

# **Thermal equilibrium of light atoms in heavy crystals**

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**Martin Fleischmann and Stanley Pons reported in 1989 their observation of nuclear products and excess heat in a palladium electrode during the electrolysis in heavy water. The experiments were interpreted by the authors as a result of nuclear fusion reaction (named cold fusion). More than 3000 papers in the field of cold fusion were published until then. The theoretical models are not able to describe these anomalies. The scientific community still rejects the interpretation of cold fusion experiments.**

**Since the initial excitement over Fleishman and Pons, the reality of the existence of cold fusion has been supported by a few researchers who have tried to reproduce excess energy production in electrolytic cells. Most scientists are dismissive of these efforts, but the researchers have managed to gain some attention in recent years and in 2006 sessions of both the American Chemical Society and the American Physical Society were devoted to low energy nuclear reactions. Still, skepticism about the existence of cold fusion is the default position of most scientists.**

**Two issues are cited as being problematic: the lack of consistently reproducible results and the lack of a theoretical mechanism.**

**The 1989 DOE panel said: "Nuclear fusion at room temperature, of the type discussed in this report, would be contrary to all understanding gained of nuclear reactions in the last half century; it would require the invention of an entirely new nuclear process". However, the panel recognized that the lack of a satisfactory explanation cannot be used to dismiss experimental evidence.**



pseudoscience



**DR. MARTIN  
FLEISCHMANN**

**Cold fusion crank**

**Prometheus?**

**Voodoo Science**

**pathological science**

**pseudoscience**

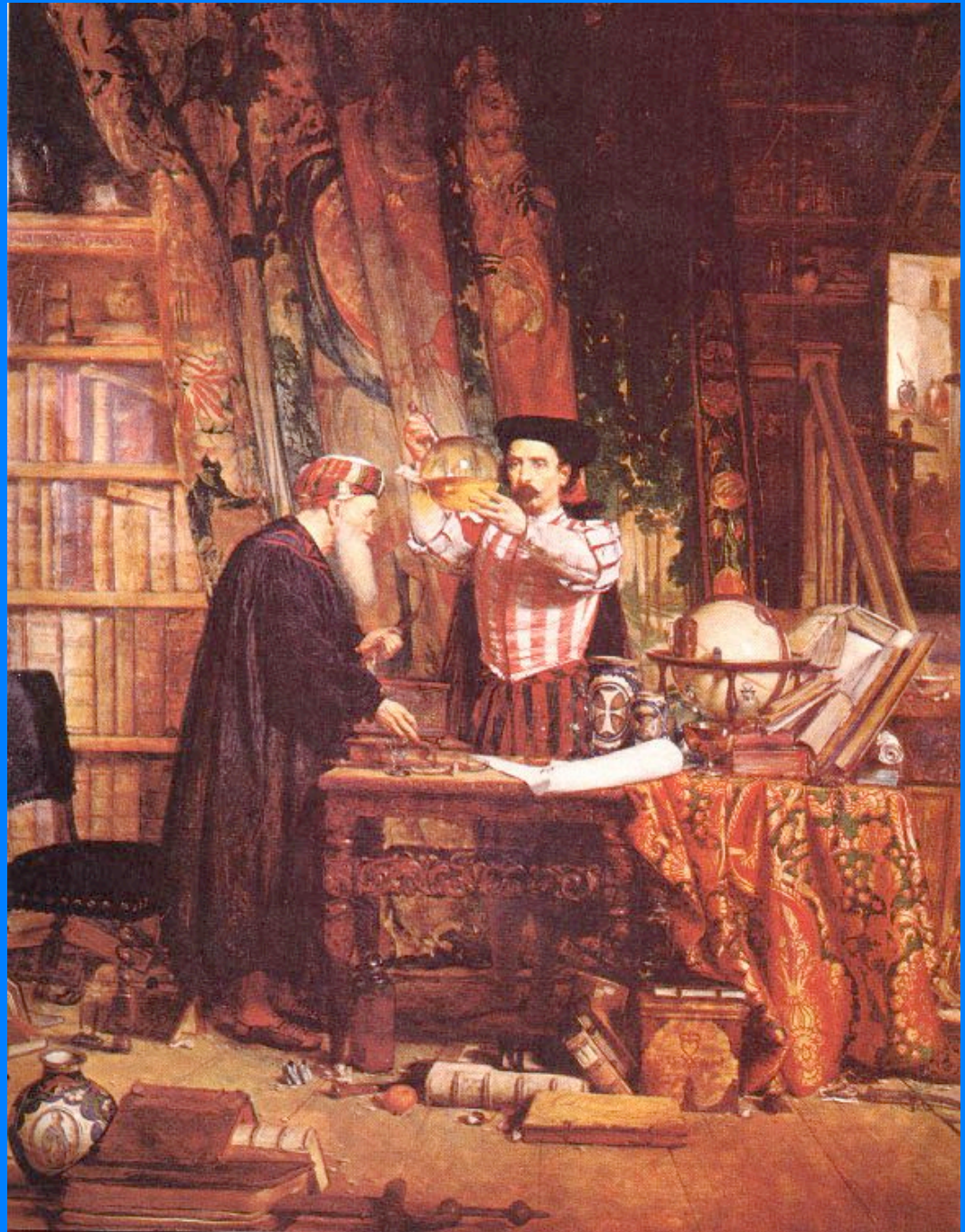
**philosopher's stone**

**fusion confusion**

# Alchemy

The alchemist  
of Sir William Douglas

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**Here are my arguments why cold fusion  
still could be possible**

# **Thermodynamics laws**

**The Zeroth Law of Thermodynamics introduces the concept of thermodynamic equilibrium, in which two objects have the same temperature.**

**The First Law of Thermodynamics states that energy can be changed from one form to another, but it cannot be created or destroyed.**

**The Second Law of Thermodynamics states that any two given system when interacting with each other will later reach the same average energy per particle and hence the same temperature.**



# Temperature

The temperature of an ideal gas is related to its average kinetic energy by the equation:

