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**SOME CONSEQUENCES OF THE LAW
OF LOCAL ENERGY CONSERVATION
IN ELECTROMAGNETIC FIELD**

1 Introduction

At a gravitational interaction of particles and bodies a defect masses arises [1], i.e. there an energy yield appear since the bodies (or particles) are attracted. In the previous work [1] it was shown, that the radiation spectrum (or energy levels) of atoms (or nuclei) in the gravitational field has a red shift since the effective mass of radiating electrons (or nucleons) changes in this field. This red shift is equal to the red shift of the radiation spectrum in the gravitational field measured in existing experiments. The same shift must arise when the photon (or γ quantum) is passing through the gravitational field if it participates in gravitational interactions. The absence of the double effect in the experiments means that photons (or γ quanta) are passing through the gravitational field without interactions.

In work [2] it was shown that changing of the effective mass of a body (or a particle) leads to changing of velocity and length measurement units (relative to standard measurement units). An expression describing the advance of the perihelion of the planet (the Mercury) is obtained. This expression is mathematically identical to Einstein's equation [3] for the advance of the perihelion of the Mercury but in a flat space. The same situation must take place at the electromagnetic interaction of particles and nuclei.

This work is devoted to search for influence of attractive electromagnetic interaction on atomic levels of electrons.

2 Some Consequences of the Law of Local Energy Conservation in Gravitational field

a). Let us consider the influence of the external electrical field $\varphi = -e\frac{Z}{r}$ (Ze is electrical charge of the external field, r -distance) on characteristics of an electron (particle) having a small velocity. The law of local energy conservation in the classical case has the following

form:

$$E = \frac{mv_1^2}{2} + e\varphi_1 = \frac{mv_2^2}{2} + e\varphi_2 \quad (1)$$

or

$$\frac{m(v_1^2 - v_2^2)}{2} = Ze^2\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad (2)$$

The Eqs. (1) and (2) characterize the balance between kinetic and potential energies (the smaller the energy—the bigger another energy and back).

In a more strict form the law of local energy conservation can be rewritten in the form

$$E = mc^2 + \frac{mv_1^2}{2} + e\varphi_1 = mc^2 + \frac{mv_2^2}{2} + e\varphi_2 \quad (3)$$

Then the Eq. (3) can be rewritten in the following form:

$$E = mc^2\left(1 + e\frac{\varphi_1}{mc^2}\right) + \frac{mv_1^2}{2} = mc^2\left(1 + e\frac{\varphi_2}{mc^2}\right) + \frac{mv_2^2}{2}. \quad (4)$$

After introduction the new masses are

$$m' = m\left(1 + e\frac{\varphi_1}{mc^2}\right) \quad m'' = m\left(1 + e\frac{\varphi_2}{mc^2}\right) \quad (5)$$

and new velocities—

$$v_1'^2 = \frac{v_1^2}{\left(1 + e\frac{\varphi_1}{mc^2}\right)} \quad v_2''^2 = \frac{v_2^2}{\left(1 + e\frac{\varphi_2}{mc^2}\right)}. \quad (5')$$

Then Eq. (4) acquires the following form:

$$E = m'c^2 + \frac{m'v_1'^2}{2} = m''c^2 + \frac{m''v_2''^2}{2}. \quad (6)$$

The eq. (6) means that in an external electrical field the effective mass of the electron (particle) changes. For clarification of this question let us consider a body (or particle) with mass m in the external electrical field φ in point r and write the law of local energy conservation for this system

$$mc^2 = E = mc^2 + \frac{mv^2}{2} + e\varphi = m'c^2 + \frac{m'v'^2}{2}, \quad (7)$$

where

$$m' = m(1 + e\frac{\varphi}{mc^2}) \quad \Delta m = m - m' = -e\frac{\varphi}{mc^2},$$

and

$$\delta v^2 = v^2 - v'^2 = +v^2(\frac{e\varphi}{mc^2}) \quad \text{or} \quad \frac{\Delta v^2}{v^2} = +\frac{e\varphi}{mc^2}. \quad (8)$$

Eqs. (7), (8) means that changing the mass (Δmc^2) of the electron (particle) in the external electrical field goes on the kinetic energy of this electron (particle).

