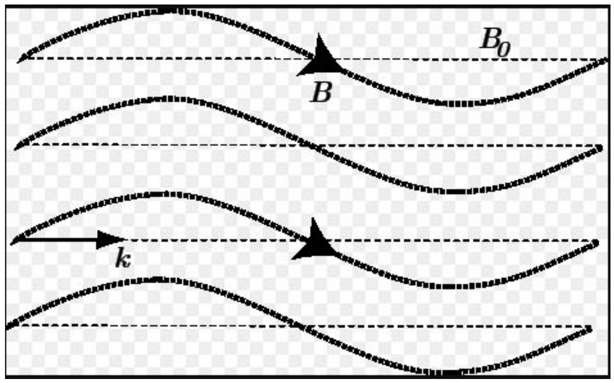
# Alfven Waves

Danny Jammooa, Manuel Catacora

Magnetohydrodynamics (MDH), is the study of fluid like matter in an electromagnetic field. Mostly studying how the magnetic properties effect the electrically conducting fluid. An electrically conducting fluid would include plasma, liquid metals, salt water and electrolytes. According to Hannes Alfven "If a conducting liquid is placed in a constant magnetic field, every motion of the liquid gives rise to an E.M.F. which produces electric currents. Owing to the magnetic field, these currents give mechanical forces which change the state of motion of the liquid. Thus a kind of combined electromagnetic-hydrodynamic wave is produced." Using the MDH model on plasma, it was seen that when a magnetic field is effecting an electrically conducting fluid, a wave was produced. This wave would be called the MDH wave, where there are several types of MDH waves. When considering plasma, using Faraday's law of induction on a plane wave we find that

$$k\tilde{E} = \omega\tilde{B} \tag{1}$$

Implying that depending on the classification of the waves in plasma, may it be electromagnetic or electrostatic, there are three types of waves. The electrostatic wave must be longitudinal, and the electromagnetic wave must be either transverse or partially longitudinal. For this project we will be focusing on the waves named Alfven waves which are transverse waves that propagate in the magnetic field direction and exhibiting electromagnetic characteristics. Alfven waves exist in plasma and are low-frequency travelling oscillation of ions in a magnetic field. The magnetic field lines act like a restoring force, while the ion's mass density provides the inertia.




Because these waves are such low-frequency, corresponds to big wavelengths that are capable of reaching the length of an earth's radius. Since it is such a long scale wavelength and is made by the oscillation of ions, these waves can transport a significant amount of energy in the form of the Poynting flux.

These Alfven waves travel in the speed $V_A = \frac{B}{\sqrt{\mu_0 \rho}}$ known as the Alfven speed, with a dispersion relation $\omega^2 = k^2 v_a^2$. Relating these two, we get the phase velocity $V_p = \frac{\omega}{k} = v_A cos\theta$, where $\theta$ is the angle with respect to the field $B_0$. This suggests when $k_{||}B_0$, we have $\theta = 0$ resulting in $v_p = v_a$, however when $k_{\perp}B_0$ and that $\theta = \frac{\pi}{2}$ this results in $v_p = 0$. Also we can generate the phase velocity of an electromagnetic wave in such a medium $V_p = \frac{v_A}{\sqrt{1+\frac{1}{c^2}v_A^2}}$, where if $v_A \ll c$ then $v_p = v_A$, and when $v_A \gg c$ we get that $v_p \approx c$. Which suguests that at high magnetic fields or low density the velocity of the alfven waves approaches the speed of light and that they becomes ordinary electromagnetic waves.

In the following parts of the poster we will be mathematically deriving the Alfven waves, and exploring their velocities, and energy through numerical calulations.

# References and Notes


1. Richard Fitzpatrick, Plasma Physics

2. Bittencourt, Fundamentals of plasma Physics

3. ScienceDaily, Discovery of Alfven waves in the corona of the Sun