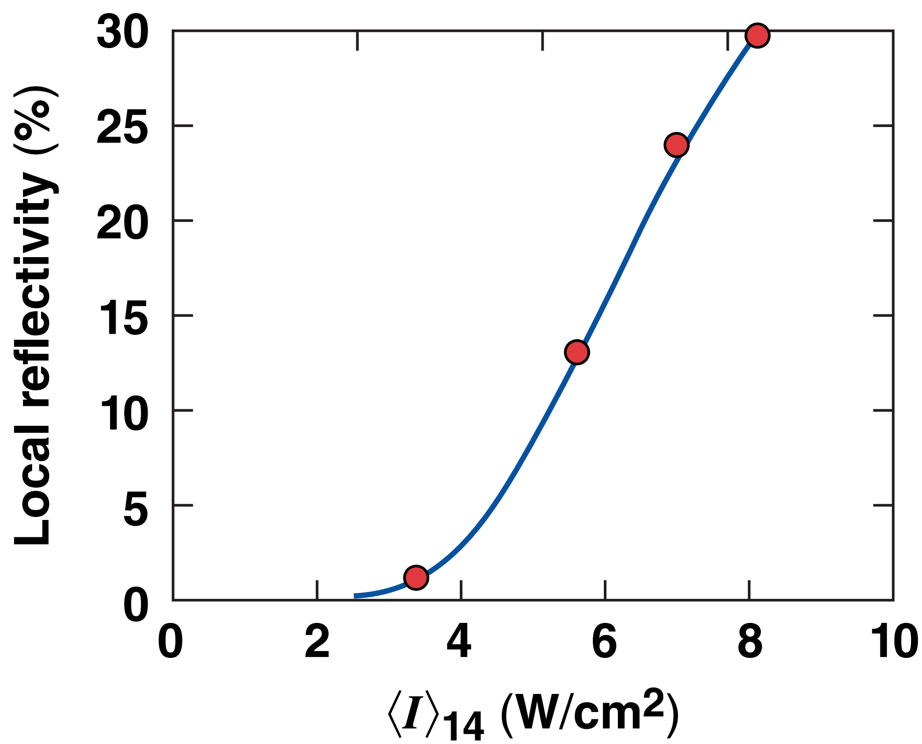
Energy Transfer Between Crossing Laser Beams in the Plasmas of Direct-Drive ICF



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Summary

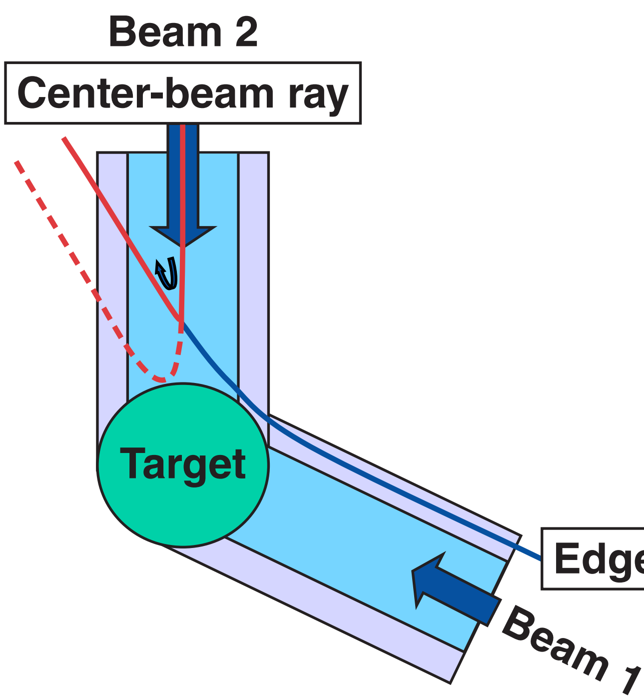
In direct-drive ICF plasmas, nonlinear interaction between crossing laser beams leads to significant scattering

