HARNESSING THE ENERGY OF VIBRATIONS

FRONTIERS IN ENERGY RESEARCH

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MECH MAT

ROADMAP

Introduction

- Motivation
- Current approach
- Limitations
- Our approach

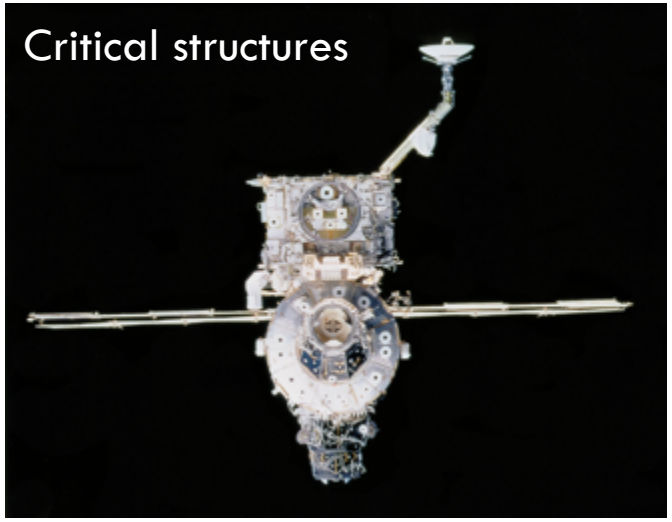
Harvesters

Surrounding structure

- **NOT AVAILABLE ONLINE**


http://www.rajant.com/wp-content/uploads/2014/12/reliability-rajant-mesh-wireless-network.jpg

WHERE?



Medical applications

Sources: http://www.tssphoto.com/2009/11/13/golden-gate-bridge/
http://cosmolearning.org/images_dir/education/photos/606-thumbnail-w700.jpg
http://www.travels321.com/glacier/
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ENERGY SOURCES

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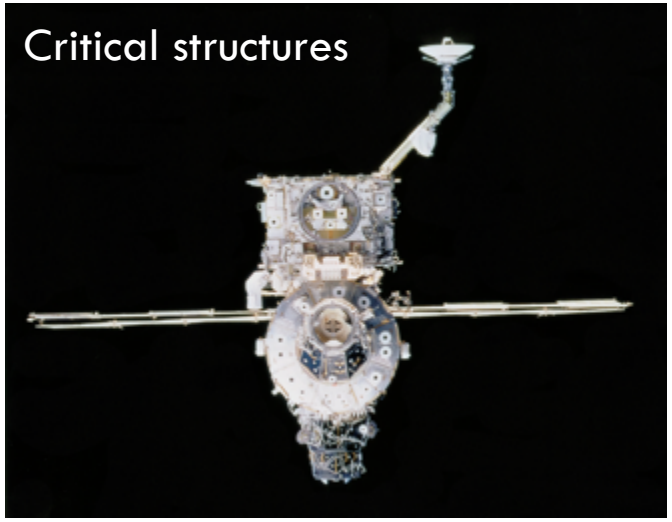
http://spaceplace.nasa.gov/templates/featured/sun/sunburn300.png

http://cliparts.co/cliparts/dc4/oBa/dc4oBaeei.gif

WHY VIBRATIONS?



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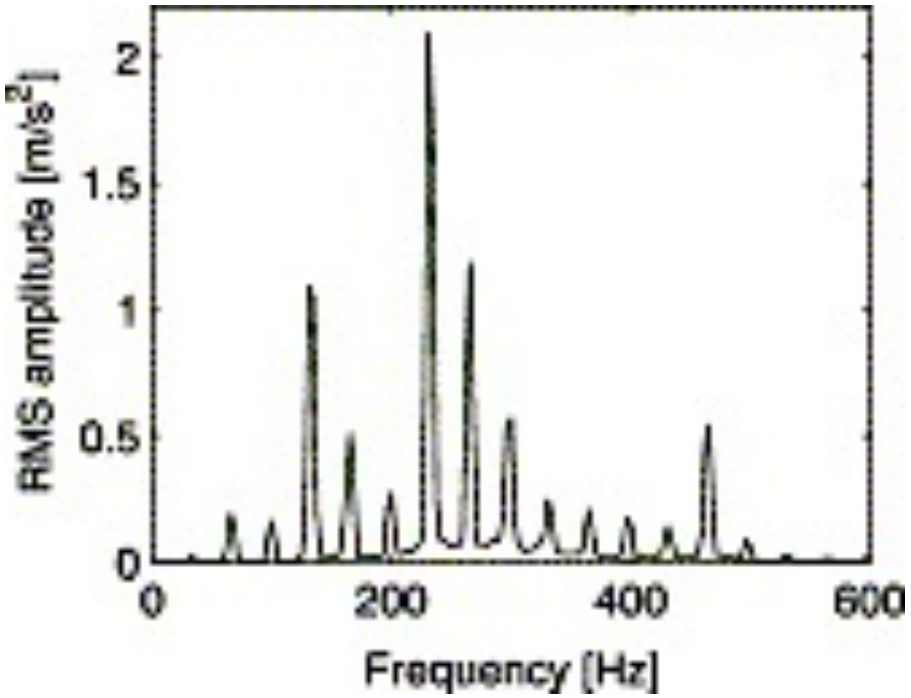
http://www.wired.com/2015/05/future-wind-turbines-no-blades/
http://newsroom.medtronic.com/phoenix.zhtml?c=251324&p=irol-mediakit&ID=Pacemakers

AMBIENT VIBRATIONS AS POWER SOURCE!

Accessible ambient vibrations are:

