Competence Center for Gas Exchange

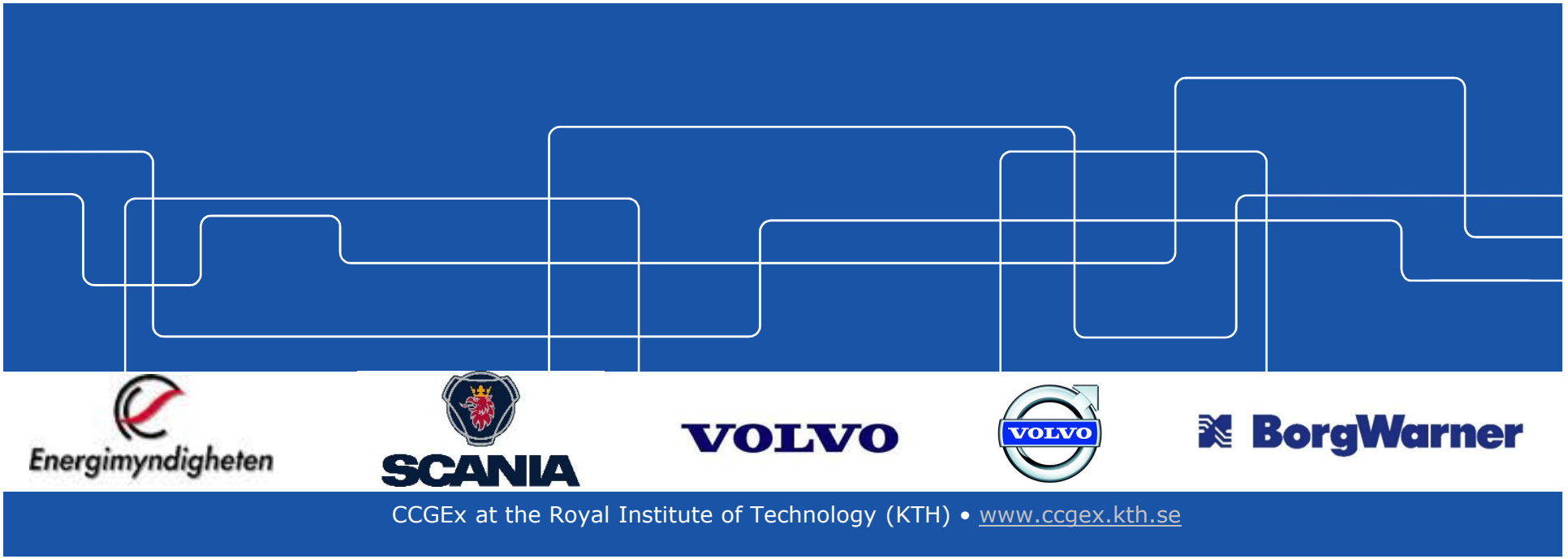
CC GEx

"Charging for the future"