- At moderate plasma densities (0.3 to 0.6 critical density), interaction between incident laser beams and a counter-propagating seed can lead to a local reflectivity exceeding 20%
- The direction of scattered light is determined by the structure of laser speckles
- Interaction in intense speckles leads to a power scaling of reflectivity with intensity
- Nonlinear propagation of laser beams near their turning points provides a seed for scattering in the lower-density region

In large-scale hydrodynamic simulations, crossed-beam energy transfer is shown* to significantly influence the laser absorption

- For direct-drive ICF plasmas, the interaction between rays is

$$\frac{dI_1}{d\ell} = I_1 I_0 \underbrace{\frac{\omega_0^2}{2c^2 n_c} \mathrm{Re}\left\{\frac{n_e k_s^2 c_s^2}{2\nu_i \omega_s + i\left[(\omega_s + k_s v_0)^2 - k_s^2 c_s^2\right]} \times \frac{1}{2k_{0x}}\right\}}_{\frac{dG_{SBS}}{d\ell}}$$



- Crossed-beam energy transfer reduces the energy of incoming center-beam light and increases the energy of outgoing edge-beam light

*I. V. Igumenshchev *et al.*, Phys. Plasmas 17, 122708 (2010).
I. V. Igumenshchev *et al.*, YI3.00001

E19905f

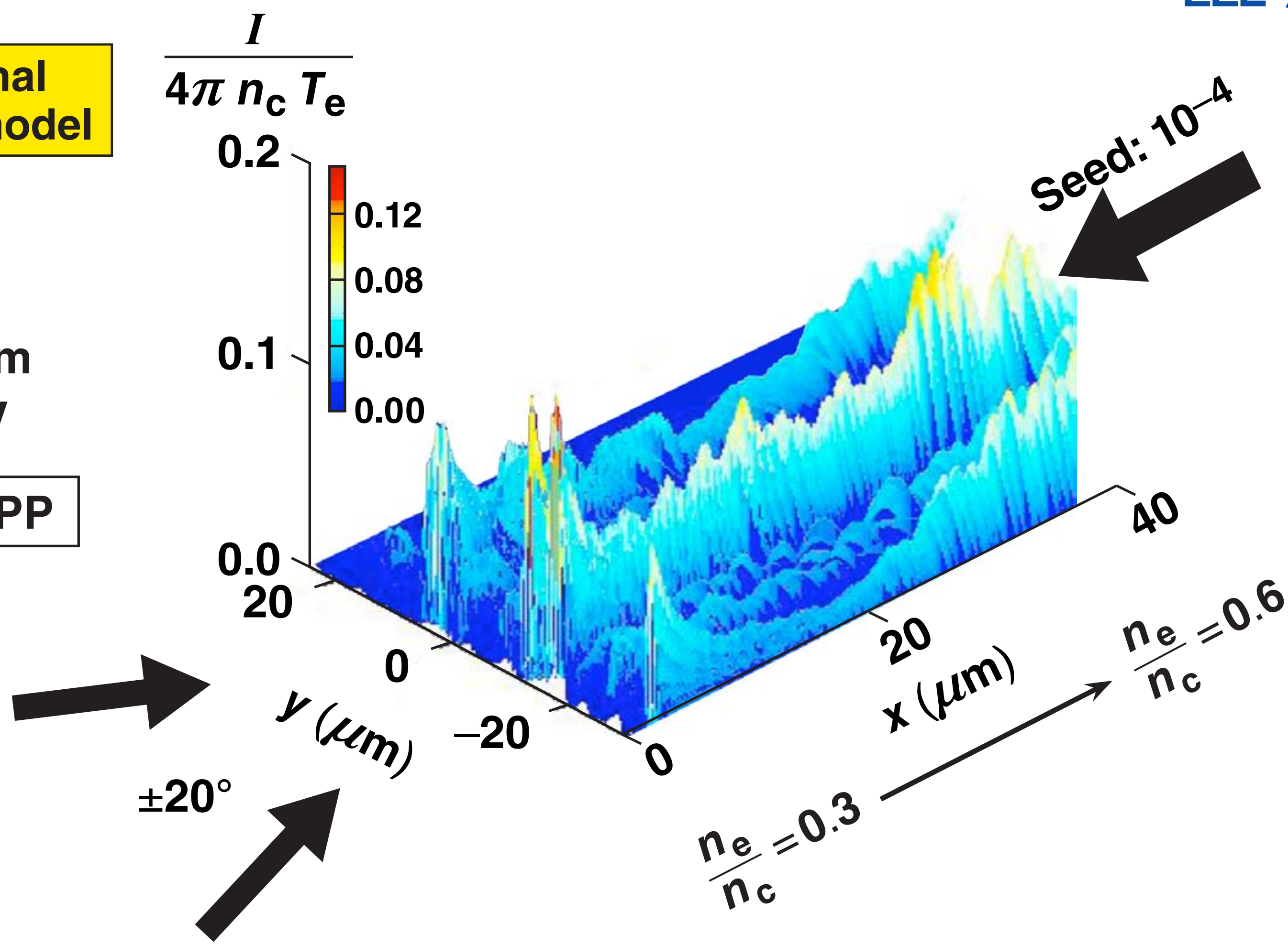
The nonlinear propagation of crossing laser beams has been modeled in the region of moderate plasma density, about 0.3 n_c to 0.6 n_c

