On the Way to Submicroscopic Description of Nature*

Volodymyr Krasnoholovets

Institute of Physics, National Academy of Sciences,
Prospect Nauky 46, UA-03028 Kyïv, Ukraine
http://inerton.cjb.net

4 August 1999

Abstract

The outline analyzes the principal difficulties, which emerge at the applying of modern quantum theory based on the Copenhagen School concept to phenomena developed in the range close to 10^{-28} cm (the point of intersection of the three fundamental interactions). It is shown that at this scale, the interaction of a moving particle with space plays an essential role and just space assigns wave and quantum properties to the particle. The main physical aspects of space structure are discussed herein. So general relativity loses its rights of the unique theory: discovered carriers of gravitation, called gravitons. are in a severe conflict with the basic hypothesis of the relativity about the emptiness of space.

Key words: space (quantum aether), quantum theory, inerton (hypothetical quasi-particle).

1 Question-marks germinating out of basement

Modern physics axiomatic is constructed on a very abstract mathematical formalism that is aimed only at the quantitative description of physical

* *Indian Journal of Theoretical Physics* **49**, no. 2, pp. 81-95 (2001);
also arXiv.org e-print archive http://arXiv.org/abs/quant-ph/9908042

phenomena. For instance, the Maxwell equations describe electromagnetic phenomena but they do not bring an idea of the structure of the charge and the electromagnetic field. The Schrödinger equation describes quantum mechanics of particles but the equation cannot explain the reason of long-range action and wave behavior of the particles. On the question what is photon?, quantum electrodynamics answers: it is something that can be described by the equation

$$\partial^2 \vec{A}/\partial t^2 - c^{-2} \partial^2 \vec{A}/\partial \vec{r}^{\,2} = 0$$

where $\vec{A}$ is a physical value called the "vector potential".

Such a structure of the formalism does not permit to reveal the origin of processes constituted the essence of quantum phenomena studied. Lorentz also pointed the same in the beginning of 20th century (see, e.g. Ref. [1]). De Broglie held the viewpoint [2] that there are hidden laws (see also Bohm [3]), which provides the basis for motion and that the description of phenomena should also be the goal of physics, not only their prediction. Nonetheless, it is now believed that so-called "unorthodox" questions are irrelevant. However, can we correctly understand the behavior of elementary particles, if the whole series of fundamental notions researchers operate with everyday have not become clear yet? For example, one can raise the following questions.

1) What is ψ-wave function? This problem still thrills the curiosity of researchers (see, e.g. review [4]).

2) All correct theories should be Lorentz invariant, i.e. they and Einstein's special relativity should agree (see, e.g. Ref. 5). Nevertheless, the Schrödinger equation is not Lorentz invariant but it perfectly describes quantum phenomena. How is it possible?

3) Why does the classical parameter M – the particle mass – enter the Schrödinger quantum equation? Where is the particle mass when the particle as the whole is fuzziness in an undetermined volume as the ψ-wave function prescribes?

4) What is mass? In modern quantum field theories mass is considered as a characteristic expressed through the energy E and momentum p. Today theorists try to assure [6-8] that mass does not depend on velocity. And this is very strange because it turns out from such determination that the notion of mass can not be considered as a quantity of matter which is found in the volume of a particle/body. Moreover such declarations are in contradict to the experiments by Bucherer [9] and Rogers *et al.* [10] who studied the dependence of mass on the velocity and confirmed the validity of the formula $M = M_0(1 - v^2/c^2)^{-1/2}$.

5) What are microscopic processes changing the geometry of space surrounding an object, which manifest themselves in the form of the Newton/Coulomb potential $1/r$? Einstein noted [11] that the geometry employing in general relativity (the Riemannian geometry) should be treated only as a macroscopic geometry. In other words, what is origin of the gravity?

6) There is no correct determination of values E and ν in the expression $E = h\nu$ applied to a moving canonical particle. In one case $E = \frac{1}{2}M_0 v^2$ (see, e.g. Ref. [12]), and in the other one $E = M_0 c^2(1 - v^2/c^2)^{-1/2}$ (see, e.g. Ref. [13]). Which is true?

7) The description of a quantum system in terms of the Dirac field or Dirac's equation is correct only at the scale $r \geq \lambda_{\rm Com}$ where $\lambda_{\rm Com}$ is the Compton wavelength. Hence, what a physical characteristic of space in the vicinity of particle does the parameter $\lambda_{\rm Com}$ describe? And what approach can make used at the scale $r < \lambda_{\rm Com}$?

