

# Ion-beam-plasma electromagnetic instabilities

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It is well known that ion-beam-plasma interactions can destabilize right- and left-hand polarized electromagnetic waves. Owing to the fact that these instabilities have mostly been studied numerically by solving the hot-plasma dispersion relation, their fluid nature has often gone unnoticed. Choosing the ion background to be the rest frame, it is shown that the right-hand polarized instabilities are the result of a merging of the magnetosonic/electron-cyclotron branch of the dispersion relation with the ion beam. For any given ion-beam density and sufficiently large beam velocity, there are always two right- and two left-hand polarized instabilities leading to forward-propagating electromagnetic waves. It is also shown that all right-hand polarized instabilities are resonant instabilities, satisfying  $\omega - kU + \omega_p = 0$  around their maximum growth rate ( $\omega$  and  $k$  are the frequency and the wavenumber respectively,  $U$  is the beam velocity, and  $\omega_p$  is the proton gyrofrequency). Likewise, when the two l