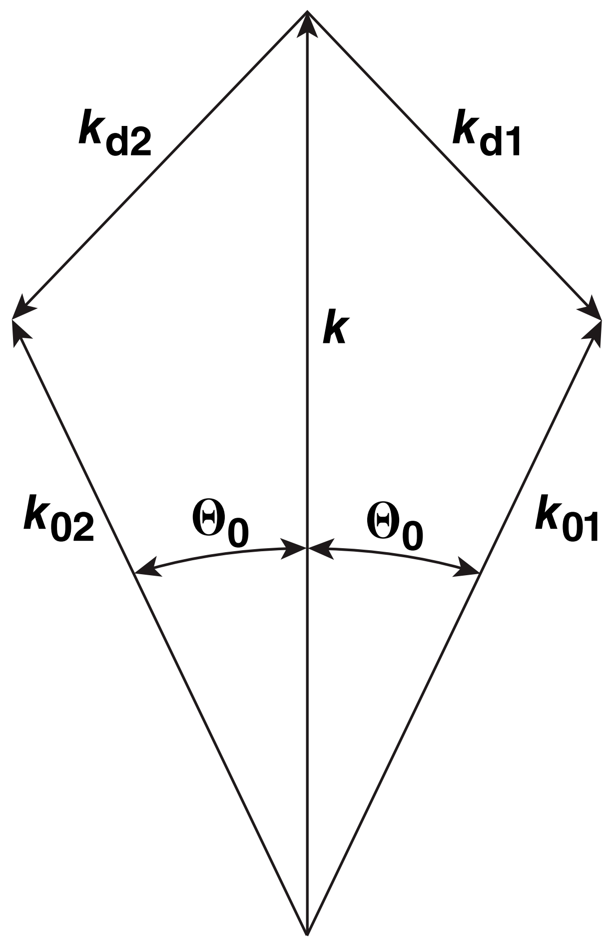
- These lead to an eighth-order ODE. Simplifications are of questionable validity near the plasma-wave turning points.

- TPD is confined to a narrow range of densities below quarter-critical, so a linear density profile should be a good approximation.

- In a linear profile the TPD equations can be greatly simplified by Fourier transforming (Liu and Rosenbluth, 1976; Simon *et al*. 1983).

The anisotropy of multibeam TPD interaction can be studied using two beams

- Each pump wave drives a common plasma wave and a satellite; the common wave is of greatest interest.