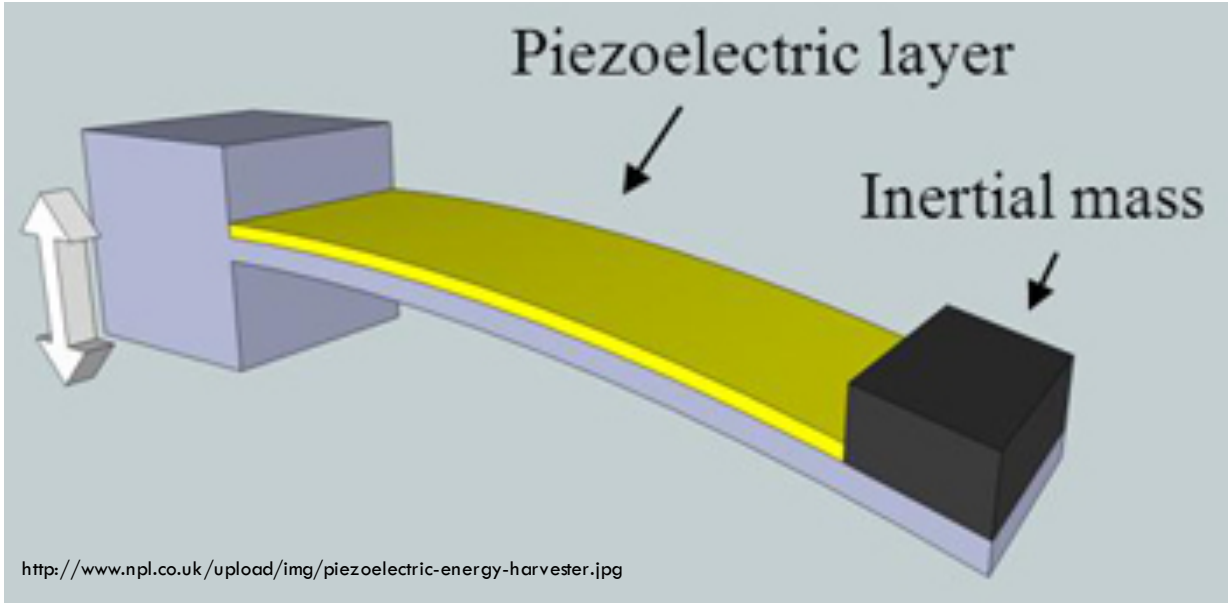
- Wideband,
- Incoherent in phase,
- Noisy, and
- Have low-frequency content.

E.g.: measurement of vibrations in a car:

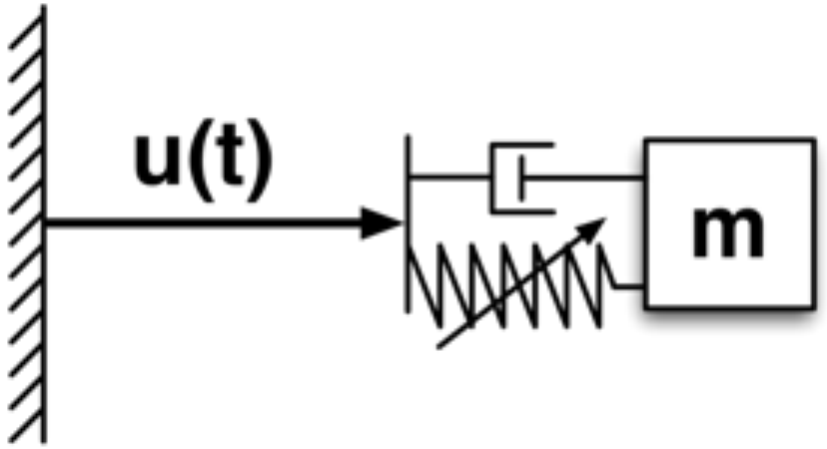


Source: C. Bohn, A. Cortabarria, V. Härtel, and K. Kowalczyk, *Control Engineering Practice,* vol. 12, pp. 1029-1039, 2004.

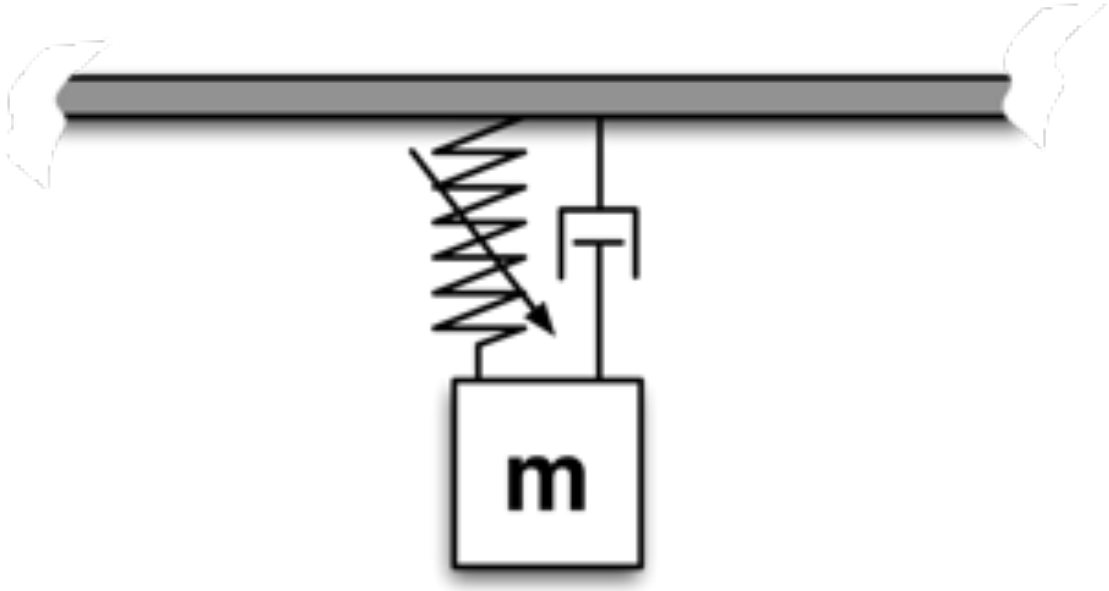
HARVESTING VIBRATIONS



http://www.npl.co.uk/upload/img/piezoelectric-energy-harvester.jpg



HARVESTING VIBRATIONS



EXISTING SOLUTION: LINEAR ENERGY HARVESTING

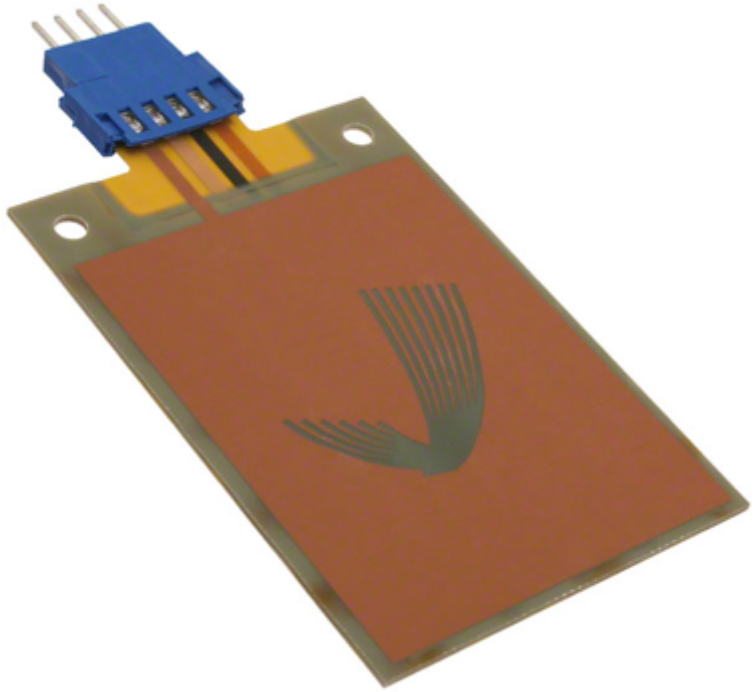
Good performance only in a narrow operating range

Harvesting low frequencies requires large devices

Simple to understand and design

See also: A. Erturk, D. J. Inman, “Piezoelectric energy harvesting”, *2011*.

