

RADIATION BELT ELECTRON ACCELERATION AND LOSS DUE TO RESONANT WAVE-PARTICLE INTERACTIONS: BACKGROUND THEORY

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GYRORESONANCE CONDITION

$$y = \frac{x + a}{\beta \cos \alpha}$$

$$x = \frac{\omega}{|\Omega_e|}, \quad y = \frac{ck}{|\Omega_e|}$$

$\alpha =$ **pitch-angle**

$$a = s\lambda/\gamma$$

$|\Omega_e| =$ **electron gyrofrequency**

$$E = E_{kin}/(m_\sigma c^2) = \gamma - 1$$

$s = 1$ **R-mode** }

$s = -1$ **L-mode** }

$$\beta = \frac{v}{c} = \frac{[E(E + 2)]^{1/2}}{E + 1}$$

$\lambda = -1$ **electrons** }

$\lambda = \varepsilon$ **protons** }

DISPERSION RELATION

$$\frac{y^2}{x^2} = 1 + \frac{1}{\alpha^* x} \left(\frac{1}{s - x} - \frac{\varepsilon \eta_1}{x + s\varepsilon} - \frac{\varepsilon \eta_2}{4x + s\varepsilon} - \frac{\varepsilon \eta_3}{16x + s\varepsilon} \right)$$

$$\alpha^* = |\Omega_e|^2 / \omega_{pe}^2$$

$$\varepsilon = m_e / m_p$$

$$\eta_1 = N_1/N_0, \quad \eta_2 = N_2/N_0, \quad \eta_3 = N_3/N_0$$

(hydrogen, helium, oxygen)

$$\eta_1 + \eta_2 + \eta_3 = 1$$

(FIELD-ALIGNED WAVES)