8) What is spin? It is one more mystery of the microworld. Quantum field theories define it as an "inseparable and invariable property of a particle" [14]. That is all.

9) What is nature of the phase transition that turns us from the description of a quantum system based on the Schrödinger equation to that based on the Dirac one?

10) What is nature of the fundamental physical constants c, h, and G? If the value of c is constant then why does the experiment register the superluminal velocity (from c to $4.7c$) [15]?

11) What is electric charge and why is it fractional in quarks? It is said that the charge is something that is written in quotation marks [16]; constants of gauge interactions are called the "charge" as well. Thereby, according to the definition [17] the electric charge is a value that is measured by the elementary electric charge unit e!

12) What is structure of real space?

It is easily seen that answers to these questions cannot be found solely in the framework of power mathematical methods of contemporary physics. Notwithstanding this, the questions are pure physical and we should look for the solvability of all these very urgent problems of fundamental science. We should answer what the canonical particle is? What is its size? And what all the properties mentioned above do mean?

2 Confusions of quantum theory

Present views on the canonical particle are restricted by the following primitive notion that is not reconcilable with a very difficult and formal mathematical construction, which is applied to the description of the quantum systems behavior. First, experimental data correspond to the length $l \geq 10^{-17}$ cm [18]. At this scale we should imagine a "black box" that unified our perception about the particle. The box is pasted over various labels, which contain legends like these: the mass is equal to M, the spin is equal to 1/2, the energy E is equal to $h\nu$, the charge is equal to e, and so on. In the case of quarks, things get worse: an isolated quark does not exist and that is why we can talk about the box only resorting to indirect information on the spin, color and so on, that is the notions which need submicroscopic investigations themselves. Second, we should rather substitute the notion of fundamental particle (i.e. our abstract black box) by the more abstract notion of fundamental symmetry [19]. Third, at the atom size the fundamental symmetry is suddenly transformed into the ψ-wave function or spinor $\hat{\psi}$, as the case requires. The case is a function of the ratio v/c where v and c are the particle and light velocity respectively. It turns out that the ψ-wave function and spinor $\hat{\psi}$ can be not only considered as the fundamental symmetry parameters but parameters of the particle as well. At the same time special relativity says that the value v_0 is not absolute and depends on a frame of reference. One may choose such a frame of reference that v_0 will be very close to c. This means that the Schrödinger formalism may be easily replaced for the Dirac one and on the contrary, we can choose such frame of reference for a quantum system described by the Dirac equation that the Dirac formalism will smoothly pass to Schrödinger's. However everybody knows that this is absurdity and moreover at this point an internal inconsistency of the theory comes to light: in the Schrödinger quantum equation the distance between two instantly interacting electrons, as was noted by Ehrenfest [20], "can be equal to any quantity of kilometers". Besides the Schrödinger equation is not Lorentz invariant and therefore formalism based on this equation can not be conjugated with that resting on the Dirac one, whereas both the formalisms are confirmed by experiment perfectly. So such a strange theory we have.

On the other hand, there are exact postulates, which directly follow experimental facts. First, there are corpuscles whose behavior similar to wave. Second, the velocity and mass are characteristics of objects; the size of objects contracts in the direction of motion and objects' masses increase with velocities. Third, two basic quantum mechanical relations are applied for any particle: $E = h\nu$ and $\lambda = h/Mv$. Forth, each particle has its own limiting length, the Compton wavelength λ_{Com}, behind of which quantum fluctuations of the vacuum are absent. Fifth, there is a quantum characteristic of the particle called the spin that can contribute the orbital momentum of the particle. Sixth, when the velocity v of the particle approaches to c, the phase transition takes place in the quantum system studied and one should pass from the Schrödinger formalism to the Dirac one.

Loud disagreements in quantum theory point towards the need for its improvement. All modification must keep pace with reliable established experimental facts. To solve the problem we should try to study the three following subjects together, which have never been previously considered as the whole: Foundations of quantum mechanics, Foundations of quantum gravity, and Foundations of quantum electricity. But the first point of the study is the structure of the geometry of space and a correct definition of real space.

