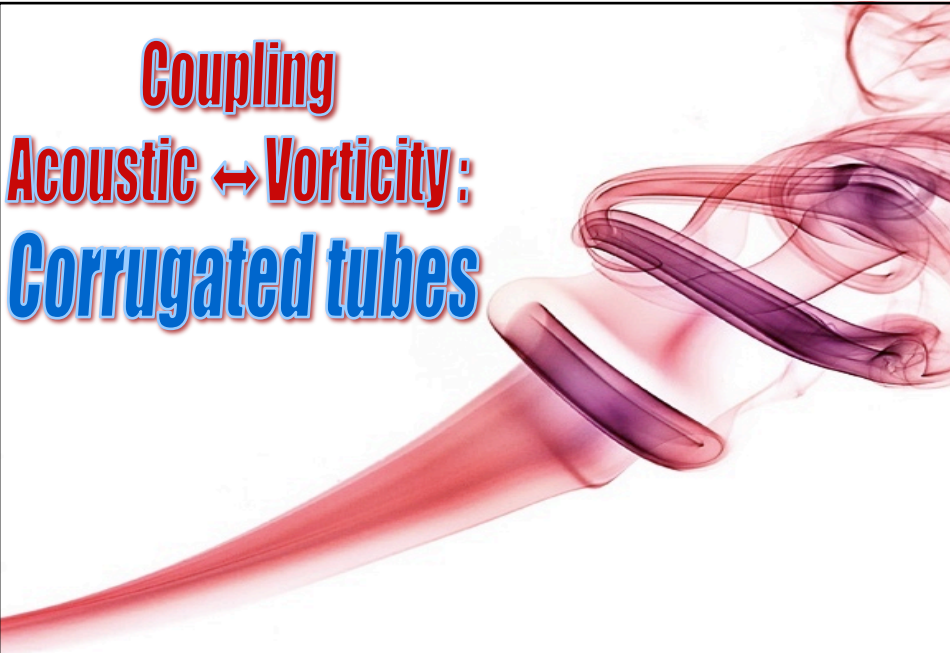


# Coupling Acoustic $\leftrightarrow$ Vorticity: Corrugated tubes



Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: *Guided Waves & Flow Interactions*

62

## Corrugated tubes



Typical flexible pipe structure

- External sheath
- Armours
- Pressure vault
- Pressure sheath
- Carcass

Velocity Magnitude

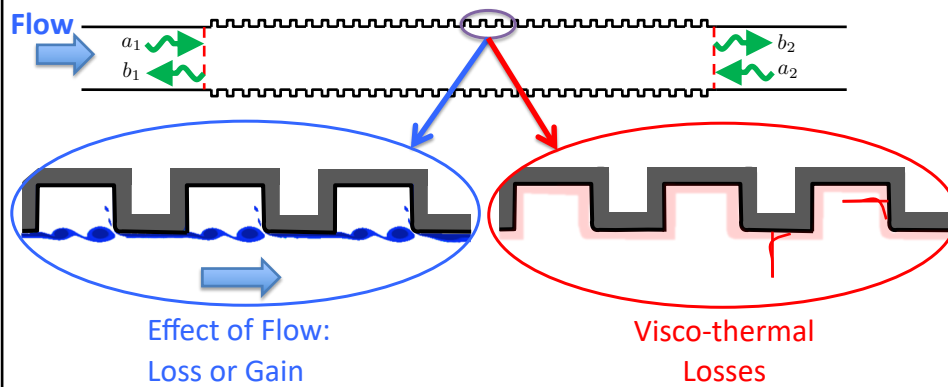
3.0 6.0

Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: *Guided Waves & Flow Interactions*

