

# Energy Localization

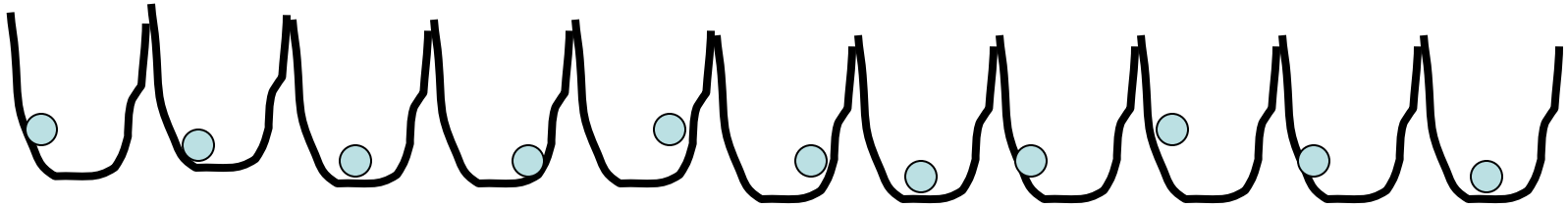
The key to Understanding Energy in  
Nanotechnology & Nature

Nature assembles ordered structures out of chaos without a temperature gradient or energy input.

Systems generally go from ordered to chaotic.

How does nature go from the chaotic to ordered?

Atoms in most solids vibrate at high frequency and **low amplitude**

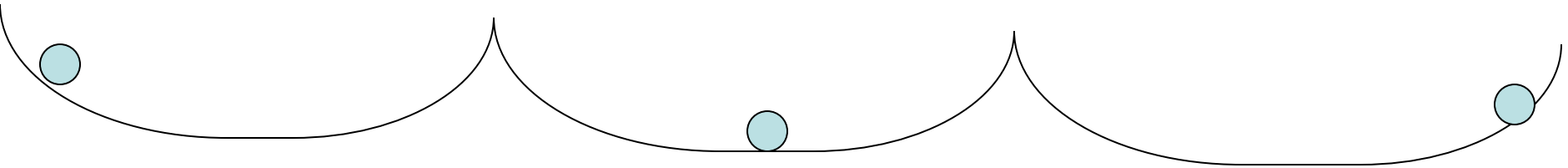


Atoms' nuclei generally reside in parabolic potential wells.

The nuclei undergo simple harmonic motion as if they were connected by springs.

Some Materials have non-parabolic  
potential wells

They produce nonlinear vibrational  
modes



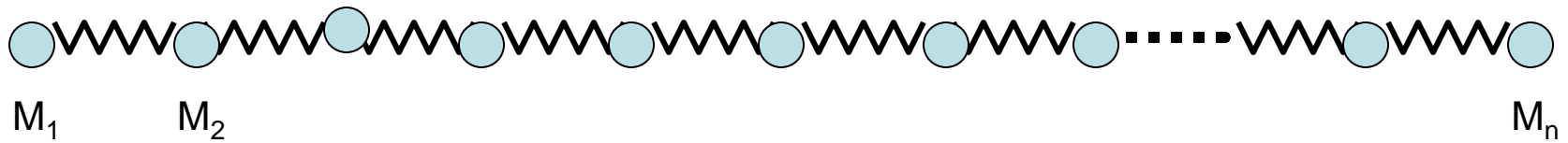
Large Amplitude, Low Frequency Vibrational modes

