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Superposition of Two Counter Propagating Relativistic Whistler Waves

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In plasma-based fusion science the primary goal is to heat the ions for efficient fusion reaction to occur. When an electromagnetic wave is incident in a plasma, normally electrons take away most of the energy of the electromagnetic field. The energy transfer to ions is not direct and hence is relatively inefficient. An important open question is whether there are methods to directly couple the electromagnetic energy to ions. In this work, we propose a novel mechanism of ion heating by the superposition of two counter propagating relativistic whistler waves.

In contrast to the non-relativistic case, with the same laser intensity and external magnetic field strength, we establish a comprehensive studies on the relativistic whistler waves interaction physics. It is found that relativistic theory predicts much stronger electric field amplitude compared to the non-relativistic case. [1–5] Evidently, the relativistic theory correctly explains the physics of such electrostatic field generation. The strong electric field in the generated stationary wave can be used to heat the ion in the plasma.

The results are then compared with the 2D Particle in Cell simulation OSIRIS. [6,7] Simulation is performed with hydrogen plasma as target [density=3.37*10^{22} /cc] and magnetic field around 100 KT. Our method of direct ion heating predict ion temperature exceeding several KeV. Therefore, standing whistler waves can provide an alternative ion heating mechanism in the fast ignition scheme. [2,3]

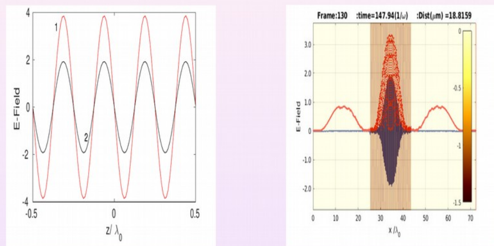

Figure: (Left) Normalized static electric field $eE_z/m\omega c$ for electromagnetic field strengths ($a_0 = 2.65$) for non-relativistic case ($1 \rightarrow$ from relativistic theory, $2 \rightarrow$ from Ref. 3). We choose $H_0/H_c = 7.47, n_0/n_c = 19.3$ with $H_c = m\omega c/e$ and $n_c = (m\omega^2/4\pi e^2)$. (Right) OSIRIS simulation result with laser electric field $eE_\perp/m\omega c$ (in red) and lomgitudinal electrostatic field $eE_x/m\omega c$ (in blue) for electromagnetic field strengths ($a_0 = 2.65$). Here we choose $H_0/H_c = 7.47, n_0/n_c = 19.3$ with $H_c = m\omega c/e$ and $n_c = (m\omega^2/4\pi e^2)$.

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