KTH ROYAL INSTITUTE
OF TECHNOLOGY

Particle Agglomeration with Acoustic Method

Zhe Zhang

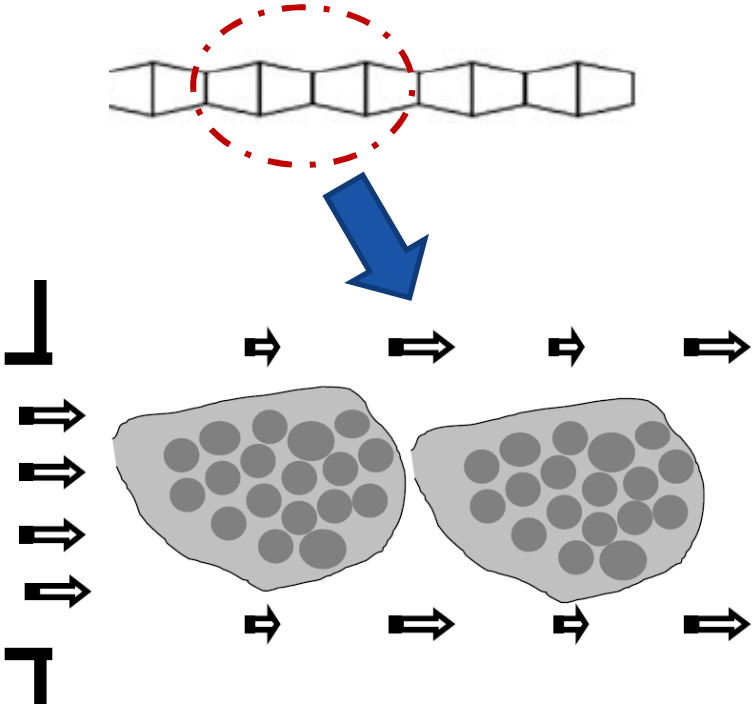


Outline

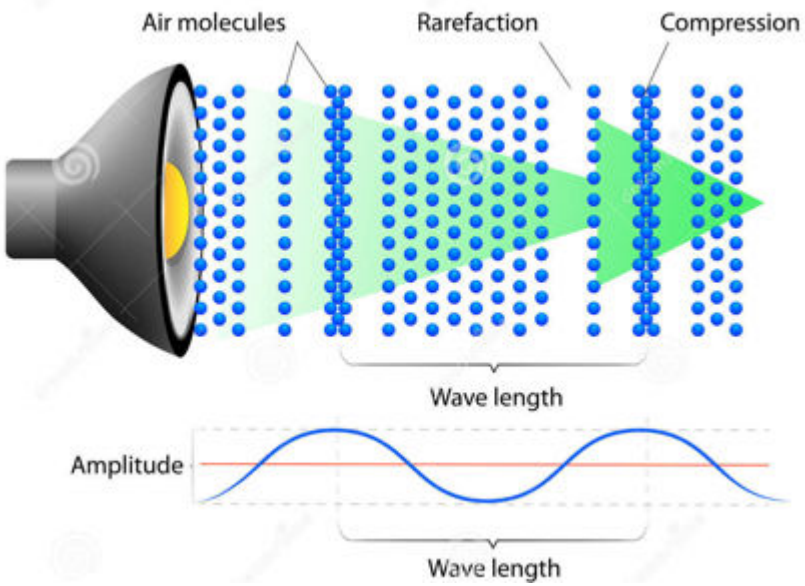
- **Introduction**
- **Model Development**
- **Acoustic Metamaterial ---- “Slow Sound”**
- **Acoustic Metamaterial ---- Agglomeration**