Levitating magnet

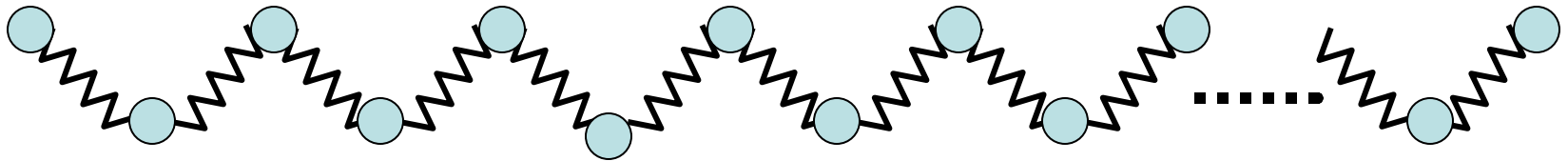


superconductors have very large  
amplitude vibrational modes

# Enrico Fermi, 1954 Los Alamos MAINIAC I



Ideal Springs obey Hooke's Law  $F = -k_1 X$



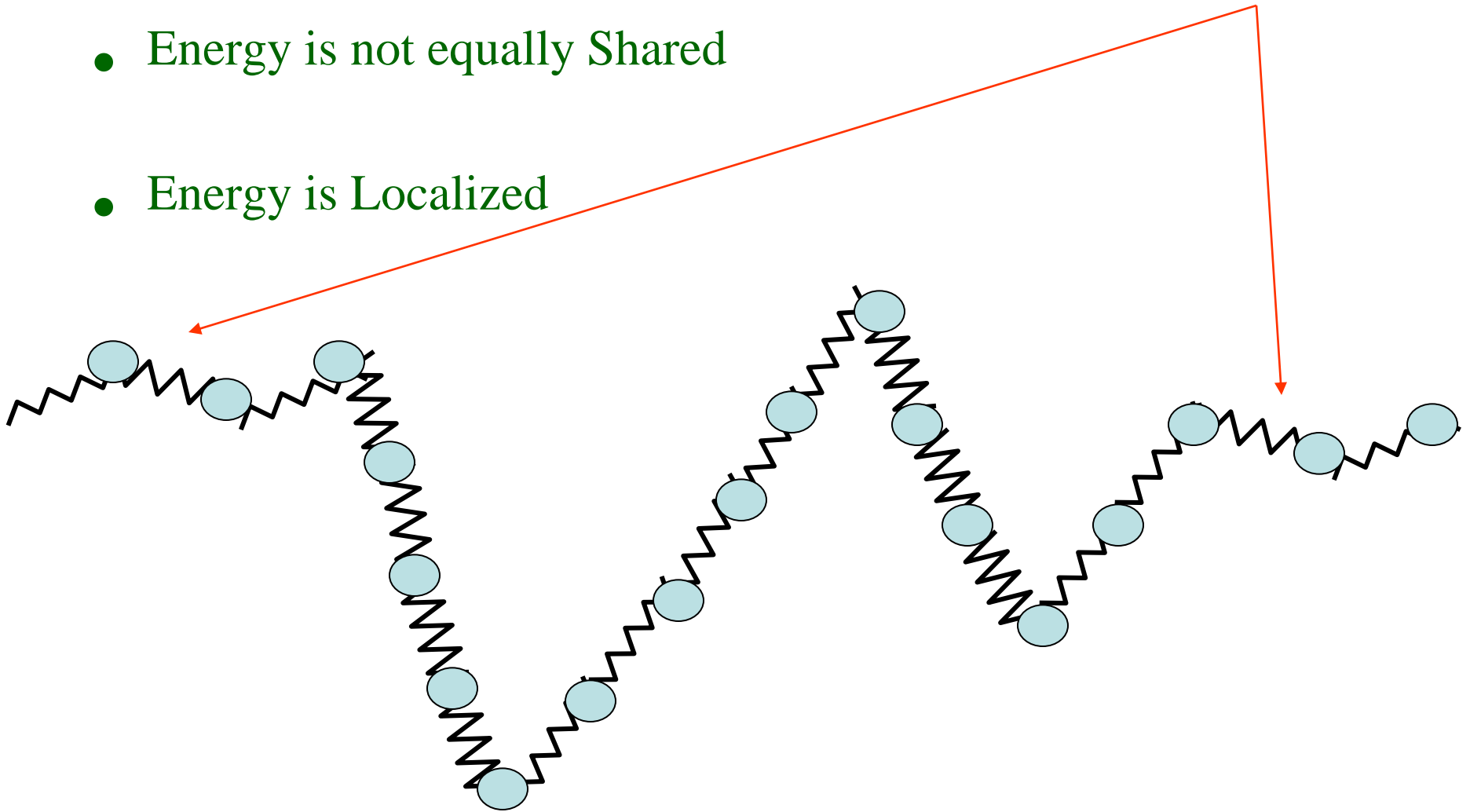
Equipartition of Energy

Every mass has the same vibrational energy

# Non ideal Springs

- $F = -k_1X + k_2X^2$
- Energy is not equally Shared
- Energy is Localized

Vibrationally cold



# Fermi & Ulam found that Energy is Localized when there is:

1. A **countable number** of elements
2. **Nonlinear coupling** between the elements



# nature

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## Oscillons observed

**Making continents from mantle plumes**

**Ligand for HIV co-receptor**

**Epidemiology of BSE**

**Software**

Energy Localized vibrational modes are so large that they can break and reform bonds.

Locally, the vibrations act like very hot regions with active chemistry.

Nanoparticles in the 3 - 12 nm size regime have both properties:

1. A countable number of atoms

A large fraction of the atoms are near the surface and reside in shallow, non-parabolic potential wells

2. Nonlinear Coupling



# Energy localization at the nanoscale circumvents the 2nd Law of Thermodynamics

Ordered structures can be assembled from Chaos

# nature

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Locally, the vibrations act like very hot regions with active chemistry.

The ferromagnetic effect is very different at the nanoscale

Energy Localization Controls the Process

Critical features for any nanodevice should be processed in the 3 - 12nm size regime.

# Nano-magnetism

## Super-Ferromagnetism

- Ferromagnetism is a cooperative phenomenon
- Ferrites processed at 3 – 12nm have cooperative oscillations
- Magnetic vortices arise at that dimension
- Vortex interactions extract energy via energy localization
- Ferrites run cold as a result
- Energy source is undetermined