

Hydrogen in Electrodynamics.

IV. The Components of the Hydrogen Field

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After a discussion of the one-component Schrödinger (1926) and the four-component Dirac (1928) representation of hydrogen it is shown that the six-component electrodynamic picture turns out to be considerably simpler and clearer. The computational effort is reduced to a fraction.

Again we start with covariant source-free electro-dynamics [1] (1) with its complex components

$$\left\{ \begin{array}{l} \text{rot } \mathbf{E} + \frac{\mu}{c} \dot{\mathbf{H}} = 0 \\ \text{rot } \mathbf{H} - \frac{\varepsilon}{c} \dot{\mathbf{E}} = 0 \\ \text{div } \varepsilon \mathbf{E} = 0 \\ \text{div } \mu \mathbf{H} = 0 \end{array} \right\} \equiv \left\{ \begin{array}{l} \text{rot } \mathbf{E} + \frac{\mu}{c} \dot{\mathbf{H}} = 0 \\ \text{rot } \mathbf{H} + \frac{\mu}{c} \dot{\mathbf{E}} = 0 \end{array} \right\} \quad (1)$$

$\text{div } \mathbf{E} = \text{div } \mathbf{H} = 0$
 $\mathbf{E} \perp \text{grad } \varepsilon$
 $\mathbf{H} \perp \text{grad } \mu$

about which we know that it possesses the hydrogen spectrum for the interfraction [1] (2). Evaluation of this system with the usual separation, e. g., for the 3rd electric and magnetic components

$$E_3 = R^E P_{l^E}^{|m_3^E|} \exp \{i m_3^E \phi\}, \quad 0 \leq |m_3^E| \leq l^E, \quad (2)$$

and

$$H_3 = R^H P_{l^H}^{|m_3^H|} \exp \{i m_3^H \phi\}, \quad 0 \leq |m_3^H| \leq l^H. \quad (3)$$

yields the two systems of differential equations [1] (26) and [1] (27), which are identical with the respective systems of the four-component preliminary theory, and which give the radial components as well as the hydrogen spectrum [1] (28). We therefore may adopt the radial components directly from the preliminary theory.

According to [2], the electric radial component R^E , for instance, has the following form for the states I and II:

$$R^{E^I} = e^{-\lambda r} \sum_{k=0}^{n_r} a_k^I r^{q^I+k}, \quad \lambda = \frac{2\pi}{hc} \sqrt{m_0^2 c^4 - (h v)^2}, \quad (4)$$

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$$q^I = -1 + \sqrt{(-l^{E^I}-1)^2 - \alpha^2}, \quad (l^{E^I} = 0, 1, \dots), \quad (5)$$

$$a_k^I = \left[\alpha - (q^I + k - l^{E^I}) \sqrt{\frac{m_0 c^2 - h v}{m_0 c^2 + h v}} \right] C_k^I, \quad (6)$$

$$[(q^I + k - l^{E^I} + 1)(q^I + k + l^{E^I} + 3) + \alpha^2] C_{k+1}^I = \frac{4\pi}{hc} [(q^I + k + 1) \sqrt{m_0^2 c^4 - (h v)^2} - \alpha h v] C_k^I \quad (7)$$

and

$$R^{E^{II}} = e^{-\lambda r} \sum_{k=0}^{n_r} a_k^{II} r^{q^{II}+k}, \quad \lambda = \frac{2\pi}{hc} \sqrt{m_0^2 c^4 - (h v)^2}, \quad (8)$$

$$q^{II} = -1 + \sqrt{(l^{E^{II}})^2 - \alpha^2}, \quad (l^{E^{II}} = 1, 2, \dots), \quad (9)$$

$$a_k^{II} = \left[\alpha - (q^{II} + k + l^{E^{II}} + 1) \sqrt{\frac{m_0 c^2 - h v}{m_0 c^2 + h v}} \right] C_k^{II}, \quad (10)$$

$$[(q^{II} + k + l^{E^{II}} + 2)(q^{II} + k - l^{E^{II}} + 2) + \alpha^2] C_{k+1}^{II} = \frac{4\pi}{hc} [(q^{II} + k + 1) \sqrt{m_0^2 c^4 - (h v)^2} - \alpha h v] C_k^{II}. \quad (11)$$

Obviously the relations

$$R^{E^I} = R^E (-l^{E^I} - 1), \quad (12)$$

$$R^{E^{II}} = R^E (l^{E^{II}}) \quad (13)$$

hold. In (5) and (9), l^{E^I} and $l^{E^{II}}$ have different bounds. l^{E^I} corresponds to the usual bound as in (2), so that we may already write after (2):

$$E_3^I = R^{E^I} P_{l^{E^I}}^{|m_3^I|} \exp \{i m_3^I \phi\}, \quad 0 \leq |m_3^I| \leq l^{E^I}. \quad (14)$$

On the other hand, $l^{E^{II}}$ starts with 1, a fact which has been discussed extensively in a paper by von Laue [3]. Since m_3^{II} has to go through zero for the smallest $l^{E^{II}}$ ($=1$), it has to be raised in the spherical harmonic of the ansatz (2):

$$E_3^{II} = R^{E^{II}} P_{l^{E^{II}}}^{|m_3^{II}+1|} \exp \{i m_3^{II} \phi\}, \quad 1 \leq |m_3^{II}+1| \leq l^{E^{II}}. \quad (15)$$

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Inserting this into the d'Alembert-ansatz [1] (3), taking into account [1] (11), we have for the present

$$E_3 = E_3^I e^{-i\omega t} \pm E_3^{II} e^{i\omega t} \quad (16)$$

if, in the sense of greatest generality, we take for the first term the state I and for the second one the state II.