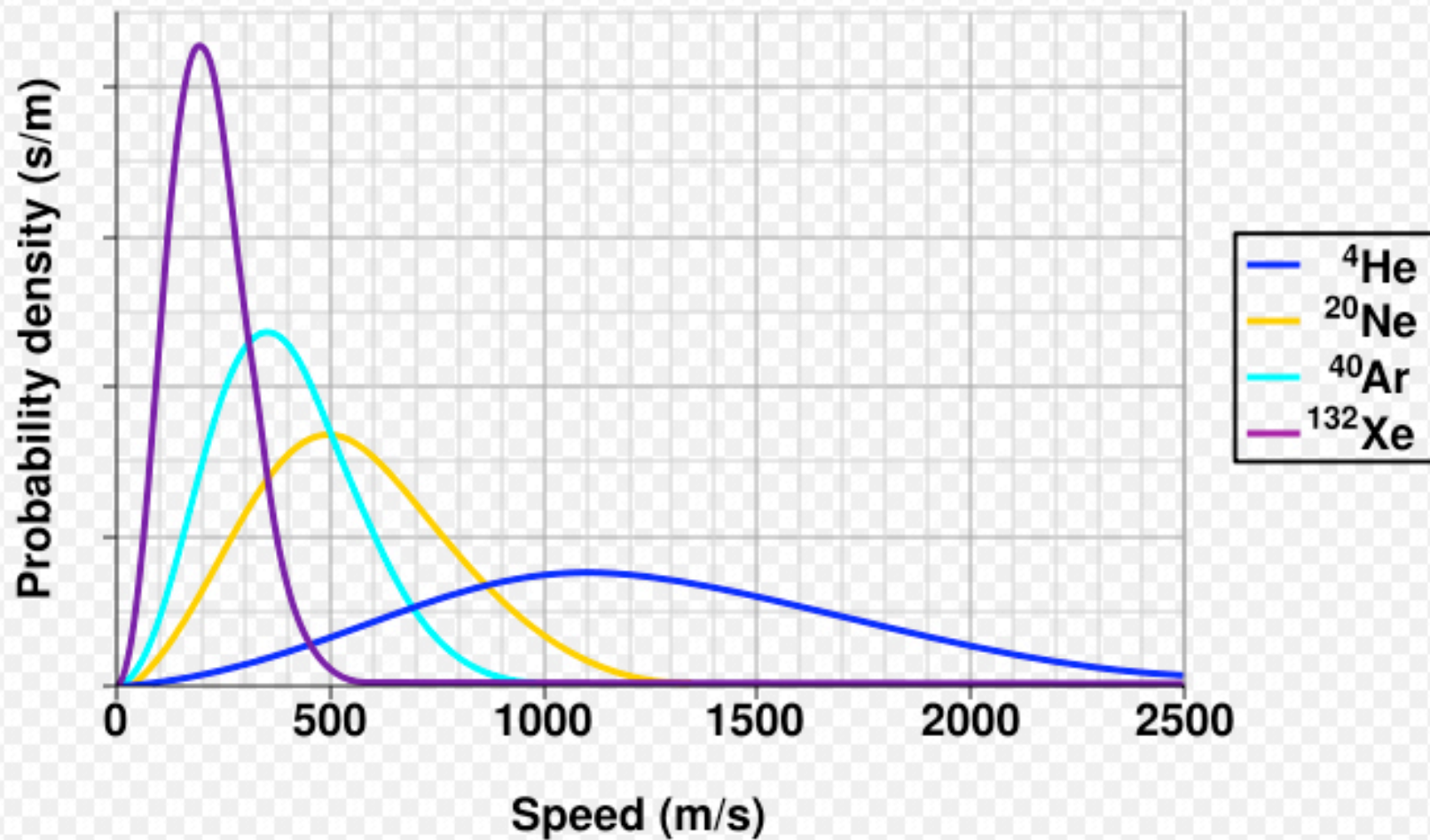
$$\overline{E}_k = \frac{3}{2} kT$$

where  $k = R/N_A$  ( $R$  = ideal gas constant,  $N_A$  = Avogadro number).  $k = 1.38 \cdot 10^{-23} \text{ J K}^{-1}$   
 $= 8.6 \cdot 10^{-5} \text{ eV K}^{-1}$

In the case of monoatomic gas the kinetic energy is:

$$E_k = \frac{1}{2} m v^2$$

## Maxwell-Boltzmann Molecular Speed Distribution for Noble Gas



$$\overline{E}_k = 3.9 \cdot 10^{-2} \text{ eV at } 300^\circ \text{ K}$$

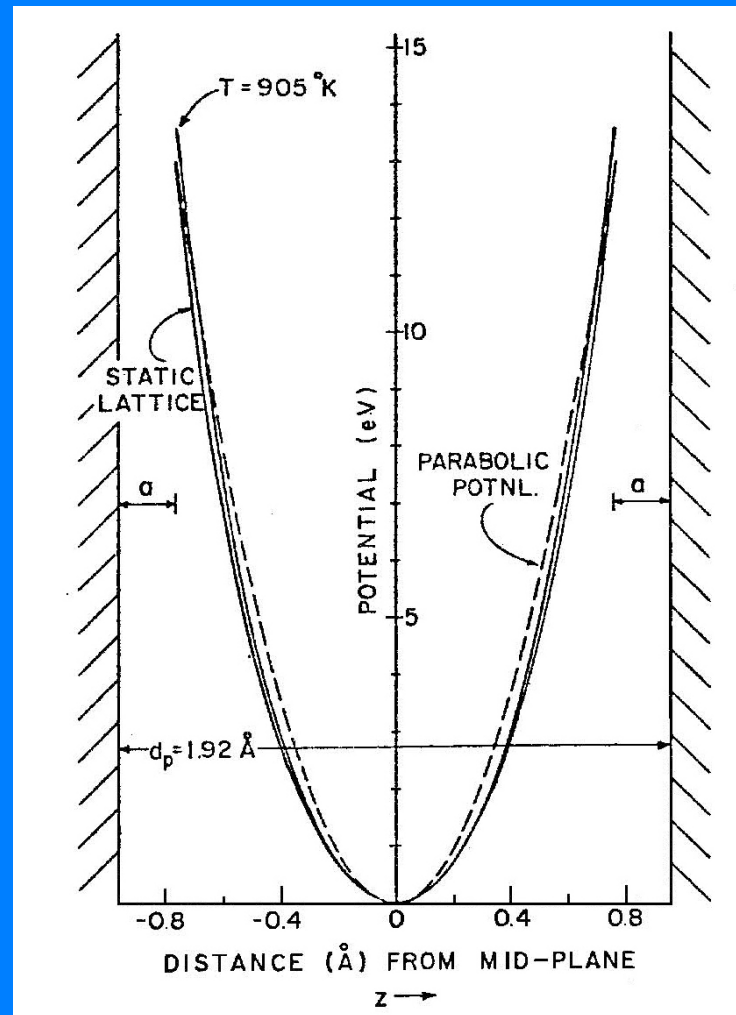


**In the case of a more complicated objects additional degrees of freedom are available, so molecular rotation or vibration must be included.**

