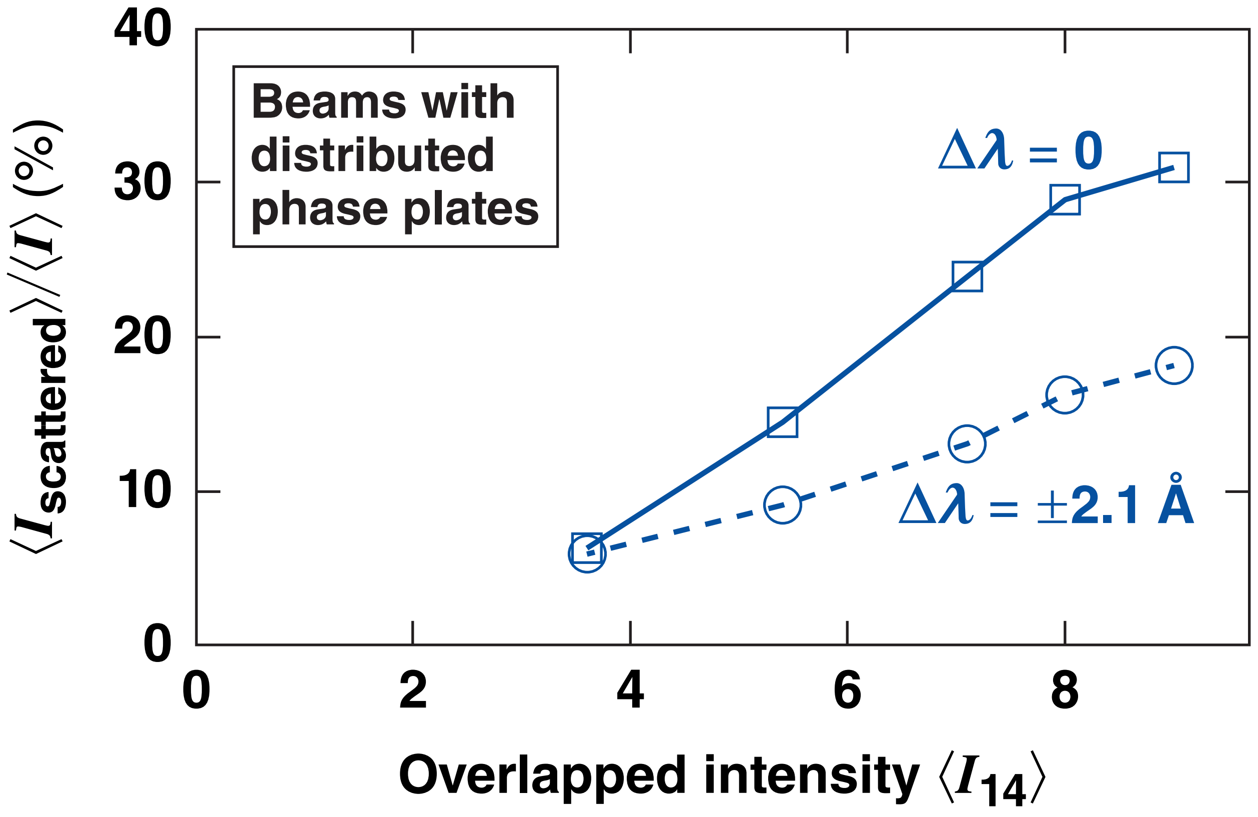
Beam-Energy Exchange Driven by Incoherent Laser Beams with Frequency Detuning



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In direct-drive inertial confinement fusion (ICF) plasmas, the frequency detuning in the driving incoherent laser beams mitigates the beam-energy exchange