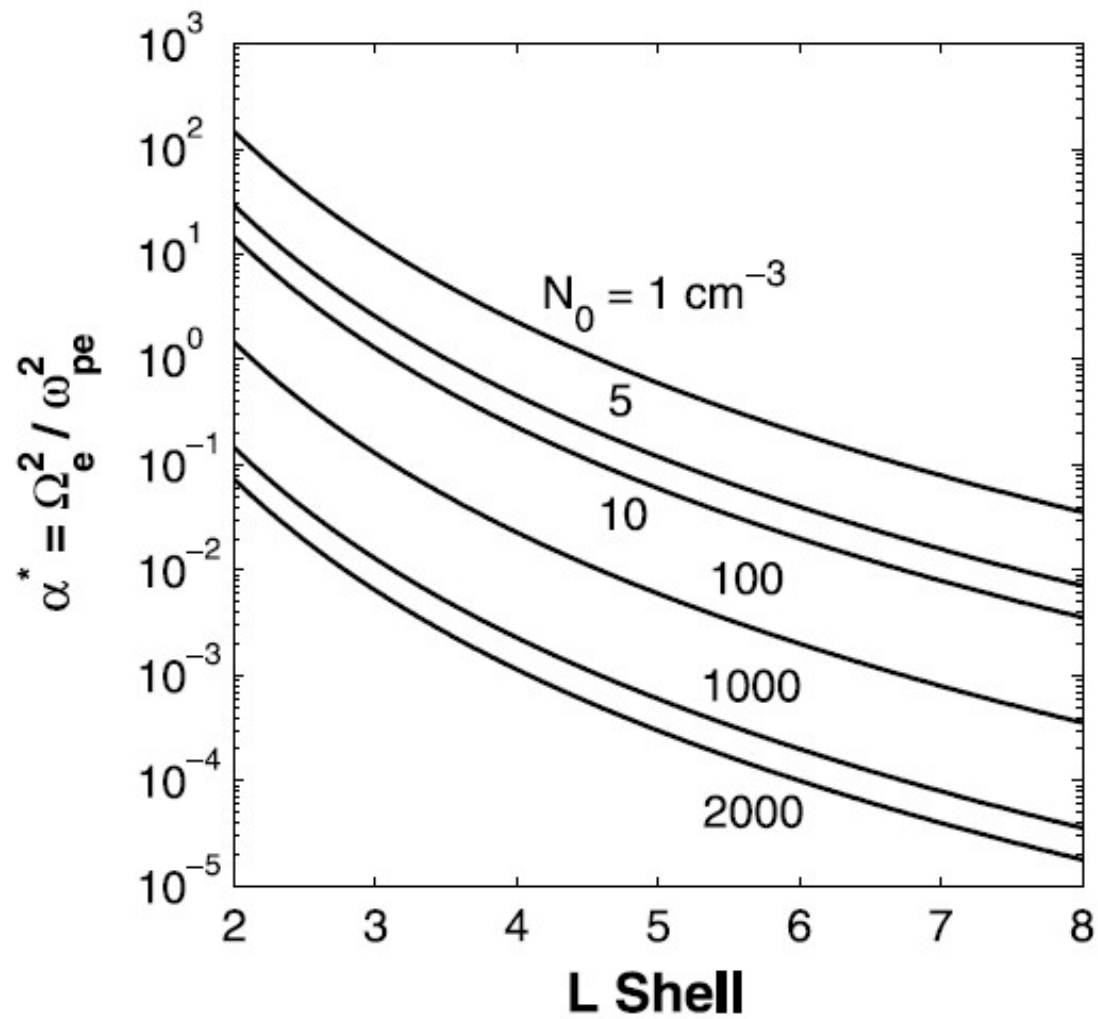


Figure 1. Equatorial variation of the parameter α^* with L , from (15), for a dipole geomagnetic field, for specified values of the electron number density N_0 .

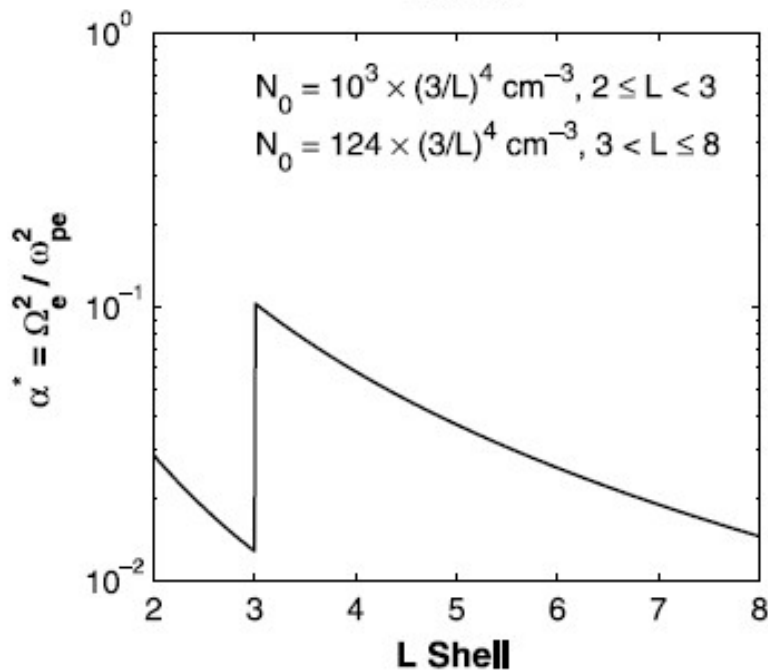
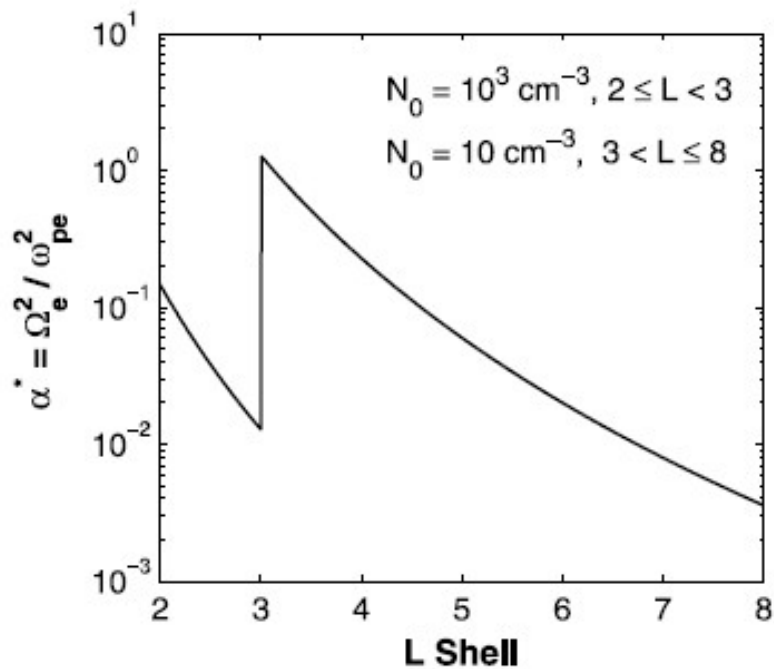