If we now also enter (14) and (15) into (16), taking into account (12) and (13), we already get

$$E_3 = R^E (-l^{EI} - 1) P_{-l^{EI}-1}^{m_3^I} e^{im_3^I \phi} e^{-i\omega t} \pm R^E (l^{EII}) P_{l^{EII}+1}^{m_3^{II}} e^{im_3^{II} \phi} e^{i\omega t} \quad (17)$$

Let then be

$$-l^{EI} - 1 = l^{EII} = l^E \quad \text{and} \quad m_3^I = m_3^{II} + 1 = m_3, \quad (18)$$

so that we finally have

$$E_3 = 2 R^E (l^E) P_{l^E}^{m_3} \exp \{i(m_3 - 1/2) \phi\} \frac{\cos \left(\frac{\phi}{2} - \omega t \right)}{i \sin \left(\frac{\phi}{2} - \omega t \right)} \quad (19)$$

or, because of the linearity of (1)

$$E_3 = 2 R^E P_{l^E}^{m_3} \exp \{i(m_3 - 1/2) \phi\} \exp \{i(\phi/2 - \omega t)\} = E_3^{Re} + i E_3^{Im}. \quad (20)$$

One might incautiously continue to write (20) in the form of the single-valued Dirac function

$$2 R^E P_{l^E}^{m_3} \exp \{i(m_3 \phi - \omega t)\}.$$

Thereby one would, however, disregard the fourfold ambiguity occurring already in (19), which results from the half-valued ambiguity of each of the two half-valued factors.

To begin with, we regard the explicit half-valued spin-factor in (19) and (20) as an essential improvement over wave mechanics. Even more serious against the background of the linearity of (1), however, is the fourfold ambiguity. For the four interpretations have to appear side by side because of the linearity, and one immediately sees that the four interfering fields cancel each other always and everywhere:

$$E_3 = \sum_4 R^E P_{l^E}^{m_3} [(+, -) \exp \{i(m_3 - 1/2) \phi\}] \cdot [(+, -) \exp \{i(\phi/2 - \omega t)\}] = 0. \quad (21)$$

Since, as in all interference processes, the independent nature, especially the energy, of each interfering field has to be preserved, we get for the energy of the quadruple of fields (21)

$$U^{E_3} = 4 E_3^* E_3 = (4 R^E P_{l^E}^{m_3})^2 \neq 0. \quad (22)$$

The self-interfering, everywhere and always vanishing hydrogen field (21) is therefore associated with the nonvanishing stationary energy field (22).

From the electrodynamic point of view, therefore, the hydrogen atom does not reveal its electromagnetic quality to the outside through the cancelling interference because of the half-integer spin. Its energy field, however, is positive, different from zero and stationary. In the one-component preliminary theory the center of this energy field obeys Newton's mechanics according to the sketch [4] (5)–(17) – here probably relativistic mechanics with its limiting signal velocity. The hydrogen atom (without electromagnetic influence from the outside) thus is perceptible only mechanically. Therby the energy field (in its most literal sense a matter-wavefield) and its center, or rather its immediate neighborhood, represent the purely mechanically acting hydrogen particle. Result: Almost all cosmic matter has half-integer spin and therefore presents itself non-electromagnetically, although being of purely electrodynamic nature.

From an epistemological point of view it should be noted here that, according to the above, mechanics would be a true sub-theory of electrodynamics.

With regard to its materialization, if not to say its substance [5], the hydrogen atom consists, from the electrodynamic point of view, of a quadruple of wave fields of the six field components a cluster of 24 wave fields or its 24 stationary energy fields, respectively. The cluster deposits itself symmetric around the origin, decreasing towards the outside according to the radial functions R^E and R^H . At the origin the field amplitudes reach (integrable) infinity only if the infinity-inducing potential function of the inverse distance is introduced into the system (1) through the interfraction [1] (2). On the other hand, they stay finite also at the origin if one calculates instead $1/r$ with

$$\Phi = \frac{1}{r + l_0}. \quad (23)$$

For small l_0 the frequency of the solution deviates only insignificantly from the hydrogen frequency [1] (28). Therefore, (21) basically is free of singularities.

The hydrogen solution (21), of course, represents a particular solution and has not been adjusted. The general solution is characterized by those symmetries which constitute the Dirac structure. We shall consider it in one of the subsequent papers.

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