Theoretical Interpretation of SBS Observations in OMEGA Long-Scale-Length Plasma Experiments

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Summary

SBS arises primarily in “hot spots” and seems to be seeded by light reflected from critical

- Polarization smoothing (PS) reduces the level of SBS to that seen at half the incident intensity without PS, implying that SBS levels are determined by hot-spot intensities.

- Overlapping beams do not seem to “cooperate” in driving SBS.

- The red-shifted portion of the spectrum appears to derive from light reflected from critical, but it is difficult to account for levels and shifts.
Outline

• Aspects of SBS spectra
• Ion-acoustic modes in multicomponent plasmas
• Strong-damping SBS model and calculation of growth factors in simulated profiles
• Summary and conclusions
SBS spectrum consists of distinct “red” and “blue” features

\[ I_{\text{peak}} = 7.4 \times 10^{14} \text{ W/cm}^2 \]
“Blue” feature depends exponentially on hot-spot intensity

![Graph showing the relationship between intensity and reflectivity. The graph includes data points for 'No PS', 'Rescaled PS', and 'PS'.]
“Red” feature depends linearly on hot-spot intensity

![Graph showing intensity vs. reflectivity with different PS conditions: IB, No PS, Rescaled PS, PS. The graph indicates a linear relationship between intensity (×10^14) and reflectivity (×10^-3).]
Damping is fairly high, even for the least-damped ion-acoustic mode.
In strongly damped plasmas the SBS gain may computed by integrating a local gain factor

\[ \frac{\partial I_{\text{SBS}}}{\partial x} + \frac{I_{\text{SBS}}}{L_{\text{abs}}} = \frac{I_{\text{pump}}}{L_{\text{gain}}}. \]

Here, \( L_{\text{abs}} \) is the absorption length and \( L_{\text{gain}} \) is the local gain length:

\[ L_{\text{gain}}^{-1} = k_0 \frac{\text{n_e}/\text{n_c}}{4 \sqrt{1 - \text{n_e}/\text{n_c}}} \frac{m_e v_{\text{osc}}^2}{T_e} \left[ \left( 1 + \frac{3T_i}{ZT_e} \right) \left( \frac{v_i}{\omega_s} \right) \right]^{-1} p(\eta), \]

where \( p(\eta) = \frac{\left( \frac{v_i}{\omega_s} \right)^2 \eta}{(\eta^2 - 1)^2 + \left( \frac{v_i}{\omega_s} \right)^2 \eta^2} \) and \( \eta = \frac{v_0}{c_s} + \frac{\omega_i}{\omega_s} \).

\[ \frac{\partial I_{\text{SBS}}}{\partial x} + \frac{I_{\text{SBS}}}{L_{\text{abs}}} = \frac{I_{\text{pump}}}{L_{\text{gain}}}. \]

The simulation code SAGE is used to provide the profiles of the plasma parameters over which the above equations are integrated.

\[ ^1 \text{C. J. Randall, J. A. Albritton, and J. J. Thomson, Phys. Fluids 24, 1474 (1981).} \]
The peak computed gain as a function of wavelength agrees well with “blue” feature.
The present model does not account for some observed features of the SBS emission

- Levels of the “red” feature lie below those expected from simple inverse bremsstrahlung absorption.
- The increasing red shift at later times is not accounted for by the SBS gain factor or the bulk hydro motion.
- These phenomena may result from hot-spot behavior near critical, e.g., enhanced localized absorption and Doppler shift.
Even at lower intensities the time history of the red feature suggests SBS rather than simple reflection.

\[ I_{\text{peak}} = 1.7 \times 10^{14} \text{ W/cm}^2 \]
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