Figure 2. Equatorial profiles of the parameter α^* for a dipole geomagnetic field, with the plasmapause boundary located at $L = 3$. Assumed density N_0 profiles inside ($2 \leq L < 3$) and outside ($3 < L \leq 8$) the plasmasphere are specified in the top and bottom.

Hydrogen Plasma

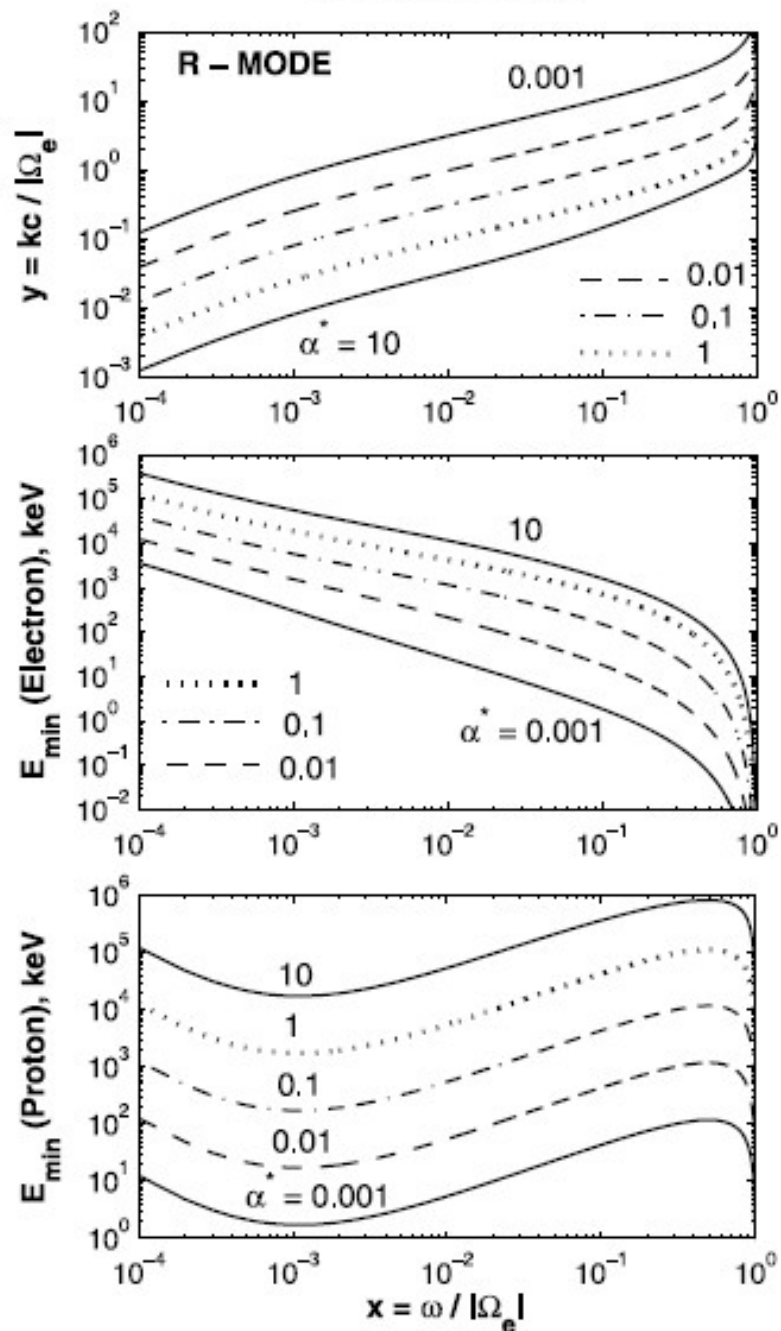


Figure 3. R-mode dispersion curves for a hydrogen plasma for specified values of $\alpha^* = \Omega_e^2 / \omega_{pe}^2$ (top). Corresponding minimum resonant energy profiles for electrons (middle) and protons (bottom).