Two-dimensional non-paraxial model

$L_n = 140\ \mu m$

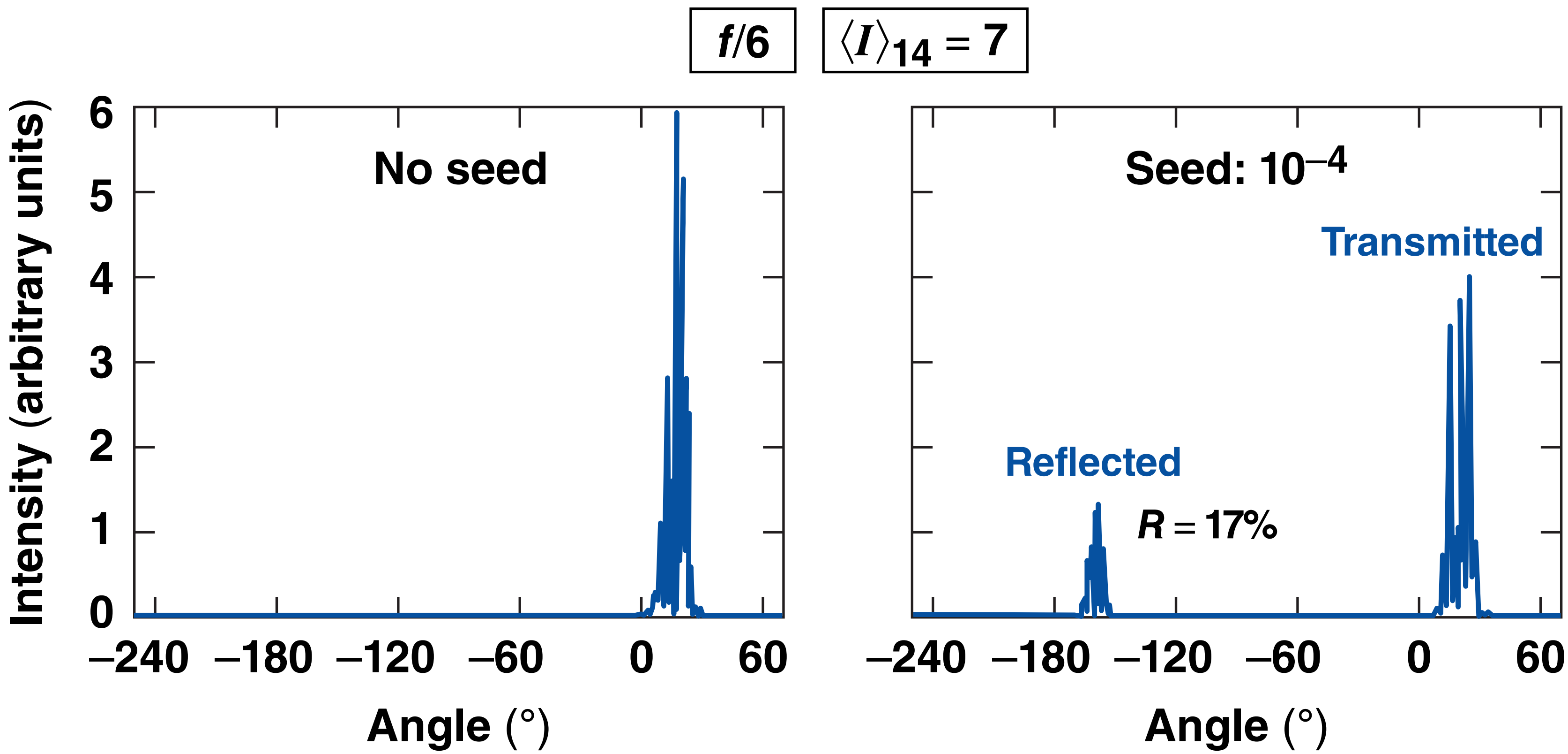
$T_e = 2$ keV

f/6 or *f*/15 DPP



The backscatter depends on the electromagnetic seed, which is