
JDJ @ MIT
The Gathering Storm (1974-1978)

Some Background

Quite a long time ago, when I was a second year graduate student having just completed my qualifying examinations, John arrived at MIT from Berkeley.

Within a few years MIT recruited JDJ, Marc Kastner and Bob Birgeneau to the faculty.

I started working with him at a time when many of you were not yet on the scene (figuratively and literally).

So here's a few snapshots from that era.

Q. Who/What is it

A. It is a concealed microphone found on burglars in the Watergate hotel. Ensuing events led to the departure shown on the right.

Q. Who/What is it

*Who: It is **Mia Farrow***

*What: It is the **first** published issue of **People** Magazine (February, 1974)*

Q. Who/What is it

*A. It is the **HP 65** Hand Held Programmable Calculator (1975)*

It could be programmed with 100 instructions in RPN.

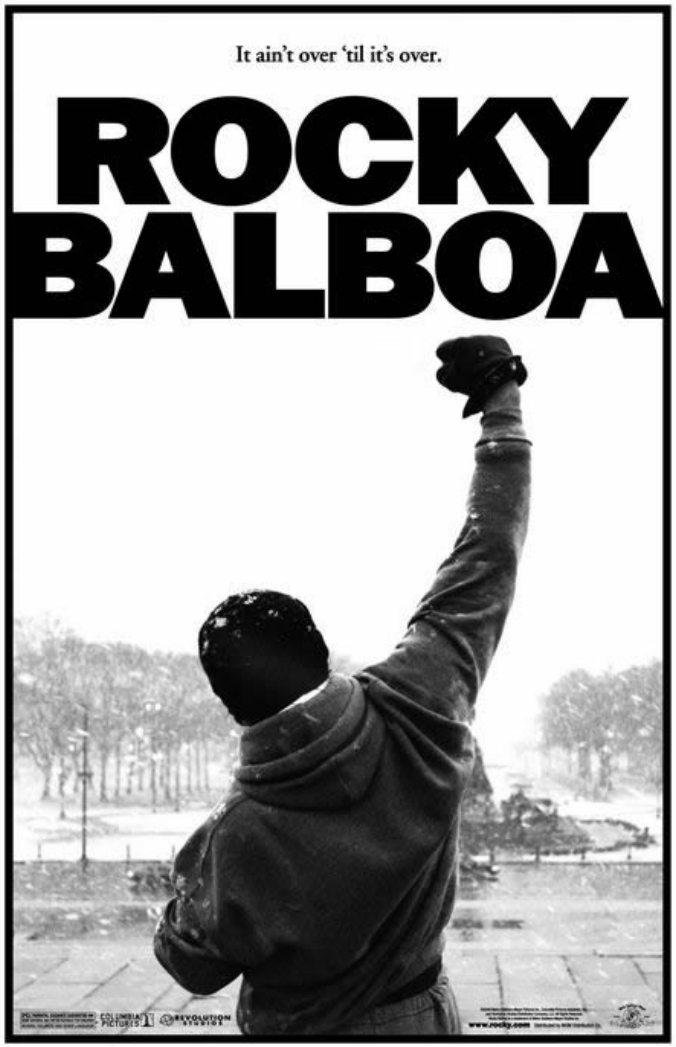
*It sold for **$800.00** (note: 1975 $)*

Q. Who/What is it

Q. Who/What is it

A. *Sylvester Stallone as **Rocky** (set and filmed in Philadelphia, winning the Academy Award for best picture in 1976).*

Q. Who/What is it



A. Sylvester Stallone <u>with</u> Rocky. The actor donated this sculpture to Philadelphia, where it returned to the Philadelphia Museum of Art in celebration of the opening of the final (!) Rocky sequel in 2006.

Q. Who/What is it

A. Photo of JDJ, ca. 2001

and ca. 1975

Some Other Newsworthy Events

October 1974*: Bill Clinton marries Hillary Rodham whom he met at Yale Law School. His wife retains her maiden name for a few years.*

April 1974*: Hank Aaron of the Atlanta Braves breaks Babe Ruth's home run record by hitting his 715th career home run.*

June 1974*: The Cleveland Indians stage an ill advised* ***Ten Cent Beer Night*** *for a game against the Texas Rangers at Cleveland Municipal Stadium. Cleveland forfeits after alcohol fueled mayhem spreads from the stands onto the field*

September 1974*: John appointed Assistant Professor at MIT*

VOLUME 34, NUMBER 21 PHYSICAL REVIEW LETTERS 26 MAY 1975

Direct Observation of Superlattice Formation in a Semiconductor Heterostructure

R. Dingle, A. C. Gossard, and W. Wiegmann
Bell Laboratories, Murray Hill, New Jersey 07974
(Received 17 March 1975)

We demonstrate, via low-temperature optical-absorption measurements on ultrathin, coupled potential wells in molecular-beam-grown $Al_xGa_{1-x}As$-GaAs heterostructures, the evolution of resonantly split discrete well states into the lowest band of a one-dimensional superlattice. Both electron and hole superlattices appear to be practical.

