Effect of β^-–charged eradiation and its calculation in the nuclear electrodynamics theory

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Abstract. The study of own fields and charged particles motion and also charged fission splinters of a heavy nucleuses into nonrelativistic approximation is the subject of this paper research. The main efforts are concentrated in quest of charged share components by the radioactive β^-–disintegration. The corresponding field equations and equations of motion in the nuclear electrodynamics processes are obtained and their solutions are found. Analysis of the microscopic equations is generalized to the level of the macroscopic description of continuous medium electrodynamics and is accompanied by quantumomechanical additions.

1. Introduction

The important peculiarity of presented work is a definition and solution of fields equations and motion equations for fission splinters in consideration of charged share of radioactive inside nuclon β^-–disintegration effect, i. e. in consideration of emited cascaded electrons but without consideration of γ–eradiation [1], [2], [3]. The obtained theoretical results can be a basis for the further mathematical modelling of generation phenomenon of a virulent directional electromagnetical fields on the toroid (the nuclear electrogenerator) in the process of nuclear chain fission [4], [5], [6]. We propose the toroid is the solenoid with the external winding. Moreover inside of this toroid all fragments of the nuclear disintegration remain in force. That is why light charges don't may escape the system and therefore enter the formalism.

2. The fields and motion of charged fission particles

We are interested by the calculation recipe of electrical $E_*(R,t) \in R^3$ and magnetical $B_*(R,t) \in R^3$ fields in the point with coordinate $R \in R^3$ at time moment t which are produced by the particles with charges Z_i, coordinates $R_i(t)$ and velocities $\dot{R}_i(t) = v_i(t),\ i = 1, 2, \ldots$. It is known that given fields into Gaussian units system (taking into account of values in order $1/c$, where c is velocity of light, and of multiplicator 4π in the expression for potentials) can be written with the aid of microscopic Maxwell-Lorenz equations system in the form

$$\nabla E_* = \sum_i Z_i\, \delta\,(R_i - R), \quad -E_*' + \nabla \times B_* = \frac{1}{c} \sum_i Z_i \dot{R}_i\, \delta\,(R_i - R),$$

$$\nabla B_* = 0, \qquad B_*' + \nabla \times E_* = 0. \tag{1}$$

We denote here: for the vector ∇ (the differential Hamiltonian operator) is the differentiation on coordinate R, the feature on top is the differentiation on ct; $\delta\,(R_i - R)$ is the delta-function from $R_i - R$ included in the field sources.

Taking into account of the vector potential $a(R,t)$: $B_* = \nabla \times a$, the scalar potential $\varphi(R,t)$: $E_* = -\,\nabla\varphi - a'$ and the Lorenzian calibrated condition: $\nabla a + \varphi' = 0$ also, the solution for system (1) in the form of nonrelativistic electromagnetical field can be found

$$E_* = \sum_i E_i, \qquad E_i = -\,\nabla\,\frac{Z_i}{4\pi\,\sigma_i}, \qquad B_* = \sum_i B_i, \qquad B_i = \frac{1}{c}\,\nabla \times \frac{Z_i\,\dot R_i}{4\pi\,\sigma_i},$$

where through $\sigma_i = |\,R_i - R\,|$ is denoted the distance between points with coordinates R_i and R in the space R^3.

The equation of i–th particle motion with the mass m_i under the influence Lorenzian force has the form

$$m_i\,\ddot R_i = Z_i\,[\,E(R_i,t) + \frac{1}{c}\,\dot R_i \times B(R_i,t)\,], \tag{2}$$

where $E(R_i,t) = \sum_j E_j + E_0$, $B(R_i,t) = \sum_j B_j + B_0$; (E,B) is full electromagnetical field in the point R_i at time moment t; (E_0,B_0) is external field, (E_*,B_*) is internal field of the charged particles in the given point, moreover $i \neq j$.

For equation (2) can been attached the canonical form: $\partial H/\partial P_i = \dot R_i$, $\partial H/\partial R_i = -\,\dot P_i$ with the aid of the Hamiltonian

$$H = \sum_i \frac{P_i^2}{2m_i} + \sum_i \sum_j \frac{Z_i\,Z_j}{8\pi\,\sigma_{ij}}$$

$$+\ \sum_i Z_i \left[\varphi_0(R_i,t) - \frac{P_i}{cm_i}\,A_0(R_i,t)\right], \qquad \sigma_{ij} = |\,R_i - R_j\,|,$$

where $i \neq j$, into the the terms of impulse variables P_i, coordinate variables R_i and potentials (scalar φ_0 and vector A_0) of external field.

