CLASSICAL ELECTRODYNAMICAL RELATIVISTIC HYDROGEN ATOM MODEL – BRIEF REVIEW*)

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A brief review of the authors results in constraction of classical electrodynamical hydrogen atom model is presented.

Classical electrodynamical hydrogen atom model appeared as a logical generalization of numerous investigations of relationship between the Dirac and the Maxwell equations. Different morphisms between the spinor and the electromagnetic fields in the terms of field strengths were investigated by many authors from the origin of quantum mecha-nics until today, see e. g. [1–16], for the case of zero mass. The most interesting for the physical consequences case of nonzero mass was investigated firstly by H. Sallhofer [18–20] (sorse-free Maxwell equa-tions in specific medium) and than by us [21–37] (Maxwell equations with gradient-like electric and magnetic souses in the same Sallhofer's medium).

Relationship between the stationary Dirac and the Maxwell equations in the case of nonzero mass was the foundation of construction of classical electrodynamical hydrogen atom model. The first version based on sorse-free Maxwell equations in specific medium was suggested by H. Sallhofer [18–20], another model of that kind based on the Maxwell equations with gradient-like electric and magnetic souses in the same medium was suggested by us and is reviewing here. Our model has important advantages in comparison with Sallhofer's model. They are: unitary relationship with the Dirac theory; both spin 1 and spin 1/2 symmetries of the Maxwell equations of motion being considered, which allows one to relate these equation with the group-theoretical description of the electron; the possibility to solve the Maxwell equations exactly, using directly the separation of variables method.

There is no doubt that the Maxwell classical electrodynamics of macroworld (without any generalization) is sufficient for the description of electrodynamical phenomena in macro region. Contrary, it is well known that for micro phenomena (inneratomic region) the classical Maxwell electrodynamics cannot work. Our main assertion is weak generalization of classical Maxwell equations, which makes one possible to use them in inneratomic region. Such generalized equations are derived on the basis of two main steps. Firstly, namely these equations are connected unitary with the Dirac equation for massive particle in external field (in stationary case). Secondly, namely these equations have maximally possible symmetry properties and may describe from the group-theoretical point of view both bosons and fermions.

The foundations of our classical electrodynamical model of atom are the following. The model is based on the weakly generalized Maxwell equations

*) Робота доповідалася на міжнародній конференції з актуальних проблем сучасної теоретичної фізики (Ужгород, 20-23 жовтня 1999 р.), присвяченій пам'яті Ломсадзе Ю.М. (14.12.1924-10.03.1988).

$$\begin{aligned} &\mathrm{rot}\vec{H} - \varepsilon\partial_0\vec{E} = \vec{j}_e, \\ &\mathrm{rot}\vec{E} + \mu\partial_0\vec{H} = \vec{j}_{mag}, \\ &\mathrm{div}\varepsilon\vec{E} = \rho_e, \\ &\mathrm{div}\mu\vec{H} = \rho_{\mathrm{mag}}, \end{aligned} \tag{1}$$

which are modeling the atom in our consideration. Here $(\vec{E},\vec{H})$ – are the electric and magnetic field strengths, the current and charge densities (we note the existence of magnetic sources) have the gradient form:

$$\begin{aligned} \vec{j}_e &= \mathrm{grad}\,E^0, \\ \vec{j}_{mag} &= -\mathrm{grad}\,H^0, \\ \rho_e &= -\varepsilon\mu\partial_0 E^0 + \vec{E}\,\mathrm{grad}\,\varepsilon, \\ \rho_{mag} &= \varepsilon\mu\partial_0 H^0 + \vec{H}\,\mathrm{grad}\,\mu, \end{aligned} \tag{2}$$

(E^0, H^0) – two scalar functions, generating the sources) ε and μ – are the electric and magnetic permeabilities of the inneratomic medium in Sallhofer's form:

$$\begin{aligned} \varepsilon(\vec{x}) &= 1 - \frac{\Phi(\vec{x}) + m}{\omega}, \\ \mu(\vec{x}) &= 1 - \frac{\Phi(\vec{x}) - m}{\omega} \end{aligned}, \tag{3}$$

$\Phi \equiv -\dfrac{Ze^2}{r}$ is the potential energy of the external field for hydrogen-like problems, m_0 is the mass (we use the system $\hbar = c = 1$ in the calculations). Thus in order to describe the hydrogen atom we solve this equations of classical electrodynamics instead of quantummechanical Dirac or Schrodinger equations. The well-known Sommerfeld – Dirac formula for the fine structure

$$w^{hyd} = \frac{m_0 c^2}{\hbar\sqrt{1 + \dfrac{a^2}{(n_r + \sqrt{k^2 - a^2})^2}}}, \tag{4}$$

as well as the Bohr's postulates are here the consequences of the classical Maxwell equations (1). Atom is interrpreting here (briefly) as a stationary electromagnetic-scalar wave in medium (3). There is no electron as a primordial charged corpuscle in the model, electron as a charged corpuscle is a secondary induced object of the model and appears as a consequence of electromagnetic induction law, when electromagnetic-scalar wave begin to interact with a conductive matter.

The details can be found in our original papers [21–37]. At first we begin to investigate the symmetry properties of the Sallhofer's model [21]. In papers [22–24] we begin the construction of foundations of new classical electrodynamical model of atom. The unitary relationship of the Maxwell equations (1) with the stationary Dirac theory can be found in papers [25–30], for the details see [25,28]. The procedure of finding the hydrogen solution of the Maxwell equations (1) with the help of the known Dirac solutions on the basis of the isomorphism between the stationary solutions of the Dirac and Maxwell equations was presented in [25].This paper is the most complete with the mathematical proofs of the assertions of the model. The using of separation of variables method directly for the Maxwell equations (1) and procedure of their exact solution were published in paper [36]. The symmetry properties of the equations (1) in the limit of vanishing interaction with medium were investigated in papers [30–34], where the group-theoretical and symmetrical foundations of the model were obtained (spin 1/2 symmetry properties of the corresponding equations were proved). The historical place of the model in a row of another similar investigations was briefly discussed in [35]. The derivation of the assertions known as Bohr's postulates and the physical interpretation of this model were presented in [32,37]. All these results were presented as oral reports on two international conferences EGAS-29 (Germany) and EGAS - 31 (France) [26,27,37].

Due to the universal character of the unitary relationship between the stationary Dirac and Maxwell equations [25,28] one can solve on the basis of Maxwell equations (1) all the problems of atomic physics which can be solve by means of the stationary Dirac equation in external field. The expansion of the model from testing hydrogen atom on the another objects of atomic and nuclear physics is now in the process of investigation.

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КЛАСИЧНО ЕЛЕКТРОДИНАМІЧНА МОДЕЛЬ РЕЛЯТИВІСТСЬКОГО АТОМА ВОДНЮ – КОРОТКИЙ ОГЛЯД

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Представлено короткий огляд результатів авторів по побудові класично електродинамічної моделі релятивістського атома водню.