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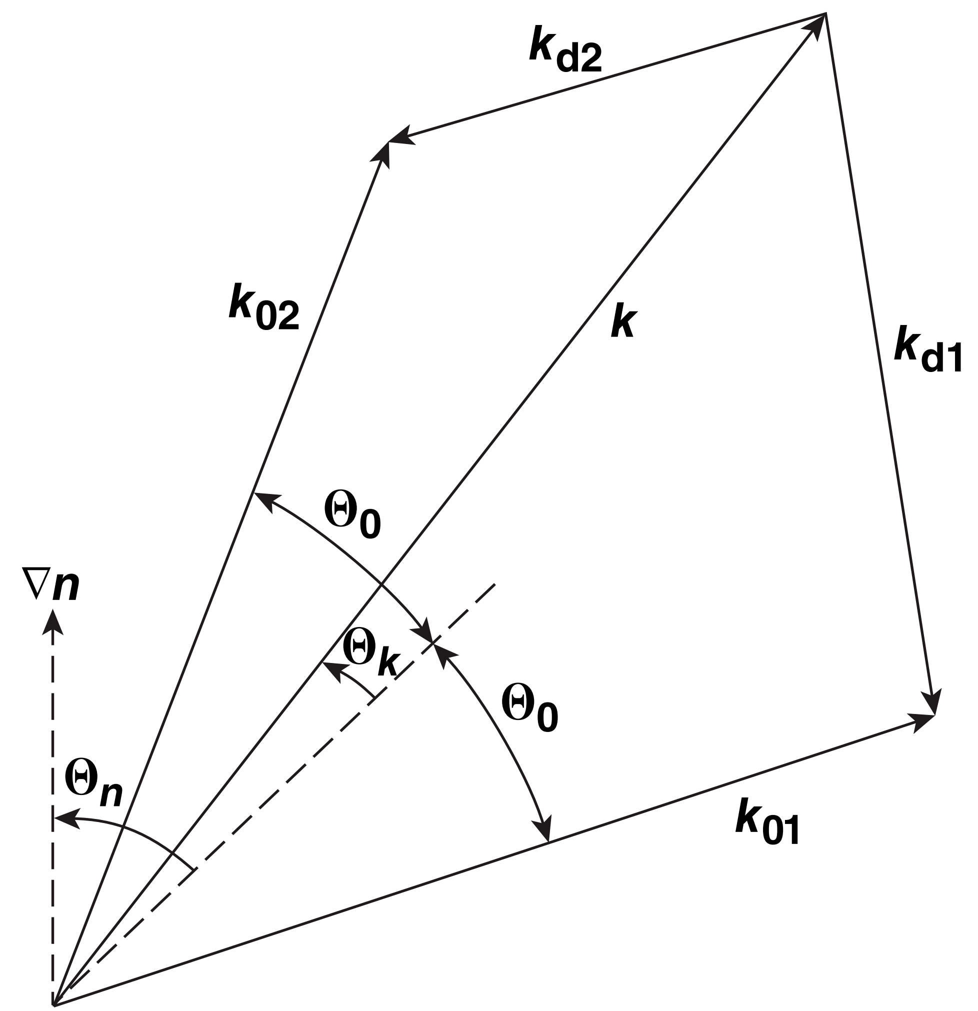
The common plasma wave can deviate from the centroid of the beams or from the density gradient



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The Fourier analysis results in a set of first-order linear equations that are readily integrated numerically

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$$\frac{du}{dk_x} = e^{\frac{3i\upsilon_e^2 k_0 L}{\omega_p^2}\left\{\cos(\theta_0+\theta_n)(k_x-k_{rx})^2+2k_r\left[\cos(\theta_0+\theta_k)-\cos\theta_0\right](k_x-k_{rx})\right\}} \frac{\left(\frac{k^2-k_{d1}^2}{kk_{d1}}\right)L}{\omega_p}\left|\upsilon_{01}\right|\left(\hat{\varepsilon}_1\cdot k\right)u_{d1}$$

$$+e^{\frac{3i\upsilon_e^2 k_0 L}{\omega_p^2}\left\{\cos(\theta_0+\theta_n)(k_x-k_{rx})^2+2k_r\left[\cos(\theta_0-\theta_k)-\cos\theta_0\right](k_x-k_{rx})\right\}} \frac{\left(\frac{k^2-k_{d2}^2}{kk_{d2}}\right)L}{\omega_p}\left|\upsilon_{02}\right|\left(\hat{\varepsilon}_1\cdot k\right)u_{d2}$$

$$\frac{du_{d1}}{dk_x} = -e^{-\frac{3i\upsilon_e^2 k_0 L}{\omega_p^2}\left\{\cos(\theta_0+\theta_n)(k_x-k_{rx})^2+2k_r\left[\cos(\theta_0+\theta_k)-\cos\theta_0\right](k_x-k_{rx})\right\}} \frac{\left(\frac{k^2-k_{d1}^2}{kk_{d1}}\right)L}{\omega_p}\left|\upsilon_{01}\right|\left(\hat{\varepsilon}_1\cdot k\right)u$$

$$\frac{du_{d2}}{dk_x} = -e^{-\frac{3i\upsilon_e^2 k_0 L}{\omega_p^2}\left\{\cos(\theta_0+\theta_n)(k_x-k_{rx})^2+2k_r\left[\cos(\theta_0-\theta_k)-\cos\theta_0\right](k_x-k_{rx})\right\}} \frac{\left(\frac{k^2-k_{d2}^2}{kk_{d2}}\right)L}{\omega_p}\left|\upsilon_{02}\right|\left(\hat{\varepsilon}_2\cdot k\right)u$$

Both absolute and convective forms of TPD can be studied using the *k*-space approach

- The convective gain can be found by integrating these equations over k_x from $-\infty$ to ∞.