3. The fields and motion of charged fission splinters

Let us set the problem about conclusion of field equations and motion equations of the charged splinters (the united particles with internal nuclear structure) which are made in consequence of the chain nuclear fission reaction. These compound united particles can be considered as many time ionizated positive ions for the reason electrons upsetting of the atom outer skin of divided substance.

We proceed from the field equation of individual particles (1). Add to the index i the index k. Then instead of vector R_i we take the vector R_{ki}, where $R_{ki} = R_k + r_{ki}$; where k is the splinter index, i is the index of the particle of given splinter, r_{ki} is the internal coordinate of ki-th particle concerning the fixed point of k-th splinter.

The charged fission splinters are not "the stable complexes" but are the powerfully nonsteady particles groups are exposed the pronounced instantaneous radioactive fission (the β^-–fission accompanied by the γ–eradiation). We have in the k-th fission splinter the individual charged particles in the point R_{ki} with the charges Z_{ki} and the charged nucleus in the point R_k is exposed β^-–fission with the charge Z_k : $Z_k = X_k + Y_k$, where X_k is the proton charge of nucleus (i. e. the original proton charge of splinter + the proton charge of β^-–fission products), Y_k is the electron charge of β^-–fission products.

The solutions E_* and B_* of field equations can be approximated as converged rows on parameter $|\,r_{ki}\,|/|\,R_k - R\,|$, i. e. the dimensions of a splinter R_{ki} smaller a distance σ_k from the observation point R to fixed point (nucleus) R_k of k-th splinter. Transform equations (1) taking into account all expansions, included the δ–function expansion into the Taylor's row on r_{ki} in the locality of the point $(R_k - R)$

$$\nabla E_* = \sum_k \sum_i Z_{ki} \sum_{n=0}^{\infty} \frac{(-1)^n}{n!} (r_{ki} \nabla)^n \, \delta(R_k - R) + \sum_k X_k \, \delta(R_k - R) + \sum_k Y_k \, \delta(R_k - R),$$

$$- E'_* + \nabla \times B_* = \frac{1}{c} \sum_k \sum_i Z_{ki} \, (\dot{R}_k + \dot{r}_{ki}) \sum_{n=0}^{\infty} \frac{(-1)^n}{n!} (r_{ki} \nabla)^n \, \delta(R_k - R)$$

$$+ \frac{1}{c} \sum_k X_k \dot{R}_k \, \delta(R_k - R) + \frac{1}{c} \sum_k Y_k \dot{R}_k \, \delta(R_k - R), \qquad \nabla B_* = 0, \qquad B'_* + \nabla \times E_* = 0.$$

The motion equation of ki-th particle into k-th splinter with the charge Z_{ki}, the mass m_{ki} and the coordinate R_{ki} at the time moment t into full electromagnetical field $(E(R_{ki},\, B(R_{ki}, t))$ has a form of equation (2), where $R_i \to R_{ki}$, i. e.

$$m_{ki} \ddot{R}_{ki} = Z_{ki} \, [\, E(R_{ki}, t) + \frac{1}{c} \, \dot{R}_{ki} \times B(R_{ki},) \,] \tag{3}$$

and

$$E(R_{ki}, t) = - \sum_j \nabla_{ki} \frac{Z_{ki}}{4\pi \, \sigma_{k,ij}} - \nabla_{ki} \frac{(X_k + Y_k)}{4\pi \, \sigma_{k,ik}} - \sum_l \sum_j \nabla_{ki} \frac{Z_{lj}}{4\pi \, \sigma_{kl,ij}}$$

$$- \sum_l \nabla_{ki} \frac{(X_l + Y_l)}{4\pi \, \sigma_{kl,il}} + E_0(R_{ki}, t), \qquad B(R_{ki}, t) = B_0(R_{ki}, t), \tag{4}$$

where $j \neq i$, $l \neq k$; ∇_{ki} is the gradient vector on the elements of vector R_{ki}. In the system (4) are denoted

$$\sigma_{k,ij} = |\, R_{ki} - R_{kj} \,|, \qquad \sigma_{k,ik} = |\, R_{ki} - R_{kk} \,| = |\, R_{ki} - R_k \,|,$$
$$\sigma_{kl,ij} = |\, R_{ki} - R_{lj} \,|, \qquad \sigma_{kl,il} = |\, R_{ki} - R_{ll} \,| = |\, R_{ki} - R_l \,|,$$

and moreover $|\, R_{ki} - R_k \,| = |\, r_{ki} \,|$.