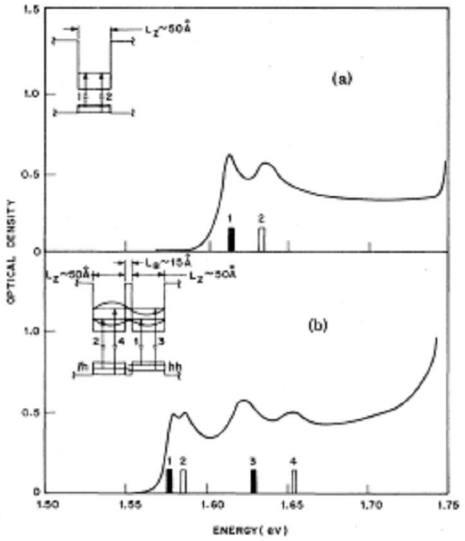
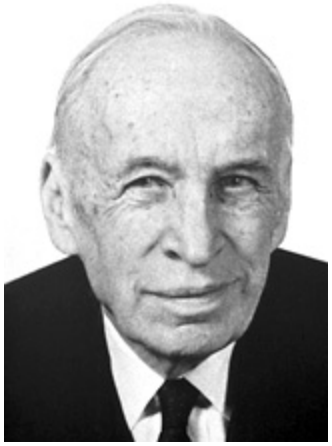


FIG. 1. (a) Optical-density spectrum of a series of eighty single GaAs wells isolated by thick (~ 180 Å) $Al_{0.27}Ga_{0.73}As$ barriers. Peaks 1 and 2 correspond to exciting an electron from $n = 1$ heavy-mass and light-mass valence-band bound states, respectively, to the $n = 1$ conduction-band bound state, as shown in inset.

Spectroscopy of
1D Quantum Confinement

There were tremendous advances in the fabrication of highly ordered crystals, but also a growing interest in electronic phenomena in partially ordered and disordered phases of matter.





1977 Nobel Prizes to Anderson, Mott and vanVleck

Electronic Density of States of Amorphous Si and Ge

M. F. Thorpe and D. Weaire
Becton Center, Yale University, New Haven, Connecticut 06520
(Received 21 June 1971)

The density of states of the valence and conduction bands of Si and Ge are discussed using a simple tight-binding Hamiltonian. It is shown that certain features of the density of states for the case of the diamond structure are related to the short-range order and hence should be retained in the amorphous state while others depend on long-range order and are expected to disappear.

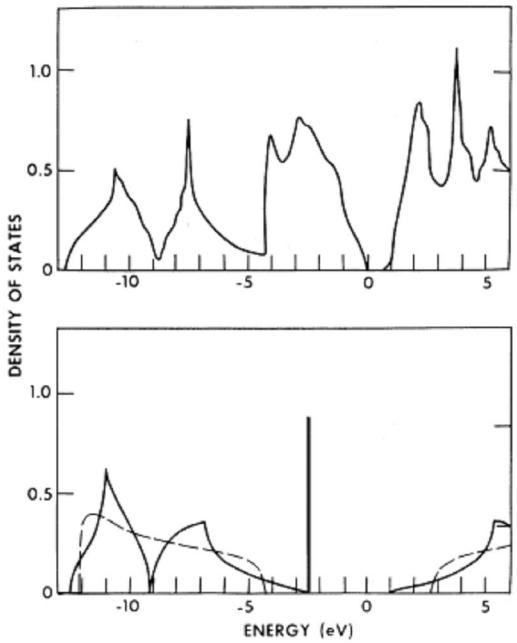
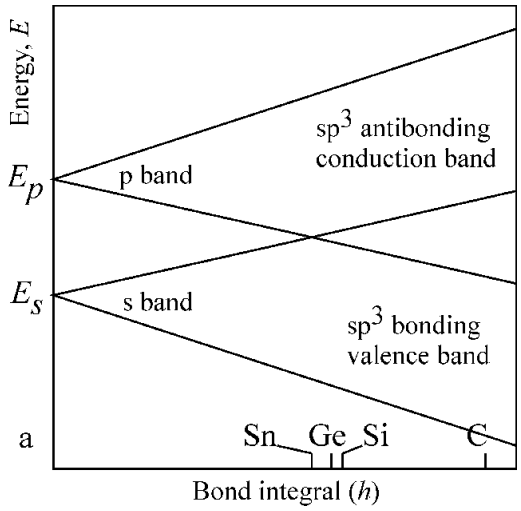
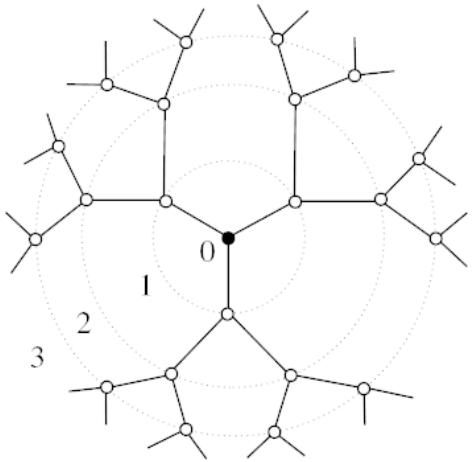


FIG. 1. Top, the density of states for Ge with the diamond structure, as calculated by Herman *et al.* (Ref. 14). Bottom, the density of states as calculated using the Hamiltonian of Ref. 10 with the diamond structure (solid line) and the Bethe lattice (dashed line). The delta function indicated by a vertical line is found in both structures. Units are states/eV atom.