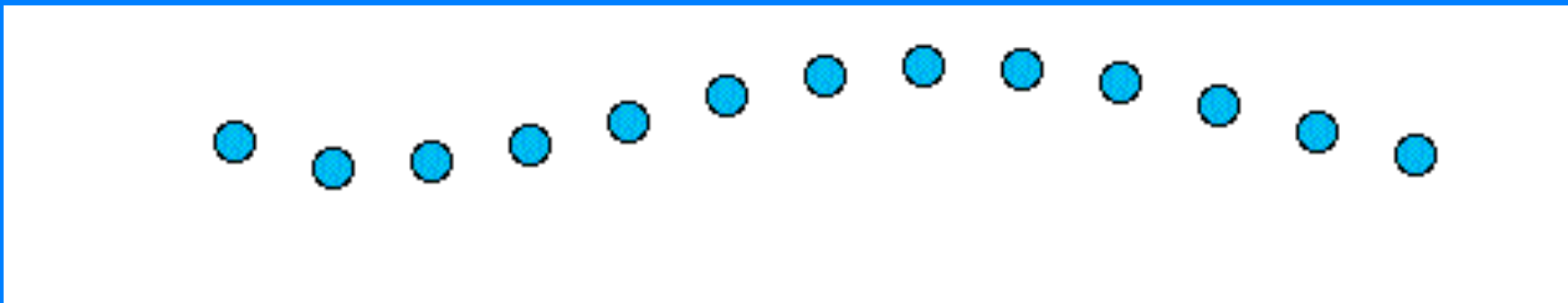
**Phonons in crystals:**

**Quantum of lattice vibration is called the phonon.**

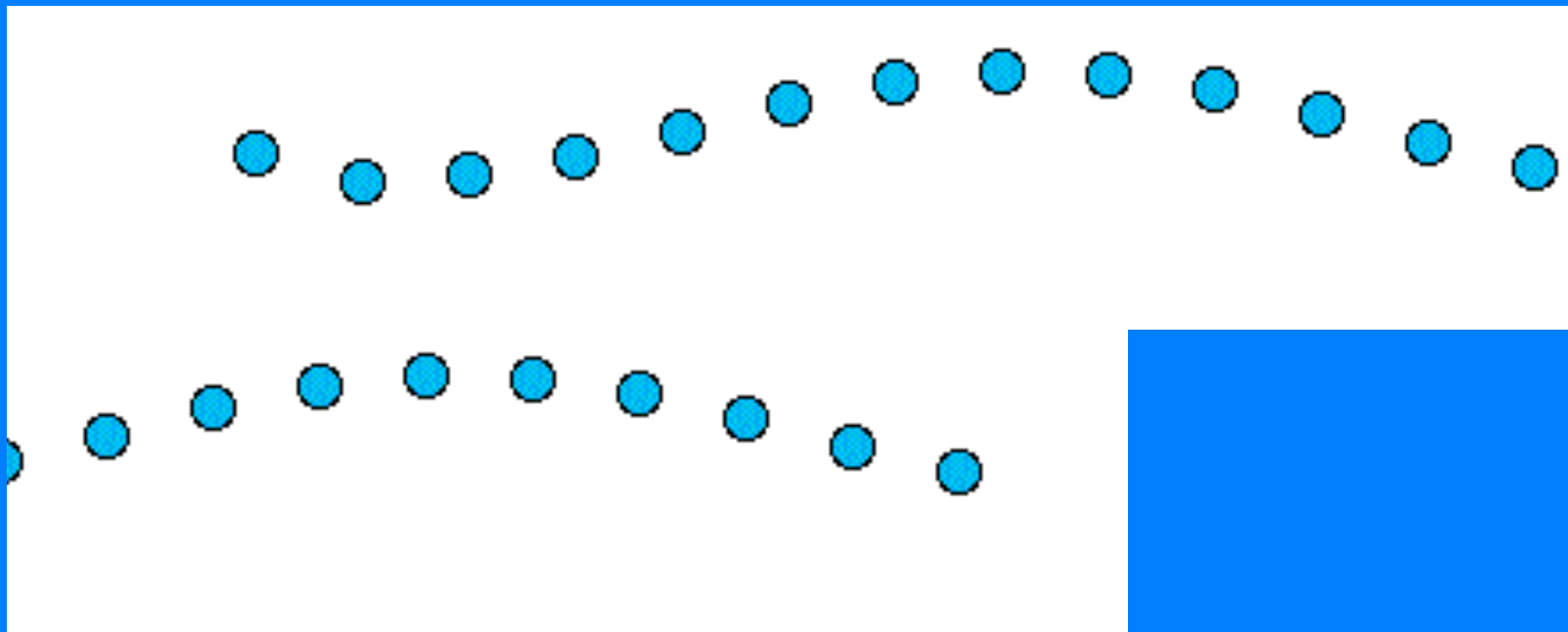
# Planar potential in Silicon



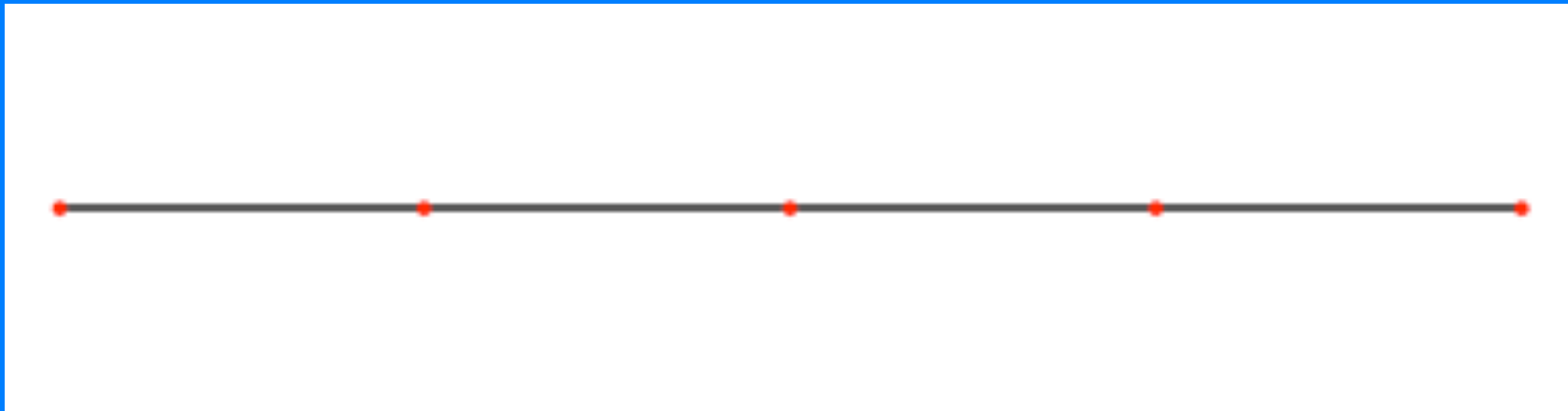
# Transverse acoustical mode for monoatomic chain



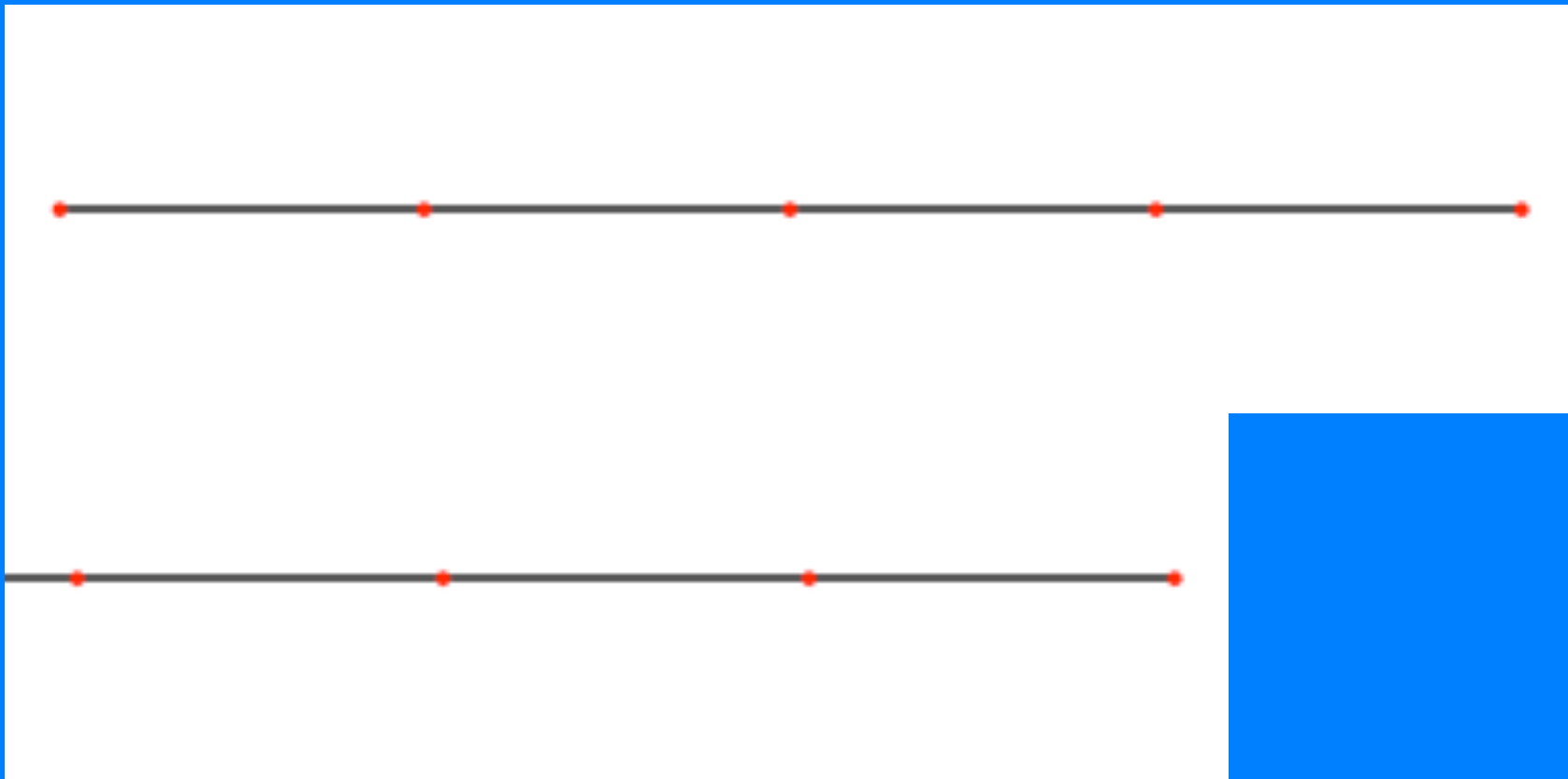
# Transverse acoustical mode for monoatomic chain