UR LLE

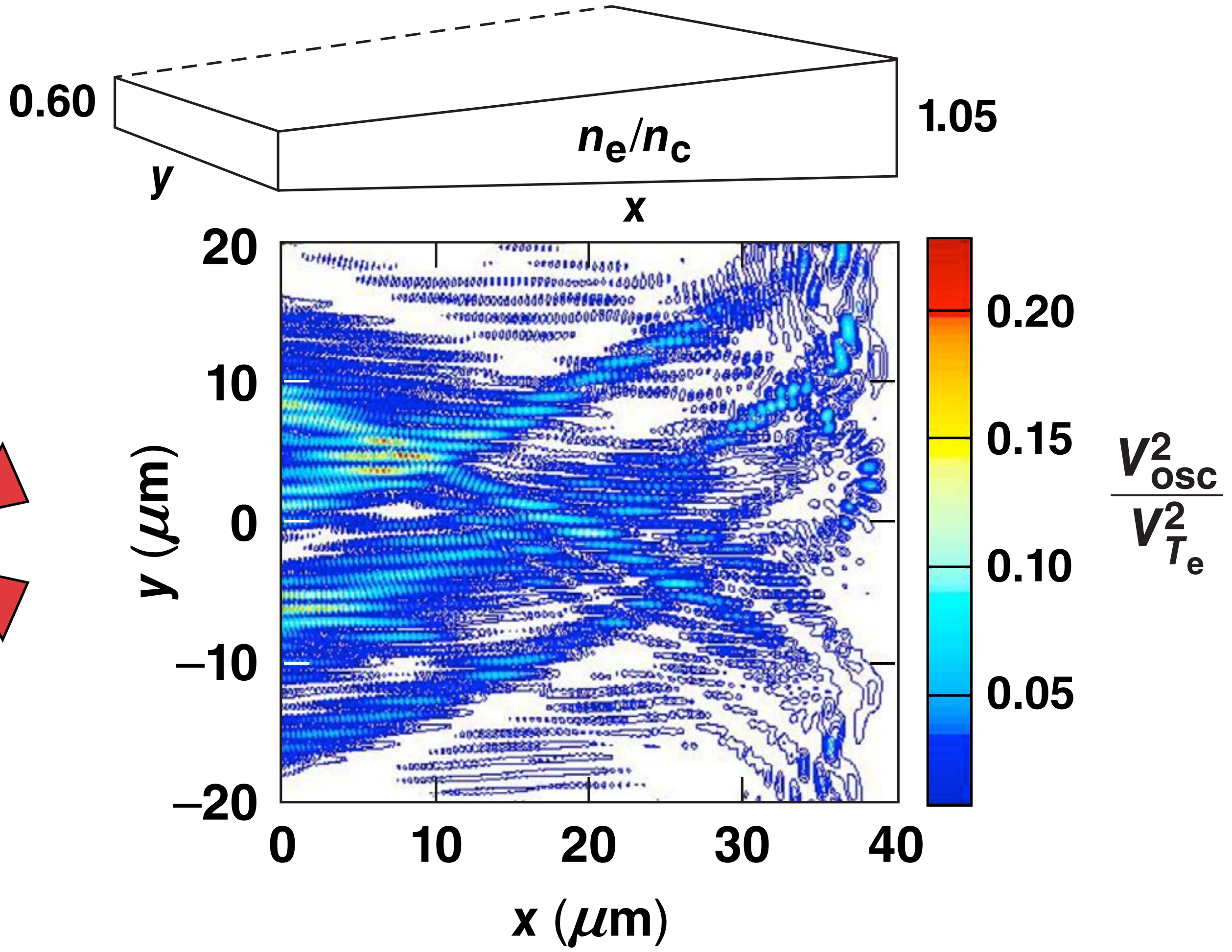
- In dense plasmas (including beam-turning points) nonlinear laser–plasma interactions (LPI's) can lead to angular broadening of scattered light
- The use of frequency detuning in laser beams can limit the beam-energy exchange in plasmas because it
  - reduces the role of common ion-acoustic waves (IAW's)
  - increases the frequency broadening of scattered light
- The scaling of the beam-energy exchange with intensity and frequency detuning in an LPI model for incoherent beams is different from the plane-wave model

Nonlinear propagation of laser beams with frequency detuning is modeled in dense plasmas

- Beams with wavelength detuning are used to limit beam-to-beam coupling
  - two-dimensional nonparaxial model near turning points
  - related to parameters from simulations of OMEGA experiments (flow velocity $\ll c_s$)

$T_e = 2$ keV
$\Delta\lambda_0 = 0, \pm 2.1$ Å

$\theta = \pm 15°, \pm 30°$
f/6
$\langle I_{14} \rangle = 8$



TC12176a

The LPI model includes backward- and forward-stimulated Brillouin scattering (SBS), beam self-focusing, field swelling, and absorption

