Laser-Plasma Interactions with and without a Magnetic Field

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Inertial Confinement Fusion (ICF) with Magnetic Field
MagLIF [Sandia]
Laser preheat: ~10 kJ, T_{ion} ~ 500 eV
B_0 ~ 30 T to confine fusion alpha's
Cylindrical liner implosion

Parametric Decay of Light Waves in a Plasma
Stimulated Brillouin scattering (SBS):
EMW (0) → IAW (2) + EMW (1)
Stimulated Raman scattering (SRS):
EMW (0) → EPW (2) + EMW (1)

- EMW: electromagnetic wave
- EPW: electron plasma wave
- IAW: ion acoustic wave

Phase Matching: Conserve Energy and Momentum
\omega_0 = \omega_1 + \omega_2
k_0 = k_1 + k_2

Parametric Instabilities can impede ICF
- Decay produces waves which are resonant in the plasma (SRS, SBS)
- Scattered light removes energy from target, damages optics
- EPW's from SRS produce "hot" electrons, can preheat capsule

B Fields can play a role in ICF:
- Imposed axial B field in MagLIF to confine thermal electrons and alphas
- Imposed field under consideration for NIF hohlraums
- Plasmas can self-generated B fields

Governing Equations for Cold Electrons and Fixed Ions
Maxwell's equations
\nabla \times E = \frac{\partial B}{\partial t}
\nabla \times B = -\frac{\partial E}{\partial t}
Continuity and fluid momentum equations
\frac{\partial n}{\partial t} + \nabla \cdot (n \mathbf{v}) = 0
\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} = -\nabla P + n e \mathbf{E} + \frac{1}{2} \mathbf{v} \times \mathbf{B}

Fourier representation of E field
E = \sum_k E_k e^{i(k_x x + k_y y + k_z z)} + c.c
Second order coupling terms in red

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

Acknowledgements
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