3 Search for a submicroscopic approach

There are different approaches to the problem. Among them one can name a new approach by Hofer [21] who has proposed to consider electrons and photons as extended particles which comply with a wave equation; the newest concept offered by Kirilyuk [22], who has constructed a theory of two fundamental fields, which lead to the universal concept of dynamic complexity and the permanently developing hierarchical structure of the universe. Kiriliuk's model demonstrates a possibility of the double solution with chaos, which takes into account the deterministic concept of quantum mechanics developed by de Broglie. Based on causal interpretation of quantum mechanics pioneered by de Broglie [23] and Bohm [24], Roy and Singh [25] have suggested a deterministic mechanics in which the quantum probability densities are simultaneously reproduced as marginal of one positive defined phase space density, which is constant along the trajectory. We shall point out also several other new views on the nature of a vacuum and real space which have appeared [26-32] during the last decade. These see a vacuum as a substance and determine matter as deformations of space, Bounias and Bounaly [31,32]; in particular, papers [31,32] studied premises for the existence of an initial cell of space in terms of the topology and the set theory. About some kind of a primordial cell and existence principle was also pointed in Ref. [33].

In high energy physics wave properties of canonical particles are neglected and the behavior of a quantum system is often described drawing an analogy with the lattice model, string model, bubble model, bag model, etc. Thus, in many cases quantum field theory can not preclude ideas and concepts used in condensed media physics. Because of this account must be taken of the microstructure of the vacuum, i.e., real space, at the scale of the order of 10^{-28} cm (at this size electromagnetic, weak and strong interactions come together). It is likely that space at this scale can be simulated as an order/disorder lattice, similar to a solid/liquid, or as a cellular structure, similar to the pack of soft spheres. (It is interesting to note that such view is conceptually close to the re-introduction of some kind of an aether, but the quantum one.)

In the author's works [34-36] real space has been simulated in the form of a quantum substance as well and an elementary cell of space – a superparticle – has been offered. The origin of matter, a local space curvature, or deformation, is created when the volume of an initial cell changes. One can consider the local deformation as a corpuscle. Let us look now if the model can explain quantum mechanics phenomena. How can the local deformation that can be treated as a corpuscle whose size is limited by 10^{-28} cm moves similar to a wave and manifests the wave behavior at the atom scale? Of course, it is not an easy problem but it has a solution. The motion of the physical "point" (corpuscle cell) in entirely packed discrete space must be accompanied by the interaction with the "points" of space (superparticle cells) giving rise to excitations in neighboring cells. Note that the similar phenomenon occurs in a solid: a particle moving in the solid brings about excitations such as excitons, solitons, etc. As the excitations are associated with the motion of the corpuscle they were called "inertons", i.e. just the corpuscle inert mass is responsible for the creation of such kind of space excitations. A portrait of the moving corpuscle is depicted in Fig. 1. When the corpuscle moves it also pulls its deformation coat, in other words, the space crystallite. The crystallite migrates by a relay mechanism: in any place of corpuscle location surrounding cells are made ready as the Figure demonstrates. The crystallite is similar to a shell that screens the corpuscle from degenerate space. Cells have mass inside the crystallite and have not it out.

The dynamics of the corpuscle and its inerton cloud was studied in Refs. [34-36]. It was shown that the cloud of inertons oscillates around the corpuscle with amplitude Λ that can be found using the relationship

$$\Lambda = \lambda c/v_0 \tag{1}$$

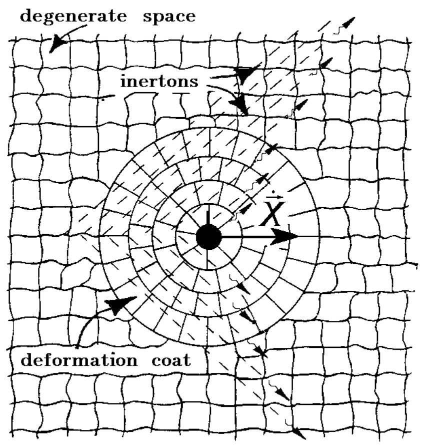

Figure 1: The corpuscle, i.e. canonical particle (•), moving in the space net.

where λ is the amplitude of spatial oscillations of the corpuscle, c is the speed of light and v_0 is the corpuscle's initial velocity.