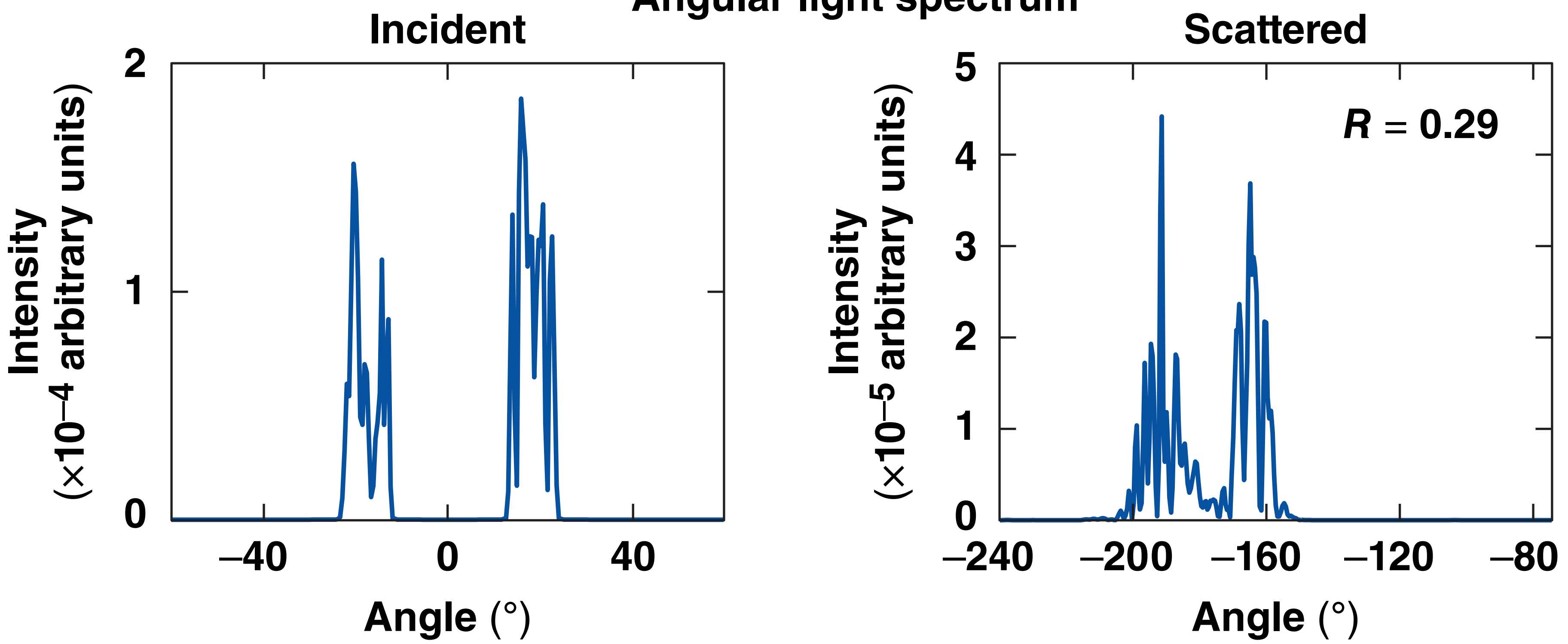
- **Beam-to-beam coupling can be described by backward SBS gains**

$$\frac{dG_{SBS}}{d\ell} = \frac{\omega_0^2}{2c^2 n_c} \mathrm{Re}\left\{\frac{n_e k_s^2 c_s^2 \times I_0}{2\nu_i \omega_s + i\left[(\omega_s + k_s v_0)^2 - k_s^2 c_s^2\right]} \times \frac{1}{2k_{0x}}\right\},$$