On the analogy of (2) $(i \to k)$ can be written the motion equation of the nucleus of k-th splinter with the charge $Z_k = X_k + Y_k$, the mass m_k, the coordinate R_k into full electromagnetical field $(E(R_k, t),\, B(R_k, t))$

$$m_k \ddot{R}_k = Z_k \, [\, E(R_k, t) + \frac{1}{c} \, \dot{R}_k \times B(R_k, t) \,], \tag{5}$$

where

$$E(R_k, t) = - \sum_j \nabla_k \frac{Z_{kj}}{4\pi \, \sigma_{k,kj}} - \sum_l \sum_j \nabla_k \frac{Z_{lj}}{4\pi \, \sigma_{kl,kj}}$$

$$- \sum_l \nabla_k \frac{(X_l + Y_l)}{4\pi \, \sigma_{kl,kl}} + E_0(R_k, t), \qquad B(R_k, t) = B_0(R_k, t), \quad l \neq k. \tag{6}$$

After the summarizing of equations (3) on i and the adding with equation (5) for description of the motion of k-th splinter with the mass $\bar{m}_k$ and the coordinate of masses center $\bar{R}_k$

$$\bar{m}_k = \sum_i m_{ki} + m_k, \qquad \bar{R}_k = \frac{\sum_i m_{ki} R_{ki} + m_k R_k}{\bar{m}_k}$$

we obtain the equation

$$\bar{m}_k \ddot{\bar{R}}_k = \sum_i Z_{ki}\,[\,E(R_{ki},t) + \frac{1}{c}\,\dot{R}_{ki} \times B(R_{ki},t)\,] + Z_k\,[\,E(R_k,t) + \frac{1}{c}\,\dot{R}_k \times B(R_k,t)\,]. \tag{7}$$

Substitute the expressions (4) and (6) into the equation (7). Then the resultant force corresponding the intrasplinter field for the set of central forces is equal zero. Consequently the equation (7) acquires the form

$$\bar{m}_k \ddot{\bar{R}}_k = -\sum_l \sum_i \sum_j \nabla_{ki} \frac{Z_{ki} Z_{lj}}{4\pi\,\sigma_{kl,ij}} - \sum_l \sum_i \nabla_{ki} \frac{Z_{ki}\,(X_l + Y_l)}{4\pi\,\sigma_{kl,il}} - \sum_l \sum_j \nabla_k \frac{Z_{lj}\,(X_k + Y_k)}{4\pi\,\sigma_{kl,kj}}$$

$$- \sum_l \nabla_k \frac{(X_l + Y_l)(X_k + Y_k)}{4\pi\,\sigma_{kl,kl}} + \sum_i Z_{ki}\,[\,E_0(R_{ki},t) + \frac{1}{c}\,\dot{R}_{ki} \times B_0(R_{ki},)\,]$$

$$+ (X_k + Y_k)\,[\,E_0(R_k,t) + \frac{1}{c}\,\dot{R}_k \times B_0(R_k,t)\,], \quad l \neq k. \tag{8}$$

For all that external field (E_0, B_0) satisfies the homogeneous equations

$$\nabla B_0 = 0, \qquad B_0' + \nabla \times E_0 = 0.$$

Thus, the equation (8) is the motion equation of k-th splinter into electromagnetical field of other splinters and external sources.

It is important to note the received equations on a level with the traditional items in the right part of the Lorenzian force contain also the items are made a force connected with radioactive charged eradiation of nucleuses into fission splinters (the accounting of β^-–charged eradiation by the radioactive electrodynamical effect).

4. Conclusions

Chain fission of heavy nuclei is one of many physical phenomena which proceed in an avalanche scheme. In fission there is an impetuous increase in the numbers of neutrons, charged particles and fission splinters with enormous kinetic energy. The present theory aims to describe the above process quantitatively. In the future it could find an application in powerful reactors operating exclusively on the basis of electronuclear conversions.

References

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