63

## Corrugated tubes



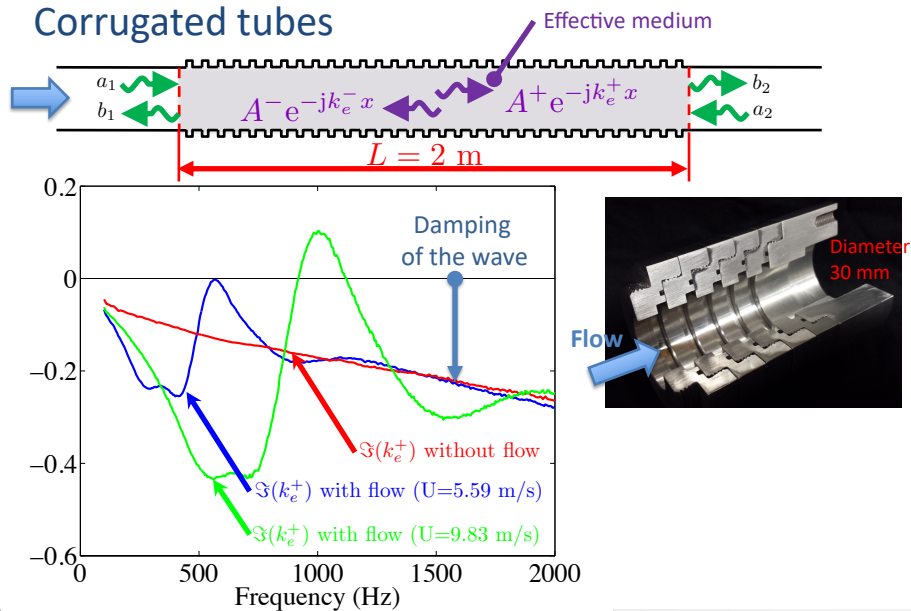
$$\begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \begin{bmatrix} r_L & t_R \\ t_L & r_R \end{bmatrix} \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}$$

Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: *Guided Waves & Flow Interactions*