Hydrogen & Multi-ion Plasmas

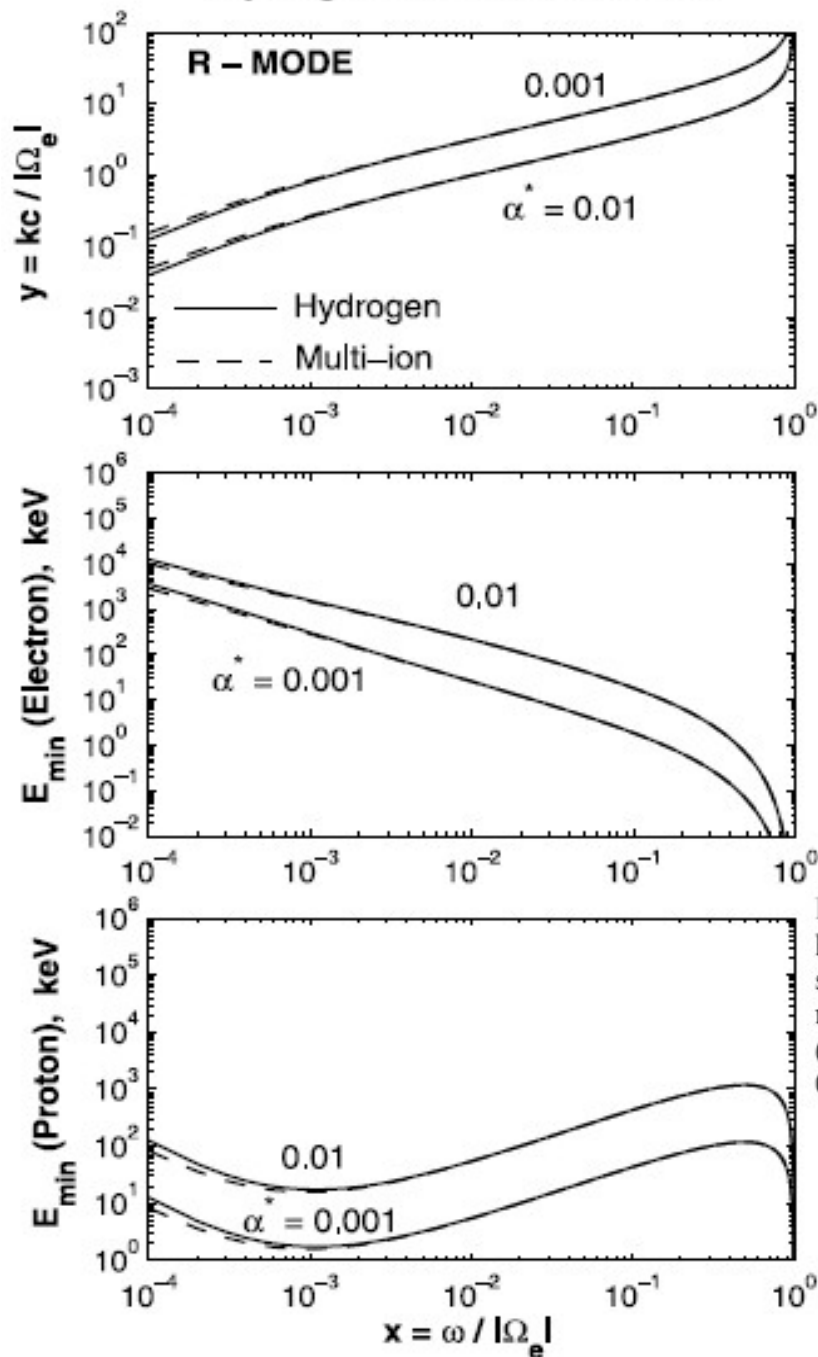


Figure 4. Comparison of R-mode dispersion curves in a hydrogen plasma and multi-ion (H^+ , He^+ , O^+) plasma for specified α^* -values (top). Corresponding minimum resonant energy