

Factorization of charge and nuclear formfactors for clustered nuclei

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Considering high energy electrons as a probe it is worth noting previous attempts to extract information on cluster structure [1]. The role of cluster configurations in the nucleus was investigated in [2]. In [1] authors used nucleon gaussian trial wave functions in the s -state to calculate cluster wave function. Only in this case, when momentum transfer is high it is possible to factorize the formfactor. In general formfactors cannot be factorized. However the first attempt to factorize charge formfactor was done by R. Helm [3]. He used a folded charge distribution given by

$$\rho(r) = \int \rho_0(\vec{r}')\rho_1(\vec{r} - \vec{r}')d^3\vec{r}' \quad (1)$$

When Eq. (1) is substituted in the expression of formfactor:

$$F(\vec{q}) = \int \rho(\vec{r})e^{i\vec{q}\vec{r}}d^3r \quad (2)$$

it follows that

$$F(\vec{q}) = F_0(q)F_1(\vec{q}) \quad (3)$$

where F_0 and F_1 result from the substitution of ρ_0 and ρ_1 respectively, in Eq. (2):

$$F_0(\vec{q}) = \int \rho_0(\vec{r})e^{i\vec{q}\vec{r}}d^3r, \quad F_1(\vec{q}) = e^{-g^2q^2/2} \quad (4)$$

$\rho_1(r)$ had the gaussian form

$$\rho_1(r) = (2\pi g^2)^{3/2}e^{-r^2/2g^2} \quad (5)$$

In his review [4] Ueberall considers the value in Eq. (5) as "smearing", because the transition charge density must be concentrated on a shell of about nuclear radius, in the form of delta-function smeared by convolution in Eq. (1). Helm's model represents the transition moments of $\rho_0(r)$ as spherical shells at a radius R ,

$$\rho_L^{tr}(r) = \hat{J}_0\beta_L^{J_0J}R^{-2}\delta(r - R) \quad (6)$$

with a strength parameter to be fitted by experiment. The reduced matrix element reads

$$\hat{J}_0^{-1} \langle J||M_L(q)||J_0 \rangle = \beta_L^{J_0J}F_1(q)j_L(qR) \quad (7)$$

If we consider a nucleus consisting of α -particles, the formfactor (spherical Bessel function) represents a spherical shell made of α -particles. This result has been obtained considering high energy electrons scattered on fullerenes [5]

$$F(q) = F_A(q) \sum_J e^{i\vec{q}\vec{r}_j} = F_A(q)n(q) \quad (8)$$

where $F_A(q)$ is the formfactor of a single carbon atom and $n(q)$ is the formfactor of the carbon atomic concentration.

We considered the model when α -particles lie within some surface shell. To certain extent this is a

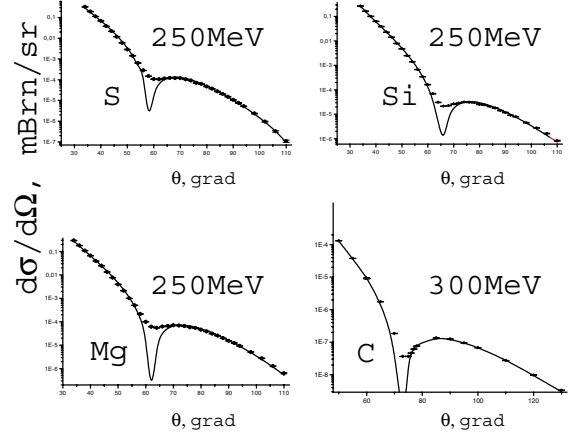


Figure 1: Electron scattering.

variant of the surface well model [6]. Assuming the quasi-crystalline structure of α -particles in nuclei we considered two possible types of α -particle density distribution, namely surface and volume distributions. In the first case the formfactor will be proportional to the Bessel function of order zero j_0 in the second case it will be the Bessel function of order one j_1 . In FIG. 1 one can see scattering of electrons on ^{12}C , ^{28}Si , ^{32}S , ^{24}Mg . At lower energies the surface distribution of α -particles in light nuclei is favorable. The Bessel function of order zero oscillates with the period $q = 2\pi/R$, where R is the nuclear radius.

We have used the factorized formfactors for clustered light nuclei assuming the α -particle density take the gaussian form. It is necessary to stress that in the microscopic approach charge densities of ^{12}C were derived by folding the finite proton size determined by gaussian [7]. Factorized formfactors give us a possibility to scan nuclear surface and some intrinsic layers of a nucleus.

References

- [1] Inopin E.V., Kinchakov V.S., Lukyanov V.K., Pol Yu.S., Annals of Physics, 118 (1979) 307
- [2] Gridnev K.A., Kartamishev M.P., Vaagen J.S., Lukyanov V.K., Anagnastatos G.S., Inter. Journ of Modern Physics, 11E (2002) 359
- [3] Helm R.H., Phys. Rev. 104 (1956)1466
- [4] Überall H., Springer Tracts Modern Physics 49 (1969), 1
- [5] Gershikov L.G., Efimov P.V., Mikoushkin V.M., Solov'yov A.V., Phys. Rev. Lett., 81 (1998) 2707
- [6] Baz A.I., Goldberg V.Z., Gridnev K.A., Semjonov V.M., Hefter E., Z. Physik 28A (1977) 171
- [7] Kamimura M., Nucl. Phys., 351A (1981) 456