Stimulated Raman scattering coupled withdecay instability in a magnetized plasma with hot drifting electrons

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Introduction to Inertial Confinement Fusion

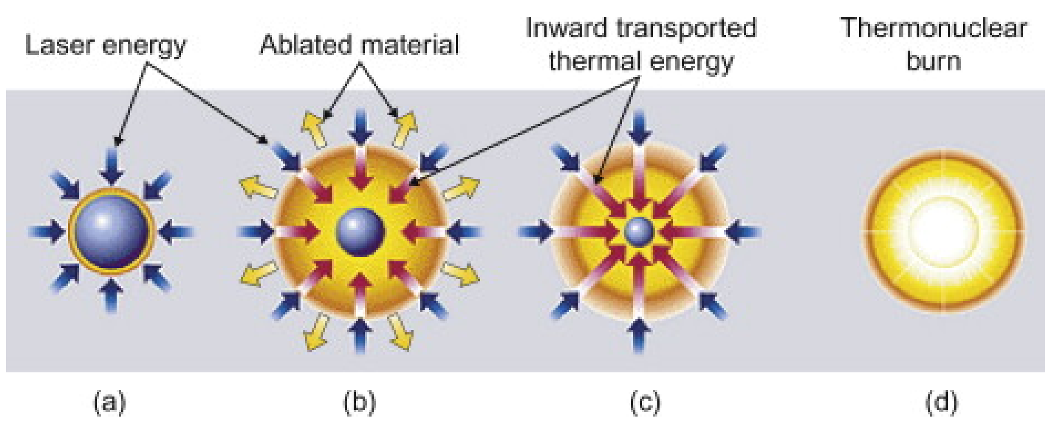


Figure 1. Inertial Confinement Fusion

- Lasers symmetrically irradiate the pellet
- Hot plasma expands into the vaccum. Rocket-like reaction to this is the implosion of the fuel.
- Most of the fuel is compressed to around 1000 g cm^3
- $\approx$ 100,000,000 Kelvin hotspot created at the center of the fuel by shock heating leads to ignition and fusion burn.

Stimulated Raman Scattering

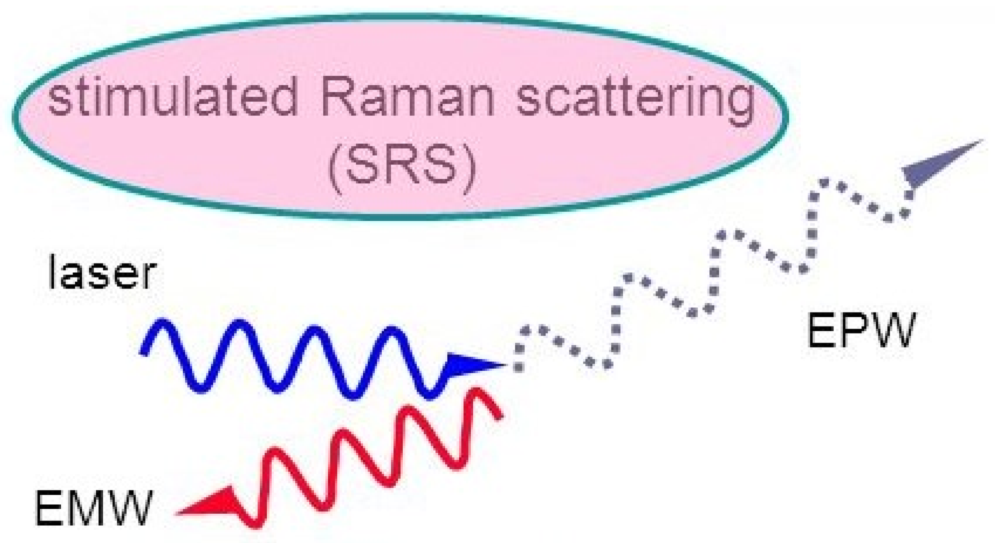


Figure 2. Stimulated Raman scattering process

- SRS, producing a langmuir wave and scattered wave (called side-band)at densities below one-forth of critical density.
- $n_o^o \leq n_{cr}/4$
- n_{cr}, i.e., critical density corresponds to where plasma frequency is equal to pump frequency

Challenge in ICF and Our Objective

- SRS is one of the major causes for pre-heating of fuel in ICF
- The objective of this work is to suppress SRS coupled with decay instability by applyig static magnetic field.