# Standing wave



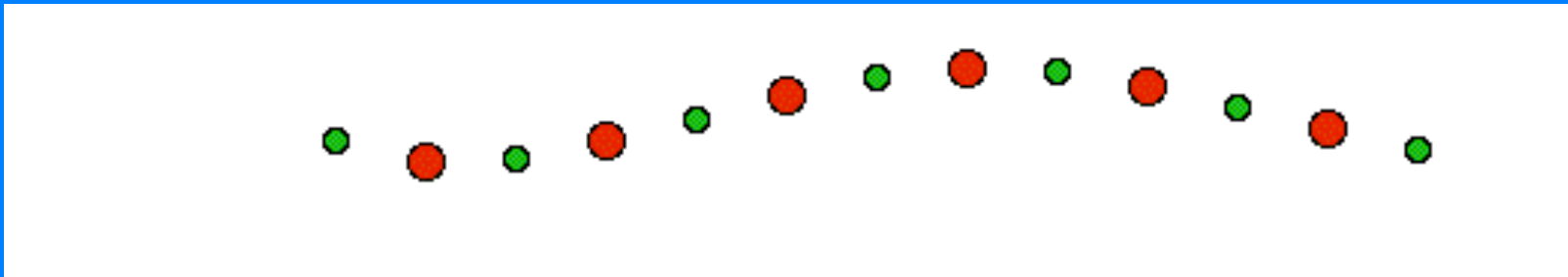
# Standing wave



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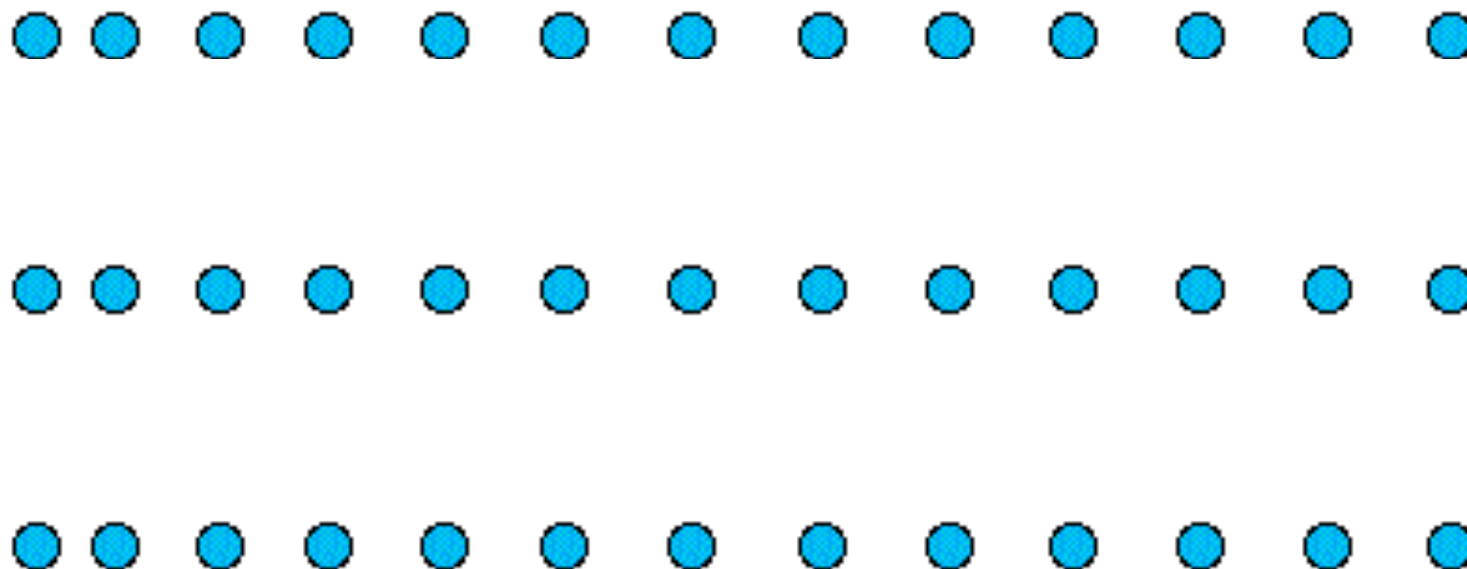
## Transverse acoustical mode for diatomic chain



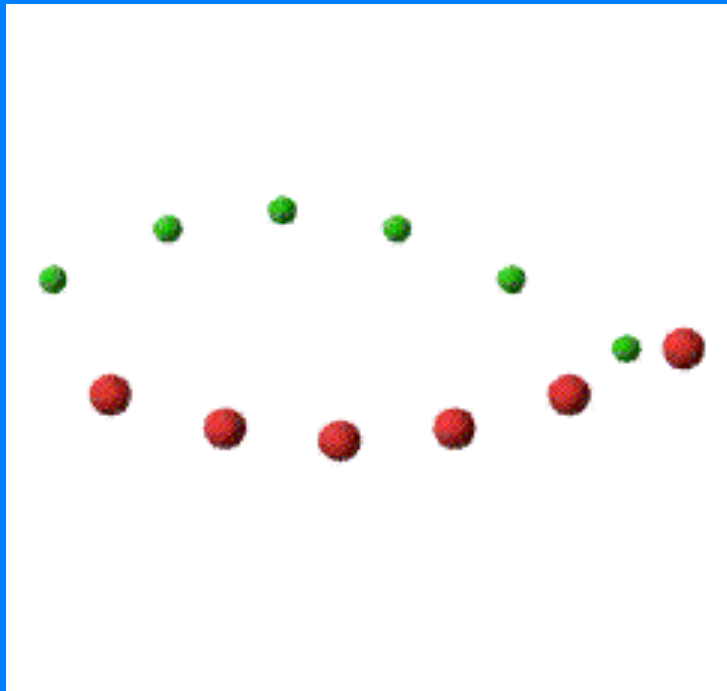
**Could be used for facilitate diffusion**

