Classical Absorption Coefficient

Fluids:

$$\alpha_{cl} = \frac{\omega^2}{2\rho_0 c^3}\left[\frac{4}{3}\eta + \frac{(\gamma-1)\kappa}{c_p}\right]$$

Viscous dissipation and thermal conduction within the body of the fluid.

From Blackstock, App B, α_{cl} can be computed from

$$\alpha_{cl} = 1.84 \times 10^{-11}\sqrt{\frac{T_k}{299.15}}\, f^2$$

(for air)

T_k = Temp in Kelvin

f = frequency in Hz

Absorption Caused By Molecular

Relaxation:

In general, it is appropriate to add absorption causes together, i.e.,

$$\alpha = \begin{matrix}\text{Total}\\ \text{Absorption}\\ \text{Coefficient}\end{matrix} = \underbrace{\alpha_v + \alpha_{th}}_{\text{Classical absorption}} + \sum \alpha_i$$

α_i = Other sources of absorption

- Molecular relaxation
- Shear & conduction at bndries.

In the text, individual sources of absorption are denoted with α_M, "M" corresponds to each type of molecular relaxation existing in a particular fluid.

~~I.e., for one rela~~ In air, there are two predominant relaxations, one caused by O_2, and one caused by N_2.

For one relaxation, the absorption takes the <u>general</u> form

$$\alpha_M = 2 \frac{\mu_{max}}{c} \frac{f_M f^2}{f^2 + f_M^2}$$

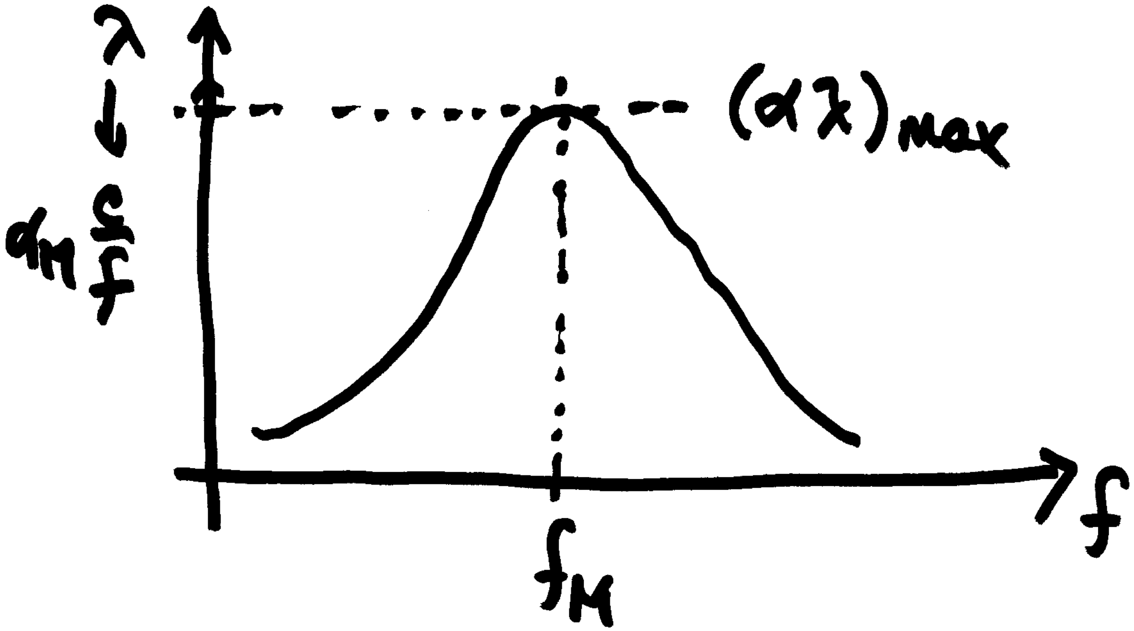
$\frac{\mu_{max}}{2}$ = Coefficient belonging to the relaxation

f_M = Relaxation frequency (Hz)

f = frequency in Hz.

As $f \to 0 \Rightarrow \alpha_M = 0$

As $f \to \infty \quad \alpha_M = 2 \frac{\mu_{max}}{c\,\infty} f_M$



8.67 $(\alpha\lambda)_{max}$
is maximum
dB/λ

It turns out, that in terms of the relaxation property $(\alpha\lambda)_{max}$, that the absorption coefficient α_M is

$$\alpha_M = \cancel{\frac{2(\alpha\lambda)_{max}}{c}} \qquad \alpha_M = \frac{2(\alpha\lambda)_{max}}{c} \frac{f_M f^2}{f^2 + f_M^2}$$

For air, there are two relaxations. Consequently, the absorption coefficient for air takes the form

$$\alpha = \alpha_{cl} + \alpha_{N_2} + \alpha_{O_2}$$