Amorphous Covalently Bonded Solids

Bethe Lattice: connected cycle free graph with coordination z



Embed cluster in Bethe Lattice Tree

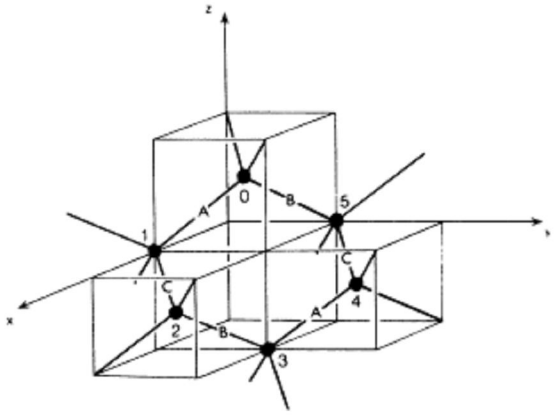


FIG. 6. Sixfold ring in the diamond-structure configuration. Bethe lattices are attached to the dangling bonds.

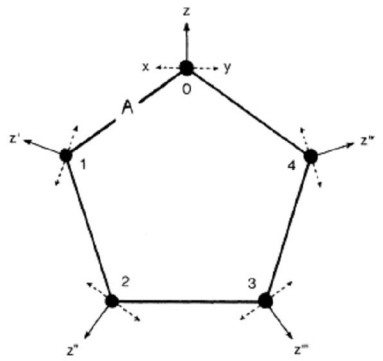


FIG. 7. Flat fivefold ring. The z direction of the coordinate system is chosen to lie in the plane of the ring. The dashed arrows represent the projections of the x and y components onto the plane of the ring. The primed coordinate systems are rotated as discussed in the text.

PHYSICAL REVIEW B VOLUME 10, NUMBER 12 15 DECEMBER 1974

"Cluster–Bethe-lattice" method: Electronic density of states of amorphous and crystalline homopolar solids

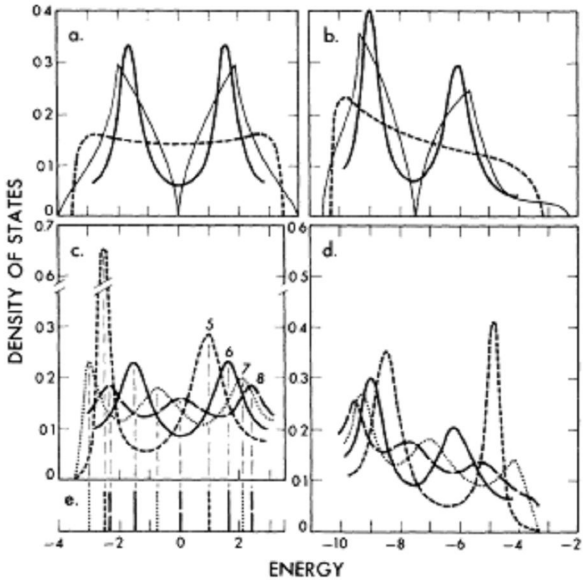
J. D. Joannopoulos*† and F. Yndurain†

Department of Physics, University of California, Berkeley, California 94720

and Inorganic Materials Research Division, Lawrence Radiation Laboratory, Berkeley, California 94720

(Received 1 July 1974)

A new method is developed to study the electronic density of states of infinite networks of atoms. The method involves treating part of the system exactly as a cluster and simulating the effects of the rest of the environment by connecting a Bethe lattice (Cayley tree) to the surface of the cluster. Calculations show that the local ringlike topologies of each atom are of primary importance in determining structure in the electronic density of states. The densities of states of the diamond, BC-8, and ST-12 structures are studied in detail using this method. These calculations are in excellent agreement with the *exact* results. Because of this, the method is used to obtain the density of states of the Polk and Connell random-network models. These models give the same radial distribution functions but exhibit striking differences in their densities of states which are interpreted in terms of topology.



PHYSICAL REVIEW B VOLUME 16, NUMBER 6 15 SEPTEMBER 1977

Theory of fluctuations and localized states in amorphous tetrahedrally bonded solids

