TAMING OF ELECTROMAGNETIC INSTABILITIES IN FAST IGNITION SCENARIOS FOR ICF AND REB STOPPING

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We focus attention on the rapidly growing electromagnetic - instabilities arising in the interaction of intense and relativistic electron beams (REB) with supercompressed thermonuclear fuel. REB-target system is considered neutralized in charge and current with a distribution function including beam and target temperatures.

The electromagnetic filamentation (Weibel) instability is first considered analytically in a linear approximation. Relevant growth rates parameters then highlight density ratio between target and particle beams, as well as transverse temperatures. Significant refinements include mode- mode coupling and collisions with target electrons. The former qualify the so-called quasi-linear (weakly turbulent) approach. Usually, it produces significantly lower growth rates than the linear ones. Collisions enhance them slightly for $kc/\omega_p < 1$, and dampen them strongly for $kc/\omega_p \geq 1$. In a low temperature target plasma, intrabeam scattering also contributes to the instability taming, while keeping it close to zero in a warm plasma. Our numerical exploration provides further support to the cone-angle configuration (Osaka experiment) with REB penetrating close to the dense core of superdense deuterium + tritium fuel.

Growth rates (GR) .of the transverse Weibel electromagnetic instabilities (WEI) are considered for the interaction of very intense relativistic electron beams (REB) and nonrelativistic protons in the MeV energy range, with precompressed deuterium + tritium (DT) thermonuclear fuel. Particle density ratios for the target and beam plasmas are in the range $10^4 \geq \frac{n_p}{n_b} \geq 10$ with respective transverse temperature T_p and T_b.

Scanning an extensive parameters range of fast ignition concern, we found that present GR are systematically much smaller than linear ones, especially in the crucial wave- number range $01 \leq \frac{kc}{\omega_p} \leq 1$.

These findings permit to limit the number of e-foldings of the WEI to an acceptable figure ≤ 5-6.

We then turn to the linear stability of the system formed by an electron beam and its return plasma current within a more general framework, namely, for any orientation of the wave vector **k** with respect to the beam and without any *a priori* assumption on the orientation of the electric field with respect to **k**. We apply this formalism to three configurations: cold beam and cold plasma, cold beam and hot plasma, and cold relativistic beam and hot plasma. We proceed to the identification and systematic study of the two branches of the electromagnetic dispersion relation. One pertains to Weibel-like beam modes with transverse electric proper waves. The other one refers to electric proper waves belonging to the plane formed by **k** and the beam, it divides between Weibel-like beam modes and a branch sweeping from longitudinal two-stream modes to purely transverse filamentation modes. For this latter branch, we thoroughly investigate the intermediate regime between two-stream and filamentation instabilities for arbitrary wave vectors. When some plasma temperature is allowed for, the system exhibits a critical angle at which waves are unstable for every *k*. Besides, in the relativistic regime, the most unstable mode on this branch is reached for an oblique wave vector.

The stopping mechanisms of relativistic electron beams (REB) in superdense and partially degenerate electron fluid targets are investigated in the framework of the fast ignitor concept for inertial confinement fusion. In order to comply with specific demands in this area, we focus attention on the target partial degeneracy parameter $\theta = T_e / T_f$, in terms of thermal to Fermi temperature ratio. Target electron fluid (TEF) is thus modelled very accurately with a random phase approximation (RPA) dielectric function. Stopping results are shown very weakly θ-dependent. However, a quantum target description is needed to recover their correct and increasing trend with increasing projectile energy. Ranges and effective penetration depths in precompressed thermonuclear fuels are shown to be nearly a factor of two shorter than earlier classical estimates in same conditions. Overall conclusions pertaining to the feasibility of fast ignition thus remain unchanged.