- The gain is represented as $\text{Max}\left\{\frac{|u^{\text{out}}|^2}{|u_{d1}^{\text{in}}|^2 + |u^{\text{in}}|^2 + |u_{d2}^{\text{in}}|^2}\right\}$.

- Divergent gain represents the onset of absolute instability.

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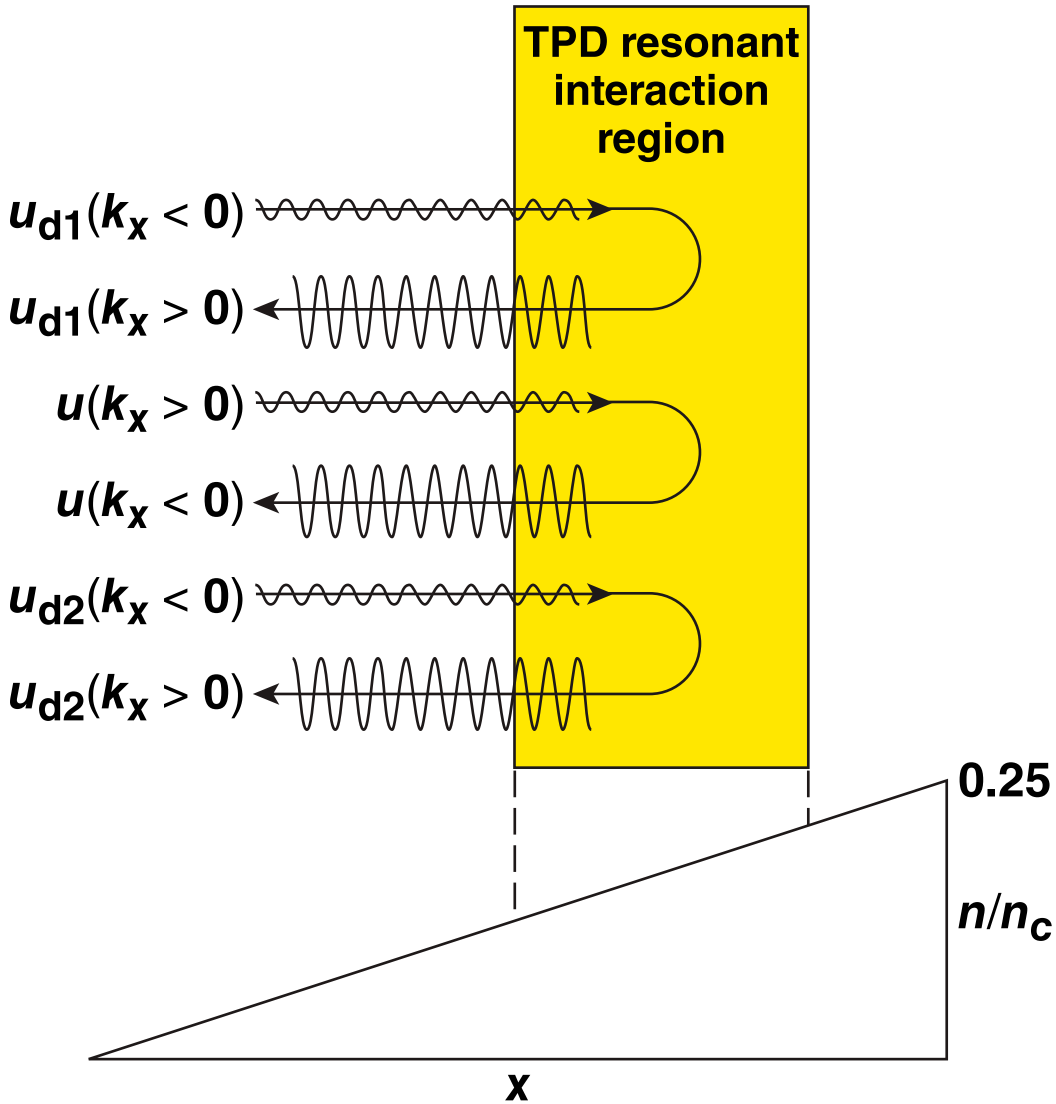
TPD amplification factors can be obtained by numerical integration of the *k*-space equations