Importance of Magnetic Field in plasma

- A charged particle undergoes a circular orbit in the plane perpendicular to the direction of the field when placed in a magnetic field. Due to the combined influence of magnetic field and ponderomotive force, charged particle executes the spiral trajectory.
- The externally applied magnetic field not only enhance the strength of ponderomotive force, but also provide an additional momentum to the plasma electrons and retains the energy to longer distance.
- The applied azhimuthal magnetic field provides the additional perpendicular component of nonlinear current density, results the significant gain in amplitude of EMW.

$\vec{B_o} = \frac{c(\vec{k_o} \times \vec{E_o})}{\omega_o}$

Laser-Plasma profile: Magnetized density rippled plasma

- n_o^o is electron populations at temperature T_e and n_h^o as density of hot electrons at temperature T_h
- Consider a high power laser with frequency ω_o, $\vec{E_o} = \hat{x} A \exp[-i(\omega_o t - k_o z)]$ propagating through plasma with static magnetic field $B_s \hat{z}$

Coupling of SRS and decay instability

- The laser couples to a backscattered electromagnetic sideband wave of field, $\vec{E_1} = \hat{x} A \exp[-i(\omega_1 - k_1 z)]$, and a daughter plasma wave (EPW_1) of potential $\Phi_w = \phi_w \exp[-i(-k_w z)]$ where $\omega_1 = \omega - \omega_o$ and $k_1 = k - k_o$
- The electron plasma wave EPW_1 decays into ion acoustic wave (IAW) of potential $\Phi_s = \phi_s \exp[-i(\omega_s t - k_s z)]$ and a back scattered EPW_2 of potential $\Phi_d = \phi_d \exp[-i(\omega_d t - k_d z)]$ where $\omega_d = \omega_s - \omega$ and $k_d = k_s - k_w$.
- The electrons acquire oscillatory velocity, $v_1 = \frac{eE_1}{im(\omega_1 - \omega_c)}$, from the scattered wave. At $(\omega, \vec{k_w})$, where $\Phi_p = \phi_s \exp[-i(\omega_d t - k_d z)]$. Here, ω_c is the cyclotron frequency.

Five wave theory

We obtain the coupled equations,

$$\frac{\partial a_o}{\partial \tau} + i\frac{l_w^2 pq^2 f_o}{4} a_w(\tau) a_1^*(\tau) \quad (1)$$

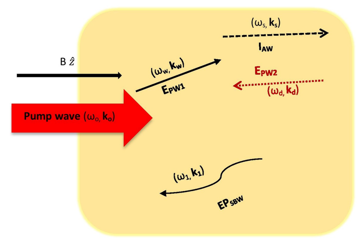
$$\frac{\partial a_1}{\partial \tau} + C a_1(\tau) + i\frac{l_w^2 pq^2 f_1}{4} a_w(\tau) a_o^*(\tau) \quad (2)$$

$$\frac{\partial a_w}{\partial \tau} + \gamma_w a_w(\tau) - i\frac{\chi_e W}{4p} a_o(\tau) a_1(\tau) + i\frac{l_d l_s^2 \chi_{es} pq^2 f_o^2}{4 l_d f_d} a_s(\tau) a_w^*(\tau) \quad (3)$$