profiles for electrons (middle) and protons (bottom). Fractional ion number densities are $\eta_1 = 0.75$, $\eta_2 = 0.2$, $\eta_3 = 0.05$.

Hydrogen Plasma

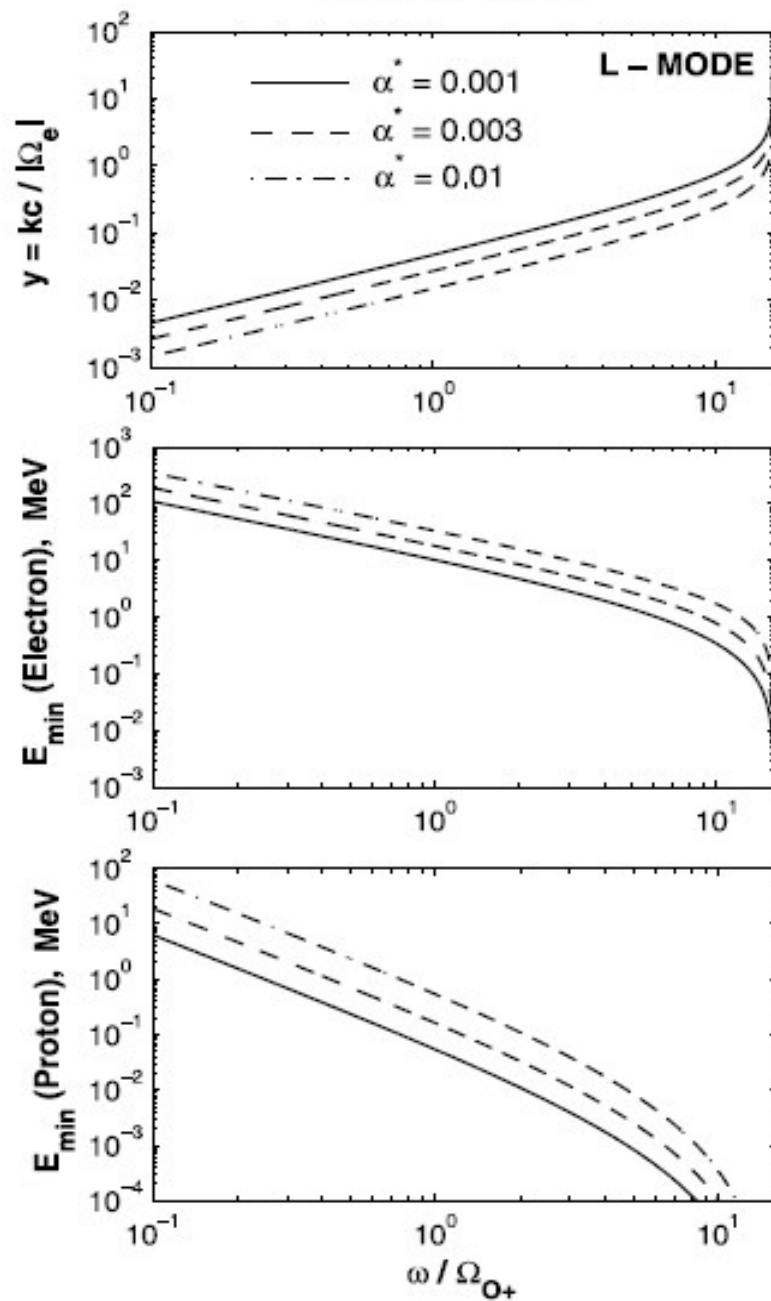


Figure 5. As in Figure 3, but for L-mode waves.

