ATOMIC NUCLEUS COULOMB ENERGY AND MODIFICATION OF PROTONS

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The problem of the experimental determination of the atomic nucleus Coulomb energy is discussed. The expression for the contribution of the proton modification to Coulomb energy is proposed.

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Coulomb energy E_C of nucleus (the total electro-static energy of the interaction of the intranuclear charges) can be determined from calculation relied on the function of density charge distribution in the nucleus $\rho(r)$. Since usually the explicit form of the function $\rho(r)$ follows from any model of nucleus then the calculation of the E_C is model in character. The single known equation for Coulomb energy of nucleus expressing this quantity in terms of the experimental data at once can be taken from paper [1]. In the representation of paper [2] this equation has the form

$$E_C = e^2\pi^{-1}\{I_1 + I_2\}, \quad (1)$$

$$I_1 \cong Z^2 \int_0^\infty F^2(q)\mathrm{d}q\,, \quad (1a)$$

$$I_2 \cong \int_0^\infty [S_{in}(q) - ZG^2(q^2)]\mathrm{d}q\,. \quad (1b)$$

Here e is the elementary electric charge, Z is charge number of the nucleus, q is the 3-momentum transfer, $F(q)$ is the longitudinal nuclear form-factor, $G(q^2)$ is proton electric form-factor, $S_{in}(q)$ is longitudinal response function zero moment (The moment $S_{in}(q)$, as in [1] and [2], is not normalized on $G^2(q^2)$).

The equation (1) was practically used in the experimental papers [2] and [3], where the E_C of the ^{6}Li and ^{12}C nuclei were evaluated. The subsequent measurements of the $S_{in}(q)$ in the region of high momentum show the necessity of the revision of the Eq.(1) interpretation.

One can see from Eq. (1), the problem of the E_C evaluation is that to calculate I_1 and I_2 integrals. So, it is necessary to have the $F^2(q)$- and $S_{in}(q)$-data in the wide momentum region.

The $F^2(q)$ quickly decreases with elevation of q, that permits to bound the range of necessary $F^2(q)$-data and, consequently, the upper limit of the integral I_1 to bound by $q \approx 1.5$ Fm^{-1}. In the case $q \geq 2$ Fm^{-1} the electron scattering on nucleus is quasi-elastic ones scattering on nucleons, and therefore it would be expected that $S_{in}(q) = ZG^2(q^2)$ at these momenta. So, the range of the necessary $S_{in}(q)$-data can be bounded by $q \approx 2$ Fm^{-1}. In this approximation the papers [2] and [3] were fulfilled.

However, later experiments (e.g. see [4]) performed as high as $q \approx 3$ Fm^{-1} show that even thought the ratio $S_{in}(q)/[ZG^2(q^2)] = \mathrm{const}$ at $q \geq 2$ Fm^{-1}, but it is less than unity and decreases with elevation of the atomic number. This phenomenon may be explained by modification of all or part nuclear protons, in the result of which the square on the form-factor of such protons $g^2(q^2) < G^2(q^2)$ (see [5]). In this case the term $ZG^2(q^2)$ in Eq.(1b) transforms into some function $f(g)$ to which tends the $S_{in}(q)$ with elevation of q. In approach of [6]

$$f(g) = Z[(1 - D)G^2(q^2) + Dg^2(q^2)], \quad (2)$$

where D is the relative part of modified protons in the nucleus. The contribution of the protons modification in the E_C according to Eq.(2) has form

$$\Delta E_C = \frac{e^2}{\pi} ZD \int_0^\infty [G^2(q^2) - g^2(q^2)]\mathrm{d}q\,. \quad (3)$$

Using this equation and results of paper [6], we evaluate that $\Delta E_C > 0$ and it equals to 0.04, 0.27, 9.1 MeV for the nuclei ^{4}He, ^{12}C, ^{208}Pb, correspondingly, that accounts for ~ 5-50 % of the early $e^2\pi^{-1}I_2$ value of the considerable nuclei or 2.5-1 % of the total Coulomb energy E_C. Other models of the protons modification ($D = 1$) show the same order of value ΔE_C.

The principal conclusion following from analysis of the nucleus Coulomb energy problem is that the accuracy of the E_C determination immediately depends on the accuracy of the $f(g)$ function, i.e. on the validity of our insight about the protons properties in the nucleus.

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