J. D. Joannopoulos*
Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
(Received 6 June 1977)

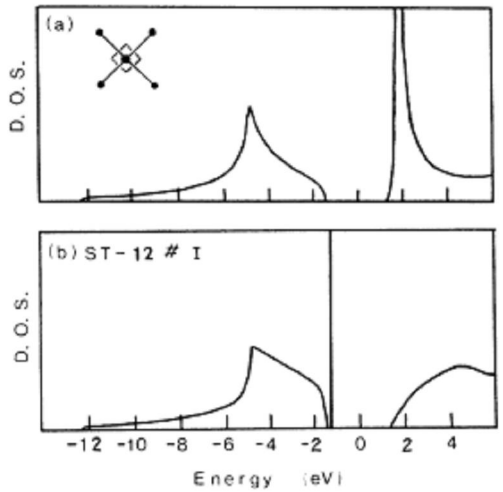


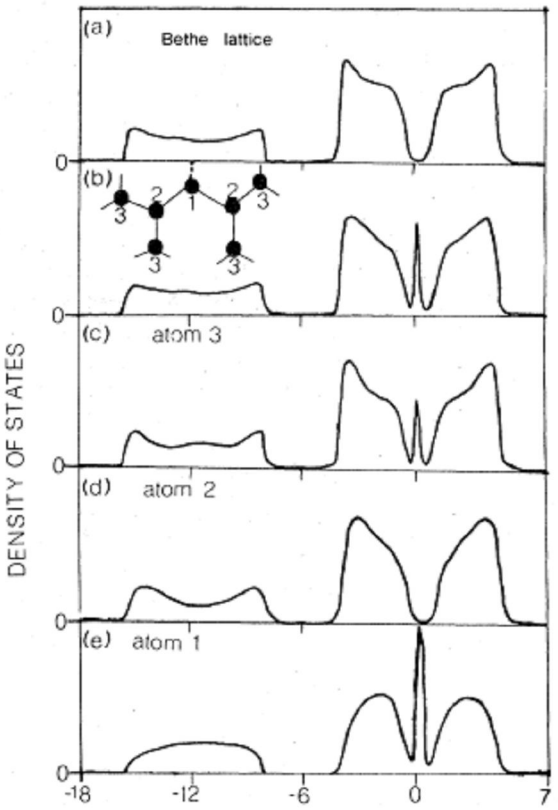
FIG. 11. Trace of p-like densities of states for an atom at the center of a distorted tetrahedral unit with Bethe lattices attached outside. (a) Flat 90° bond-angle configuration. The bonding and antibonding states corresponding to the perpendicular p orbital coalesce near 2.0 eV. (b) Configuration of atom type I in the ST-12 structure. A bona fide localized state produced by bond-angle distortions is represented by a δ function in the density of states.

Band tail at CB edge comes from fluctuations in network connectivity but at the VB edge it comes from from bond angle fluctuations

PHYSICAL REVIEW B VOLUME 19, NUMBER 8 15 APRIL 1979

Electronic structure of defects in amorphous arsenic

W. B. Pollard and J. D. Joannopoulos
Department of Physics and Center for Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
(Received 30 October 1978)



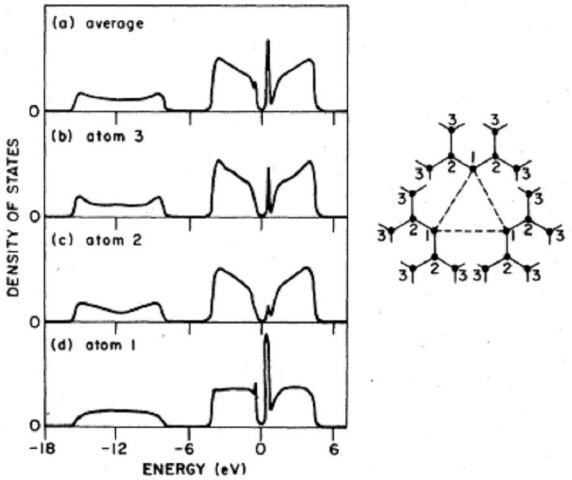


FIG. 5. DOS spectra for atoms surrounding an "ideal" vacancy in the Bethe lattice. (Note right-hand side of figure; the dashed lines schematically indicate the interactions between the dangling orbitals at the vacancy.) In (a), the average DOS for the atoms surrounding the vacancy is shown. In (b)–(d), the local DOS about atoms Nos. 3, 2, and 1 are shown, respectively.

PHYSICAL REVIEW B VOLUME 16, NUMBER 6 15 SEPTEMBER 1977

Phonons in amorphous silica*

R. B. Laughlin and J. D. Joannopoulos
Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
(Received 16 May 1977)

A new theory of lattice vibrations in amorphous silicon dioxide is presented in which the randomness of the solid is treated separately from its chemistry. The theory attributes all measurable properties of phonons in silica to the nearly crystalline nearest-neighbor geometry of the lattice and to the disruptive effects of bond-angle disorder. Neutron, infrared, and Raman spectra are calculated and compared with experiment. The theory is an application of the recently developed cluster–Bethe-lattice approach to studying amorphous solids.

FIG. 1. Topology of the Bethe lattice. Every pair of atoms is connected by one and only one path of bonds.

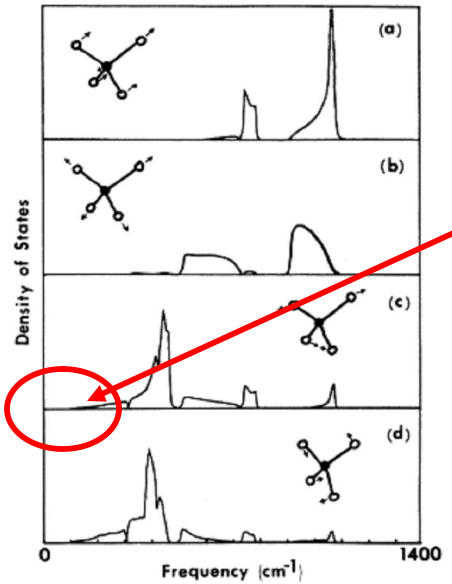
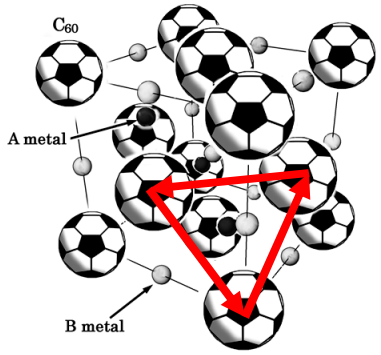


FIG. 4. Bethe-lattice density of states projected onto normal modes of SiO_4 molecule. The modes are identified in Ref. 9 in order (a)–(d) as $\nu_3, \nu_1, \nu_4, \nu_2$. Averages were performed over the degenerate modes.