caused by opposing beams or turning beams

Scattering from a single DPP beam*

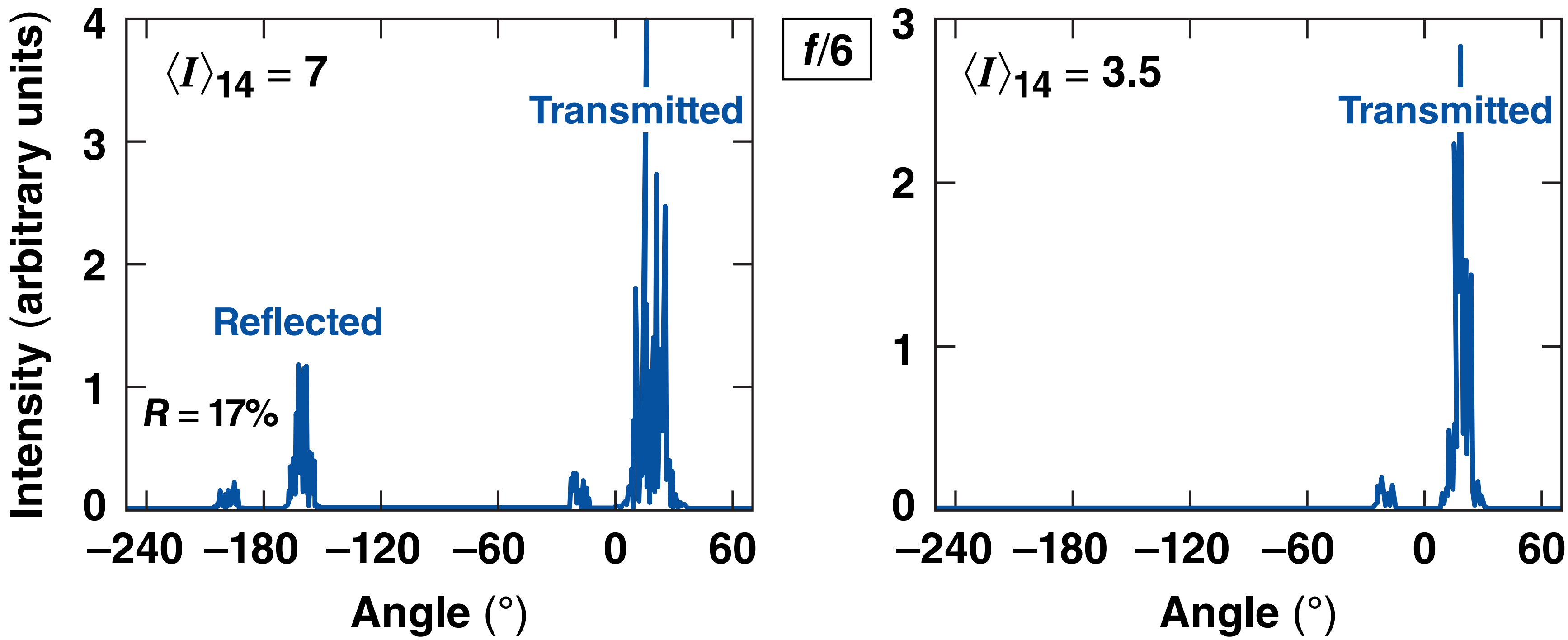


TC9501a

*H. A. Rose and D. F. DuBois, Phys. Rev. Lett. 72, 2883 (1994).