$$I_0 = |E|^2 / 4\pi n_c T_e$$

Angular light spectrum

$\langle I_{14} \rangle = 8$



The angular width of scattered light is increased

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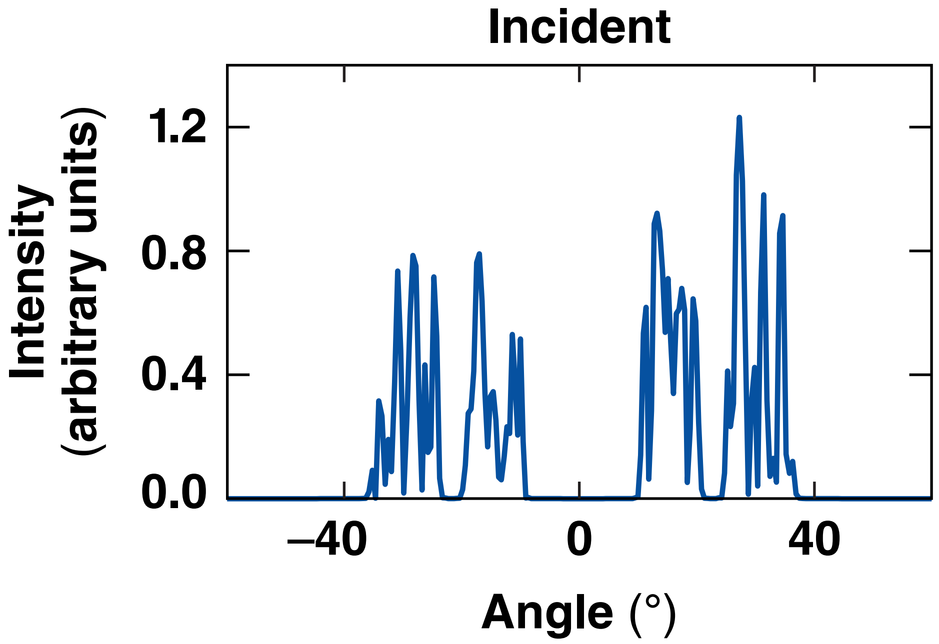
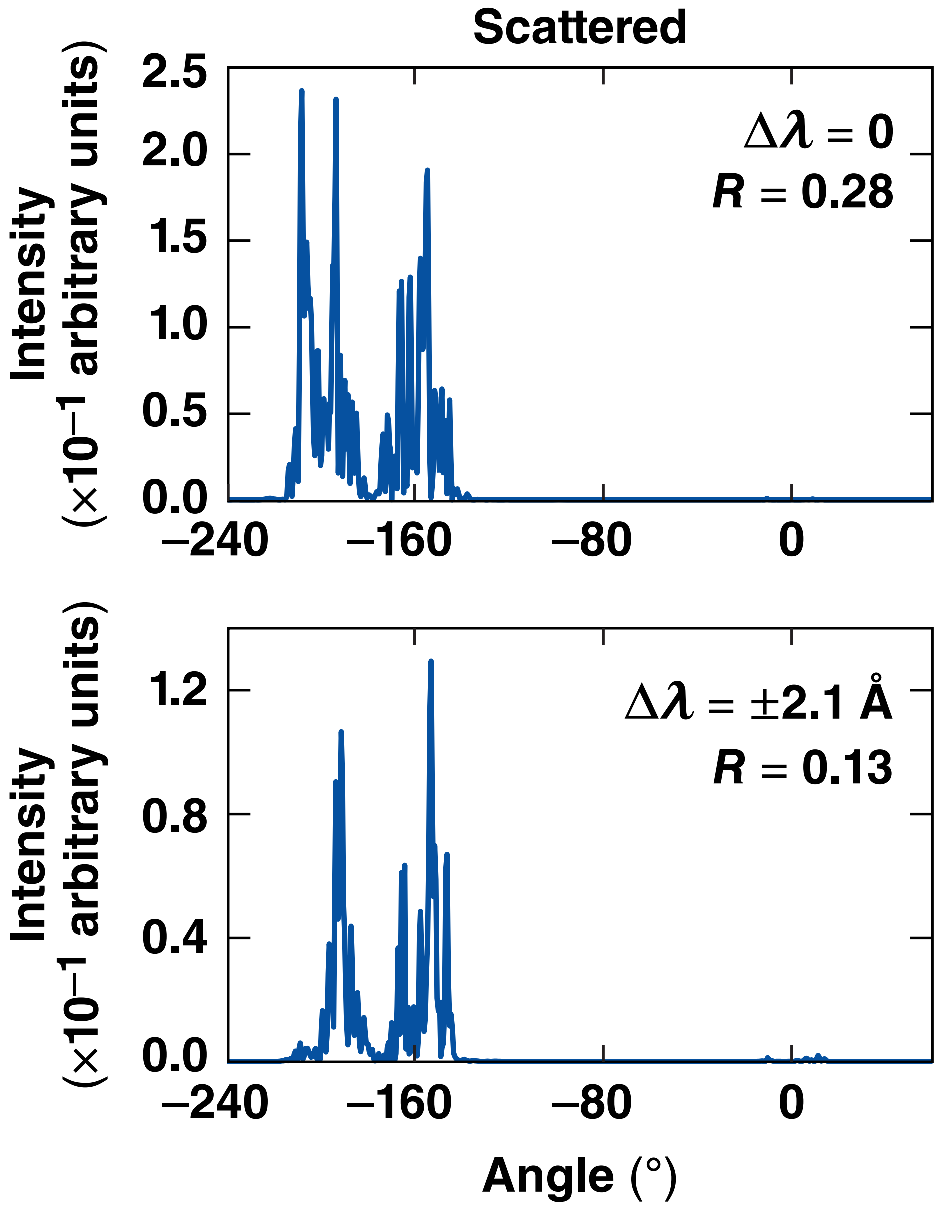
The beam-energy exchange is significantly reduced when frequency detuning (color) is applied to crossing laser beams