64

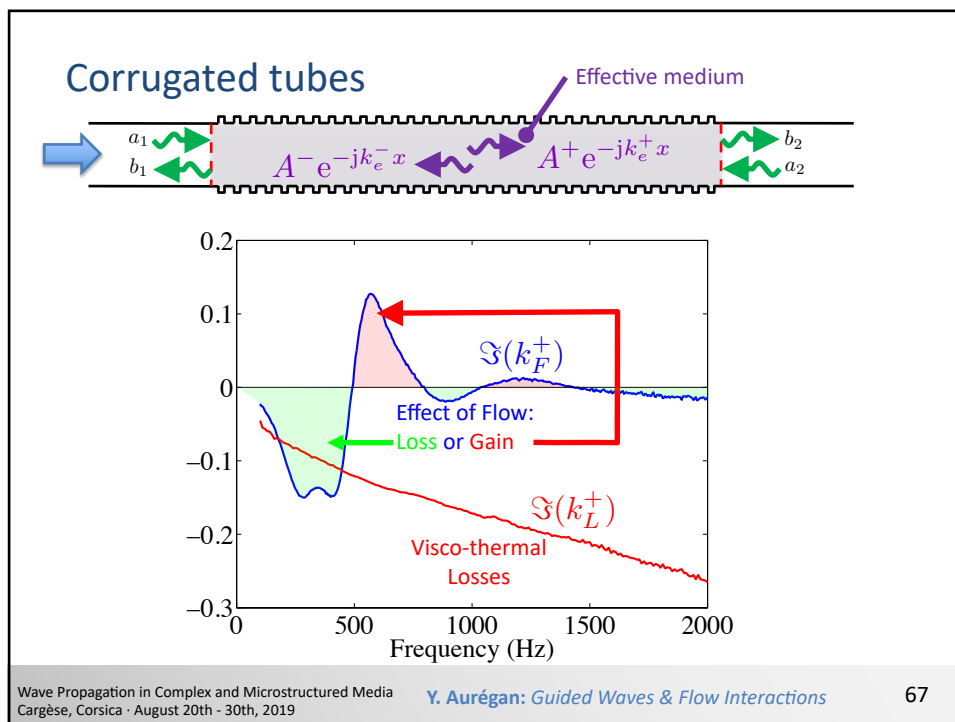
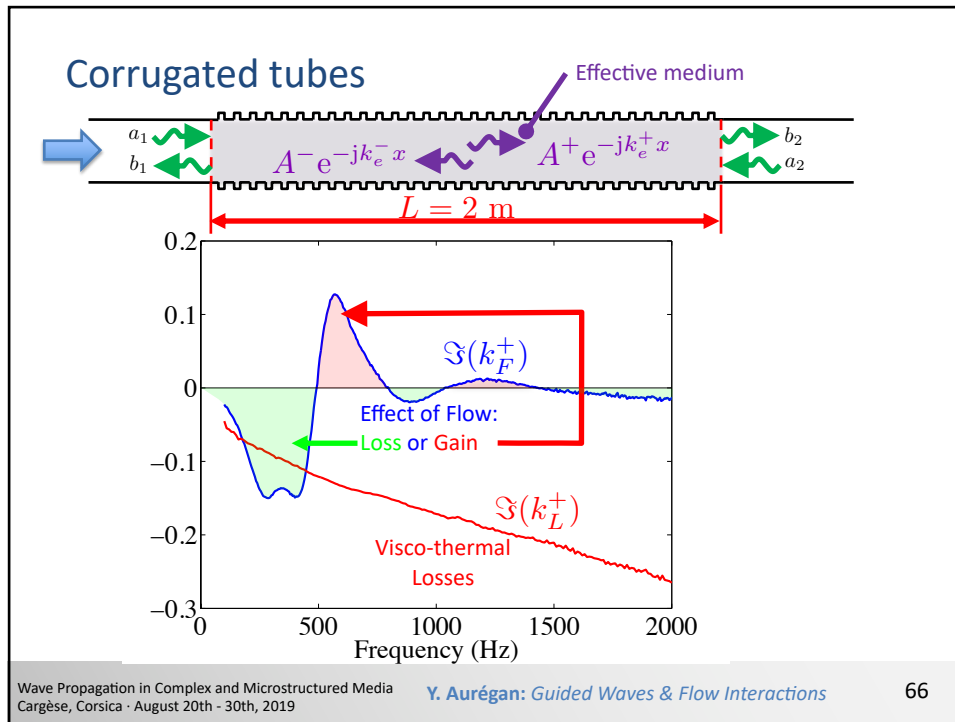
## Corrugated tubes



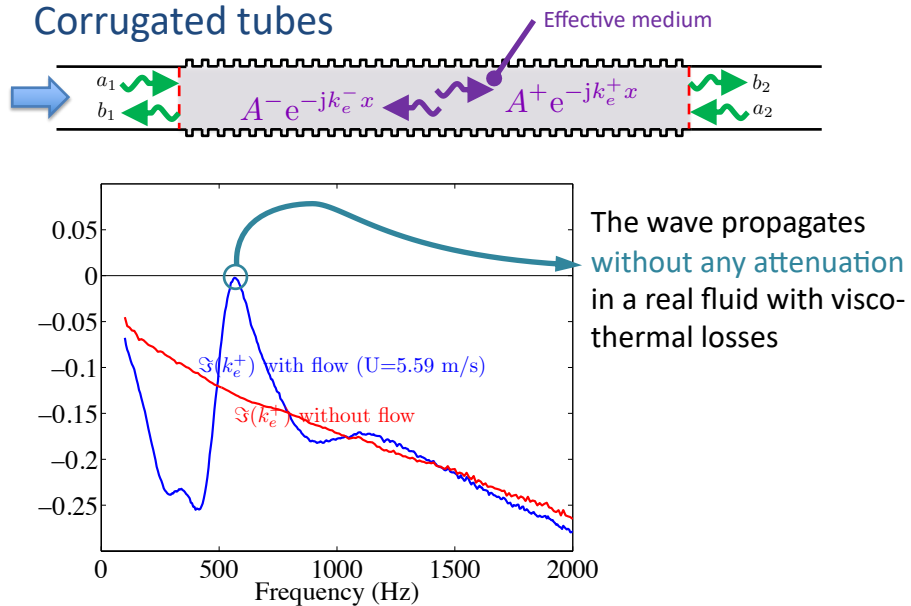
Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: *Guided Waves & Flow Interactions*

