Comparison of Raman Scattering Measurements and Modeling in NIF Ignition Experiments


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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
    - $\lambda_{30} = \lambda_{\text{outer}} + 7.5 \text{ A}$
    - $\lambda_{23} = \lambda_{30} + 1 \text{ A}$

black: 23° cone
red: 30° cone
solid: nominal
dashed: repointed

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

N111013: nominal
N111014: 30° repointed
N111016: both repointed
Shot N111014: substantial SRS on both inner cones; little SBS

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

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

measured SRS spectrum in FABS  gain spectrum from LASNEX simulation
Shot N111014, 30° cone: SRS gain from two distinct regions; one from high density not observed

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