It is quite reasonable to center the notion of corpuscle, i.e., local deformation of space, on the notion of canonical particle. This enables [34,35] to make a deeper microscopic interpretation of the de Broglie wavelength λ as amplitude of spatial oscillations of the particle along its path: on the first half of spatial period of oscillations $\lambda/2$ the particle emits inertons and its velocity decreases from v_0 to 0. The emitted inertons gradually retarded by elastic cellular space. Then space returns the inertons to the particle and hence on the second half of the period $\lambda/2$ the particle absorbs the inertons and its velocity increases from 0 to v_0, and so on. It is significant that the inertons emitted ahead of the particle are absorbed behind of it (owing to the difference between the inerton and the particle velocities, $c > v_0$). The submicroscopic mechanics of the particle permits to deduce correctly the basic quantum mechanical relations:

$$E = h\nu, \qquad \lambda = h/p; \tag{2}$$

here, in our case $p = Mv_0$ and $M = M_0(1 - v_0^2/c^2)^{-1/2}$. Relations (2) were not obtained previously from any theory; they were only postulated by de Broglie who showed [37] that the Schrödinger equation is their consequence. However, unlike the traditional presentation, the Schrödinger equation gained in paper [35] is Lorentz invariant because it includes time t as a natural parameter that is Lorentz invariant by definition.

Space covered by the inerton cloud determines the range of the wave ψ-function action. The cloud of inertons accompanying the moving particle contacts any obstacles around the particle in a distance $\sim \Lambda$ and transmits a respective information to the particle and this is the easiest explanation of the particle diffraction phenomenon. The size of the deformation coat, or the crystallite is equal to the Compton wavelength λ_{Com}; it is just the parameter that characterizes the relativistic behavior of the particle, in particular, the photon scattering by it.

What is inerton? It is a quasi-particle that carries an elementary deformation from cell to cell by a relay mechanism like the Frenkel (molecular) exciton transferring the energy in a molecular crystal. Owing to the comparison of the deformation with mass (see Refs. [34,35]) it is reasonable to assume that inertons should substitute for hypothetical gravitons – carriers of the gravitational interaction of general relativity. Indeed, i) inertons have mass (gravitons have not); ii) inertons are a part of any quantum and classical physical system (gravitons were deduced only from the pure classical behavior of objects and these particles can not be introduced in quantum mechanics in principle); iii) inertons can be easily revealed in any physical laboratory by means of many different tools (the existence of gravitons has never been confirmed).

The general theory of relativity did not take into account the existence of matter waves, which quantize space at the microscopic scale. Therefore the macroscopic requantization of space that general relativity predicts is highly conjectural. Moreover the relativity lumped together real space with time which is a non-geometric parameter. This is the amalgamation that builds up enormous obstacles on the way to a microscopic consideration of the gravitation phenomena. The problems of the construction of a mathematical space and time emergence in it has recently been raised by Bonaly and Bounias [31,32]; they have shown that time is associated with the mapping of intersections of topological spaces. A detailed theory of space conforming to the experimental results in the fields of microscopic and macroscopic phenomena is stated in Ref. [38].

The impact of inertons on the structure of test specimens has been demonstrated in paper [39] (other manifestations of inertons are described in Refs. [40,41]). At the same time many other physicists have observed unusual effects, which may be caused by inertons as well. In particular, *Europhys. News* has reported about one of them [42]: a large group of researchers could observe the electron wave ψ-function on metal surface. Nonetheless, everybody knows that the wave ψ-function is just the mathematical function like to the Boltzmann function $f(\vec{r}, \dot{\vec{r}})$, the Hamilton-Jacobi function $S(\vec{r}, E)$, etc. All these do not act in real space and only set connections between particle's parameters. This is why spherical and elliptical images showed in the figures in Ref. [42] should be interpreted as images of inerton clouds surrounding electrons.

The concept of cellular degenerate space and the submicroscopic mechanics, which are progressing allow us to disclose many significant details of the microworld and it is valid to say that the first significant result obtained in the framework of the concept is the solution of two difficult problems of nonrelativistic quantum mechanics. First, the theory developed in Refs. [34,35] removed a very unpleasant conflict that took place between nonrelativistic quantum mechanics and special relativity: Unlike the traditional presentation, the Schrödinger equation gained in paper [35] is Lorentz invariant owing to the invariant time entered in the equation. Second, due to inertons introduced in the quantum system nonrelativistic quantum mechanics no longer suffers from long-range action.