Introduction

Hydrodynamic

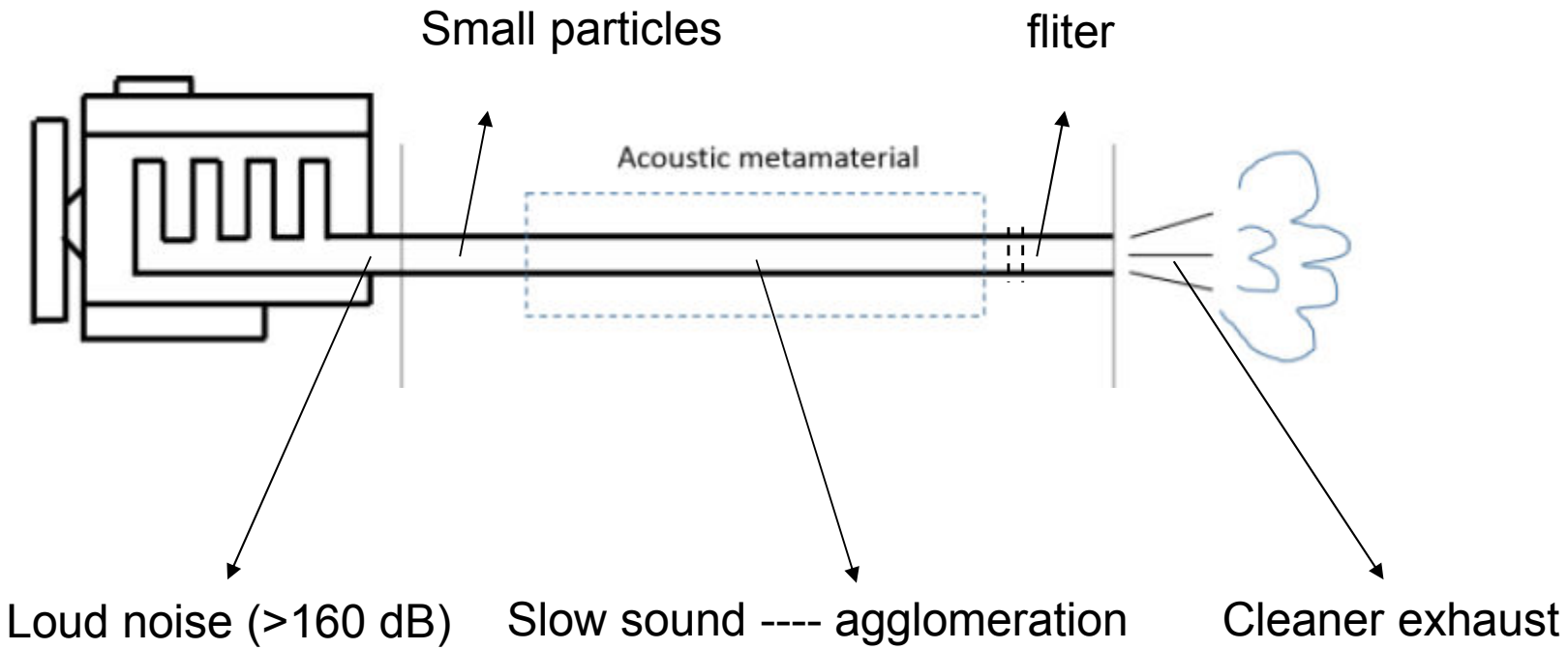


Acoustic



- **Acoustic metamaterials**

Introduction



Model Establishment

$$\rho_p V_p \frac{dv_p}{dt} = F_d = 6\pi r_p \mu_f (v_f' - v_p)$$

$$\frac{du_p'}{d\tau} = \frac{1}{St}(u_f' - u_p')$$

$$v_f' = V_a - V_{ac}\sin(kx - \omega t)$$

Acoustic particle velocity

$$\frac{dU_p'}{d\tau} = \frac{1}{St}(U_a - U_{ac}\sin X - U_p' - 1)$$