E.g.: Mide Volture harvesting devices

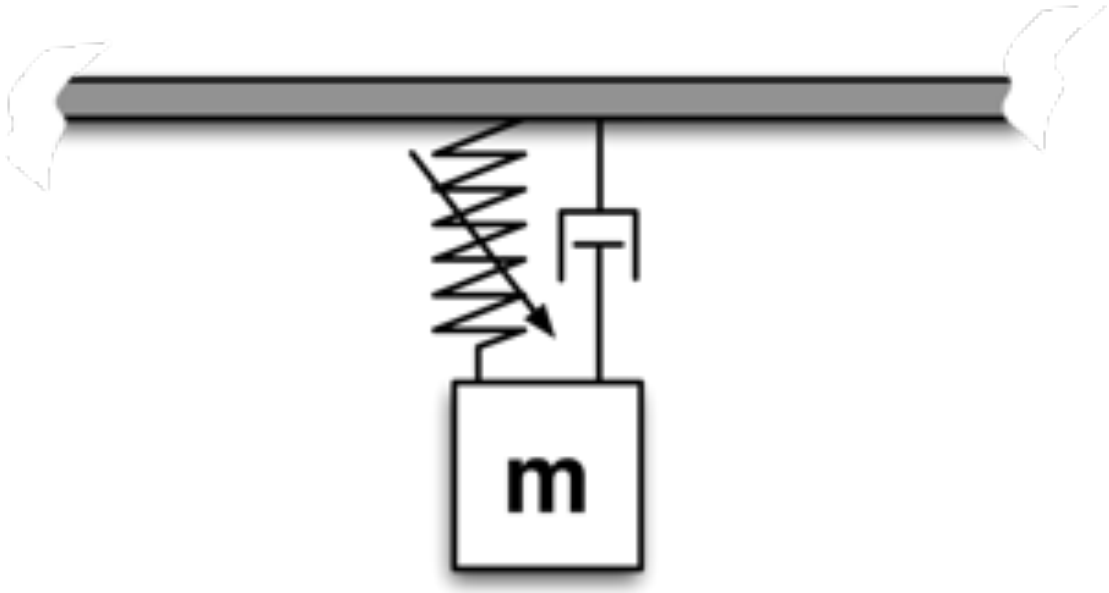


Source: http://media.digikey.com/Photos/Mide%20Tech%20Photos/V20W.jpg

LINEAR RESONANCE: BANDWIDTH

Q-Factor Bandwidth tradeoff

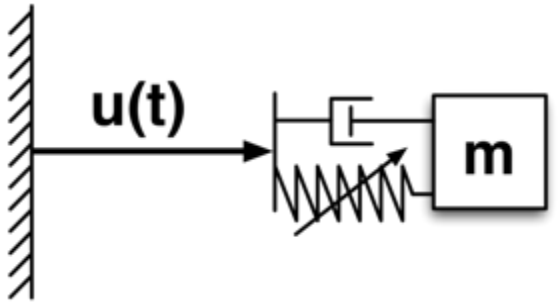
REALITY

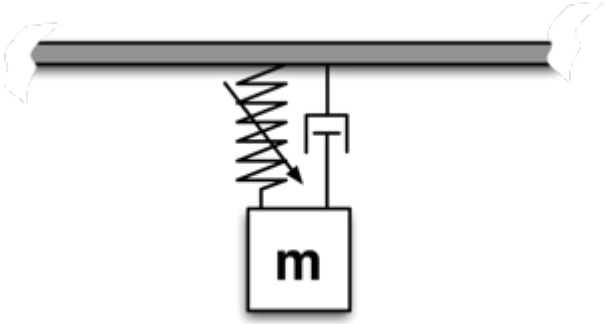


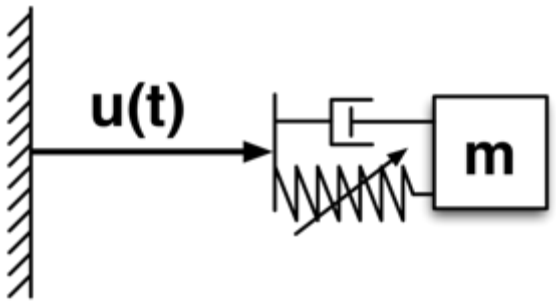
TARGET PROBLEM

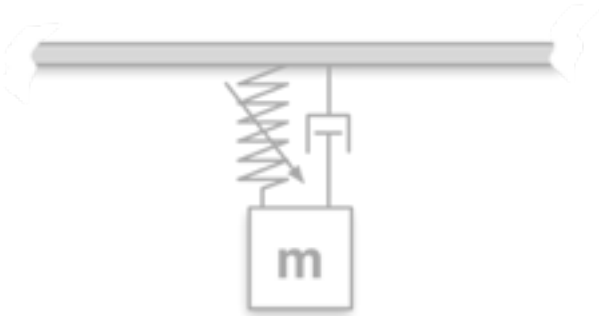
Tabletop sized setups

- Wideband harvester
  - Piezoelectric
- Energy localization









HARVESTING DEVICES

ROADMAP: HARVESTING

Objective

Current Approaches

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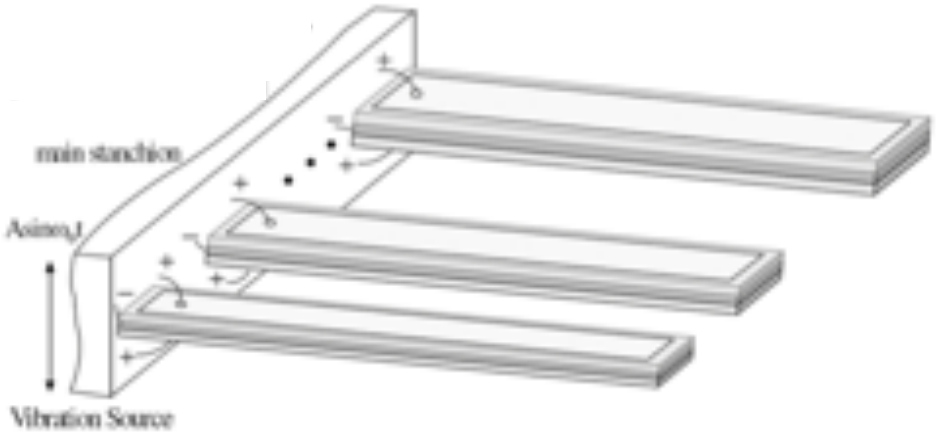
OBJECTIVES: HARVESTER

