Comparison of Raman Scattering Measurements and Modeling in NIF Ignition Experiments


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Comparison of Raman Scattering Measurements and Modeling in NIF Ignition Experiments


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APS-DPP Salt Lake City

November 17, 2011
Raman measurements and linear gain analyses agree in mid peak power, differ early and late

• “High Flux Model” (HFM) for rad-hydro:
  – DCA opacities, $f=0.15$ electron heat flux limiter
  – Cross-beam energy transfer: linear model w/ clamp
  – Measured backscatter removed

• Linear gain spectrum and measurements:
  – Early peak power: gain redshifted from measurement
  – Mid peak power: they agree well
  – Late peak power: gain redshifted again

• Overlapped laser (multi-quad) intensity:
  – Early peak power: gain spectrum blueshifted

• Gain and reflectivity time histories:
  – Early peak power: large reflectivity but small gain
  – Gain continuously increases in time
  – Reflectivity decreases late in peak power
Raman scattering on N111014: symcap with 30° cone pulled away from capsule

- Inner-cone repointing series
  - 1.2 MJ laser energy
  - Si-doped symmetry capsules
  - scale 5.75mm gold hohlraum
  - 3 laser colors to control spherical and azimuthal symmetry
    - $\lambda_{30} = \lambda_{\text{outer}} + 7.5 \text{ A}$
    - $\lambda_{23} = \lambda_{30} + 1 \text{ A}$

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**this talk focuses on this shot, SRS from 30° cone**

N111013: nominal
N111014: 30° repointed
N111016: both repointed

**black: 23° cone**
**red: 30° cone**
**solid: nominal**
**dashed: repointed**
Shot N11014: substantial SRS on both inner cones; little SBS

- 3 laser colors used:
  - more transfer to 23° cone to tune azimuthal symmetry

- Significant SRS early in peak power
- SRS drops before laser power late in pulse

Action reflectivity: accounts for plasmon energy by Manley-Rowe, max. of unity
Shot N111014, 30° cone: SRS gain spectrum with high-flux model simulations vs. measurements

- Rise to peak power: gain redshifted vs. measurement
- Mid peak power: good agreement
- Late peak power: gain redshifted again

Long-wavelength SRS not seen in FABS – neglected in finding max. gain
Shot N111014, 30° cone: SRS gain from two distinct regions; one from high density not observed

Gain spectrum at 18.8 ns

<table>
<thead>
<tr>
<th>wavelength [nm]</th>
<th>BSRS gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>550</td>
<td>10</td>
</tr>
<tr>
<td>600</td>
<td>30</td>
</tr>
<tr>
<td>650</td>
<td>40</td>
</tr>
</tbody>
</table>

Each ray
Ray avg

seen in FABS
not seen

Gain regions for different wavelengths

Why 600 nm SRS not seen?
- scattered light refracted out of FABS
- pump depletion from 560 nm SRS
- re-absorption
- plasma conditions
- CH / gas mix
- Langmuir decay instability saturation?
Shot N111014, 30° cone: reflectivity(t) vs. peak gain(t) from “560 nm” branch

- Early peak power: large reflectivities but small gains
- Late peak power: reflectivity drops but gains rise

- Possible reasons:
  - plasma conditions not right early in peak power
  - cross-beam transfer: saturation clamp, time history, spatial non-uniformity
  - re-amplification by crossing lasers
  - kinetic inflation early in time
gains with overlapped laser intensity: 5 nearest neighboring quads

Shot N111014, 30° cone

- Multi-quad gains peak at shorter wavelength than single-quad gains:
  - beams overlap near LEH: lower electron density

- Early peak power: single- and multi-quad gains bracket observed wavelength

- Late peak power: gain peaks beyond overlap region, single- and multi-quad agree
Multi-quad gains are larger than single-quad; same qualitative time history

Shot N111014, 30° cone:
SRS on NIF: better PLI (plasma, laser, and interaction) models should improve connection of gain to experiment

• Early peak power: current understanding is incomplete
  – Single-quad gain redshifted vs. measurement
    • Multi-quad gain blueshifted: brackets measurement

  – Large reflectivity for small gain
    • cross-beam transfer
    • Re-amplification
    • Kinetic inflation

• Mid peak power: Gain and measured spectra agree
  – Reflectivity large for gain 15-20

• Late peak power: reflectivity drops, gain doesn’t
  – Gain redshifted vs. measurement again
  – Scattered light refracted out of detector?
  – Re-absorption?
  – Trapping / Langmuir decay instability saturation?
Backup slide

time = 17.5046 ns
one Q [blk], other 23 [red], sum [blu], FABS [grn] 2*G1+others [mag]