$$\beta = \frac{U_a - 1}{U_{ac}} = \frac{V_a - c}{V_{ac}} = \frac{c_0}{V_{ac}}$$

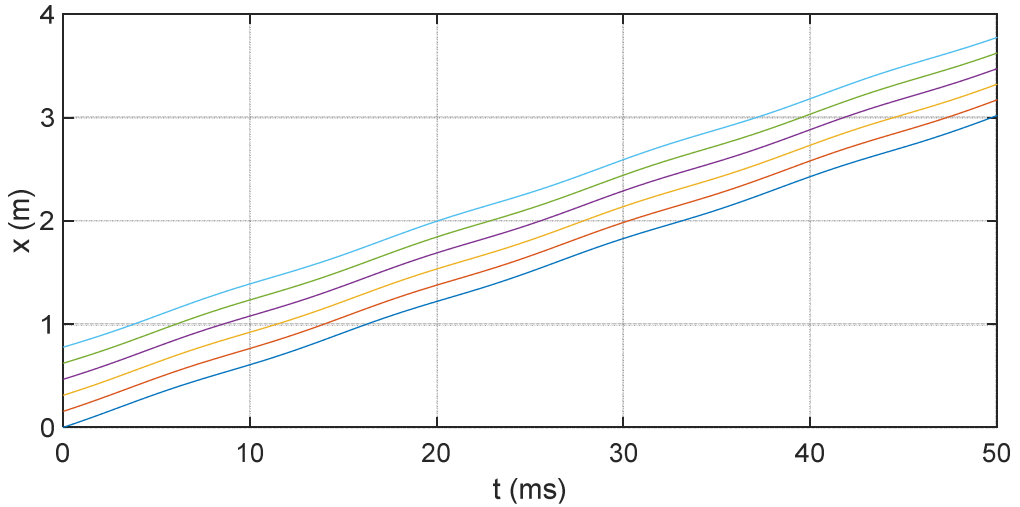
$$|\beta| \le 1$$

Numerical Example ---- Normal Sound

$$V_a = 60m/s$$
$$V_{ac} = 6.8m/s(160dB)$$
$$c = c_0 + V_a = 400(m/s)$$

$$\beta = \frac{U_a - 1}{U_{ac}} = \frac{V_a - c}{V_{ac}} = 50$$

Particle trajectory



Numerical Example ---- Slow Sound

$$V_a = 60 m/s$$

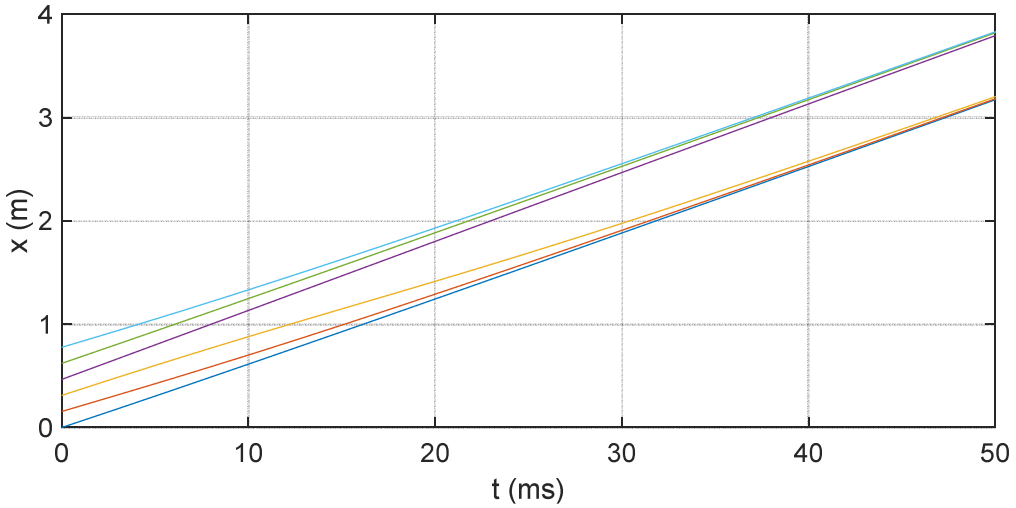