Wideband response

CANTILEVER ARRAYS



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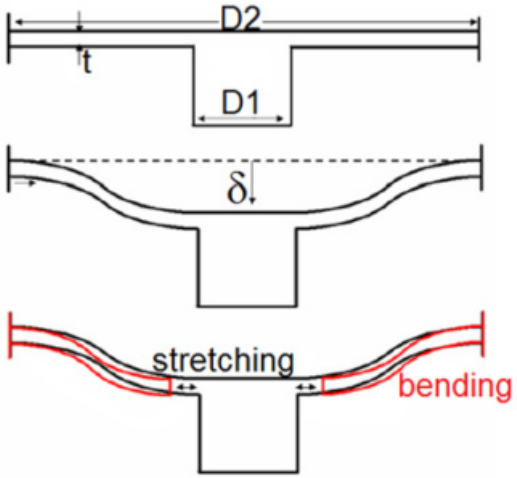
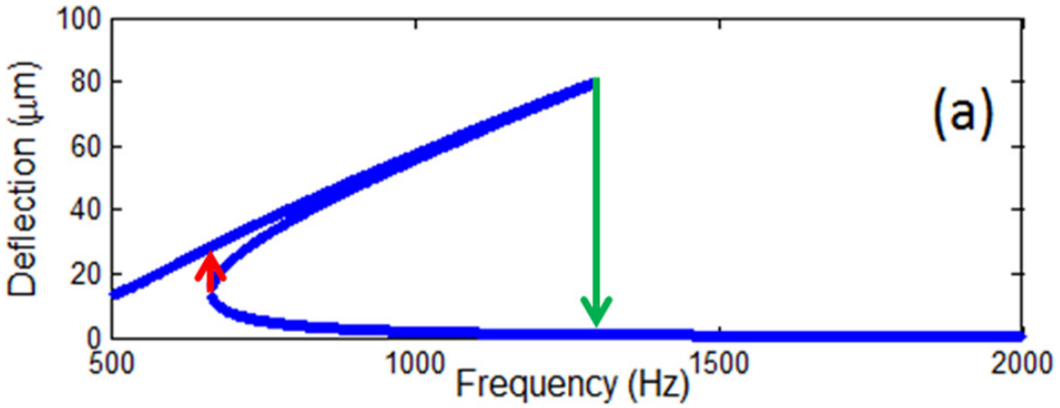
DUFFING-OSCILLATORS





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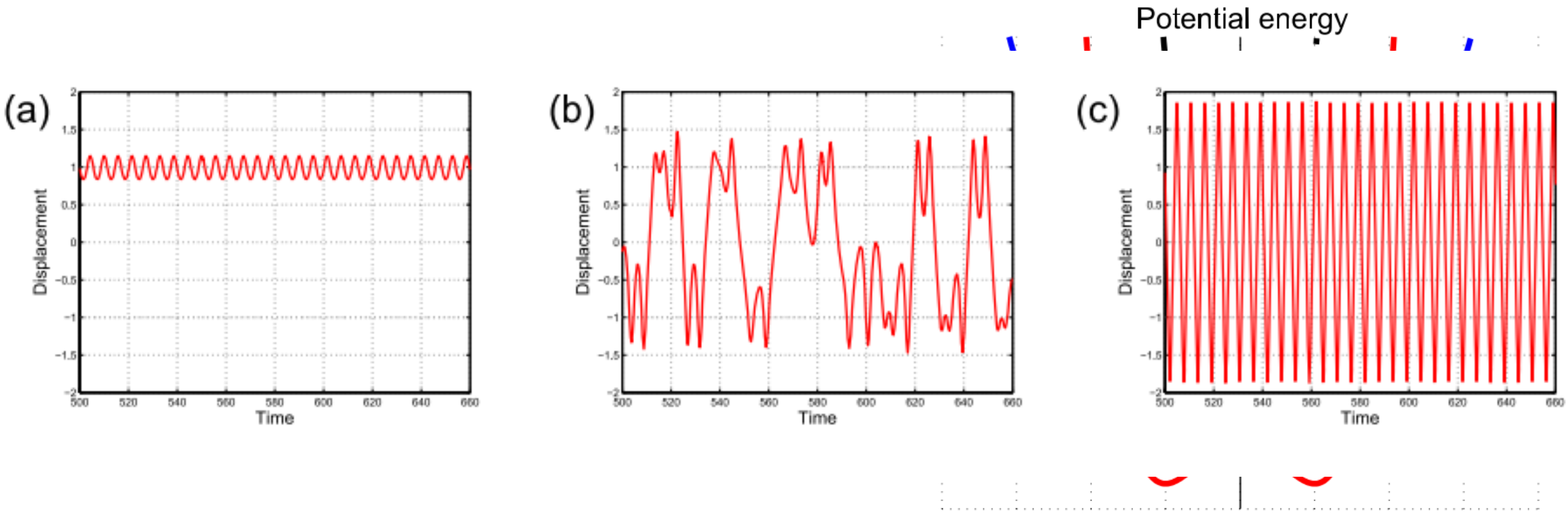
BI-STABLE SYSTEMS



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HARVESTERS: PLANNED WORK

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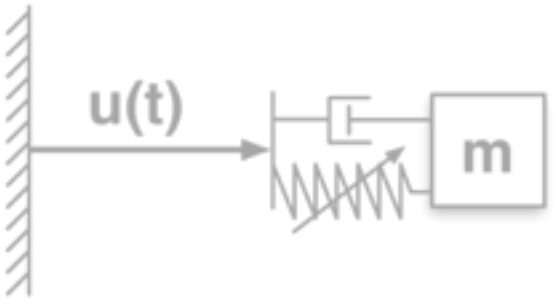

