Assignment 3

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Task 11

From $\omega_{pe}^2 = \frac{ne^2}{m_e \varepsilon_0}$ => density $n = \frac{\omega_{pe}^2 \cdot m_e \varepsilon_0}{e^2}$

where ω_{po}^2 - plasma frequency.

If we consider a situation

$$\begin{cases} n_c = \omega^2 \cdot (e^2/m_e \varepsilon_0)^{-1} \text{ and} \\ n_c = \left(\frac{\lambda_{laser}}{1\,\mu m}\right)^{-2} \times 10^{21} /cm^3 \end{cases}$$

and $n_c = n_c$

$$\omega^2 \left(\frac{e^2}{m_e \varepsilon_0}\right)^{-1} = \left(\frac{\lambda_{laser}}{1\,\mu m}\right)^{-2} \cdot 10^{21} \Rightarrow$$

$$\Rightarrow \omega^2 = \left(\frac{\lambda_{laser}}{1\,\mu m}\right)^{-2} \cdot 10^{21} \times \frac{e^2}{m_e \varepsilon_0}$$

$$n = \omega_{pe}^2 \frac{m_e \varepsilon_0}{e^2} = \left(\frac{\lambda_{laser}}{1\,\mu m}\right)^{-2} \cdot 10^{21} \frac{e^2}{m_e \varepsilon_0} \frac{m_e \varepsilon_0}{e^2}$$

$$n = \left(\frac{\lambda_{laser}}{1\,\mu m}\right)^{-2} \times 10^{21} \text{ el.}/cm^3$$

$$n = \left(\frac{1.053\,\mu m}{1\,\mu m}\right)^{-2} \times 10^{21} = \boxed{9.0 \times 10^{20} \text{ electrons}/cm^3}$$

$$\rho = \frac{A}{Z} n \cdot m_p = \frac{13}{7} \cdot 9.0 \times 10^{20} \times 1.67 \times 10^{-24} = 2.8 \cdot 10^{-3} \frac{g}{cm^3}$$

where A is atomic number, Z - charge.

if the laser has 3ω,

$$\lambda_{laser} = \frac{1}{3} \times 1.053\ \mu m$$

$$n_e = \left(\frac{1/3 \cdot 1.053\ \mu m}{1\ \mu m} \right)^{-2} \times 10^{21} = 8.1 \times 10^{21}\ \frac{\text{electrons}}{cm^3}$$

$$\rho = \frac{A}{Z} n_e \cdot m_p = \frac{13}{7} \cdot 8.1 \times 10^{21} \times 1.67 \cdot 10^{-24} =$$

$$= 2.5 \times 10^{-2}\ \frac{g}{cm^3}$$

Task 12

SRS (Stimulated Raman Scattering) is the decay of a laser photon into Electromagnetic wave (EM wave) and electron plasma wave.
SBS (Stimulated Brillouin Scattering) is the decay of a reflected photon and ion sound wave.
Two plasmon decay ($2\omega_{pe}$) is decay of a photon into 2 electron plasma waves.

In general these instabilities are undesirable: they scatter light in unintended directions and generate hot electrons, which preheat the fuel.
SRS generate electrons of energy of 50 keV,

SRS happens below 1/4 critical density.
$\rho < 1/4 \cdot 2.8 \cdot 10^{-2} = 7 \cdot 10^{-3}\ g/cm^3$
SBS happens at any plasma density < crtitical, $\rho < 2.8 \cdot 10^{-2}\ g/cm^3$
$2\omega_{pe}$ occurs only at 1/4 surface.
($7 \cdot 10^{-3}\ g/cm^3$)

Task 14

$$\left(\frac{T_{R\,crit}}{100\,eV}\right) = 4.23 \cdot \left(\frac{\rho}{1\,g/cm^3}\right)^{2/5} \mu^{-3/5}$$

$$T_{R\,crit} = 100 \times 4.23 \cdot \left(\frac{\rho}{1\,g/cm^3}\right)^{2/5} \cdot \mu^{-3/5}$$

$$\mu = \frac{A}{Z+1} = \frac{12+1}{6+1} = \frac{13}{7} = 1.85,$$

where A is atomic number,
Z is charge

$$T_{R\,crit} = 100 \times 4.23 \cdot \left(\frac{0.050}{1\,g}\right)^{2/5} \cdot (1.85)^{-3/5} =$$

$$= 100 \times 4.23 \times 0.30 \times 0.69 = \underline{88\ eV}$$

$$\boxed{T_{crit} = 88\ eV}$$

Task 16

Rayleigh Taylor (RT) Instability is "perturbation" or "bubble and spike growth" of materials, it occurs when grad of preasure has opposite direction of density.

a) "Ablative Stabilisation" is an injection of exhausted plasma from high adiabat materials into the capsule in order to surpress RT instability.

b) "Adiabat shaping" is making a capsule of low and high adiabat materials. We need such a structure because higher ablation velocities result in greater ablative stabilisation of RTI. But inside the shell the fuel needs to remain a low adiabat for effiecient compression. Such a structure of the capsule can be achieved by shoting an ultrashot laser pulse before the main pulse.