$$V_{ac} = 6.8 m/s (160 dB)$$

$$c \in [53.2, \quad 66.8](m/s)$$

$$\beta = \frac{U_a - 1}{U_{ac}} = \frac{V_a - c}{V_{ac}} \in [-1,1]$$

$$c_0 \in [-6.8, \quad 6.8](m/s)$$

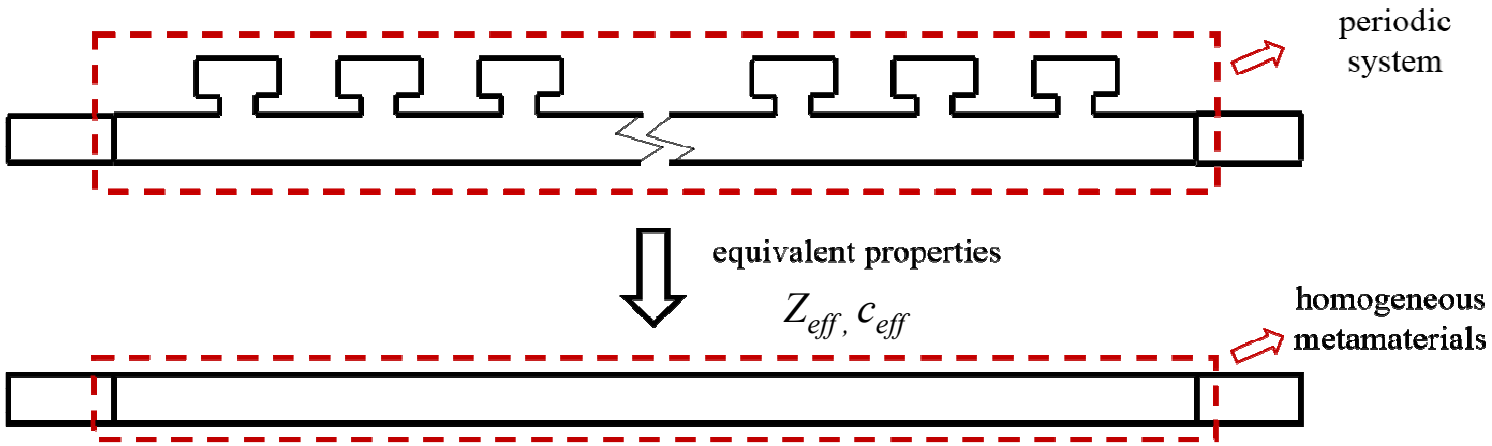
Particle trajectory



Acoustic Metamaterial

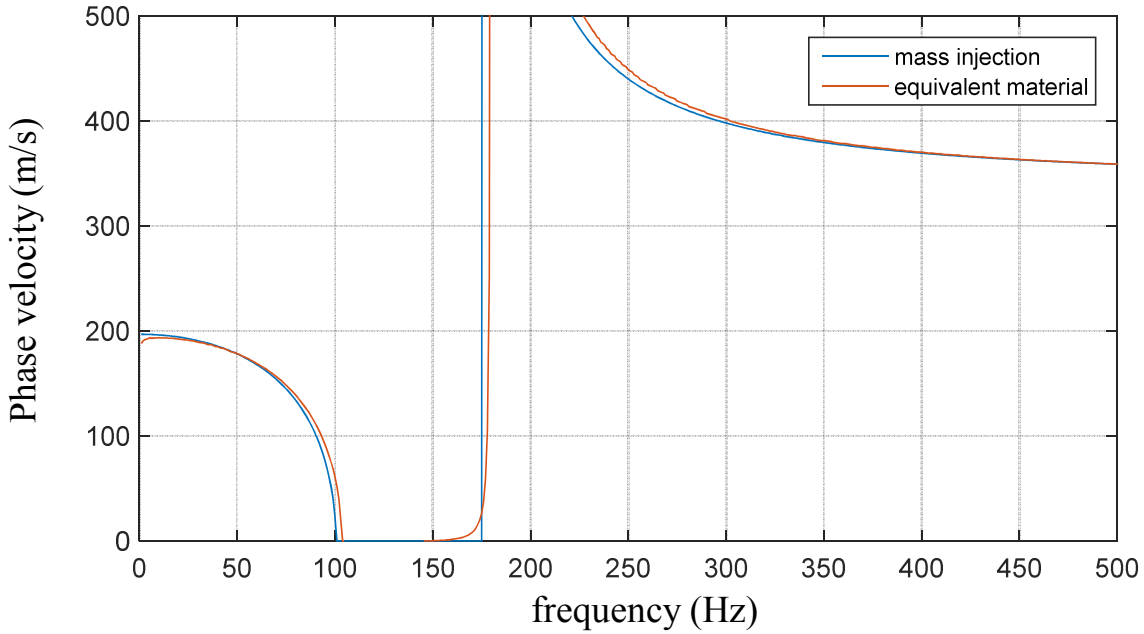
- artificially fabricated composite structures
- periodic structures
- equivalent homogeneous material ($\rho_{eff} < 0$, $\beta_{eff} < 0$)