Such submicroscopic approach is able to give us great insight into both the submicroscopic structure of canonical particles and the particles dynamics, which are hidden from observation inside the "black box" that presents an impenetrable barrier to the quantum field theory, string theory, supersymmetry, supergravity, and others. The theory based on the concept of fine-grained degenerate space is a newest one, however, it would be the shortest way to the unified theory of matter. The new concept needs new mathematical ideas, new approaches and a new research methodology.

Acknowledgement

I am very thankful to Professor Michel Bounias for fruitful discussions and valuable remarks.

References

[1] H. A. Lorentz, *Aether Theories and Aether Models* (Nauchno-Technicheskoe Izdatelstvo NKTP USSR, Moscow, Leningrad, 1936) (Russian translation) p. 66.

[2] G. Lochak, Preface to: L. de Broglie, *Heisenberg's Uncertainty Relations and the Probabilistic Interpretation of Wave Mechanics* (Mir, Moscow, 1986) (Russian translation), p. 9.

[3] D. Bohm, On the role of hidden variables in the fundamental structure of physics, *Found. Physics* **26**, 719 (1996).

[4] S. Sonego, Conceptual foundations of quantum theory: a map of the land, *Ann. de la Fond. L. de Broglie* **17**, 405 (1992); errata: *ibid.* **18**, 131 (1993).

[5] L. B. Okun, *Elementary Particle Physics* (Nauka, Moscow, 1988) (in Russian), p. 197.

[6] *Ibid.*, p. 184.

[7] L. B. Okun, The notion of mass, *Uspekhi Fizich. Nauk* **158**, 511 (1989) (in Russian).

[8] C. G. Adler, Does mass really depend on velocity? *Am. J. Phys.* **55**, no. 8, 739-743 (1987).

[9] About A. H. Bucherer and his activity see *Phys. Zs.* **30**, no. 1, 1-8 (1929); *Neue Deutcsh. Biographie*, Bd. II, 1955, S. 700.

[10] M. M. Rogers, A. W. McReynolds, and F. T. Rogers, Jr. *Phys. Rev.* **57**, p. 379 (1940).

[11] A. Einstein, *Ather und Relativitatstheorie.* Verlag von Julius Springer, Berlin, 1920. Cited by A. Eistein, *Collected Scientific Works*, Nauka, Moscow, 1965, v.1, p.682 (Russian translation).

[12] L. I. Schiff, *Quantum Mechanics* (Izdatelstvo Inostrannoy Literatury, Moscow, 1959) (Russian translation), p. 33.

[13] *Ibid.*, p. 364.

[14] See Ref. 5, p. 17.

[15] G. Nimtz and W. Heitmann, Superluminal photonic tunneling and quantum electronics, *Prog. Quant. Electr.* **21**, 81-108 (1997).

[16] See Ref. 2, p.74.

[17] See Ref. 2, p.75.

[18] V. L. Ginzburg, *About Physics and Astrophysics* (Nauka, Moscow, 1985) (in Russian), p. 86.

[19] W. Heisenberg, *The Perception of Nature by Physicist* (1973). Cited by: G. Lochak, *Ukrain. J. Phys.* **38**, 632 (1993) (in Ukrainian).

[20] P. Ehrenfest, Einige die Quantenmechanik betreffende Erkundigungsfragen *Z. Phys.* **78**, 555 (1932).

[21] W. A. Hofer, Internal structure of electrons and photons: the concept of exteded particles revised, *Physica A* **256**, 178-196 (1998)(also *e-preprint* quant-ph/9806066); Arealist view of the electron: recent advances and unsolved problems, *e-preprint* quant-ph/9910036.

[22] A. P. Kirilyuk. *Universal Concept of Complexity by the Dynamic Redundance Paradigm: Causal Randomness, Complete Wave Mechanics, and the Ultimate Unification of Knowledge* (Ky¨ıv, Naukova Dumka, 1997; 550 p., in English)(see also http://xxx.lanl.gov physics/9806002, gr-qc/9906077 and references herein).

[23] L. de Broglie, *Non-linear Wave Mechanics. A Casual Interpretation.* (Elsevier, 1960).

[24] D. Bohm, A Suggested Interpretation of the Quantum Theory, in Terms of "Hidden" Variables. I. *Physical Review* **85**, 166 (1952). A Suggested Interpretation of the Quantum Theory, in Terms of "Hidden" Variables. II, *ibid.*, **85**, 180 (1952).

