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Plasma Physics

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The Curious name whistler wave for the branch of the dispersion relation lying between the ion and electron cyclotron frequencies is originally derived from ionospheric physics. whistler waves are a very characteristic type of audio-frequency radio interference, most commonly encountered at high latitudes, which take the form of brief, intermittent Pulses, starting at high frequencies, and rapidly descending in pitch.

Whistlers were discovered in the early days of radio communication, but were not explained until much later. whistler waves start off as 'instantaneous' radio Pulses.

Generated by lightning flashes at high latitudes. The Pulses are channeled along the Earth's dipolar magnetic field and eventually return to ground level in the opposite hemisphere. fig 2 ~~illus~~ illustrates the typical path of a whistler wave. Now, in the frequency range $\Omega_i \ll \omega \ll |\Omega_e|$, the dispersion relation reduce to

$$n^2 = \frac{k^2c^2}{\omega^2} \simeq \frac{\Pi_e^2}{\omega|\Omega_e|} \quad \text{— ⑦}$$

As is well known Pulses Propagate at the group velocity,

$$V_g = \frac{d\omega}{dk} = 2c\frac{\sqrt{\omega|\Omega_e|}}{\Pi_e} \quad \text{— ⑧}$$

Clearly the low frequency components of a pulse propagate more slowly than the high-frequency components. It follows that by the time a pulse returns to ground level it has been stretched out temporally, because the high-frequency components of the pulse arrive slightly before the low-frequency components. This also accounts for the characteristic whistling-down effect observed at ground level.

The shape of whistler pulses, and the way in which the pulse frequency varies in time, can yield a considerable amount of information about the regions of the earth's magnetosphere through which ~~they~~ they have passed. For this reason, many countries maintain observatories in polar regions, especially Antarctica, which monitor and collect whistler data e.g. the Halley research station, maintained by the British Antarctic Survey, which is located on the edge of the Antarctic Mainland.

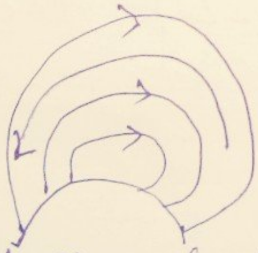

figure (2)

For a left-handed circularly polarized wave, similar considerations to the above give a dispersion curve of the form sketched in fig ③.

In This Case n^2 goes to infinity at The ion cyclotron frequency Ω_i, corresponding to the so called ion cyclotron ~~frequency Ω_i, corresponding~~ cyclotron resonance (at $L \to \infty$). At This resonance, the rotating electric field associated with a left-handed wave resonates with the gyromotion of The ions, allowing wave energy to be converted into perpendicular kinetic energy of the ions. There is a band of frequencies, lying above the ion cyclotron frequency in which the left handed wave does not propagate. At very high frequencies a propagating mode exists, which is basically a standard left handed circularly polarized electromagnetic wave, somewhat modified by The presence of The plasma. The cut off frequency for This wave is

$$\omega_2 \simeq -|\Omega_e|/2 + \sqrt{\Omega_e^2/4 + \Pi_e^2} \,. \quad — ⑨$$

As before the lower branch in fig ③ describes a wave that can only propagate in the presence of an equilibrium magnetic field, whereas the upper branch describes a wave that can propagate in the absence an equilibrium field. The continuation of The Alfven wave to just below the ion cyclotron frequency is generally called the ion cyclotron wave,

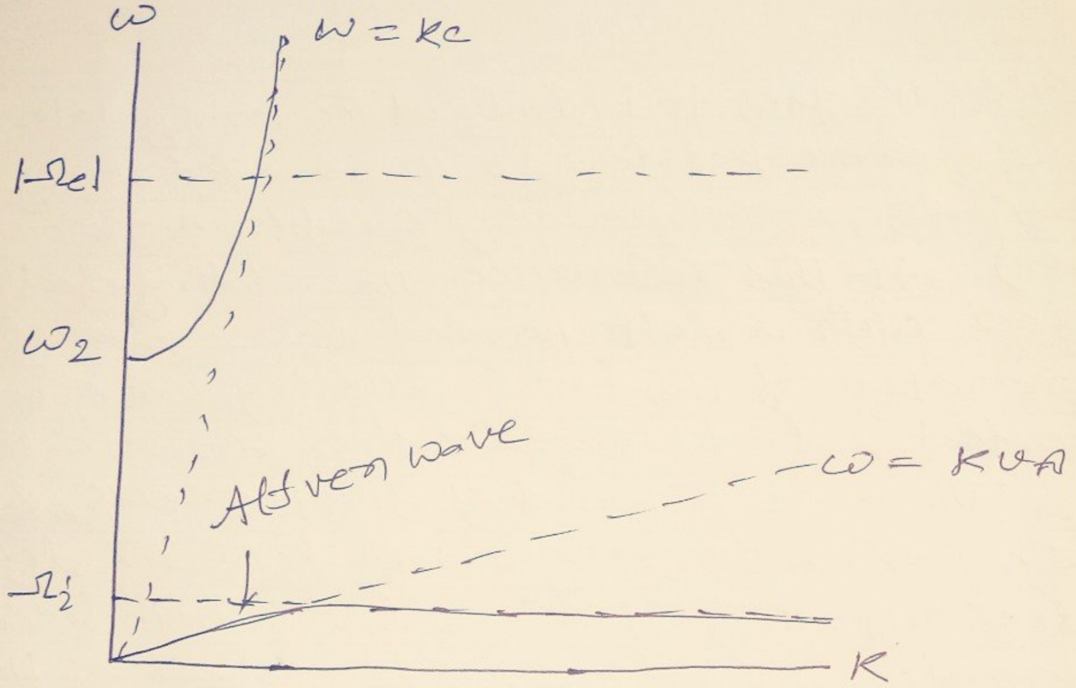

fig-3

Dispersion relation for a left handed wave propagating parallel to the Magnetic field in a Magnetized plasma