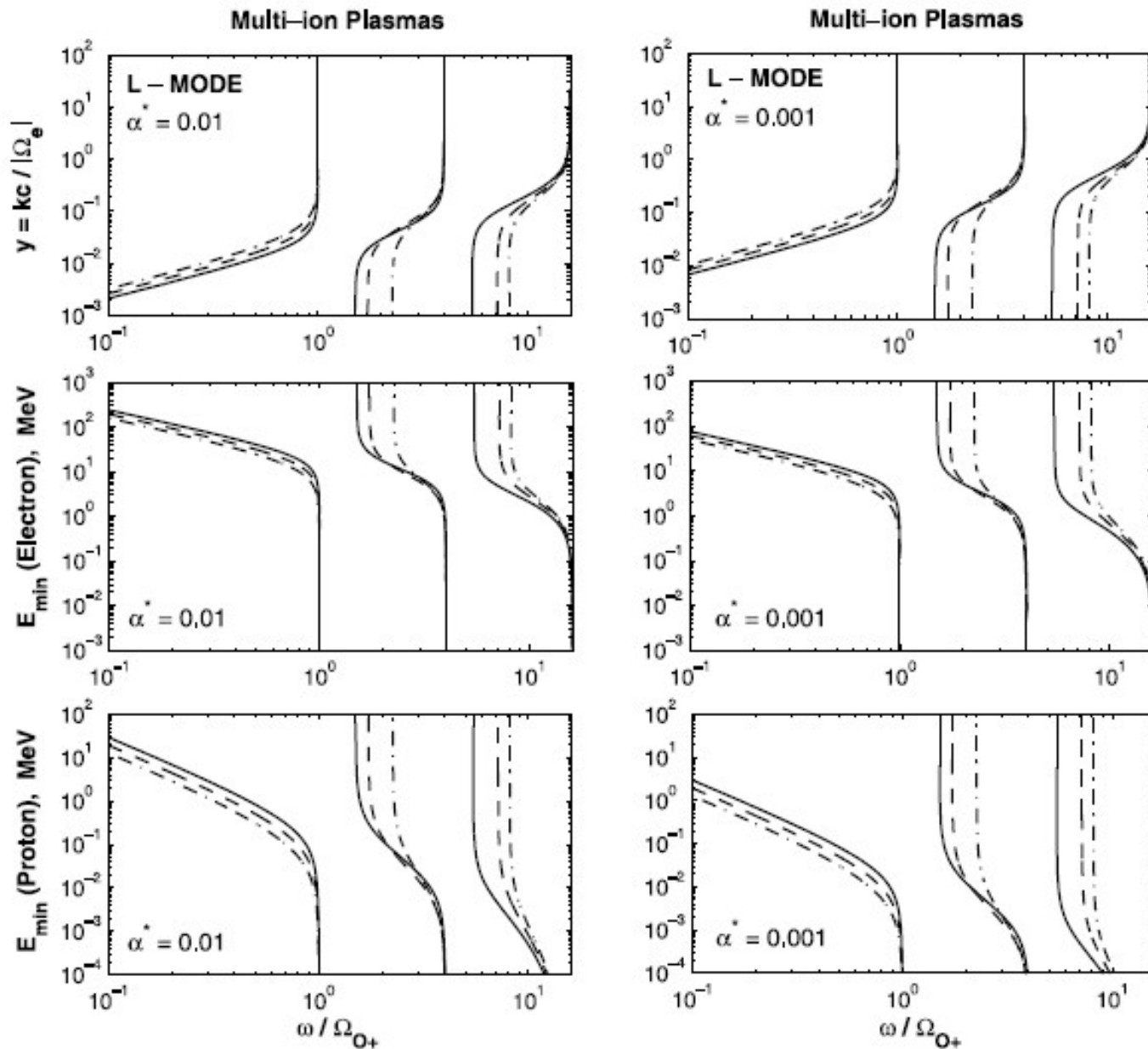


Figure 6. L-mode dispersion curves for multi-ion (H^+ , He^+ , O^+) plasmas for specified α^* - values (top). Corresponding minimum resonant energy profiles for electrons (middle) and protons (bottom). Fractional ion number densities are $\eta_1 = 0.85$, $\eta_2 = 0.1$, $\eta_3 = 0.05$ (solid curves); $\eta_1 = 0.7$, $\eta_2 = 0.2$, $\eta_3 = 0.1$ (dashed); $\eta_1 = 0.6$, $\eta_2 = 0.2$, $\eta_3 = 0.2$ (dot-dashed).

(E_k, α) Resonance Regions

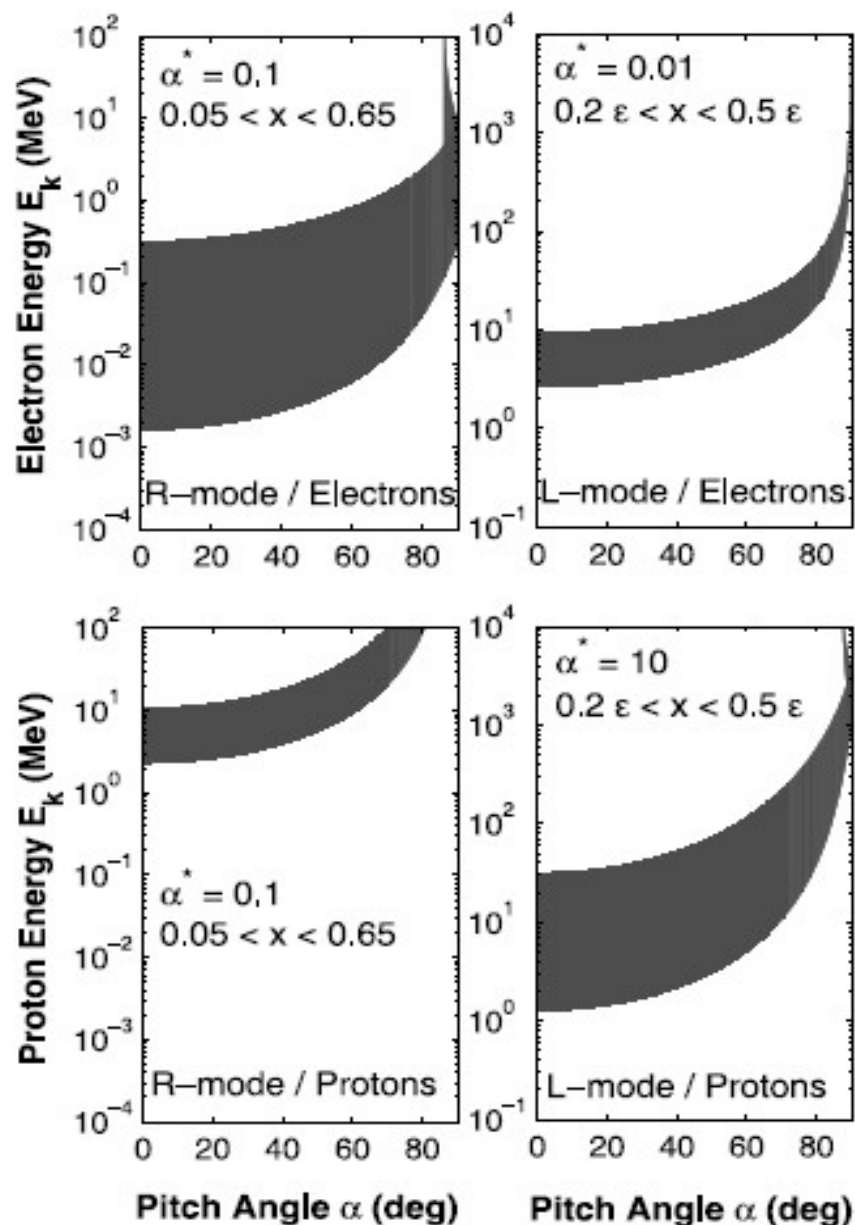


Figure 7. Examples of (E_k, α) resonance regions for the specified wave-particle interactions and the given parameter values.