65



## Corrugated tubes

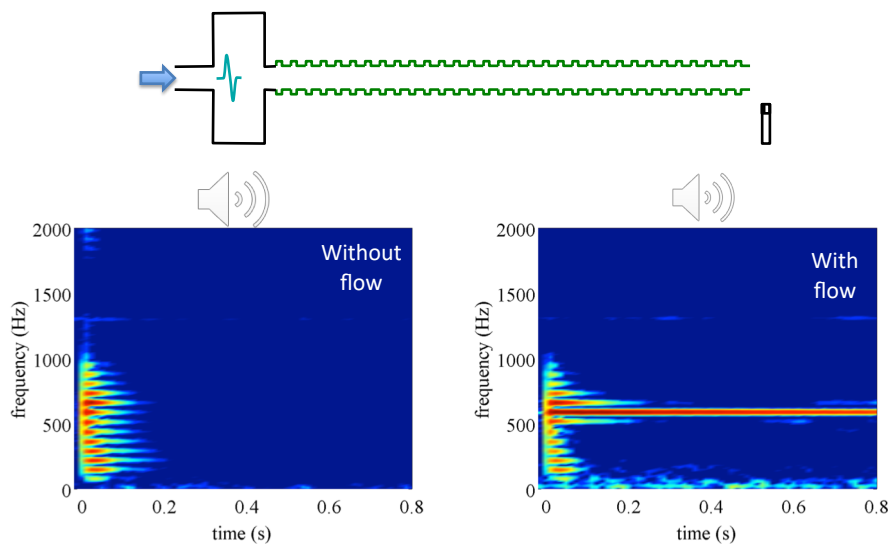


Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: Guided Waves & Flow Interactions

68

## Corrugated tubes



Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

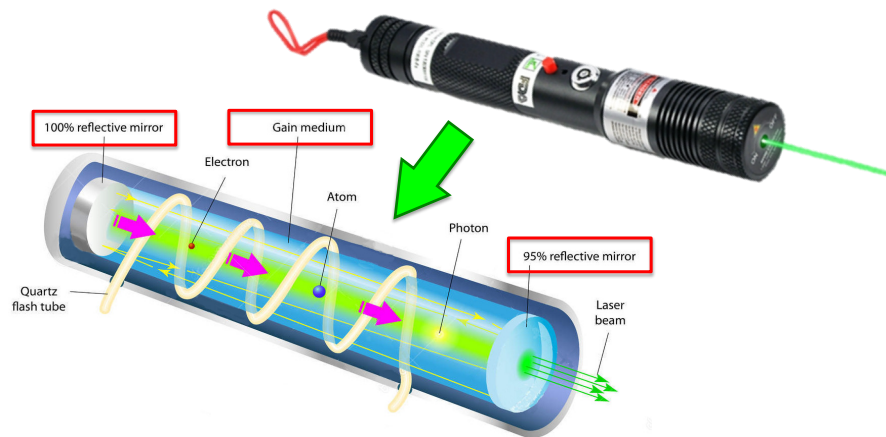
Y. Aurégan: Guided Waves & Flow Interactions

69

## Non-Hermitian physics with corrugated tubes

See:

