# On the problem of the "Schrödinger atom"

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In Usp. Fiz. Nauk **163**(2), 93 (1993) [Translated in Phys. Usp. **36**(2), 94 (1993)] in the section "From the History of Physics," there was published the paper by A. D. Vlasov entitled "The Schrödinger Atom."[1] The interest in the personality and the work of Schrödinger is, of course, completely justified. The brilliant physicist E. Schrödinger, along with W. Heisenberg, is the creator of the mathematical apparatus of quantum mechanics. This apparatus was from the outset formulated in such a perfect form that it has not undergone any noticeable changes up till the present time.

However, in the article in Ref. 1 there are assertions which, in my opinion, may confuse the reader.

An appreciable part of the article is devoted to a defense of the physics theory which the author names the "Model of the Schrödinger Atom" that differs from the usual quantum mechanics. In application to the hydrogen atom this theory is obtained from the usual theory if one adds to the potential energy of the electron in the field of the nucleus the quantity "$U_s$—the potential energy of the electron charge in its own field." Thus, instead of the usual Schrödinger equation one obtains the nonlinear system:

$$\frac{\hbar^2}{2m}\Delta\psi+(E-U-U_s)\psi=0, \qquad (1)$$

where "the quantity $U_s$ is determined from the Poisson equation"

$$\Delta U_s=-2\pi e\psi\psi^*. \qquad (2)$$

In doing so the author cites Schrödinger's 1926 paper of Ref. 2. However, equations (1) and (2) do not appear in this article. The only comment which relates to the problem in question is contained in a note on p. 70 of the translation: "However, one should keep in mind the possibility that the transfer of the assertion concerning the potential energy from ordinary mechanics will no longer be allowed if both "point changes" in reality are smeared interpenetrating vibrational states." Here Schrödinger speaks about the possibility (subsequently rejected) to change the form of the interaction between the particles and not about the introduction of a "self-action" of the electron.

However, it is more important that the system of equations (1) and (2) is without any doubt incorrect since it is in contradiction with well-established experimental data. Indeed, one of the first successes of quantum mechanics was the quantitative explanation of the hydrogen spectrum (and later also that of helium) in complete agreement with experiment. This agreement, however, will be immediately violated if we would try to use, instead of the ordinary Schrödinger equation, equations (1) and (2), since the additional term $U_s$ if far from being small. For example, already in the first approximation the degeneracy with respect to the quantum number $l$ which is characteristic for the hydrogen atom will be removed. The entire theory of the fine structure of the lines of the hydrogen atom that is based on taking relativistic effects into account, and that is also in brilliant agreement with experiment, will lose its meaning. The impossibility of such kind of changes in quantum mechanics was clear to Schrödinger already in 1927. He wrote in the article of Ref. 3: "...one cannot treat the neutralization potential in such a manner as the values of the terms would in such a case be completely changed." (The neutralization potential here corresponds to the potential $U_s$.)

All the more so, it is impossible to regard the system of equations (1) and (2) seriously, in our time, when the validity of the "usual," and even of relativistic, quantum mechanics has been confirmed by a tremendous amount of experiments of the highest accuracy.

We note that a system of equations analogous to (1) and (2) actually arises in the approximate description of atomic states by the Hartree–Fock method. However, this method as no sense if applied to the hydrogen atom.

The article contains a number of other assertions with which one cannot agree. Thus, for example, the electron cannot possibly have a radius "of the order of $10^{-8}$ cm." In this case the scattering of fast electrons by nuclei which have, as is well known, a much smaller size would definitely differ from the observed one. The number $10^{-8}$, by the way, does not at all follow from the theory defended by the author. In this theory the electron has no fixed size at all, since the size of the electron cloud depends on the state being examined. The indicated number is merely the "size" of the electron in the hydrogen atom. From electrons with a wavelength of $3.7\cdot10^{-10}$ cm mentioned in Ref. 1, one can construct a wave packet of the same size, so that the radius of the electron in the theory of Ref. 1 for this case will be just of the order of $3.7\cdot10^{-10}$.

There is no basis at all for considering that the Schrödinger equation describes the states of the discrete spectrum ("the internal states" according to the terminology in Ref. 1) any better (or worse) than those of the continuous spectrum.

The derivation of the Maxwell equations "on the basis

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of the special theory of relativity" was not at all given for the first time by M. Bowler in 1976 as is stated in the appendix to the article of Ref. 1. This was done by H. Minkowski at the dawn of the theory and the corresponding material can be found in any normal textbook. By the way, such a derivation, as a commonly known one, is used by Schrödinger in Ref. 3.

In conclusion, I will once again formulate my point of view. The existing quantum mechanics including the relativistic quantum theory of Dirac and quantum electrodynamics is confirmed by experiments with a high degree of accuracy and in the smallest detail. Any "improvement" of the foundations of the theory, which alters its observable consequences, will violate this agreement. Therefore, any proposal of this kind must, as a minimum, be accompanied by an exact comparison with experiment.

[1] A. D. Vlasov, Usp. Fiz. Nauk **163**(2), 97 (1993) [Phys. Usp. **36**(2), 94 (1993)].
[2] E. Schrödinger, Ann. Phys. (Leipzig) **79**, 361 (1926) [Russ. transl. in E. Schrödinger, *Selected Papers on Quantum Mechanics*, Nauka, M., 1976, p. 56].
[3] E. Schrödinger, Ann. Phys. (Leipzig) **82**, 178 (1927) [Russ. transl. in E. Schrödinger, *Selected Papers on Quantum Mechanics*, Nauka, M., 1976, p. 145].

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