$$c_{eff} = \sqrt{\beta_{eff} / \rho_{eff}}$$

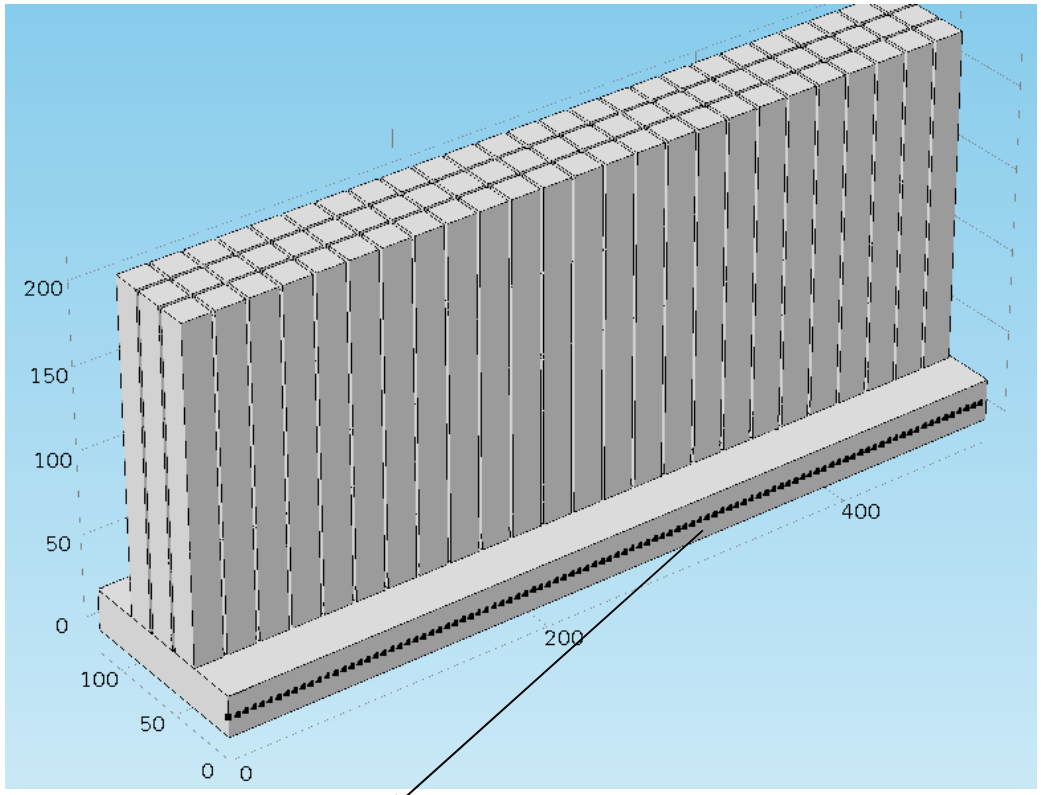


Slow Sound Calculation

- Equivalent material assumption
- "Mass injection"