A. Douglas Stone - Understanding lasers with non-hermitian physics (on YouTube)

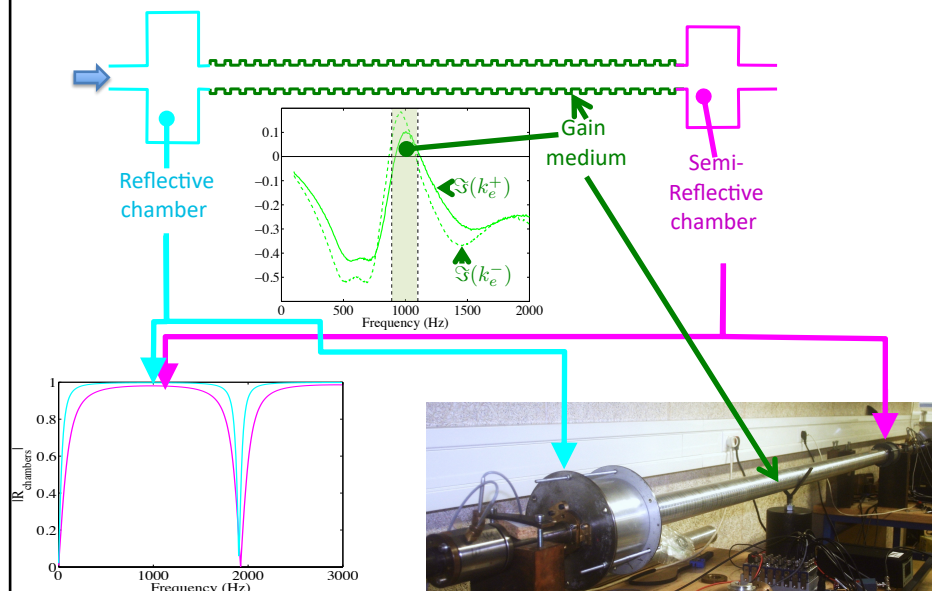


Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: Guided Waves & Flow Interactions

70

## Non-Hermitian physics with corrugated tubes

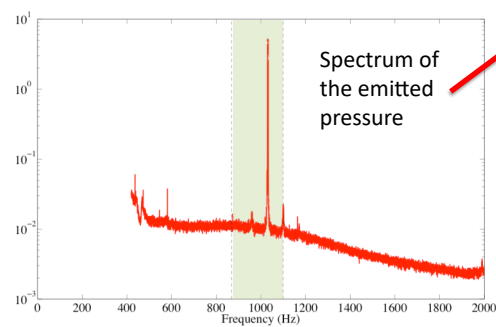


Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: Guided Waves & Flow Interactions

71

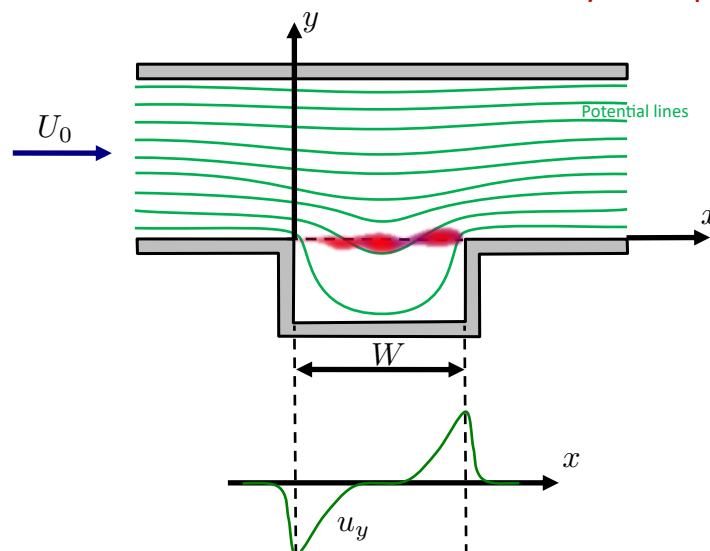
## Non-Hermitian physics with corrugated tubes