# Longitudinal acoustical mode for monoatomic chain

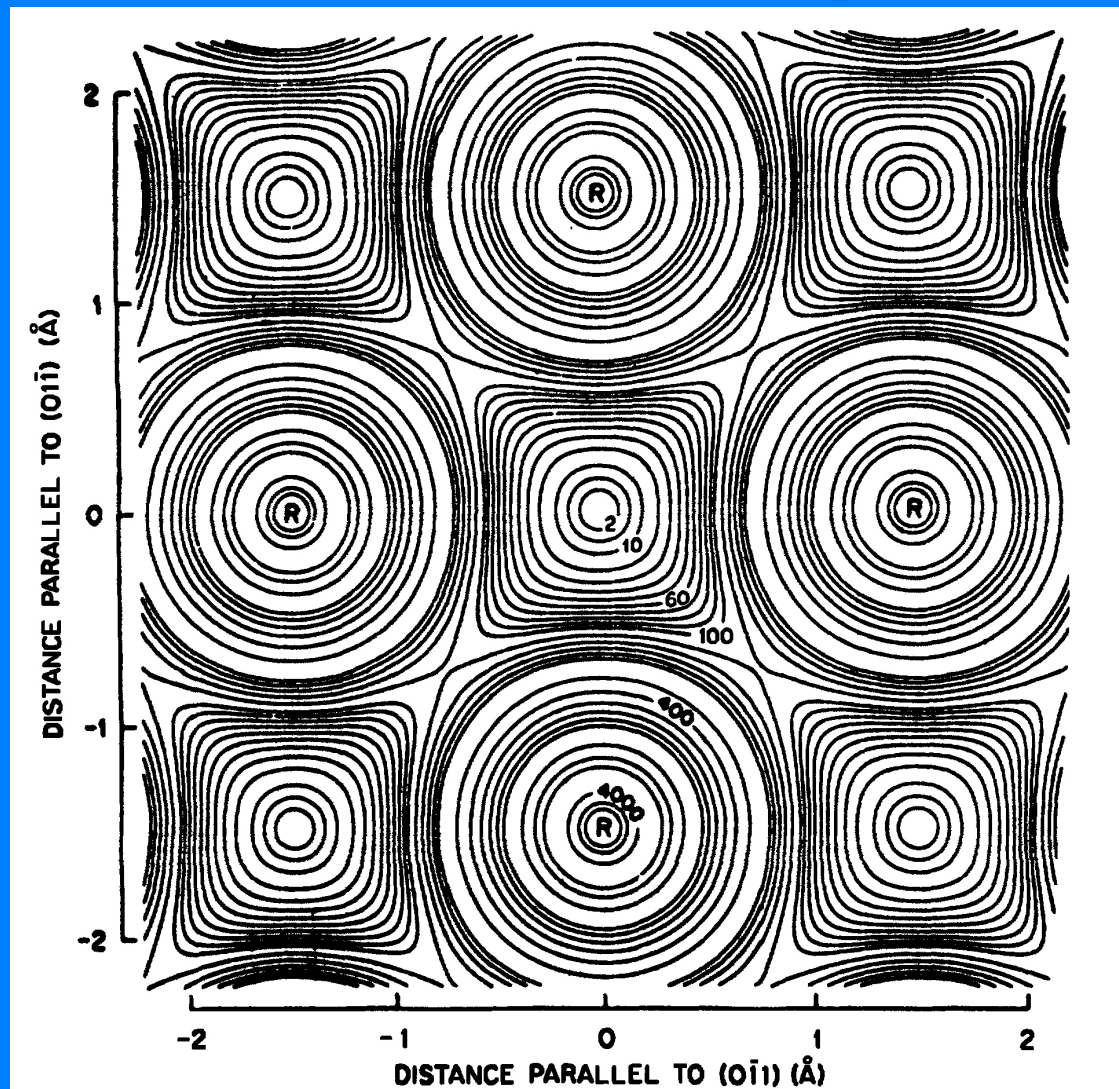




# Optical phonons in diatomic crystals

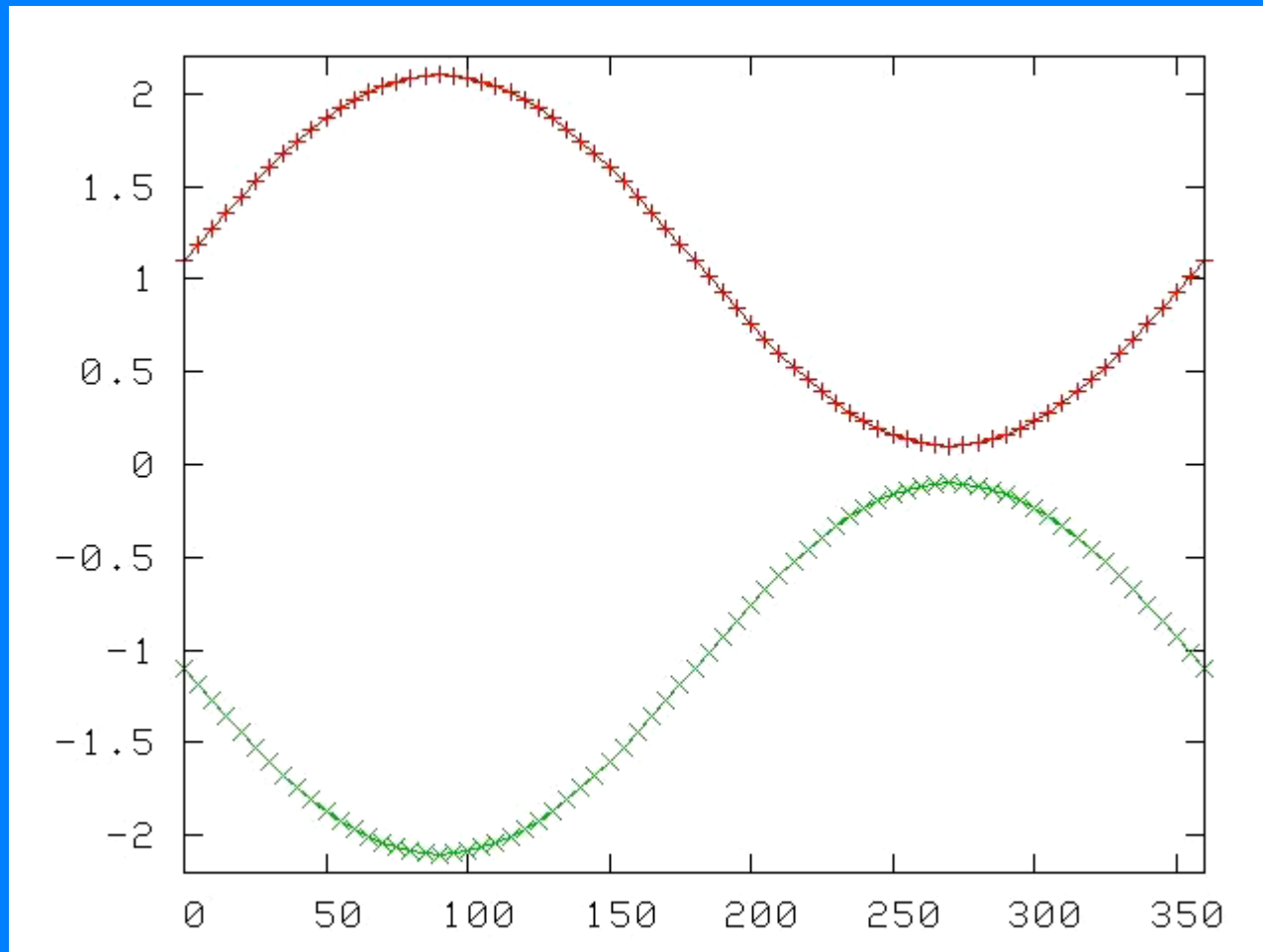


# Potential - energy contours in the (100) channel of silver crystal



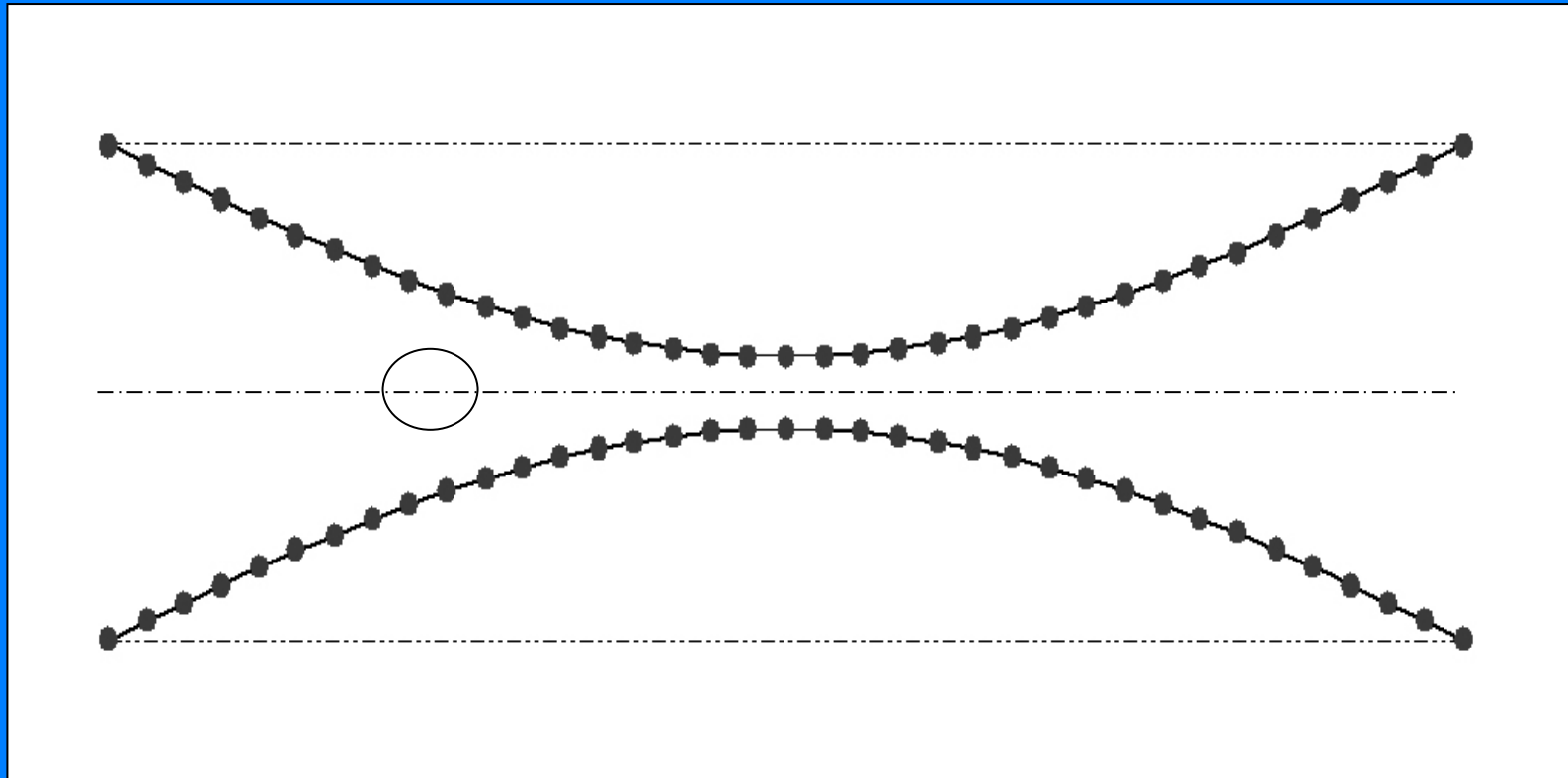
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# Standing waves in crystal