The threshold for the backscattering driven by crossing laser beams has been found at moderate laser intensities

- The intensities of the two driving beams are different by a factor of 10.



$$G_{SBS} = 0.24 \langle I \rangle_{14} \left(\frac{I_{max}}{\langle I \rangle} \right)$$

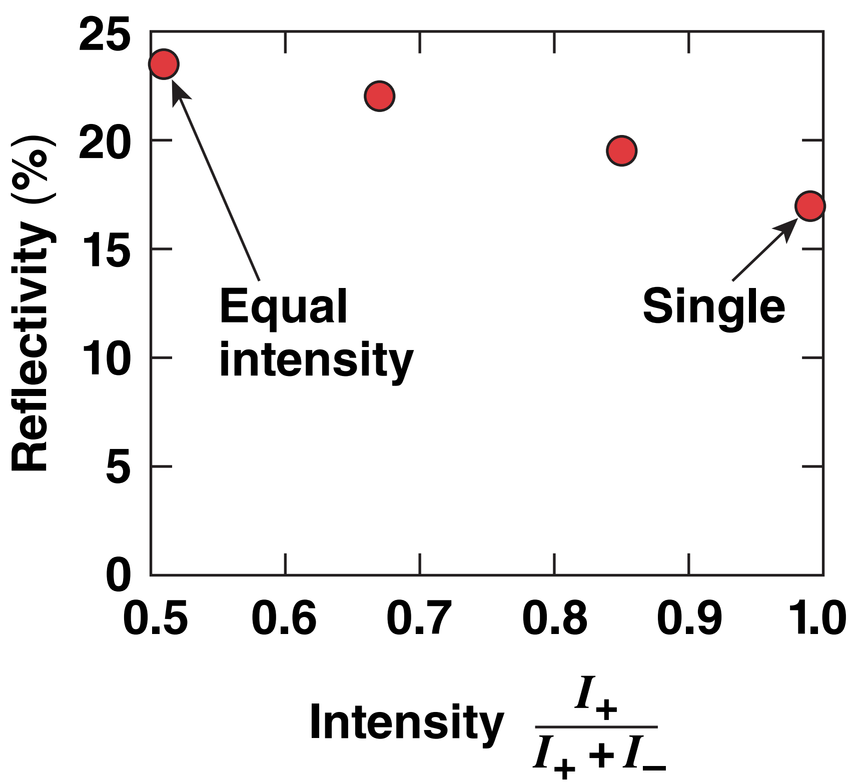
Interaction in intense hot spots

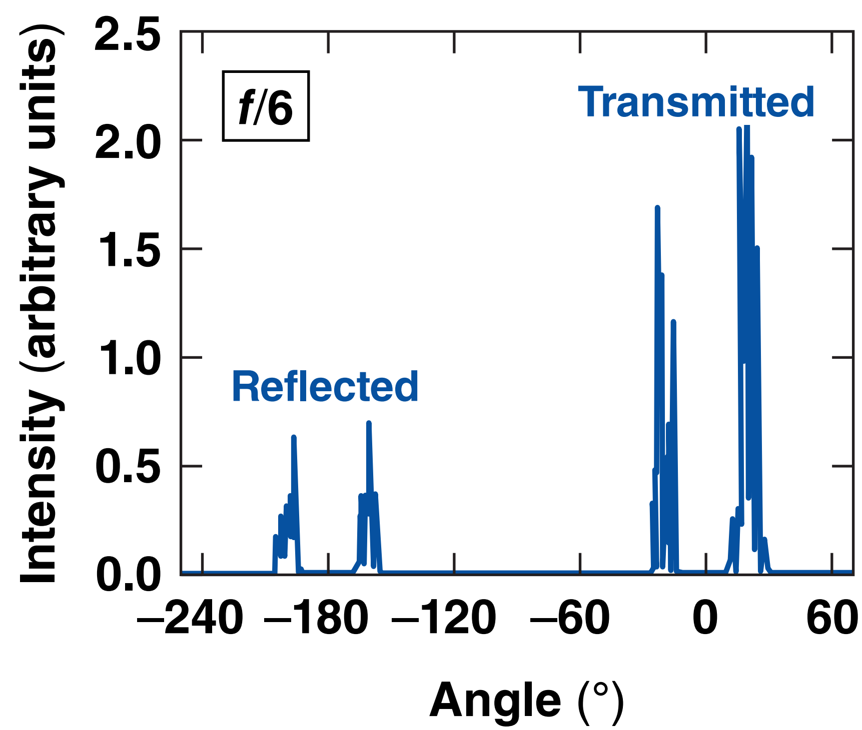
TC9445a

The reflectivity has a moderate dependence on the distribution of intensity between the driving laser beams

UR LLE

$\langle I \rangle_{14} = 7$





The hot-spot structure determines the direction of scattered light.

