ON THE DEPENDENCE OF THE CUTOFF IN UPSHIFTED SEE

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A new mechanism for the cutoff mechanism in stiulated electromagnetic emissions from optically pumped plasma is presented.

The phenomena of SEE is now well known [1]. It ocurs when the ionosphere is pumped by a radio–frequency O–mode wave. When the pump wave frequency, ω_0, is slightly above an electron cyclotron harmonic, $p\Omega_e$, p being an integer and Ω_e the electron cyclotron frequency, the SEE spectrum exhibits a prominent maximum, upshifted from the pump and emprically observed to be at the frequency around $2\omega_0 - p\Omega_e$. There is a cutoff in the spectrum when the upshifted feature, known as the Broad Upshifted Maximum, approaches the pump. We present a new and simple explanation of the cutoff. In a previous work [2] the cutoff frequency was interpreted as the minimum possible lower hyrbrid wave frequency participating in a three wave parametric instability plus turbulent upconversion mechanism. The three wave process involved the pump wave, whose frequency ω_0 was slightly greated that an integer p times the electron cyclotron frequency Ω_e, decaying into a lower hybrid and electron Bernstein wave. Due to the presence of pump induced density irregularities, lower hybrid waves in this process necessarily picked up a large wavenumber component $\vec{k}_\perp$ perpendicular to the ambient magnetic field, $\vec{B}_0$. The corresponding minimum frequency of the lower hybrid wave then introduced a cutoff in the SEE spectrum.

A simple mechanism for the cutoff discussed in that work was that it is only possible for lower hybrid waves and electron Bernstein waves to coexist within a small angle, $\theta = k_0/k_\perp \ll \sqrt{\frac{m}{M}}$ around an axis perpendicular to $\vec{B}_0$. This limitation gives a minimum perpendicular wavenumber which then gives a minimum lower hybrid wave frequency and hence cutoff frequency in the mechanism proposed for the BUM feature. However, for left hand polarized electromagnetic pump waves of frequency ω_0 the cutoff frequency will then go like $\sqrt{p}$. In contrast, a linear relation is seen in experiment and this simple and elegant mechanism was dismissed. In the present work we have included large density depletion which significantly modify the dispersion relation of the pump wave and yield a cutoff frequency which is linear in p as in experiment. Taking the dispersion relation for left hand polarized electromagnetic waves, including large scale depletions via the ansatz $\omega_e^2 = \omega_{e0}^2(1 + \delta n/n_0)$, we calculate k_0 at the upper hybrid resonance. Substituting

k_0 into the above inequality for θ, $k_\perp$ is found. With this value of $k_\perp$ the dispersion relation for lower hybrid waves then gives

$$\omega_c^2 = \Omega_i\Omega_e + b: \quad b \gg p\Omega_e^2 \frac{v_e^2}{c^2}(1 + 3T_i/T_e)(1 + (p-1)\delta n/n_0). \qquad (1)$$

In physical dimensions b gives a cutoff at an offset of a few kiloherz for ionospheric parameters but because of the inequality we cannot predict exactly what the cutoff should be at this moment, only its qualitative behaviour and lowest allowed value, which does not contradict experiment. It is seen that even for $\delta n/n_0$ there is a large increase in ω_c for high enough harmonics.

Large depletions, larger that 50% have been observed in Arecibo, albeit under rather special conditions. It the arguments presented here are correct, then observation of the cutoff effect may serve as a method of investigating ionospheric depletions. Thus, SEE could be used as a remote diagnostic to complement radar, rocket or satellite measurements.

REFERENCES

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