Four laser beams

$$\theta = \pm 15^\circ, \pm 30^\circ$$

$$\langle I_{14} \rangle = 8$$

$$I_{outer} / I_{inner} = 1$$

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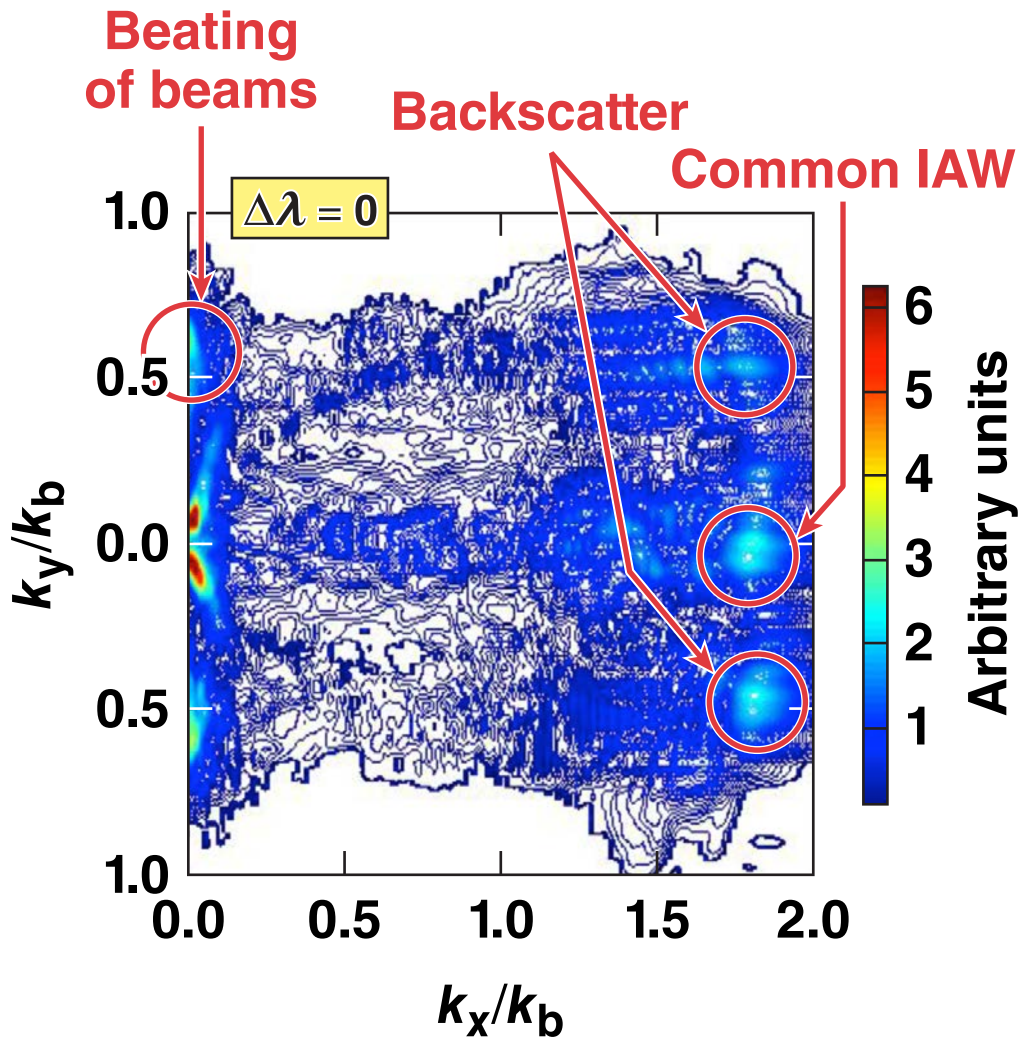
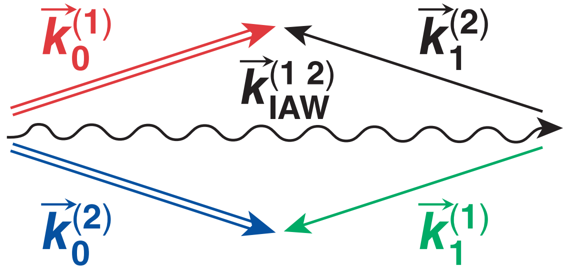
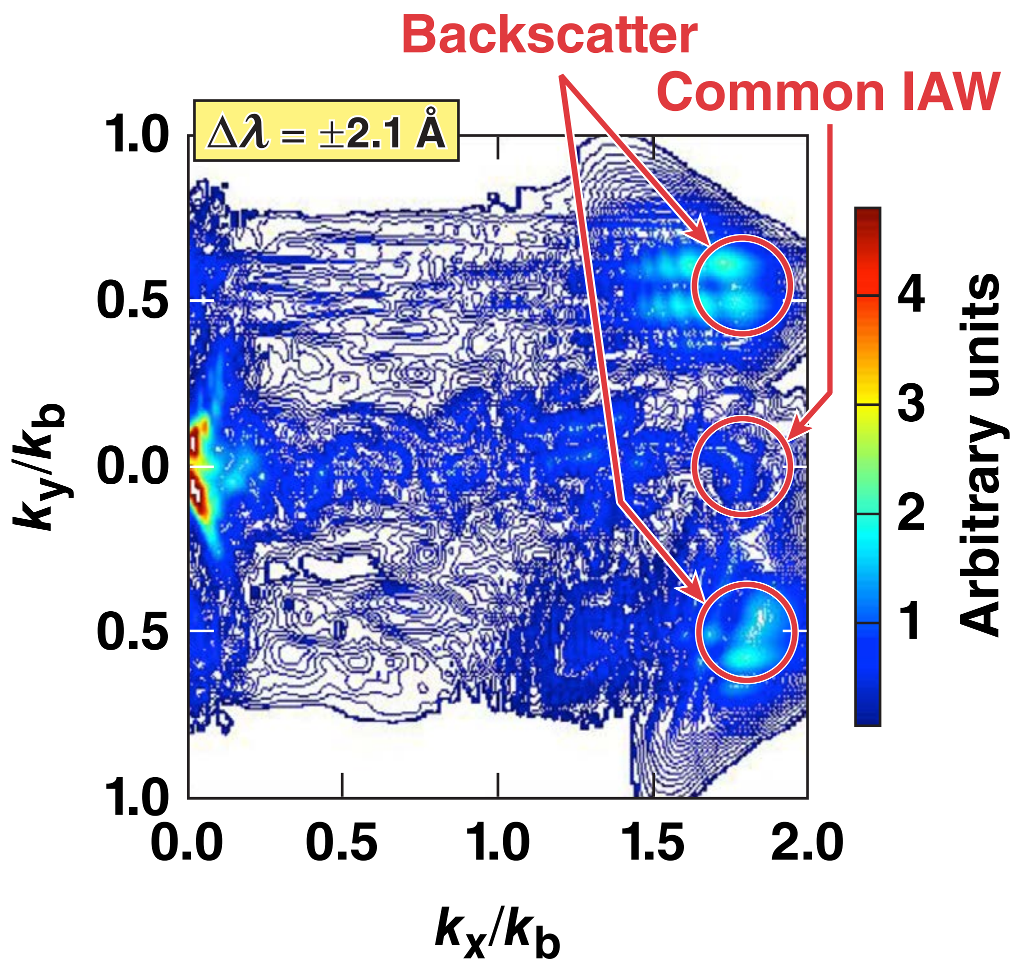
The spectra of density perturbations show different ion-acoustic waves driven in dense plasmas