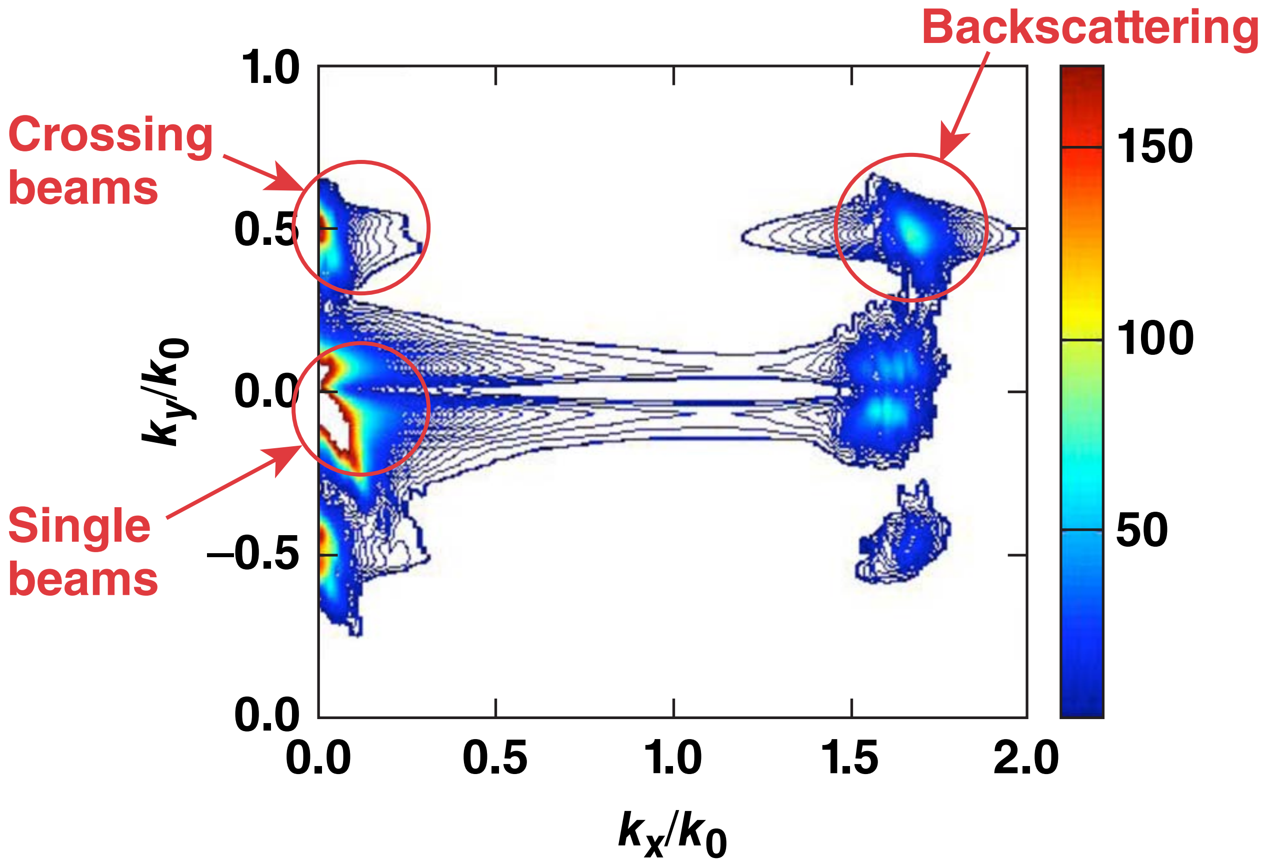
TC9798

The interaction of incoherent crossing laser beams with plasmas produces a broad spectrum of low-frequency density perturbations

UR LLE

L_n = 140 μm
T_e = 2 keV

f/6



Laser beams can share density perturbations.

TC9448a

Nonlinear interaction in intense laser speckles determines the scaling of reflectivity with intensity