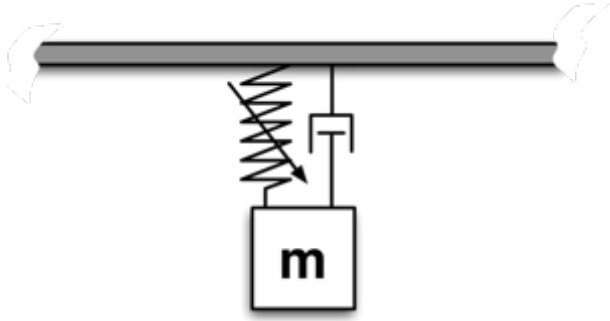

VIBRATION LOCALIZATION

ROADMAP: LOCALIZATION

Motivation & Aim

Metamaterials

Tunable Metamaterials

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WHAT TO OPTIMIZE

Complete structure

Local structure

- Material vs. mechanical design

OBJECTIVES: SURROUNDING MATERIAL

Amplify

- Focus energy of vibrations

For changing system properties

- Tuneability

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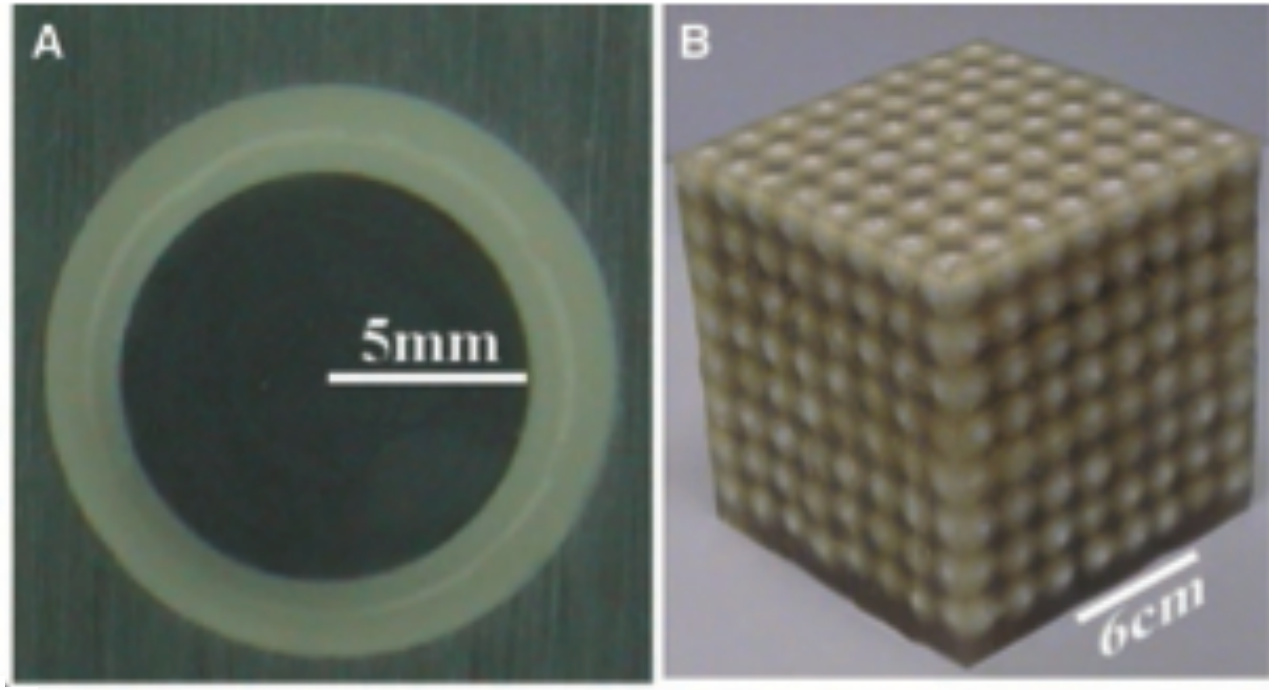
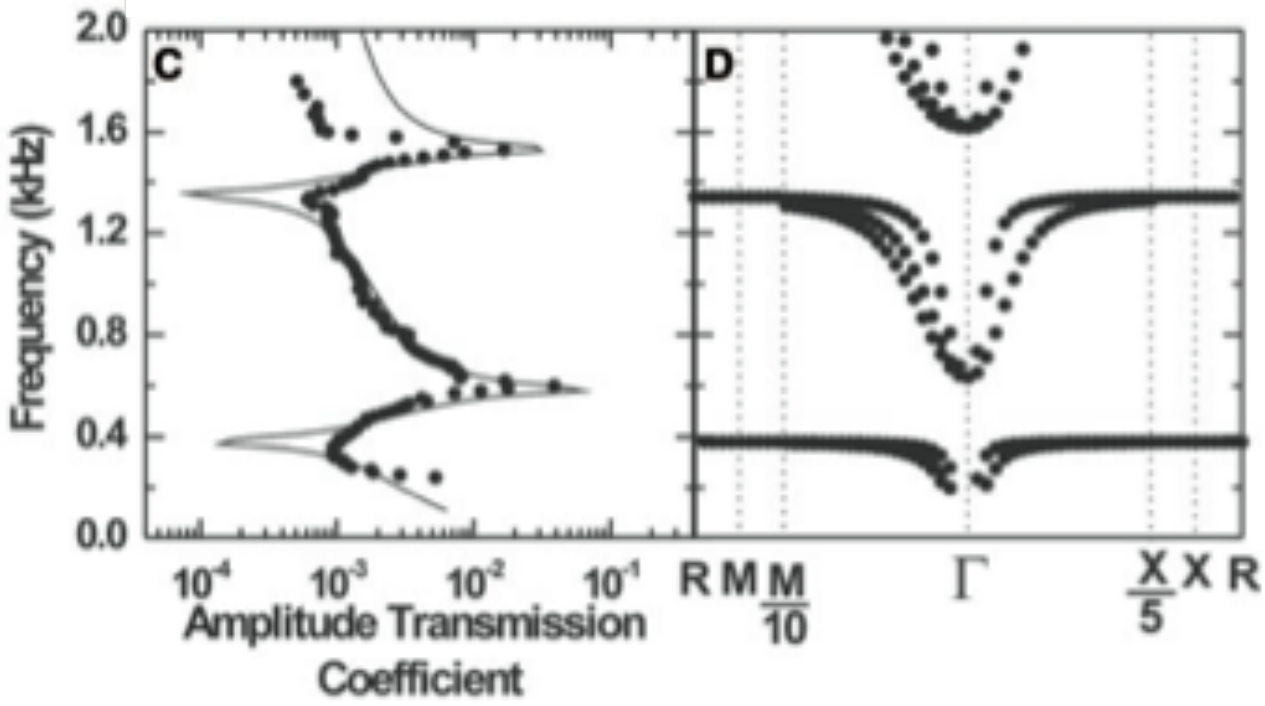
METAMATERIALS