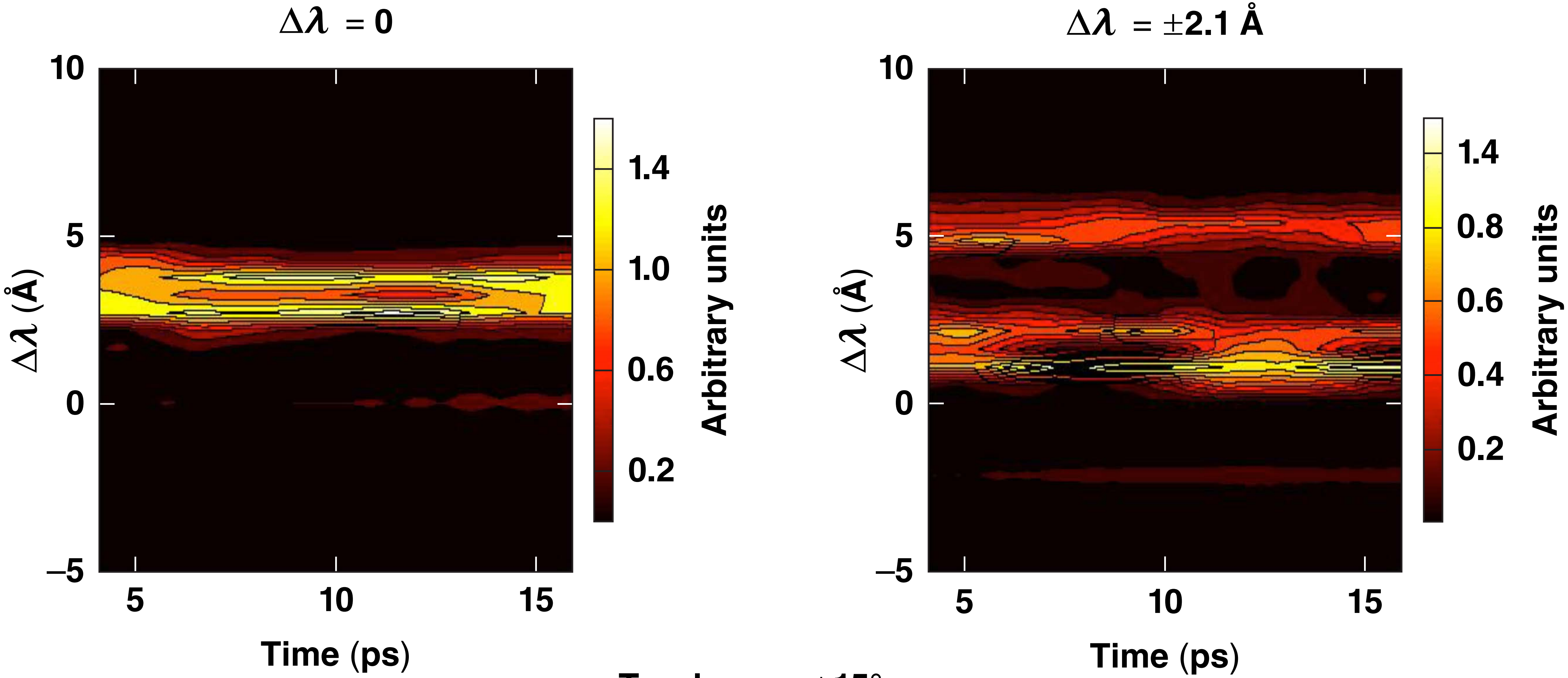


Two beams ±15°, $\langle I_{14} \rangle = 8$

$$k_b = \frac{\omega_0}{c}\sqrt{1 - \frac{n_b}{n_c}}$$

TC12545

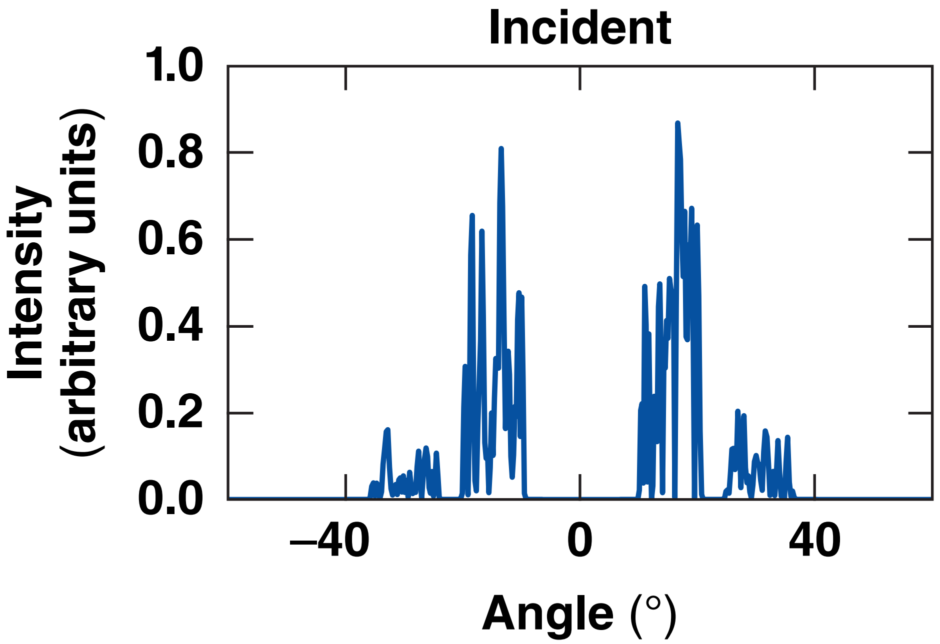
The frequency detuning in driving laser beams strongly modifies the frequency spectra of scattered light