Reflectivity

$$\frac{d\langle R\rangle}{dx} \sim U_m^3 e^{-U_m},$$

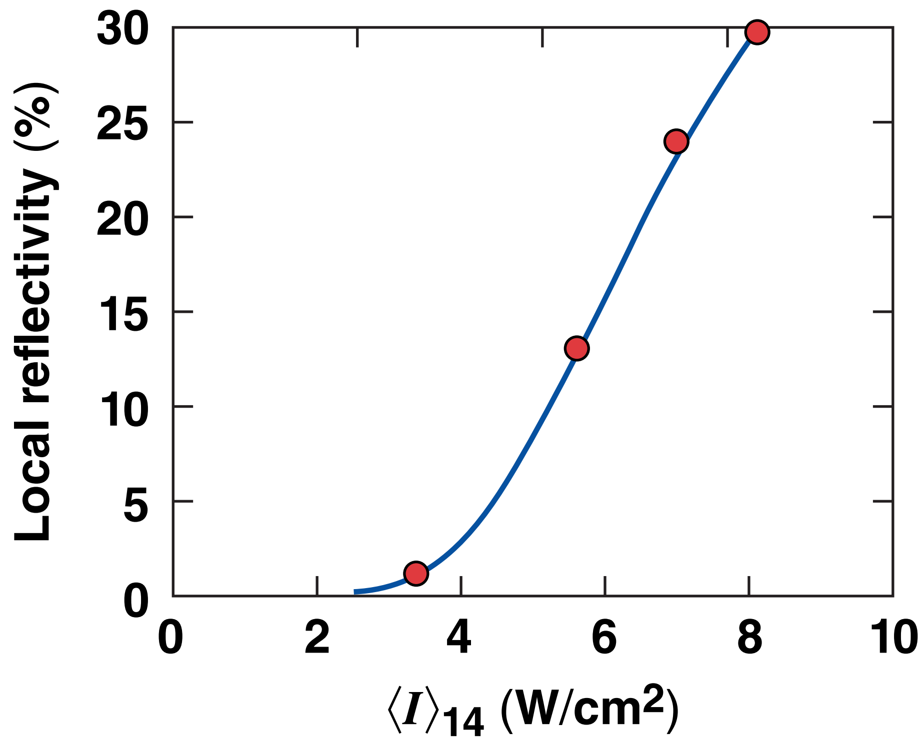
where

$$U_m \equiv \frac{I_m}{\langle I\rangle}$$

for the saturation R_{sat}

$$R_{sat} = \varepsilon\, e^{\langle G_{SBS}\rangle U_m}$$

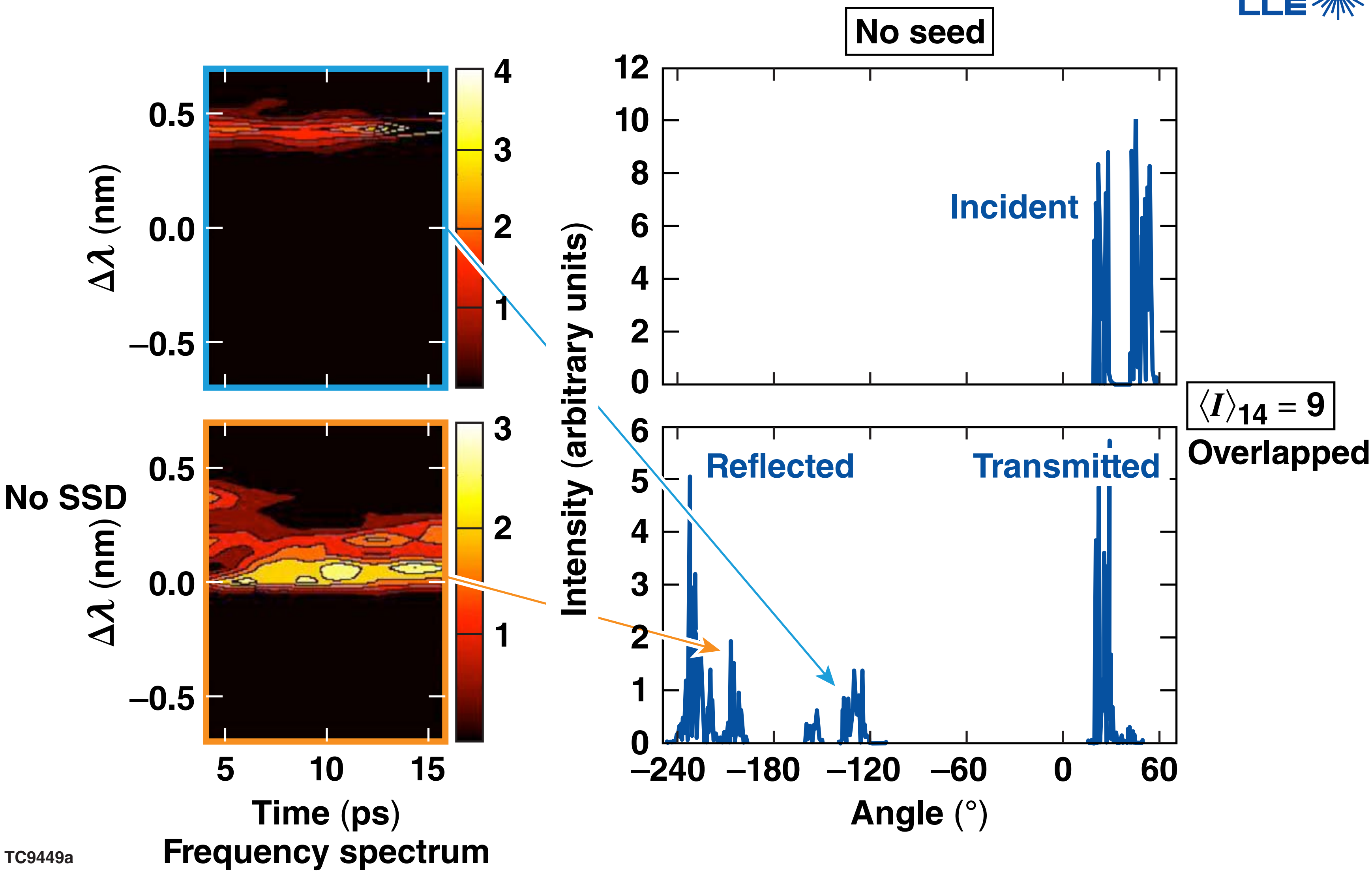
ε – seed



The reflectivity scaling is influenced by the hot-spot structure.

TC9446a

At moderate plasma densities, the interaction between beams incident at different angles leads to a broad spectrum of backscattered light



TC9449a

Summary/Conclusions

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UR LLE

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