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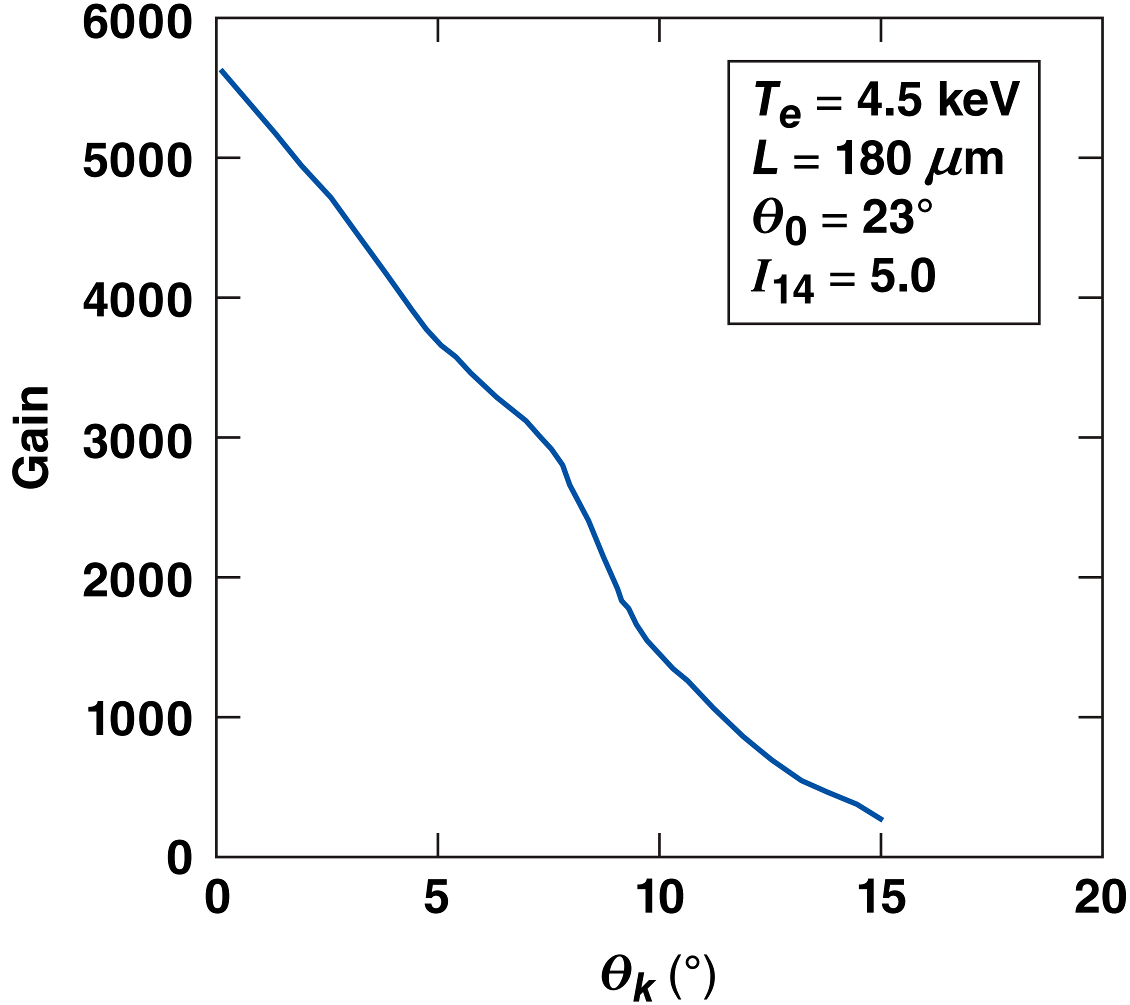
The gain diminishes significantly when *k* deviates from the centroid of the pump beams



