

CORRECTION TO THE ELECTRON ENERGY IN THE NUCLEAR REACTIONS

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The Coulomb correction to the electron energy in the direct electronuclear reactions is considered.

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1. When the first Born approximation is used for the electron scattering analysis some energy E_q is added to the initial one E_0 . This correction is the result of the electron energy increasing in the nuclear Coulomb field and taking into account this correction is alternative for the more difficult calculation using the second Born approximation.

At first the Coulomb correction E_q was applied during the investigation of the elastic electron scattering by nuclei and for light nuclei it had the form

$$E_q = 1.33 Ze^2 \langle r_N^2 \rangle^{-1/2}, \quad (1)$$

for medium and heavy nuclei:

$$E_q = 1.5 Ze^2 R^{-1}. \quad (2)$$

Here $\langle r_N^2 \rangle^{1/2}$ is the mean-square nuclear radius, $R = (5/3 \langle r_N^2 \rangle)^{1/2}$ is the radius of the nuclear equivalent homogeneous distribution, e is the electron charge and Z is the nuclear charge number. Expression (1) is derived from the Gaussian charge distribution model. Expression (2) is derived from the homogeneous distribution model.

2. Later the correction in the form (1) or (2) was used in the research of quasi-elastic electron scattering by nuclear nucleons [2]. One can think, that in this case, the addition electron energy of the scattering by a proton (p) or a neutron (n) can be presented as

$$E'_{q,p/n}(r) = E_{1,p/n} + E_{2,p/n}(r), \quad (3)$$

where $E_{1,p/n}$ is the correction for scattering by a free nucleon ($E_{1,n} = 0$), and $E_{2,p/n}(r)$ is the term taking into account the influence of the Coulomb field of the rest nuclear part on the energy of the electron scattering when the distance between the electron and the nuclear center is r . It is not difficult to see, that

$$E_{2,p/n}(r) = e \int_r^\infty \frac{Q_{p/n}(r')}{r'^2} dr', \quad (4)$$

where

$$Q_{p/n}(r) = 4\pi \int_0^r \rho_{p/n}(r') r'^2 dr'. \quad (5)$$

The function $\rho_{p/n}(r)$ in the case of the scattering by a neutron is $\rho_n(r) = \rho(r)$, $\rho(r)$ is the nuclear charge density; by the proton: $\rho_p(r) \approx (1-Z^{-1}) \rho(r)$. Probability of the scattering by a nucleon is proportional to $\rho(r)$; from here we can conclude that the nuclear volume averages $E_{q,p/n}(r)$ are:

$$\langle E'_{q,p} \rangle = E_{1,p} + (1-Z^{-1}) \langle E_{2,n} \rangle, \quad (6)$$

$$\langle E_{2,p/n} \rangle = \frac{4\pi}{Ze} \int_0^\infty E_{2,p/n}(r) \rho_{p/n}(r) r^2 dr. \quad (7)$$

Using expression (1), we derive $E_{1,p} = 2.4$ MeV. For the homogeneous distribution model ($U_0 = Ze^2 R^{-1}$):

$$E_{2,n}(r) = [1 + 0.5(1 - r^2/R^2)] U_0, \quad r \leq R; \quad (8)$$

$$\langle E'_{q,n} \rangle = \langle E_{2,n} \rangle = 1.2 U_0, \quad (9)$$

$$\langle E'_{q,p} \rangle = 2.4 U_0 + (1-Z^{-1}) 1.2 U_0. \quad (10)$$

3. We pay attention on some consequences of the approach considered.

I. Analysis of the Coulomb correction contribution shows that using of average values of corrections in the form (9), (10) instead of (2) leads, in some cases, to the change of experimental values of the nuclear characteristics by an order of magnitude of the measurement error.

II. One can see from Eq. (9) and (10) that the Coulomb correction depends on the sort of a scattering nucleon and from Eq. (8) this one depends on the nucleon location inside the nucleus. From here the resulting spread of values

$$\Delta E'_q \approx E_{1,p} + 0.5 U_0 \quad (11)$$

means that the effective interaction energy $E_{\text{eff}} = E_0 + E'_q$ has the same spread: $\Delta E_{\text{eff}} = \Delta E'_q$. Since, the transfer momentum is $q \propto E_{\text{eff}}$ than its amplitude of the spread is $\Delta q \approx \Delta E'_q / E_{\text{eff}} q$. For example, for ^{208}Pb at $E_0 = 100$ eV $\Delta q \approx 0.1 q$. This can be important for interpretation of (e, e') and especially $(e, e'p)$, $(e, e'n)$ experiments.

III. The Coulomb nuclear field influences not only on the energy of electron interaction but on the angle of the electron scattering too. It can be shown, that as a result, under electron scattering both by nucleus and by nuclear nucleon, the interval $\theta = \theta_0 \pm \Delta\theta$, where $\Delta\theta \approx 0.5 U_0 / E_{\text{eff}}$, but in this case more than one scattering angle θ_0 corresponds to the single value of the transfer momentum. Taking into account $\Delta\theta$ for measurement interpretation must lead to the very interesting results, in particular: a) increasing of experimental values of the charge radii; b) decreasing the EMC-effect.

In conclusion we note that all above-mentioned calculations and conclusions are related not only to the electron scattering but to any charged lepton scattering too. In the case of scattering not by a nucleon but by a nuclear cluster it is necessary to replace, in the corresponding expressions, $E_{q,p}$ value and $(1-Z^{-1})$ factor by their cluster analogies.

REFERENCES

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