Shock ignition
- Shock ignition (SI) [1]: an initial low-intensity drive compresses the target with a low-implosion velocity to avoid hydrodynamic instabilities, followed by a high-intensity spike that ignites the target.
- Laser–plasma instabilities (LPSE) [2] in the SI regime: the high-intensity spike ($\sim 10^{19} \text{ W/cm}^2$) strongly drives LPIs in the near plasma, potentially generating a large amount of hot electrons.

- Stimulated Raman scattering (SRS): coupling between the pump wave (frequency $\omega_p$) and electron density perturbation (frequency $\omega_{\text{RI}}$, generating backscattered light (Raman frequency $\omega_{\text{R}} = \omega_p + \omega_{\text{RI}}$)). Its saturation can cause hi-electron production.
- Stimulated Brillouin scattering (SBS): coupling between the pump wave and ion-density perturbation (frequency $\omega_{\text{B}}$, creating backscattered light (Brillouin frequency $\omega_{\text{B}} = \omega_p - \omega_{\text{IC}}$)).
- AII: modeling of SRS and SBS in 1D with LPSE under plasma and laser conditions relevant for SI; comparison to particle-in-cell (PIC) simulations and experimental results.

LWSE
- LWSE [3]: a time-enveloped, non-perturbative code for studying parametric instabilities and electron acceleration at scales intermediate to hydrodynamic and kinetic codes; linear fluid/plasma description; lower numerical noise than PIC codes.
- LPSE includes the following equations:
  - Pump electric field: time enveloped around the laser frequency $\omega_p$: accounts for laser collisional absorption, diffraction, and self-focusing and absorption as a result of SRS and two-plasmon decay (TPO is not modeled in 1D).
  - Langmuir waves $\omega_{\text{LW}}$: a Zakharov-like equation, enveloped at frequency $\omega_{\text{LW}}$: the Langmuir wave is seeded by a small noise term and accounts for collisional absorption and Landau damping.
  - Raman field: time enveloped around the Raman frequency $\omega_{\text{R}} = \omega_p + \omega_{\text{IC}}$: excitation of the Raman light by coupling between the pump field and the LW; accounts for collisional absorption.
  - Ion-acoustic fluctuation: fluid/plasma equations for linear ion perturbation: there is one equation for particle conservation and another for momentum conservation; the plasma response is coupled to fields through ponderomotive terms; accounts for ion wave damping.
  - Hybrid particle evolution: test particles package; switched off throughout this work.

Comparison to PIC results
- LPSE accuracy is tested in the SI regime against long spatial and time-scale PIC simulations [3]: goal: compare measurable quantities such as the total reflectivity and SRS spectra.

LPSE
- Instantaneous SRS and SBS reflectivity as functions of time: $R_{\text{RS}}$ and $R_{\text{SB}}$ as functions of time, with different pump intensities.

PIC
- Red curve: peaks are a result of SBS behavior (transient stage—up to 35 ps), followed by saturation at $\sim$50% to 40% caused by absolute SRS and caviton.

Reflectivity saturation around 57% is caused by Langmuir decay instability; the initial spike results are from SBS, then suppressed by SRS.

Raman spectra
- $I_{\text{LW}} (t)$ vs. $n_i$: LPSE results for Raman scattering.

Conclusion and perspectives
- Laser–plasma instabilities within the shock-ignition regime are studied with the code LPSE. Electron acceleration is neglected here.
- LPSE results concerning experimentally measurable quantities, such as light reflectivity and Raman spectrum, are in agreement with PIC results.
- Simulations of experimental results: the early laser–plasma interaction shows a strong pump depletion for simulations around quarter critical. A shift in the Langmuir wave oscillation position may be associated with a weaker signal from LPSE.
- Future studies:
  - Simulations around critical stage: shift in the LW oscillation position as a result of strong pump depletion; gives a lower absolute SRS signal, as seen in the spectrum.

Conclusion
- Broad spectrum in Raman light found in LPSE, as in data; cut off on the maximum frequency of the convective SRS spectrum for LPSE caused by the envelope limit.
- Simulations around quarter critical: shift in the LW oscillation position as a result of strong pump depletion; gives a lower absolute SRS signal, as seen in the spectrum.

References