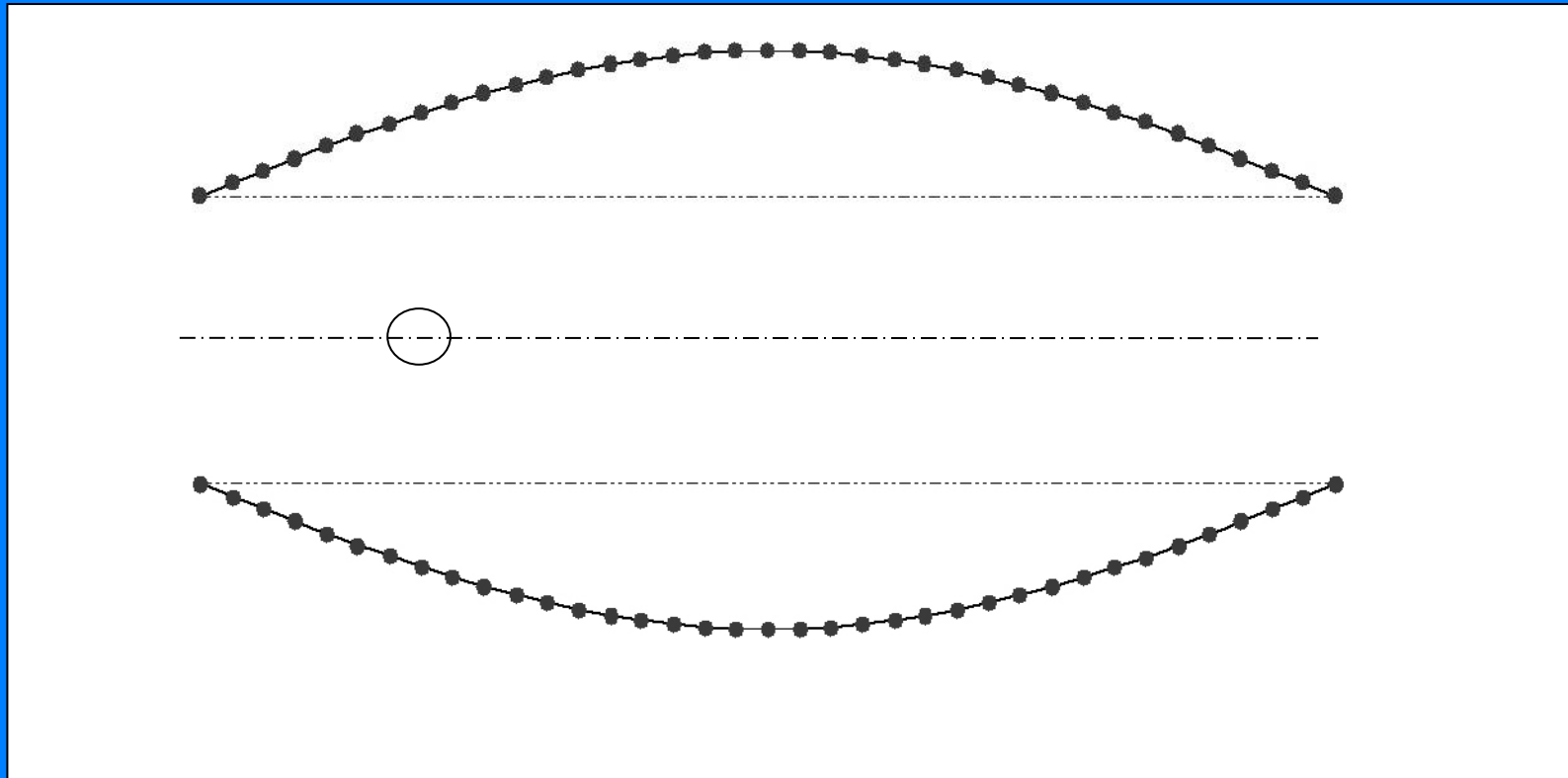




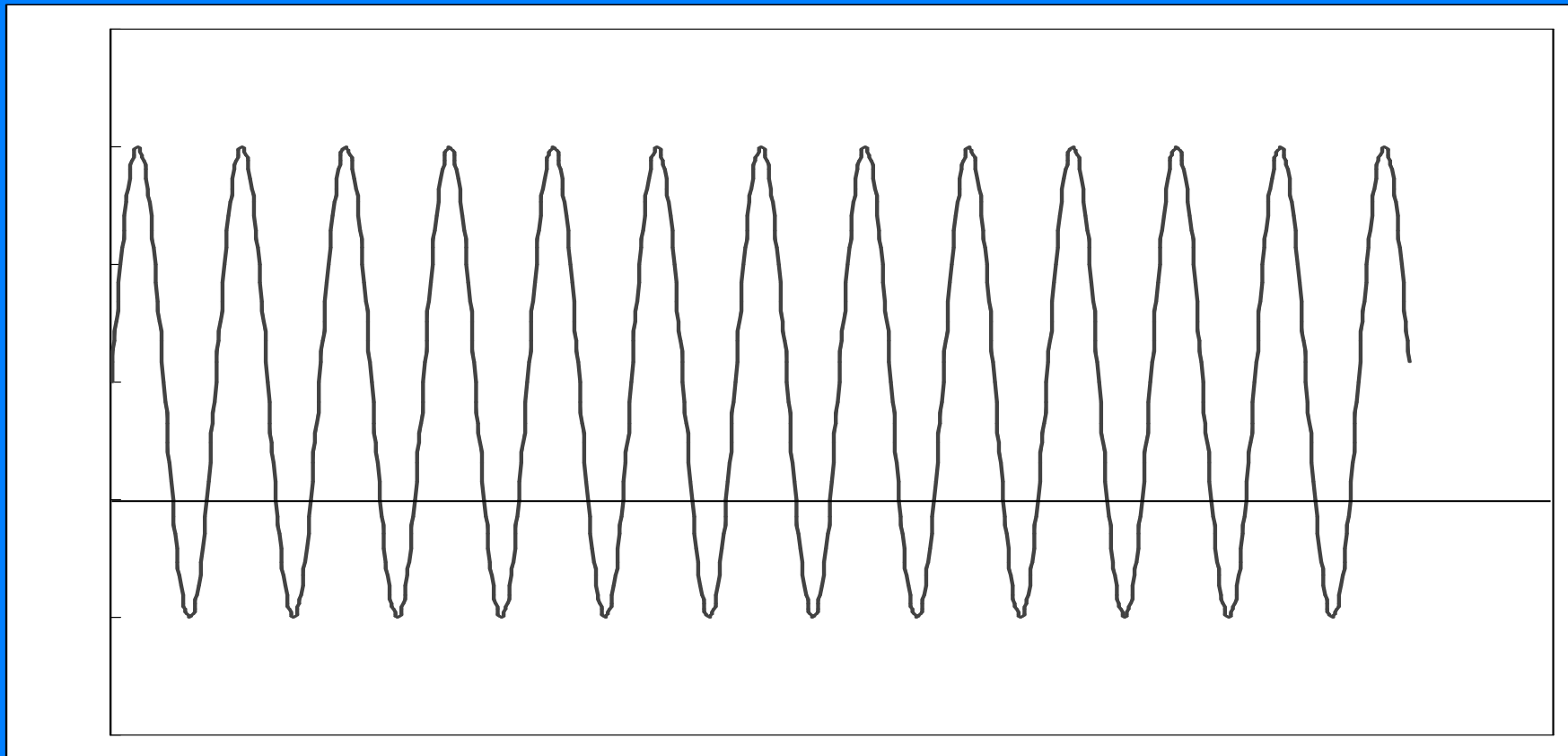
## Standing waves, phase 1



## Standing waves, phase 2



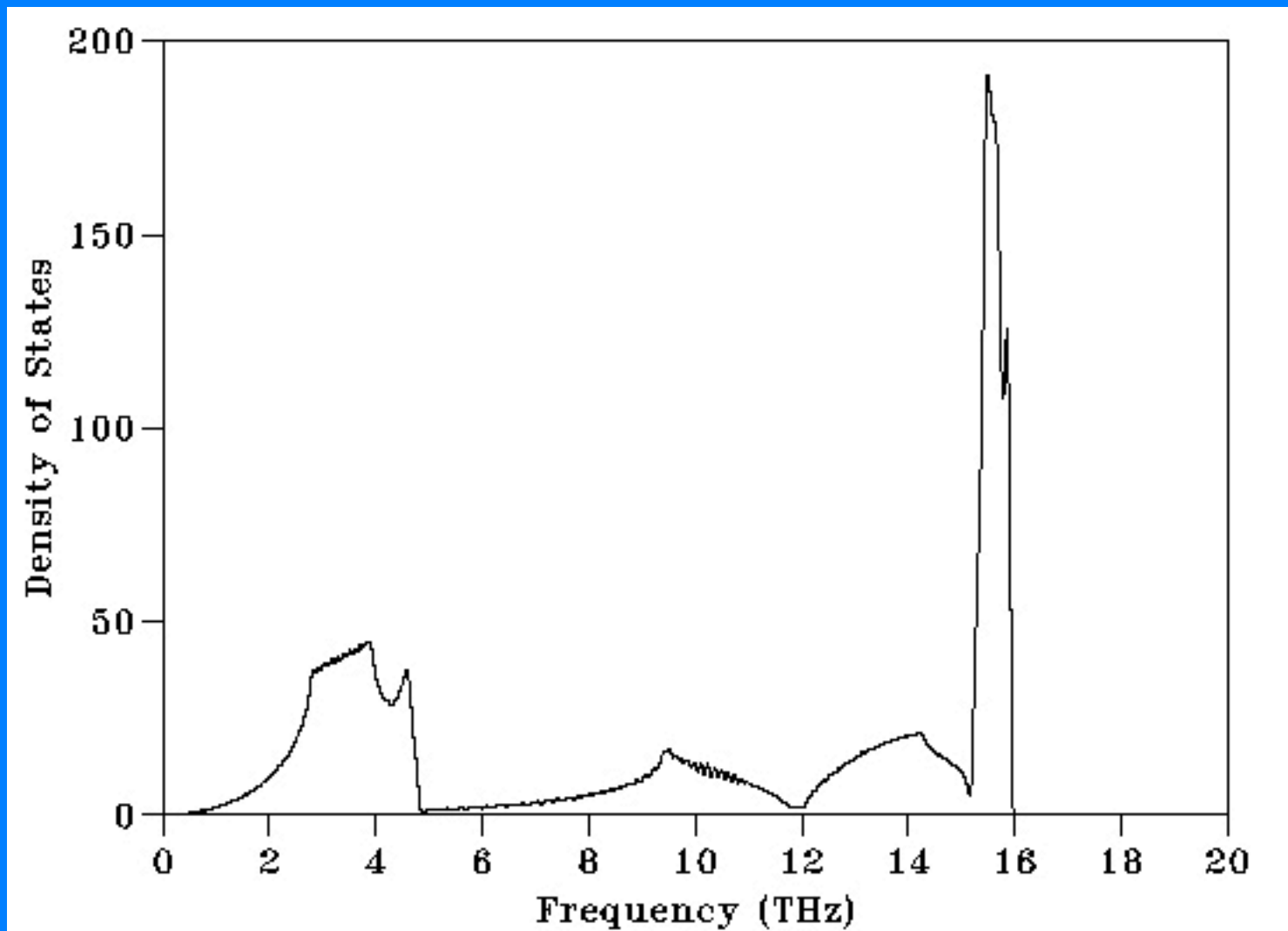
# Electrical force during standing wave oscillation