This part had Bob flummoxed

Alkali Fulleride is Translationally Ordered but Orientationally Disordered



Deshpande, Erwin, Hong, GM (1993)

In view of this we now construct an effective medium for which *only* the retracing paths are included in the single-particle Green's function. This network has the topology of a tree, or Bethe lattice, with one "ingoing" bond and eleven "outgoing" bonds at every node of the network. This network should be distinguished from the

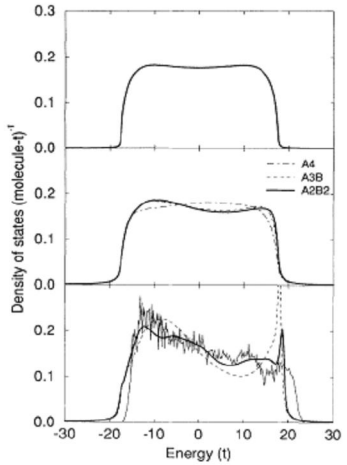
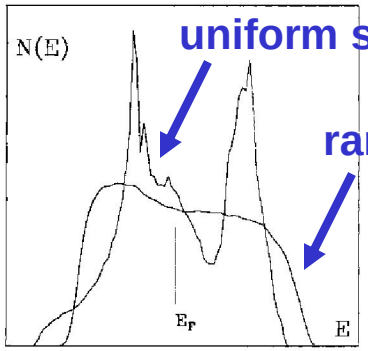


FIG. 1. Densities of states calculated for the fulleride tree and for molecular clusters embedded in the tree. Here and elsewhere in the paper the energy axis is in units of $t \approx 10$ meV, which sets the energy scale for electronic hopping between neighboring sites. Top panel: Density of states for the tree. Middle panel: Densities of states for three embedded tetrahedral clusters with various molecular settings. Bottom panel: Densities of states at the core of embedded 19-site (dashed) and 43-site (heavy solid) clusters. The noisy curve gives the results of a quenched average on an orientationally disordered lattice.

Gelfand and Lu (1992)



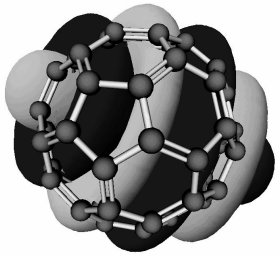


FIG. 3. Densities of states vs energy for the $Fm\bar{3}$ structure and its maximally disordered version; the former is the one with two large peaks. The Fermi energy for three electrons per molecule is indicated; it is nearly unchanged upon disordering.


Physics at Surfaces

PHYSICAL REVIEW B VOLUME 23, NUMBER 10 15 MAY 1981

Simple scheme for surface-band calculations. I

D. H. Lee and J. D. Joannopoulos
Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
(Received 21 August 1980)

The "effective-field" method[9-11] obtains the surface Green's function using a continued-fraction approach, where

$$G^{s}_{00}(E) = [E - H_{00} - H_{01}\Phi(E)]^{-1} \tag{1}$$

and

$$\Phi(E) = [E - H_{00} - H_{01}\Phi(E)]^{-1}H^{+}_{01} . \tag{2}$$

Zero labels the surface layer and Φ is called an effective field or sometimes a "transfer matrix"

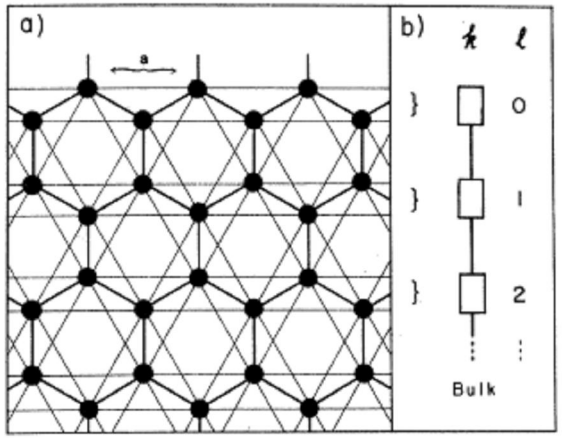


FIG. 2. A semi-infinite two-dimensional honeycomb lattice represented as (a) a system of atoms (black dots) with nearest-neighbor interactions V_1 (thick solid lines) and second-neighbor interactions V_2 (thin solid lines). The atoms along the surface are spaced a distance a apart. (b) A chain of principal layers (l) for each wave vector k in the surface Brillouin zone. Each principal layer (represented as a rectangle) contains two atomic layers as shown.