Two beams ±15°
$\langle I_{14} \rangle = 8$

TC12546

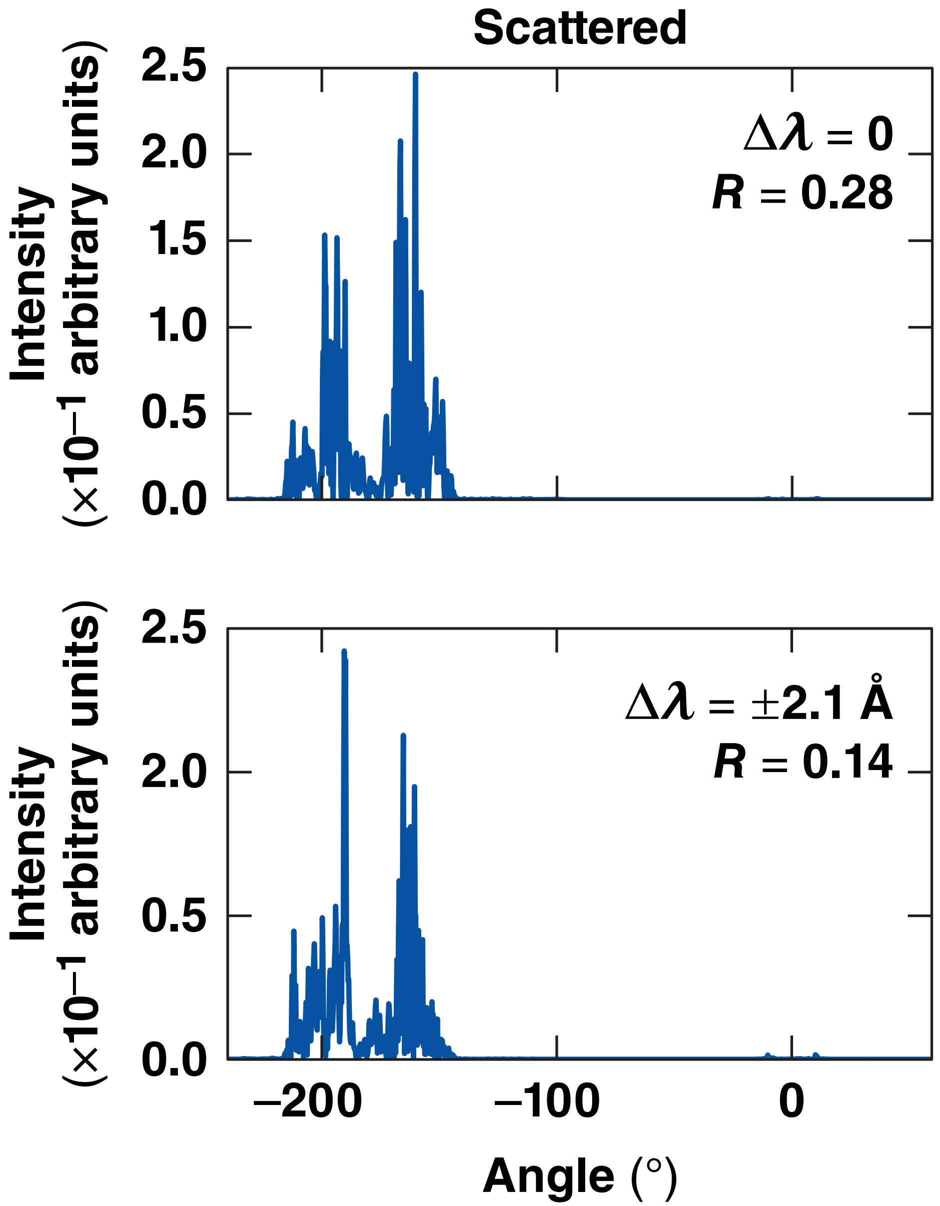
The beam-energy exchange driven by incoherent beams with an intensity contrast leads to the angular broadening of scattered light