$$\overline{E}_k = 3.9 \cdot 10^{-2} eV \cdot 10^8 = 3.9 MeV$$

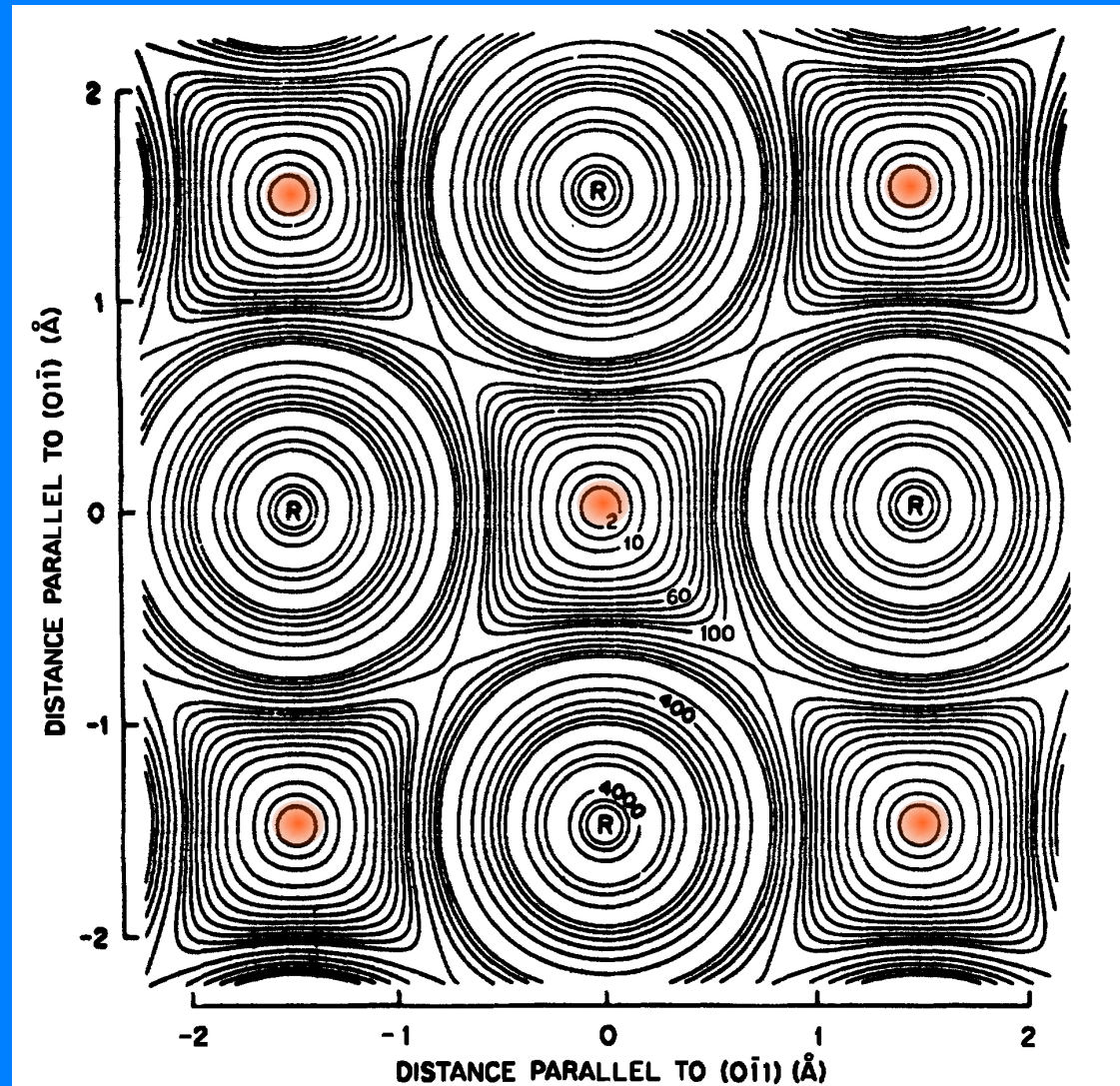
**Although transversal standing wave is more graphic and obvious, longitudinal standing wave produce very similar effects in potential configurations and will give about the same results.**

## Phonon frequency for diamond



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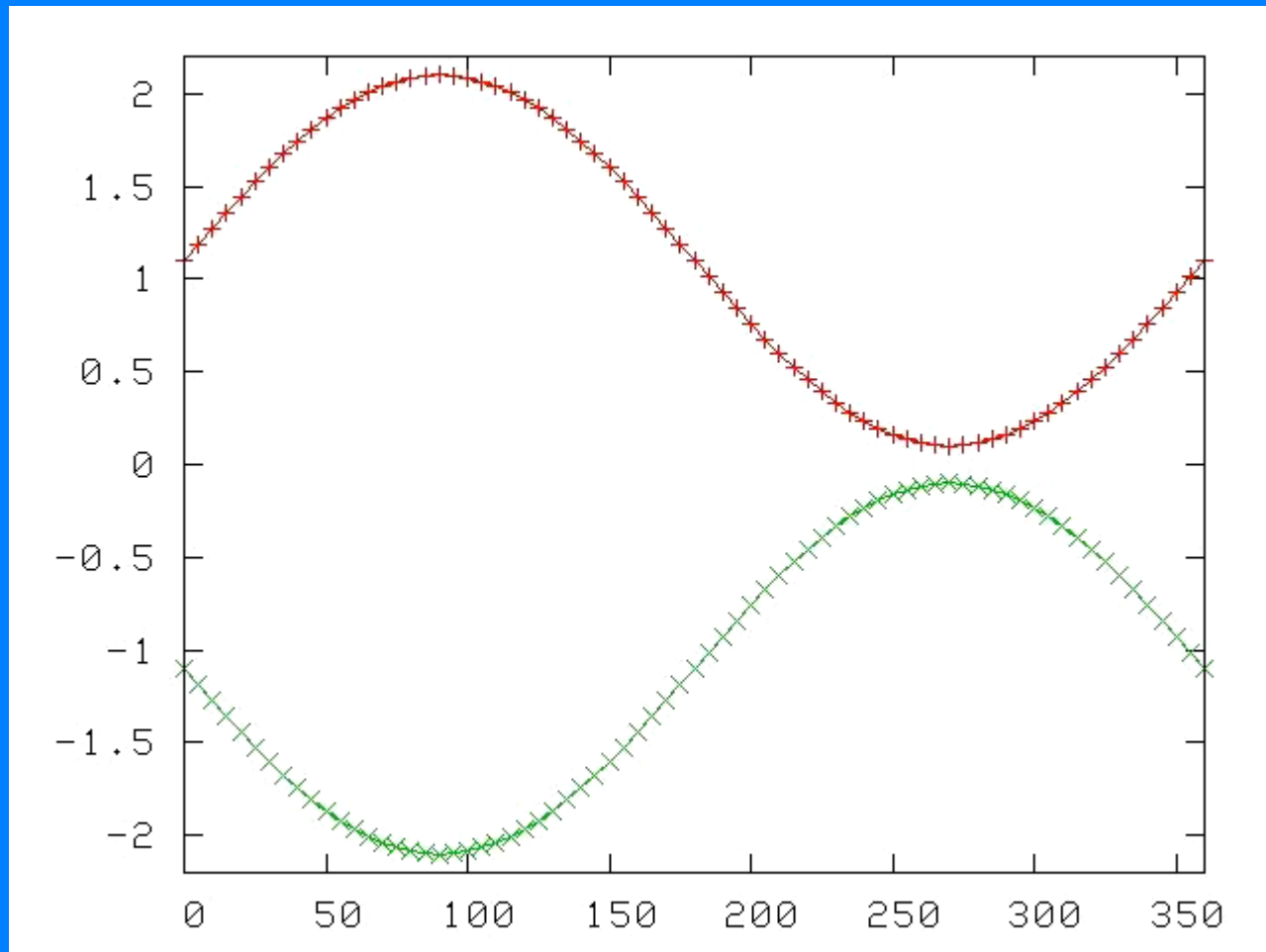
# The Hint of the Nature