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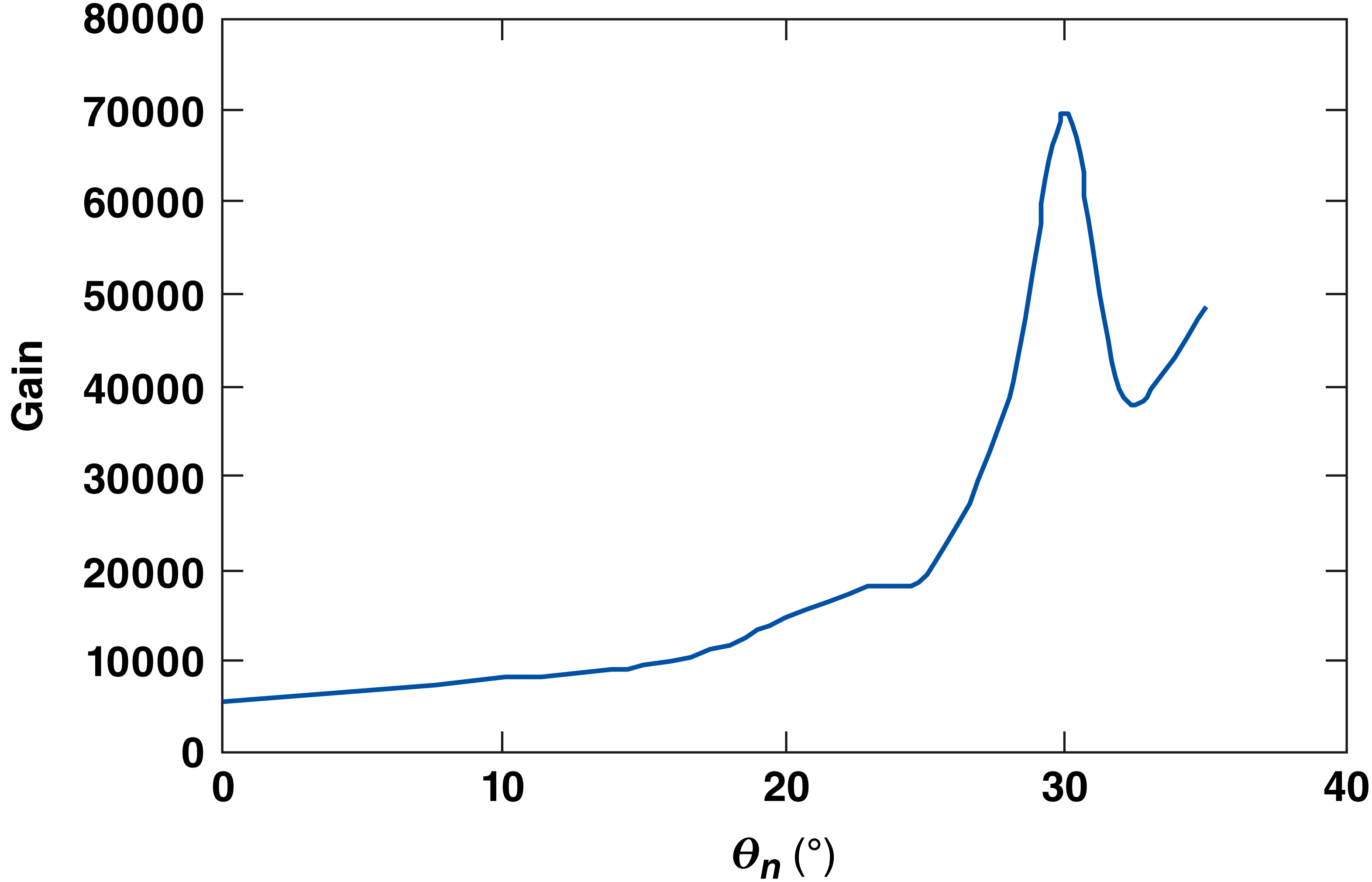
Gain increases and may lead to absolute instability as the beam centroid diverges from the density gradient



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Summary/Conclusions

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