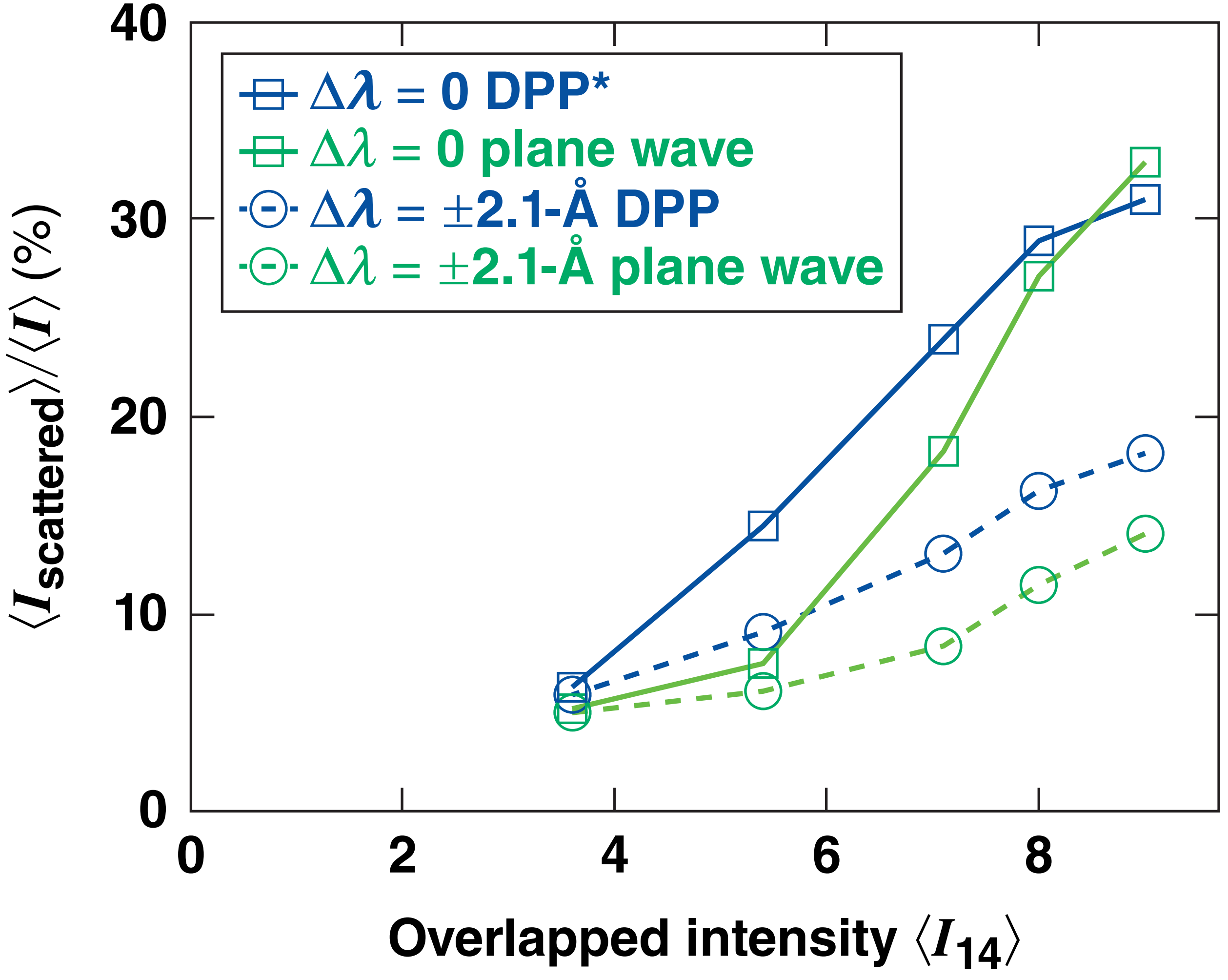
Driving beams with large intensity contrast

$$\langle I_{14} \rangle = 8$$

$$I_{outer} / I_{inner} = 0.2$$



The frequency detuning in incoherent laser beams leads to a significant reduction in the scattered-light intensity



The ray-based beam-energy exchange models do not account for the speckled distribution of the laser intensity in plasmas.

*DPP: distributed phase plate

TC12548

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