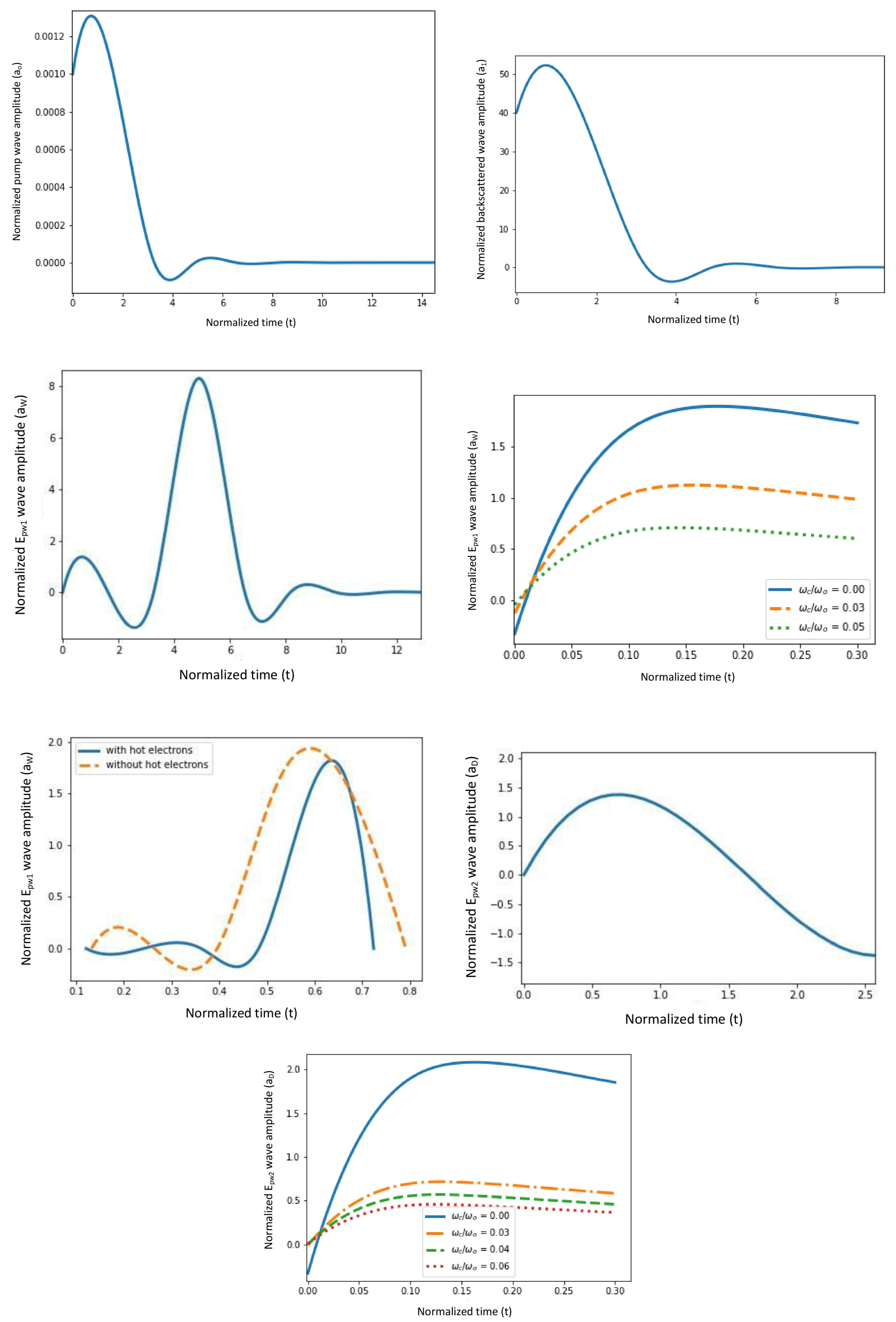
$$\frac{\partial a_d}{\partial \tau} + \gamma_d a_d(\tau) - i\frac{l_w l_s^2 \chi_{es} pq^2 f_o^2}{4 l_d f} a_s(\tau) a_w^*(\tau) \quad (4)$$

$$\frac{\partial a_s}{\partial \tau} - i\frac{f_s^3 \chi_{es} l_d l_w pq^2 f_o^2}{4 l_d f} a_s(\tau) a_d(\tau) \quad (5)$$

Schematic Diagram



Results and Conclusions



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