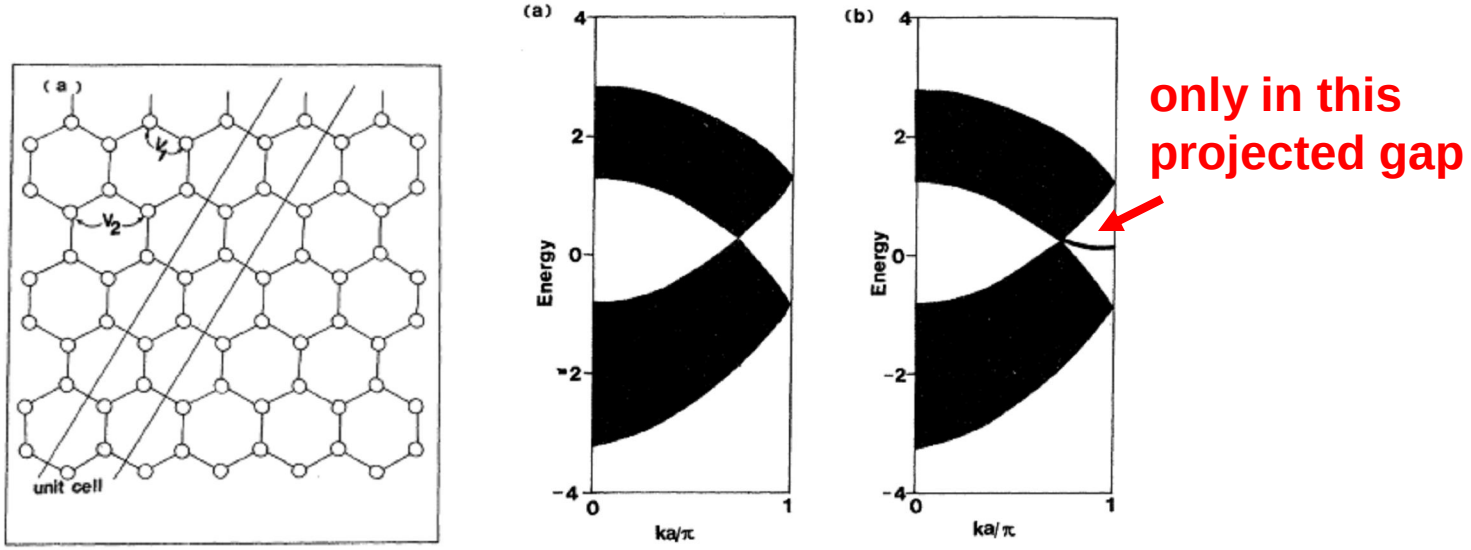


FIG. 4. (a) Projected band structure of the system shown in Fig. 3, where the energy is plotted in units of $|V_1|$. (b) A band of surface states is found for $k \gtrsim 2\pi/3a$ for energies near 0.2.

only in this projected gap

Edge Modes of the Honeycomb Lattice

Intrinsic Surface Phonons in Porous Glass

R. B. Laughlin and J. D. Joannopoulos
Department of Physics and Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

and

C. A. Murray, K. J. Hartnett, and T. J. Greytak
Department of Physics and Center for Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
(Received 3 November 1977; revised manuscript received 4 January 1978)

Raman scattering and infrared reflectivity measurements have been performed on samples of porous Vycor glass. Three features in the spectra are due to intrinsic surface phonons. This identification is supported by a simple new theory for the surface.

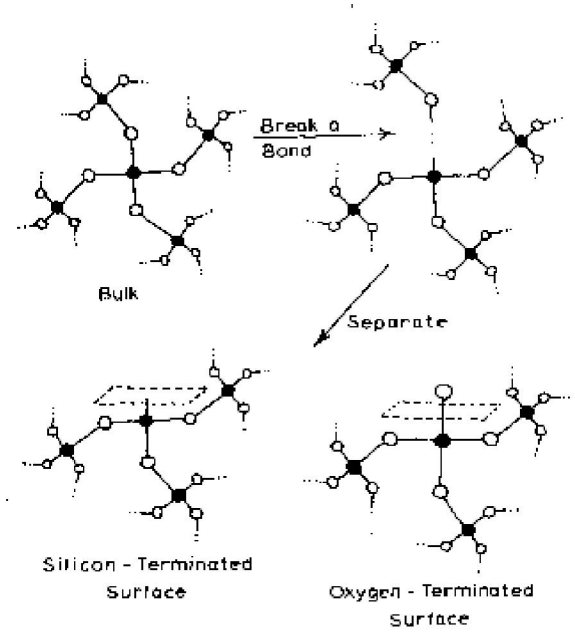


FIG. 1. Transformation of Bethe lattice from model for the bulk to model for the surface. Breaking a bond generates two fundamental kinds of surface.