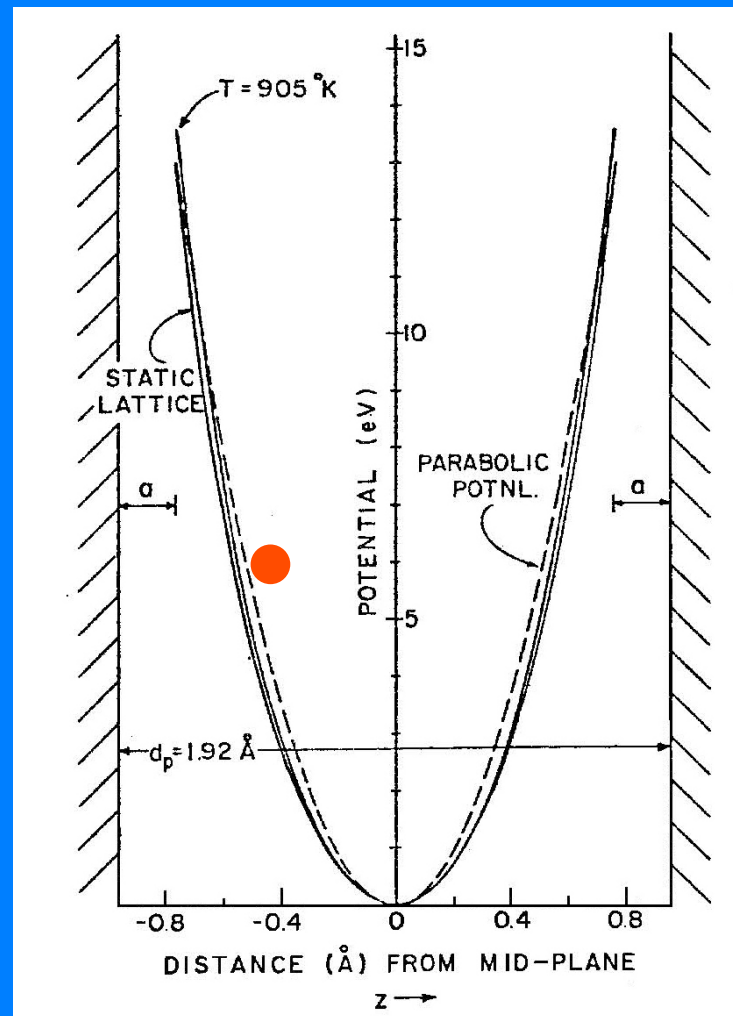
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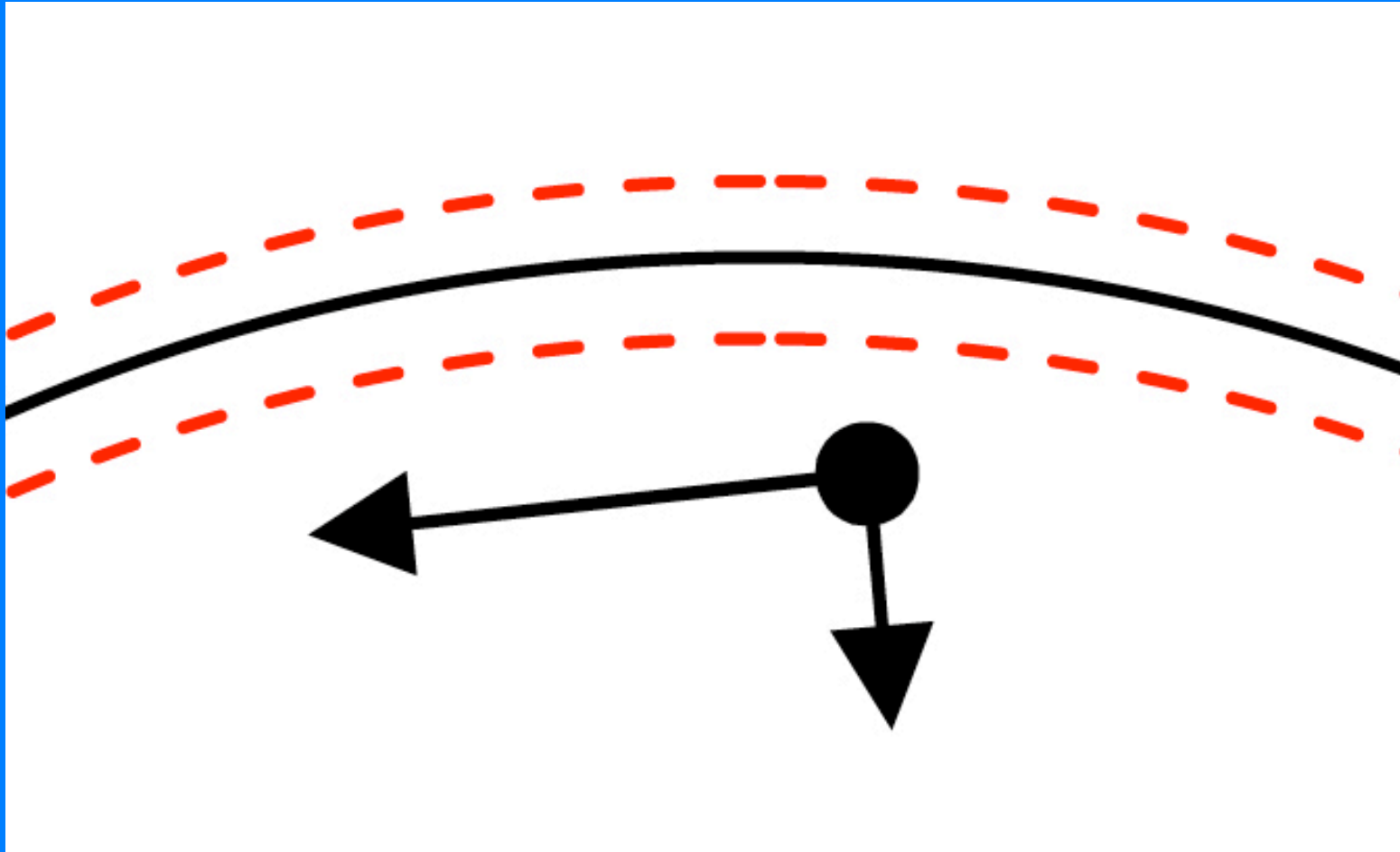
## nanotubes



# Bent crystal (due to distortions, etc). Swing effect. Could energy transfer efficiency be enhanced?



## Swing effect



## Problems

**1. Ratio of different products in D+D fusion:**

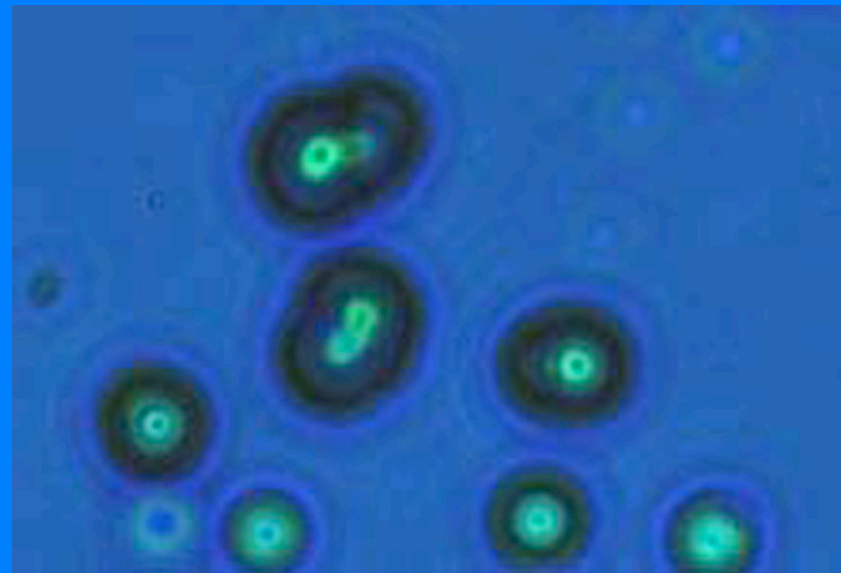
**neutron +  $^3\text{He}$**

**proton +  $^3\text{H}$**

**$\text{D} + \text{D} = ^4\text{He} \text{ (+ 23.8 MeV )}: 10^{-7}$**

**2. Ionization losses (could be compensated?)**

# **A low energy nuclear reaction cell used this year at the University of California, Berkeley**



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**There are more things in heaven and earth,  
Horatio, than are dreamt of in your philosophy.**

**Есть многое на свете, друг Горацио,  
Что и не снилось нашим мудрецам.**

**W. Shakespeare**

# **Acknowledgements**

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