To which result do come? In contrast to the classical physics the velocity of the electron (particle) is v' and

$$\Delta v^2 = v^2 - v'^2 = +v^2\frac{e\varphi}{mc^2}, \quad \Delta v = +v\frac{e\varphi}{2mc^2}. \quad (9)$$

The following question arises: how can we see this changing of the effective mass or velocity?

This effect, in principle, is very small. We can register this effect in atomic transitions as changing of the atomic levels relatively the standard levels. It is clear, that we must learn these transitions in nuclei with large Z where this effect will be sufficiently visible.

The atomic levels are given by the following expression [4]:

$$E_n = \frac{\alpha^2 m_{eff} c^2 Z^2}{2n^2} [1 + \frac{\alpha^2 Z^2}{n} [\frac{1}{(j+1/2)} - \frac{3}{4n}] + \dots], \quad (10)$$

where

$$\alpha = \frac{e^2}{4\pi\hbar c}; \quad n' = 0, 1, 2, \dots;$$

$$j = \frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \dots; \quad n = n' + j + \frac{1}{2} = 1, 2, 3, \dots, \quad ,$$

n is an orbital number.

The law of the local energy conservation is fulfilled if we take into account that the mass of the electron $m' = m_{eff}$ in the connected (bound) state is

$$m_{eff} = m - 2E_n, \quad (11)$$

where E_n is a radiating energy and $\frac{mv^2}{2} \simeq E_n$ is the energy of the orbital movement of the electron.

Putting (11) into (10) we come to the following expression:

$$E_n = \frac{\alpha^2(m - 2E_n/c^2)c^2 Z^2}{2 n^2} \left[1 + \frac{\alpha^2 Z^2}{n} \left[\frac{1}{(j+1/2)} - \frac{3}{4n} \right] + \dots \right], \quad (12)$$

From (12) we come to the following expression for the real electron levels E_n for the nucleus with charge Z :

$$E_n = \frac{\alpha^2 m c^2 Z^2}{2 n^2} \left[1 + \frac{\alpha^2 Z^2}{n} \left[\frac{1}{(j+1/2)} - \frac{3}{4n} \right] + \dots \right] \cdot \frac{1}{1 + \alpha^2 \frac{Z^2}{n^2} \left[1 + \frac{\alpha^2 Z^2}{n} \left[\frac{1}{(j+1/2)} - \frac{3}{4n} \right] + \dots \right]}, \quad (13)$$

It is clear that electron in the connected (bound) state cannot radiate a photon if it's mass does not change.

When we take into account the law of energy conservation in a strict form changing the energy of the electron levels ΔE_n is

$$\Delta E_n = -\frac{\alpha^2 m c^2 Z^2}{2 n^2} \left[1 + \frac{\alpha^2 Z^2}{n} \left[\frac{1}{(j+1/2)} - \frac{3}{4n} \right] + \dots \right] \cdot \left[\alpha^2 \frac{Z^2}{n^2} \left[1 + \frac{\alpha^2 Z^2}{n} \left[\frac{1}{(j+1/2)} - \frac{3}{4n} \right] + \dots \right] \right], \quad (14)$$

If the transitions take place between levels n and m , then in the expression (14) it is necessary to do the following changing:

$$\frac{1}{n^2} \rightarrow \left(\frac{1}{n^2} - \frac{1}{m^2} \right) \quad (15)$$

3 Conclusion

At electromagnetic interactions of particles there arises defect of masses, i.e. the energy is liberated since the particles of the different charges are attracted. It is shown that this change of the effective mass of a particle in the external electrical field (of a nucleus) results in displacement of atomic levels of electrons. The expressions

describing these velocity changes and displacement of energy levels of electrons in the atom are obtained.

It is necessary to stress that the same effects will take place in the nuclei at the strong interactions of the protons and neutrons.

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Некоторые следствия закона локального сохранения энергии
в электромагнитных полях

При электромагнитных взаимодействиях частиц возникают дефекты масс, т.е. высвобождается энергия, так как частицы разных зарядов притягиваются. Показано, что изменение эффективной массы частицы во внешнем электрическом поле (ядра) приводит к изменению скорости и смещению энергетических уровней атомов. Получены выражения, описывающие изменения скорости и смещения энергетических уровней электронов в атоме.

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