Periodic structures with unexpected properties

LOCALLY RESONANT METAMATERIALS





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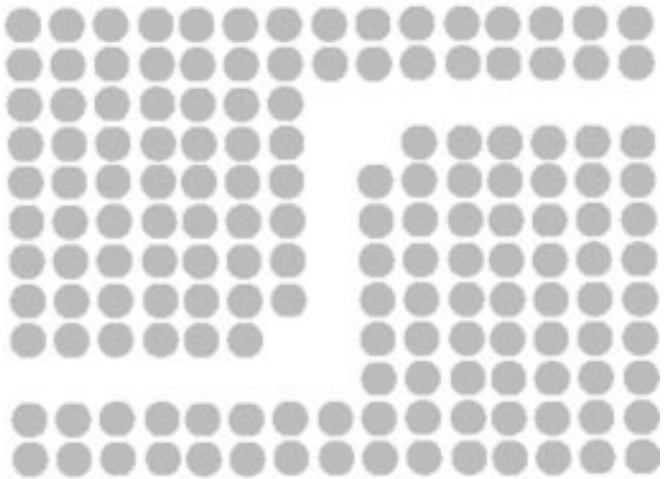
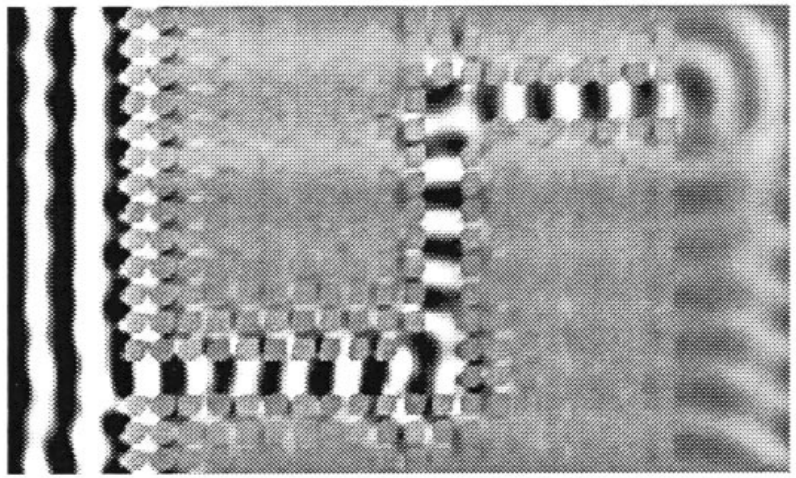
METAMATERIALS: WAVE GUIDING





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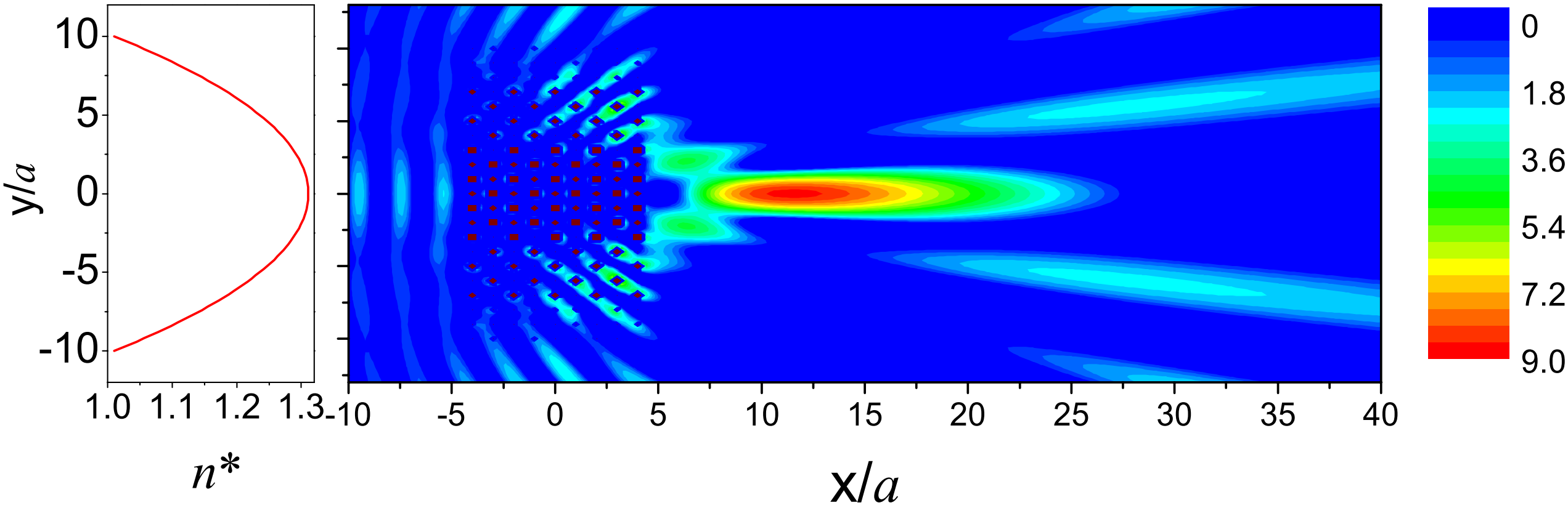
METAMATERIALS: FOCUSING



