

Experimental measurements of dispersion relations in a disordered mechanical chain

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Background

- **Disorder induced localization applications**
 - Charge accumulation in nano-sized structures
 - Macroscopic structures like photonic crystals
- **We built a mechanical setup to measure natural frequencies and modes**
 - Major improvement over earlier attempts
 - Minimal friction
 - Allows for a system with many degrees of freedom
 - Can have uniform structure, or
 - Can easily be modified with localized disorder points with magnets, weights, etc. to mimic lattice imperfections
- **Device consists of a damped, sinusoidal-forced system of many masses coupled with springs**
 - The amplitude and phase of each mass's vibration can be obtained for each drive frequency
 - This gives expected transmission through the system as a function of frequency

Device Setup

- **23 identical metal cubes linked by springs**
 - Springs "KrazyGlued" to cubes
 - Cubes hanging from long strings (such that $\sin \theta \approx \theta$)
 - Strings attached to "2 x 4" hanging from ceiling
- **Excited at one end by a variable frequency mechanical vibrator**
 - Essentially a speaker cone attached to a rod
 - Amplitude and frequency controlled with a digital signal generator
- **Output response can be measured at any of the cubes**
 - Using piezoelectric accelerometer
 - Lock-in amplifier used to obtain signal in noisy environment (big air conditioning on top of building and car traffic at the bottom)
 - Only took measurements for the last cube. But can be done for any.
- **Disorder can be introduced by:**
 - Changing one or more of the masses
 - Changing one or more of the springs
 - Introducing other forces (i.e. magnetic) at one mass

Device Setup



The mechanical vibrator



A few blocks in the middle section

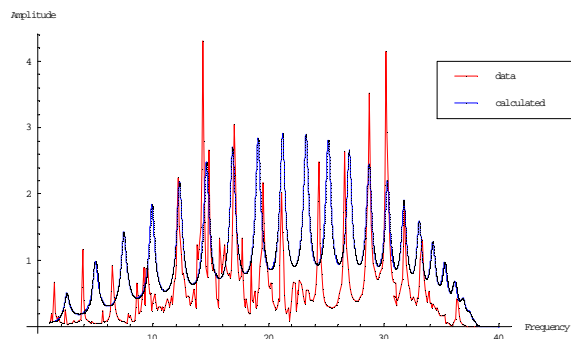


Piezoelectric accelerometer attached to last block

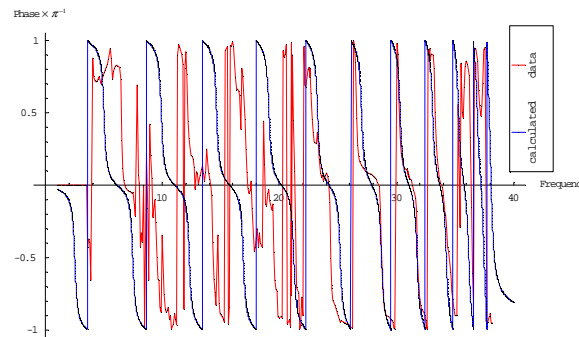


The complete system

Amplitude Measurements



Phase Measurements



Outlook

- In simplest system we were successful in measuring some resonance peaks and phase changes
- **Experimental Problems**
 - **Intrinsic**
 - Due to low friction, response time is slow
 - Single sweep of frequencies takes at least a few days
 - Various external conditions (i.e. temperature, mechanical breakage) can occur over the course of a set of measurements
 - Response properties of accelerometer at low frequencies has not yet been determined
- Although there are technical hurdles still to overcome, fundamentally this device can be very useful for measuring the effects of localized disorder