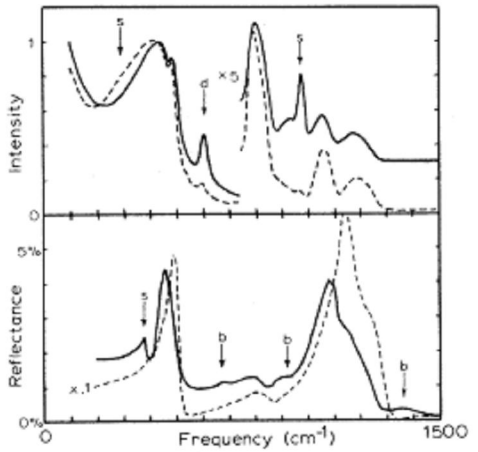
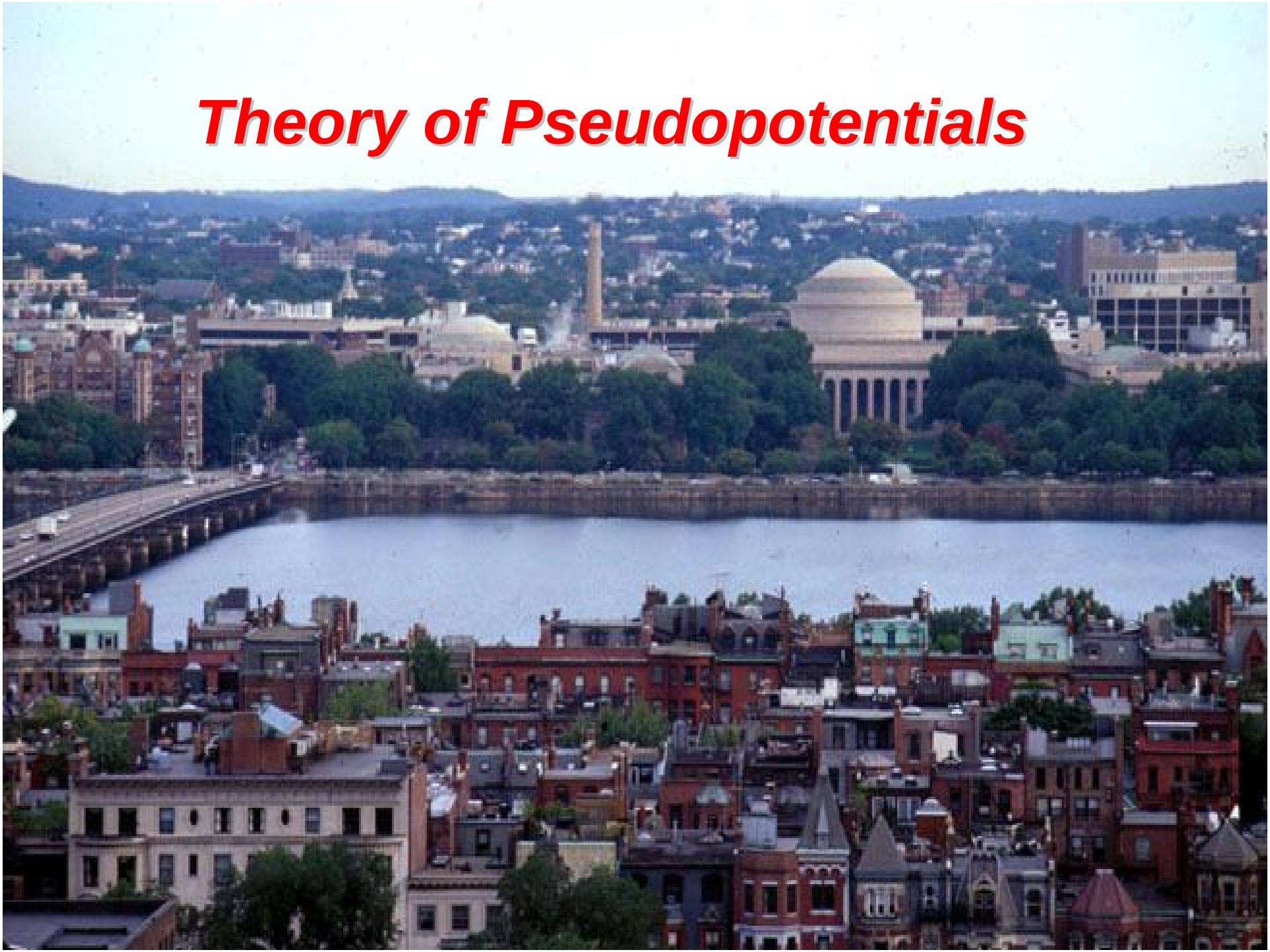


FIG. 1. Experimental spectra of porous Vycor (solid line) and vitreous silica (dashed line). Top, Raman intensities normalized to 1 at 440 cm^{-1}; bottom, absolute infrared-reflectance measurements. Typical error bars are comparable to the line thickness for the traces with the exception of the low-frequency (< 450 cm^{-1}) region in the reflectance measurements, where they are ± 0.3%. Arrows designate important changes in the spectra as discussed in the text.