Test Prototype

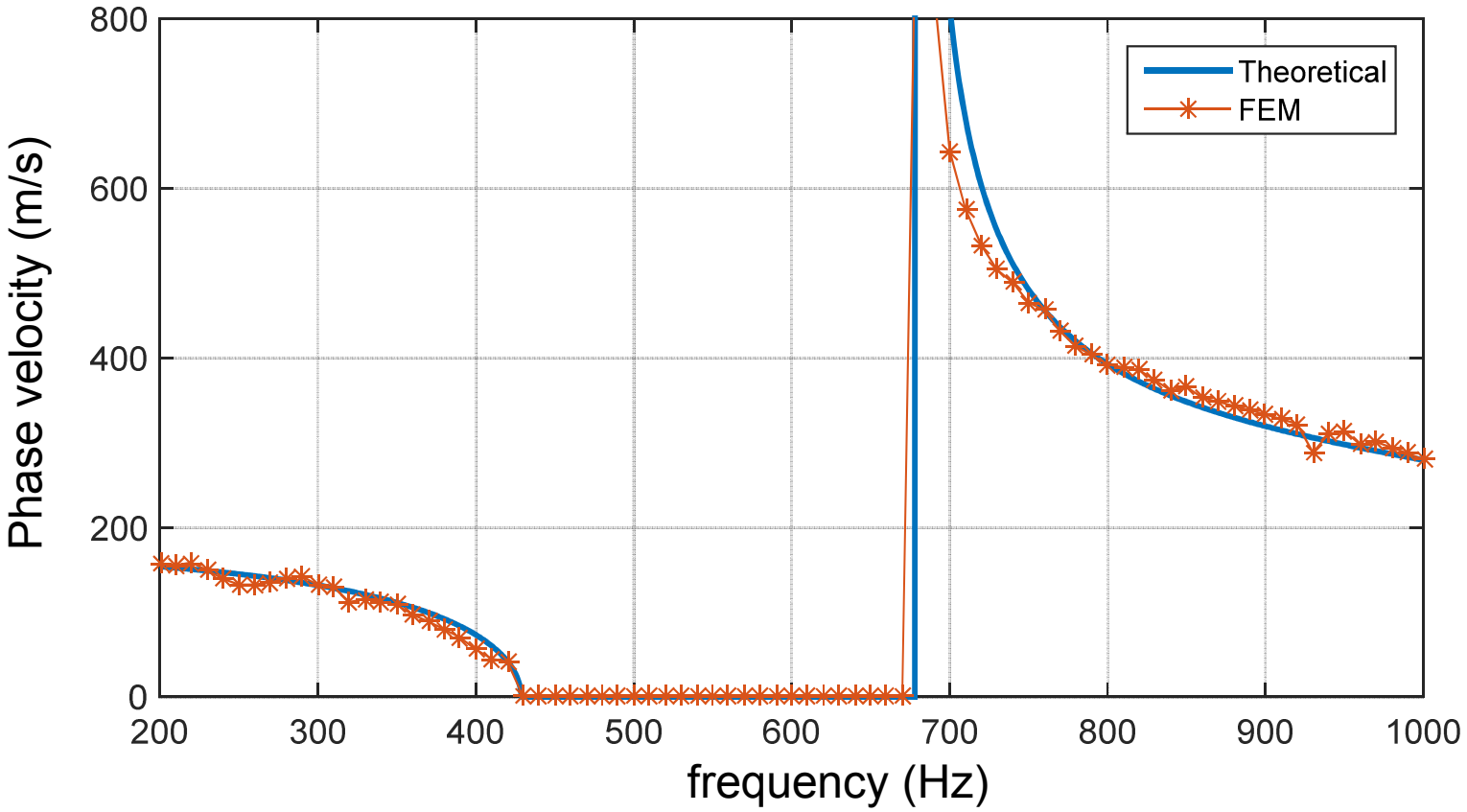


$$m' = -\rho_0 u_w' / d_h$$

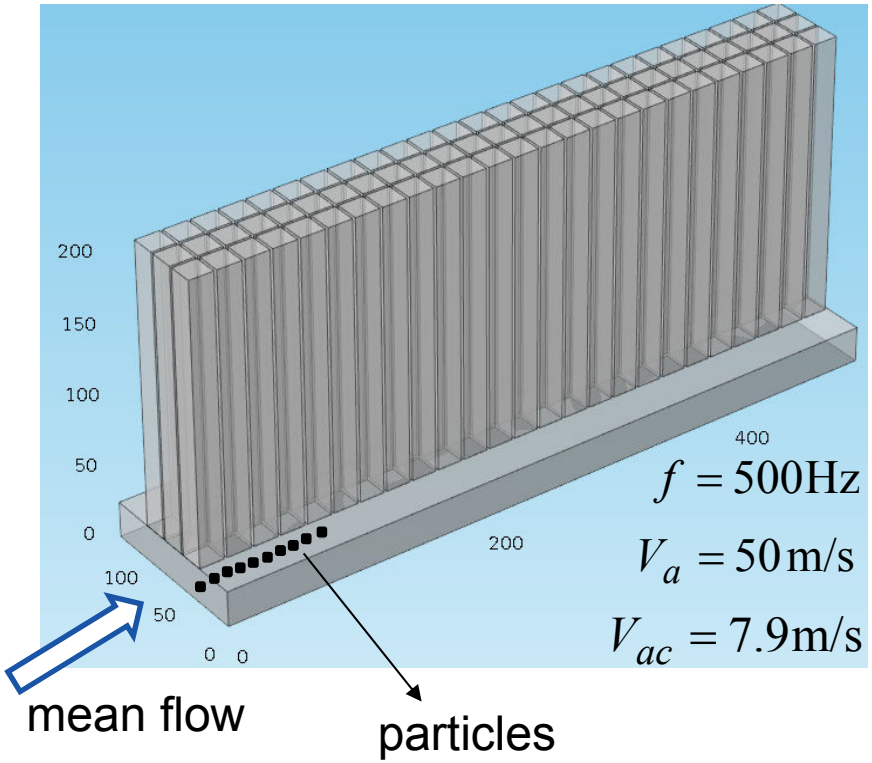
$$k = \sqrt{(\omega / c_0)^2 - (\rho_0 i\omega / d_h Z_w)}$$

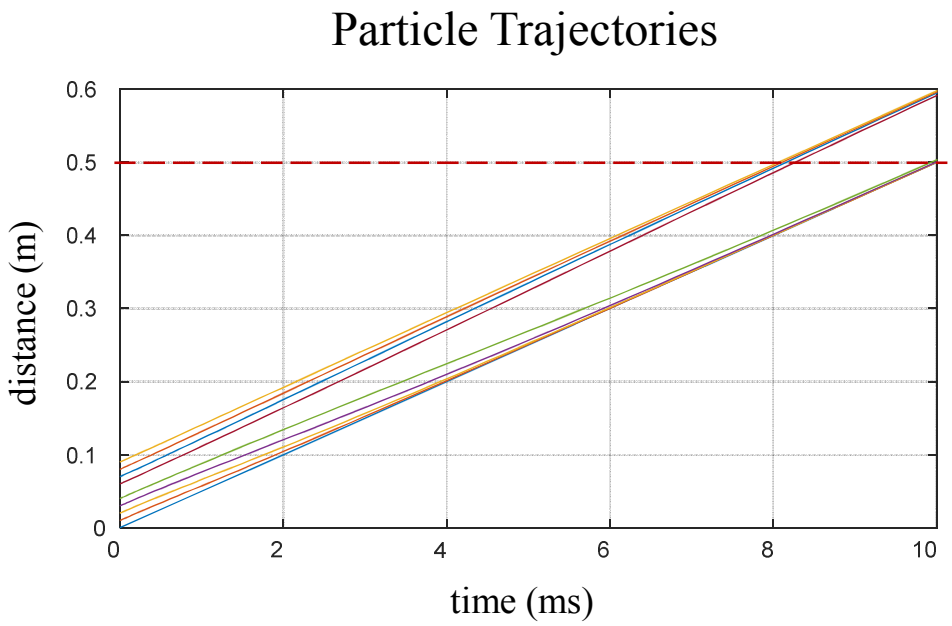
$$c_{ph} = \mathrm{Re}(\frac{\omega}{k}) = \mathrm{Re}(\frac{c_0}{\sqrt{1 + (\rho_0 c_0^2 / i\omega d_h Z_w)}})$$

Slow Sound


Theoretical
FEM
Phase velocity (m/s)
frequency (Hz)
0
200
400
600
800
200
300
400
500
600
700
800
900
1000

Agglomeration in Metamaterial





Futrure Plan

- **Experiment on “slow sound”**
- **Experiment on particle agglomeration**

Thank you for your attention!

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