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OUR APPROACH

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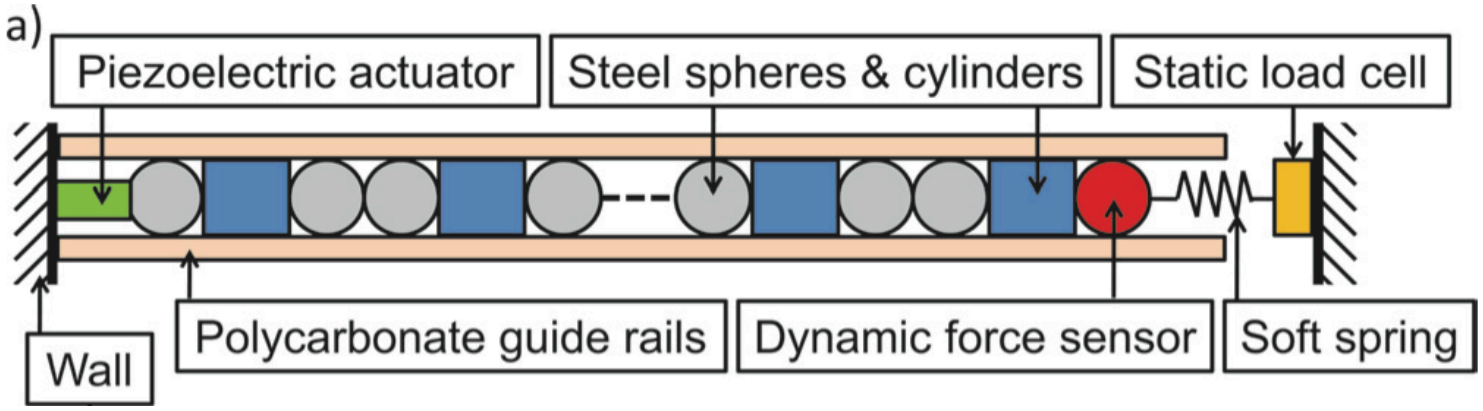
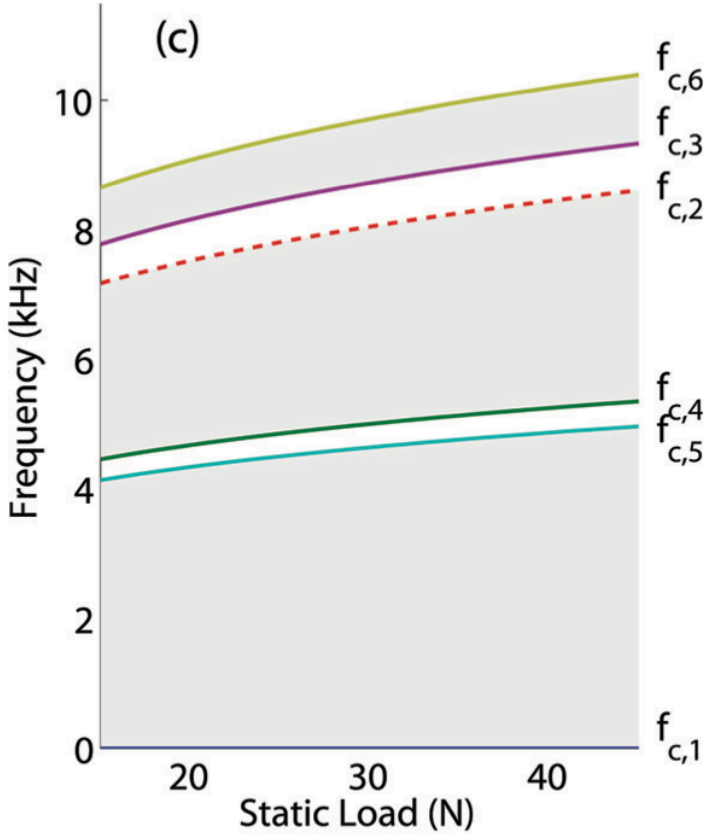
TUNABILITY OF METAMATERIALS

HERTZIAN CONTACT





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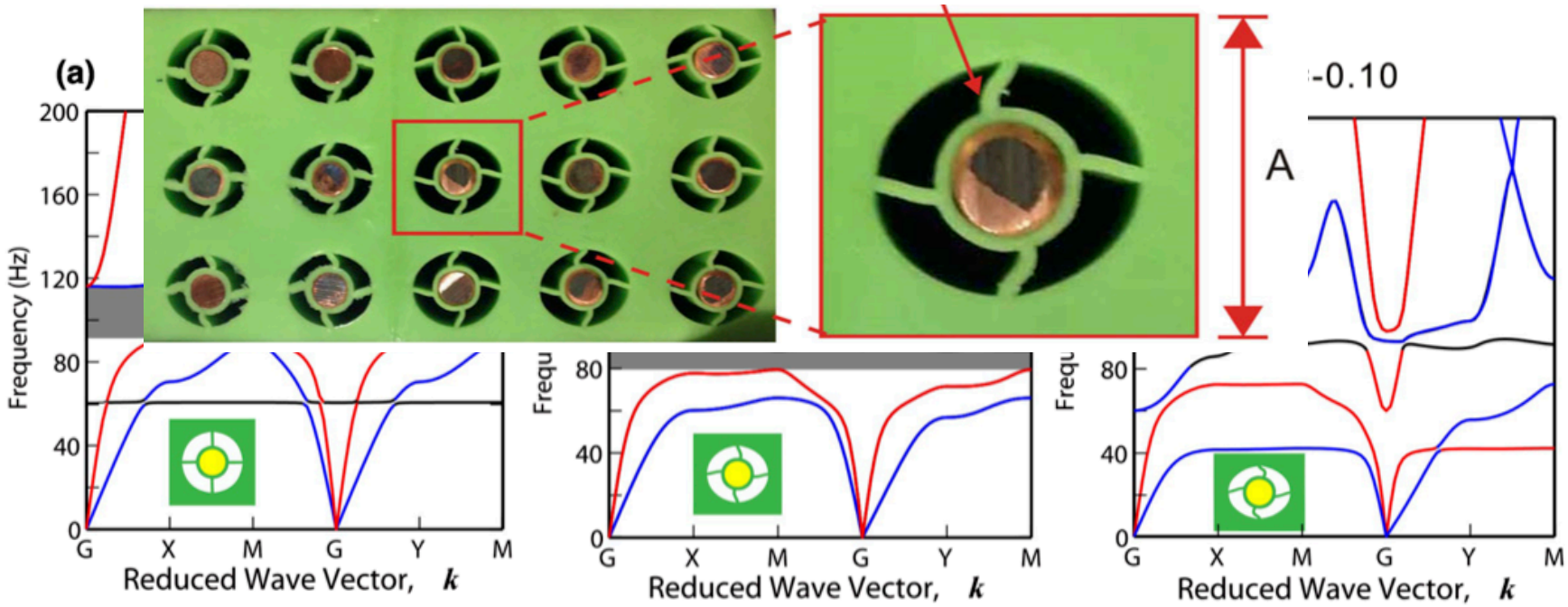
BUCKLING