Bob at Stanford, Stockholm and in Daejeon

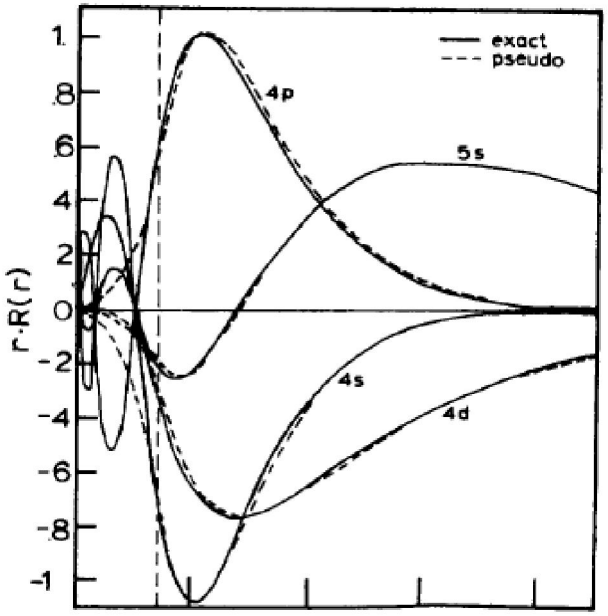
Theory of Pseudopotentials

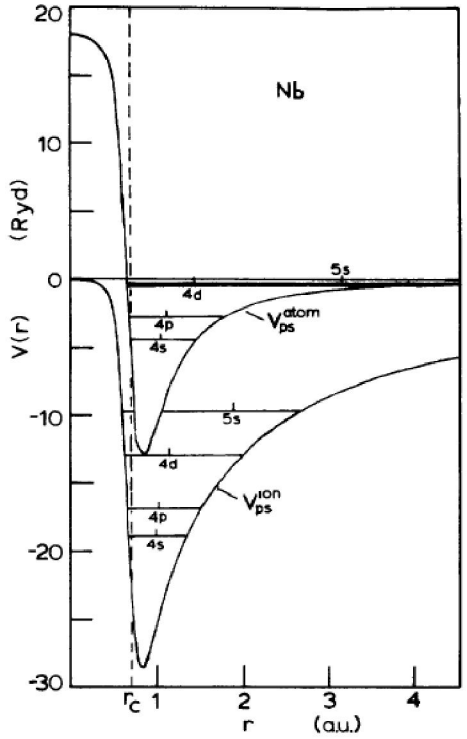


PHYSICAL REVIEW B VOLUME 16, NUMBER 12 15 DECEMBER 1977

Local pseudopotential theory for transition metals

Th. Starkloff* and J. D. Joannopoulos†
Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
(Received 28 June 1977)





The IOPW Method

R.B. Laughlin, E.J. Mele, D.H. Vanderbilt and J.D. Joannopoulos
Bull. Am. Phys. Soc. 24, 466 (1978)

The plane waves $\left|\vec{k}\right\rangle$

When orthogonalized to the core $\left|\underset{\sim}{\vec{k}}\right\rangle = \left|\vec{k}\right\rangle - \sum_c \left|\phi_c\right\rangle\left\langle\phi_c\right|\left.\vec{k}\right\rangle$

Are no longer orthogonal $\left\langle\underset{\sim}{\vec{k}}\right|\left.\underset{\sim}{\vec{k}}'\right\rangle = \sum_c \left\langle\vec{k}\right|\left.\phi_c\right\rangle\left\langle\phi_c\right|\left.\vec{k}'\right\rangle \neq \delta(\vec{k}-\vec{k}')$

But Can Be Made So $\left|IOPW,\underset{\sim}{\vec{k}}\right\rangle = \hat{S}_{\vec{k},\vec{k}'}{}^{-1/2}\left|\underset{\sim}{\vec{k}}'\right\rangle = \left[\frac{\hat{P}_c}{\sqrt{1+a_c^2}} + (\hat{I}-\hat{P}_c)\right]\left|\underset{\sim}{\vec{k}}'\right\rangle$

~~*(haiku)*~~

The IOPW Method

R.B. Laughlin, E.J. Mele, D.H. Vanderbilt and J.D. Joannopoulos
Bull. Am. Phys. Soc. 24, 466 (1978)

Plane waves made

$$\left|\vec{k}\right\rangle$$

Normal to the core

$$\left|\underset{\sim}{\vec{k}}\right\rangle = \left|\vec{k}\right\rangle - \sum_c \left|\phi_c\right\rangle\left\langle\phi_c\right|\left.\vec{k}\right\rangle$$

Aren't orthonormal

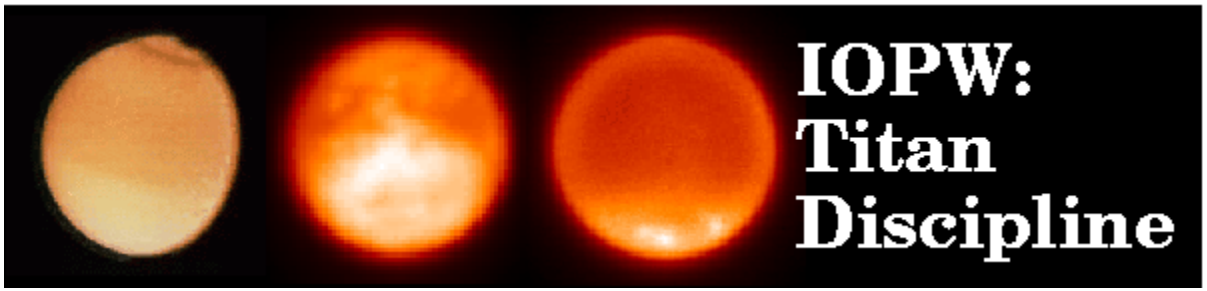
$$\left\langle\underset{\sim}{\vec{k}}\right|\left.\underset{\sim}{\vec{k}}'\right\rangle = \sum_c \left\langle\vec{k}\right|\left.\phi_c\right\rangle\left\langle\phi_c\right|\left.\vec{k}'\right\rangle \neq \delta(\vec{k}-\vec{k}')$$

An-y-more

$$\left|IOPW,\underset{\sim}{\vec{k}}\right\rangle = \hat{S}_{\vec{k},\vec{k}'}{}^{-1/2}\left|\underset{\sim}{\vec{k}}'\right\rangle = \left[\frac{\hat{P}_c}{\sqrt{1+a_c^2}} + (\hat{I}-\hat{P}_c)\right]\left|\underset{\sim}{\vec{k}}'\right\rangle$$

(haiku)

International Outer Planet Watch



Some Reasons I'm Glad to Have Worked With JDJ

1. He introduced me to Kimo

2. His signature was easy to forge

3. RBL wanted to spend more time in his office than mine

4. He was designated driver from the Hilltop Steakhouse

5. I could house-sit his home in Belmont

Happy 60th, John!