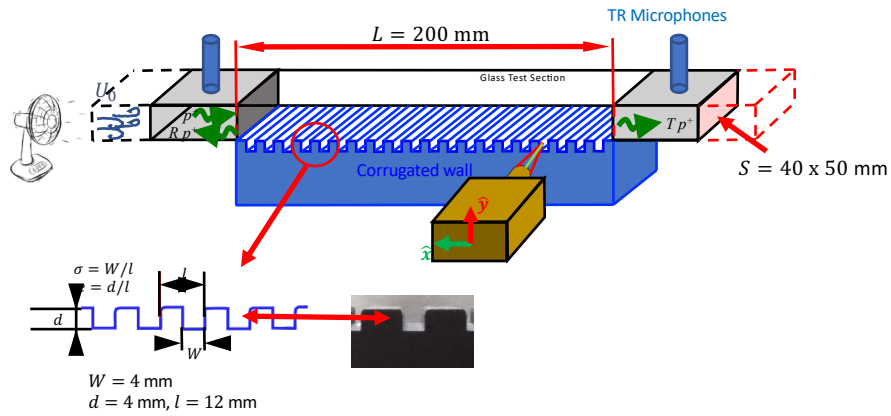
= whistle

## Corrugated tubes

shallow cavity  $\neq$  deep cavity



## Corrugated tubes

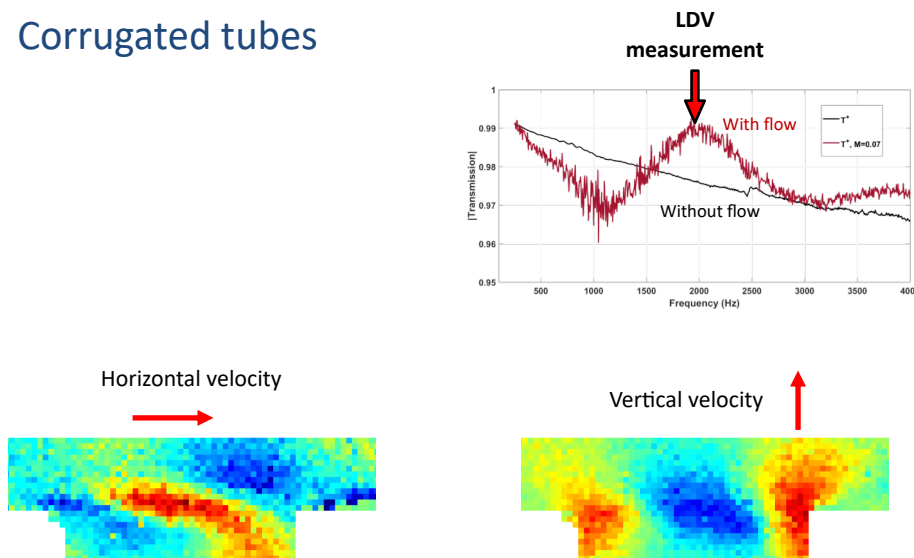


Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: *Guided Waves & Flow Interactions*

74

## Corrugated tubes



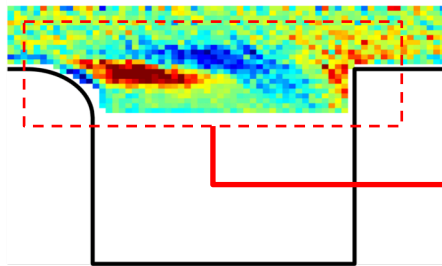
Wave Propagation in Complex and Microstructured Media  
Cargèse, Corsica - August 20th - 30th, 2019

Y. Aurégan: *Guided Waves & Flow Interactions*

75

## Corrugated tubes

Phase-Averaged Vorticity



Howe energy corollary

$$\mathcal{P} = - \int_{\Omega} \rho_0 \langle (\vec{\omega} \times \vec{u}) \cdot \vec{u}_a \rangle dV$$

LDV  
measurement