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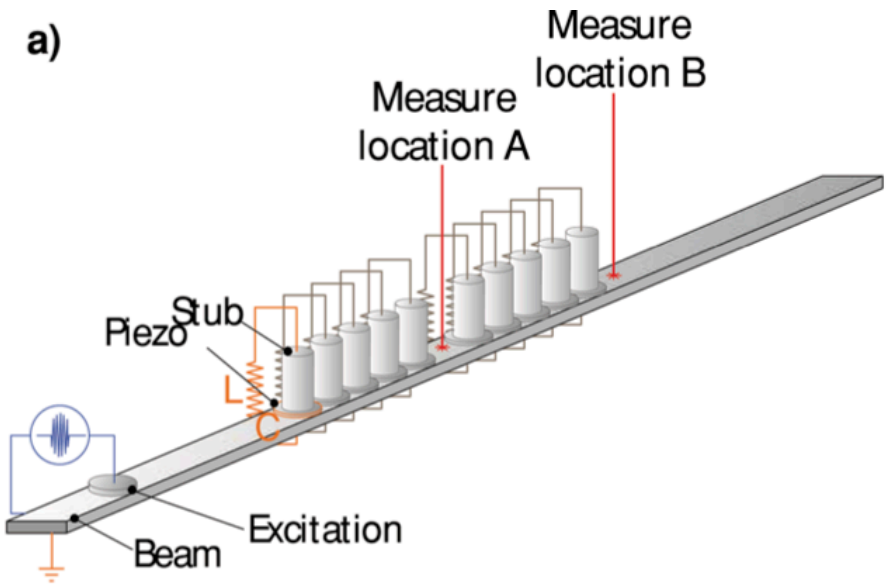
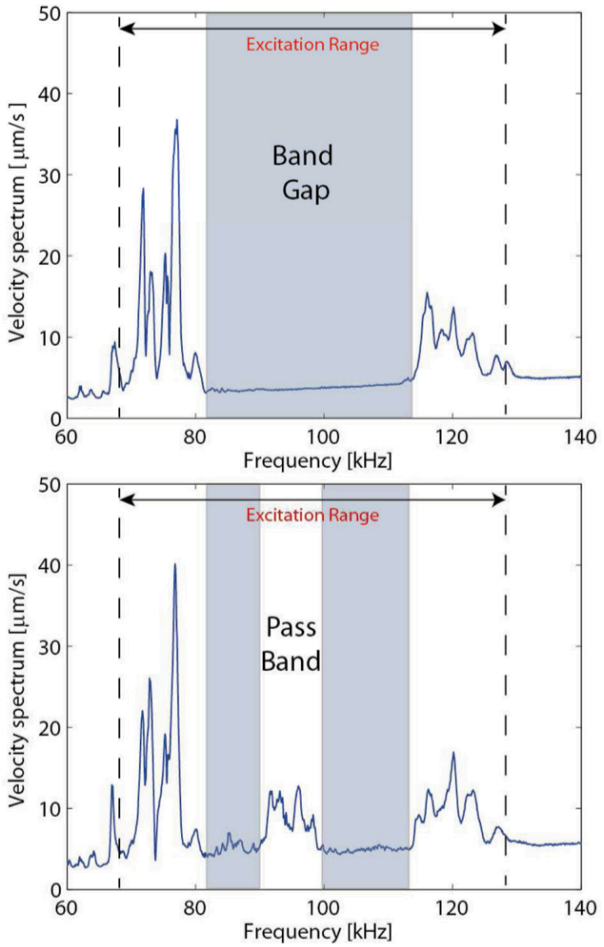
ELECTROMECHANICAL COUPLING





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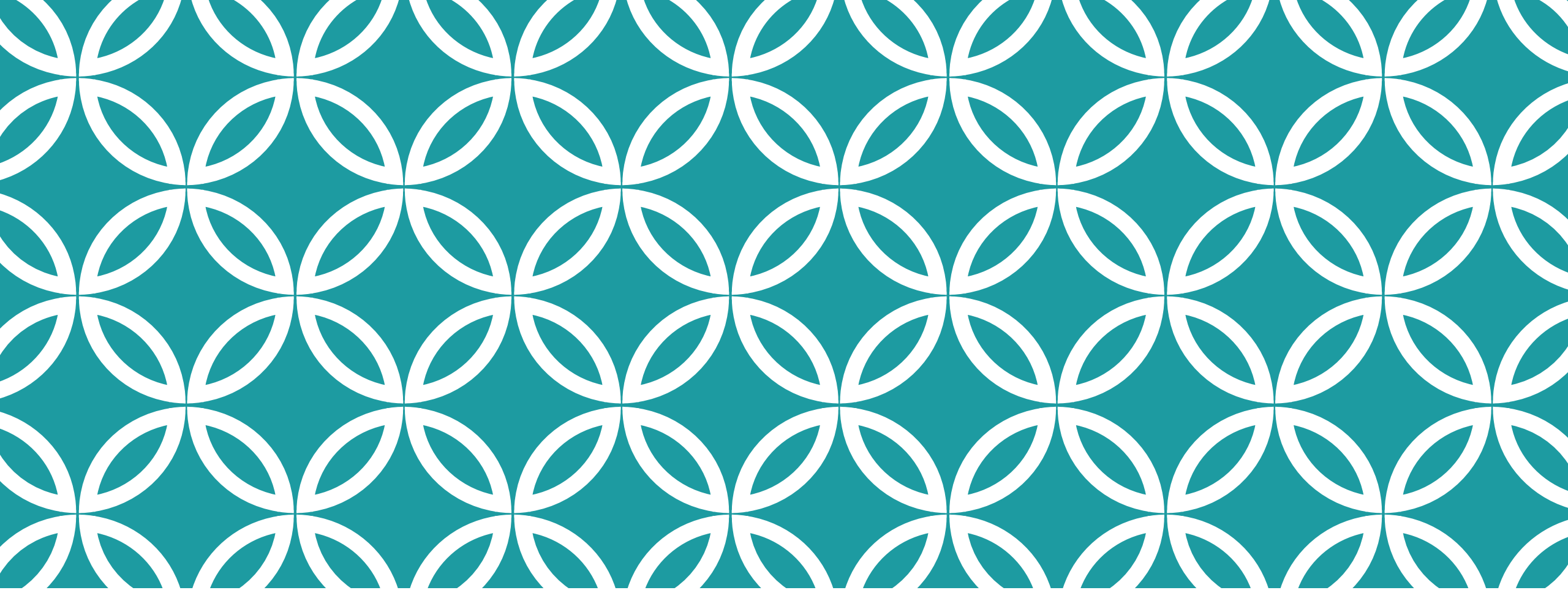

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*ALUMNI

QUESTIONS?

ETH zürich

MECH MAT