(E_k, α) Resonance Regions

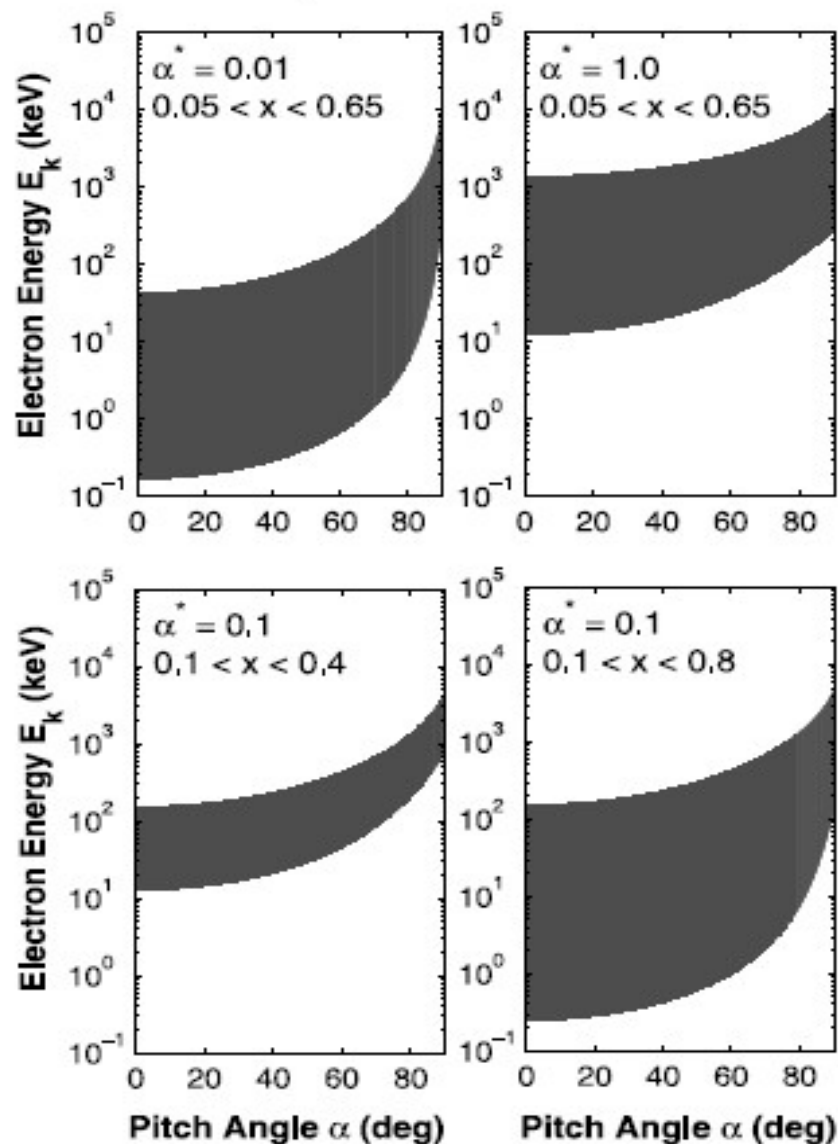


Figure 8. (E_k, α) resonance regions for R-mode/electron interaction. Sensitivity of the resonance region to a change in the value of $\alpha^* = \Omega_e^2 / \omega_{pe}^2$, for a fixed frequency band, is tested in the top; sensitivity to a change in the frequency band, for a fixed α^* , is tested in the bottom.