[25] S. M. Roy, and V. Singh, *Mod. Phys. Lett. A* **10**, 709 (1995); *Phys. Lett. A* **255**, 201 (1999); S. M. Roy, Contextual deterministic quantum mechanics, *e-preprint* quant-ph/9908062.

[26] P. I. Fomin, in *Quantum Gravity. Proc. of IV Seminar on Quantum Gravity*, Moscow, USSR, May 1987, eds. V. Markov, V. Berezin, and V. P. Frolov (World Scientific Publishing Co., Singapore, 1988), p. 813.

[27] H. Aspden, *Aether Science Papers* (Subberton Publications, Southampton, 1996).

[28] J. W. Vegt, A particle-free model of matter based on electromagnetic self-confinement (III), *Ann. Fond. L. de Broglie* **21**, 481 (1996).

[29] F. Winterberg, Equivalence and gauge in the Planck-scale aether model, *Int. J. Theor. Phys.* **34**, (1995) 265; Planck scale physics and Newton's ultimate object conjecture, *Z. Naturforsch.* **52a**, 183 (1997).

[30] A. Rothwarf, An aether model of the universe, *Phys. Essays* **11**, 444-466 (1998).

[31] M. Bounias, and A. Bonaly, On mathematical links between physical existence, observebility and information: towards a "theorem of something" *Ultra Scientist of Phys. Sci.* **6**, 251-259 (1994); Timeless space is provided by empty set, *ibid.* **8**, 66-71 (1996); On metric and scaling: physical co-ordinates in topological spaces, *Ind. J. Theor. Phys.* **44**, 304-321 (1996); Some theorems on the empty set as necessary and sufficient for the primary topological axioms of physical existence, *Phys. Essays* **10**, 633-643 (1997).

[32] M. Bounias, A theorem proving the irreversibility of the biological arrow of time, based on fixed points in the brain as a compact or Δ-complete topological space, *Proceeding CASYS'99* (Mathematical Conference on Anticipatory Systems, Belgium 1999), Symposium 8, p. 20; The theory of something: a theorem supporting the conditions for existence of a physical universe, from the empty set to the biological self, *Proceeding CASYS'99*, Symposium 10, p. 25.

[33] A. Magnon, *Arrow of Time and Reality: a Conciliation* (World Scientific, Singapore, 1996).

[34] V. Krasnoholovets, and D. Ivanovsky, Motion of a particle and the vacuum *Phys. Essays* **6**, 554 (1993) (also arXiv.org e-print archive quant-ph/9910023).

[35] V. Krasnoholovets, Motion of a relativistic particle and the vacuum *Phys. Essays* **10**, no. 3, 407 (1997)

[36] V. Krasnoholovets, On the nature of spin, inertia and gravity of a moving canonical particle, *Ind. J. Theor. Phys.* **48**, 97-132 (2000) (also arXiv.org e-print archive quant-ph/0103110).

[37] L. de Broglie, *Heisenberg's Uncertainty Relations and the Probabilistic Interpretation of Wave Mechanics* (Mir, Moscow, 1986), p. 42 (Russian translation).

[38] M. Bounias, and V. Krasnoholovets, Scanning the structure of ill-known spaces, in preparation.

[39] V. Krasnoholovets, and V. Byckov, Real inertons against hypothetical gravitons. Experimental proof of the existence of inertons, *Ind. J. Theor. Phys.* **48**, no. 1, 1-23 (2000) (also *e-preprint* quant-ph/0007027).

[40] V. Krasnoholovets, and B. Lev, Systems of particles with interaction and the cluster formation in condensed matter, *Condensed Matter Physics* **5**, no. 2 (2002) in press.

[41] V. Krasnoholovets, On the theory of the anomalous photoelectric effect stemming from a substructure of matter waves, *Ind. J. Theor. Phys.* **49**, no. 1, 1-32 (2001) (also *e-preprint* quant-ph/9906091).

[42] G. Briner, Ph. Hofmann, M. Doering, H. P. Rust, A. M. Bradshaw, L. Petersen, Ph. Sprunger, E. Laegsgaard, F. Besenbacher, and E. W. Plummer, Looking at electronic wave functions on metal surfaces *Europhys. News* **28**, 148 (1997).