MULTIPHYSICS MODELLING OF FLOW-DRIVEN PIEZOELECTRIC ENERGY HARVESTERS

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MOTIVATIONS

- Take advantage of ambient energy sources (e.g., wind) to drive small-sized and low-power electronic devices.
- Piezoelectric energy harvesters (PEHs) can convert mechanical energy into useable electric energy.
- Predict and optimize electromechanical performance of PEHs by numerical simulations.

ACHIEVEMENTS

- An electromechanical model for thin-walled PEH structures is established and validated.
- A simplified fluid model based on the potential flow theory is successfully used to induce limit cycle oscillations (LCOs) for the above PEH model.
- A fluid-structure interaction (FSI) scheme suitable for non-volumetric representation of the solid is developed.

METHODOLOGY

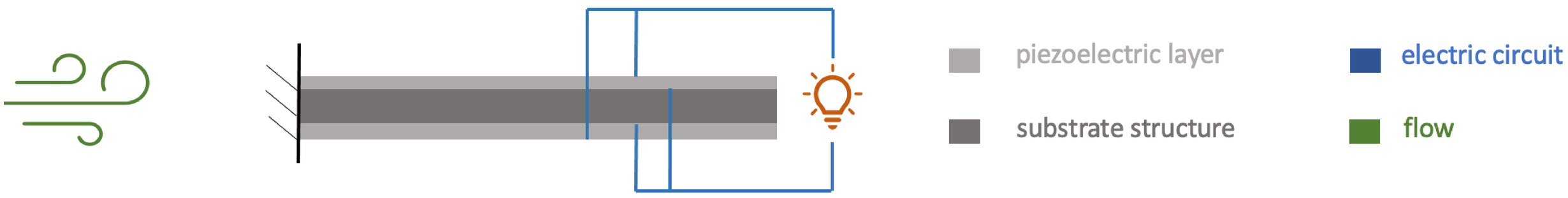

Figure 1 Schematic diagram of a flow-induced piezoelectric energy harvester

Fluid
- Potential flow theory: fluid force acting on the structure as a deformation-dependent function
- Imcompressible N-S equations: FSI in arbitrary Lagrangian Eulerian (ALE) framework with body-fitted mesh

Structure
- Geometrically nonlinear beam model
- Piezoelectric layers are coupled with the substrate structure using the no-slip condition between layers

Circuit
- Ohm's law
- Gauss's law.

Numerical discretisation: finite element method in space and generalized-α method in time, implemented in FEniCS

RESULTS

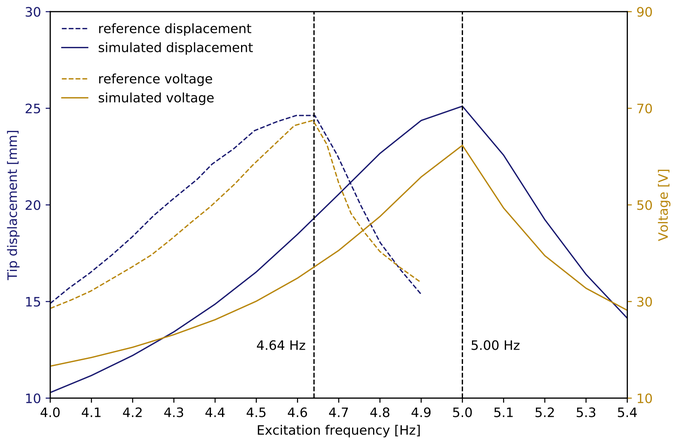

Figure 2 Validation of a thin-walled PEH model

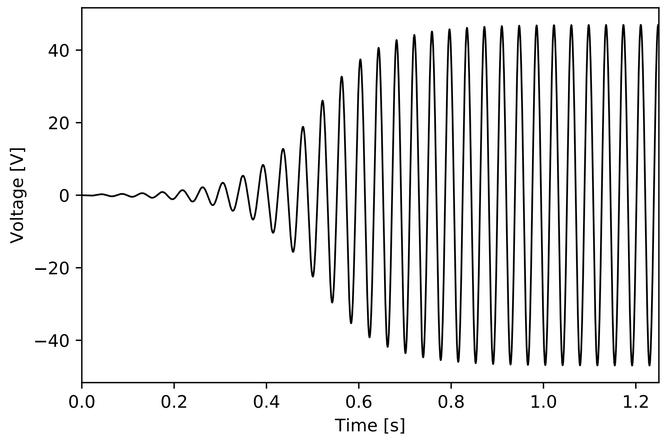

Figure 3 Harvest energy from LCOs

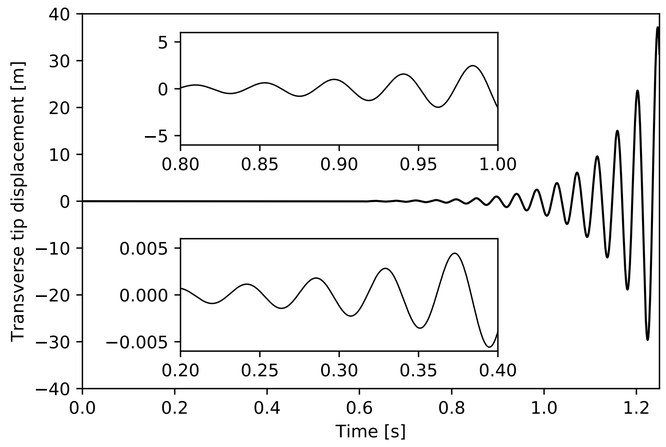

Figure 4 Unbounded response of a linear structural model

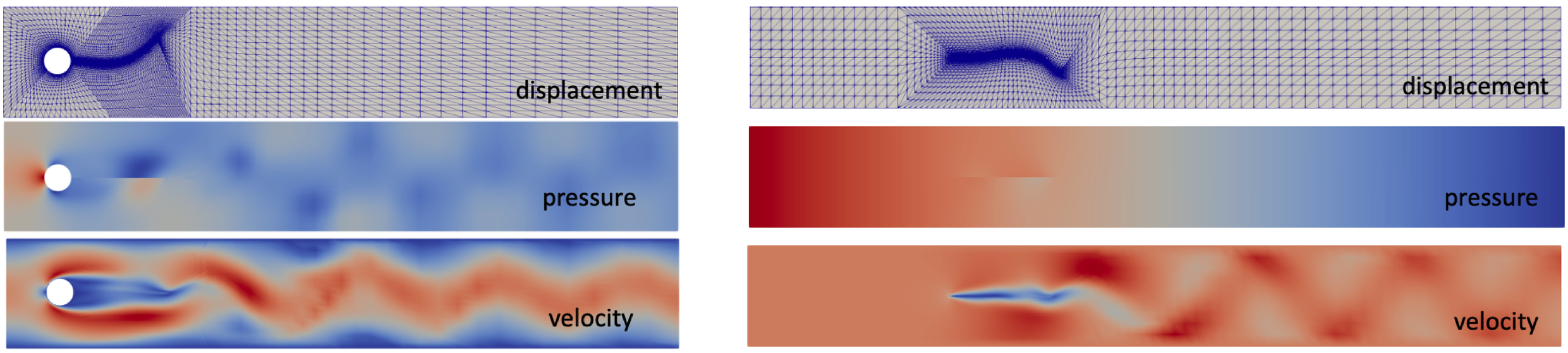

Figure 5 FSI of a non-volumetric immersed solid: (left) vortex-induced vibration and (right) self-sustained vibration

PERSPECTIVES

Reduce the order of the above high-fidelity multiphysics model to improve computational efficiency.

ACKNOWLEDGEMENT

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