DEYTRONNING UGLEROD-12 YADROSIDA ELASTIK SOCHILISHI

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ANNOTATSIYA

Ushbu maqola fizikaning eng muhim bo‘limlaridan biri bo‘lgan “Sochilish nazariyasi” ga bag‘ishlangan bo‘lib, zarrachaning moddadagi elastik sochilishiga katta e’tibor qaratiladi. O‘rganishlar zarrachaning energiyasining kichik qiymatlarida, taxminan 2 MeV atroflarida ko‘rib chiqiladi va zarracha va yadro qo‘shilishidan boshqa yadro hosil bo‘lmaydi deb faraz qilinadi, ya’ni to‘laqonli elastik sochilish hodisasi yuz beradi.

Kalit so‘zlar: elastik sochilish, potensial, faza siljishi, sochilish kesim yuzasi, energiya.

ELASTIC SCATTERING OF DEUTRONS IN THE CARBON-12 NUCLEUS

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ABSTRACT

This article is dedicated to one of the most important branches of physics, "Theory of Scattering," in which great attention is paid to the elastic scattering of matter at the atomic level. Observations are made at low energy levels of the matter, approximately at 2 MeV, and it is assumed that the interaction of matter and nucleus does not result in the creation of new nuclei, meaning a purely elastic deformation phenomenon occurs.

Key words: elastic scattering, potential, phase shift, cross section, energy.

Tadqiqot ishida sochilish nazariyasining statsionar formulasi taqdim etiladi va zarrachaning tashqi maydondagi to‘lqin funksiyalari ko‘rib chiqiladi. Sochilish fizikasida xulosalar chiqarishga imkon beruvchi sochilish amplitudasining analitik xususiyatlari o‘rganiladi va sochilish parametrlari aniqlanadi.

Modelning tushuntirilishi. Ko‘rib turganimizdek, zarrachaning berilgan kuch maydonidagi sochilishining differensial effektiv kesimi va to‘la kesimlari δ_l fazalar jamlanmasi orqali ifodalanadi. [1]

$$\sigma = \sum_{l=0}^{\infty} \frac{4\pi}{k^2}(2l+1)\sin^2\delta_l \tag{1}$$

$^{12}_{6}C$ uchun uyg‘ongan va asosiy holatlar orasidagi farq: 4.43982 ± 0.21 (MeV $\pm$ keV). Biz mutlaqo elastik sochilishni qaraganimiz uchun energiya deytronning parchalantirish energiyasidan 2.22 MeV kichik bo‘lishi kerak. Agar og‘irlik markazida to‘qnashish energiyasi $E > 5$ MeV bo‘lsa, deytronni parchalantirib yuborishi va uglerodni uyg‘otishi mumkin.

Deytron va uglerod ham yadro, ham Kulon (Coulomb) potensiali bilan ta’sirlashadi. Umumiy ta’sirlashuv potensial energiyasi quyidagicha bo‘ladi:

$$V = V_{yad} + V_C \tag{2}$$

Shu o‘rinda tug‘iladigan muammo esa yadroning potensial maydoniga oydinlik kiritishdir. Agar yadro kuchlarini hamda nuklonlarni o‘ziga tortib turish energiyasini juda kuchli ekanligini (MeV tartibida) hamda bu ta’sir faqat qisqa masofalarda sezilishligini inobatga olsak, potensial o‘rani chuqur va yadro chetlarida keskin nolga intiluvchi degan xulosaga kelamiz. Haqiqatga yaqinrog‘i esa Gaussian potensialidir ($U_G(r)$):

$$U_G(r) = -U_0 \exp[-\frac{(r - r_0)^2}{2a^2}] \tag{3}$$

bu yerda a - diffuziya masofasi ($a \cong 0{,}5 * 10^{-15}$ m) va $U_0 \approx 50$ MeV.

Analitik hisoblashlar. Demak, yadro kuchlari qisqa masofalarda ta’sir qiladi. Bizning holda esa massa soni A bo‘lgan yadroning ta’sir masofasi R:

$$R = 1.25 \cdot \left(12^{\frac{1}{3}} + 2^{\frac{1}{3}}\right) \text{ fm} \approx 4.436687 \text{ fm} \approx 4.44 \cdot 10^{-15} \text{ m}.$$

$$V_{yad} = \begin{cases} -V_0, & r < R \\ 0, & r > R \end{cases} \tag{4}$$

Yadro potensial energiyasi taxminan 50 MeV.

Deytron ham, uglerod ham zaryadga ega bo‘lganligi uchun Kulon potensiali bilan ham ta’sirlashadi. $r < R$ masofalarda Kulon potensial energiyasi o‘zgarmas son bo‘lib, V_C ni o‘rtachalash orqali aniqlanadi:

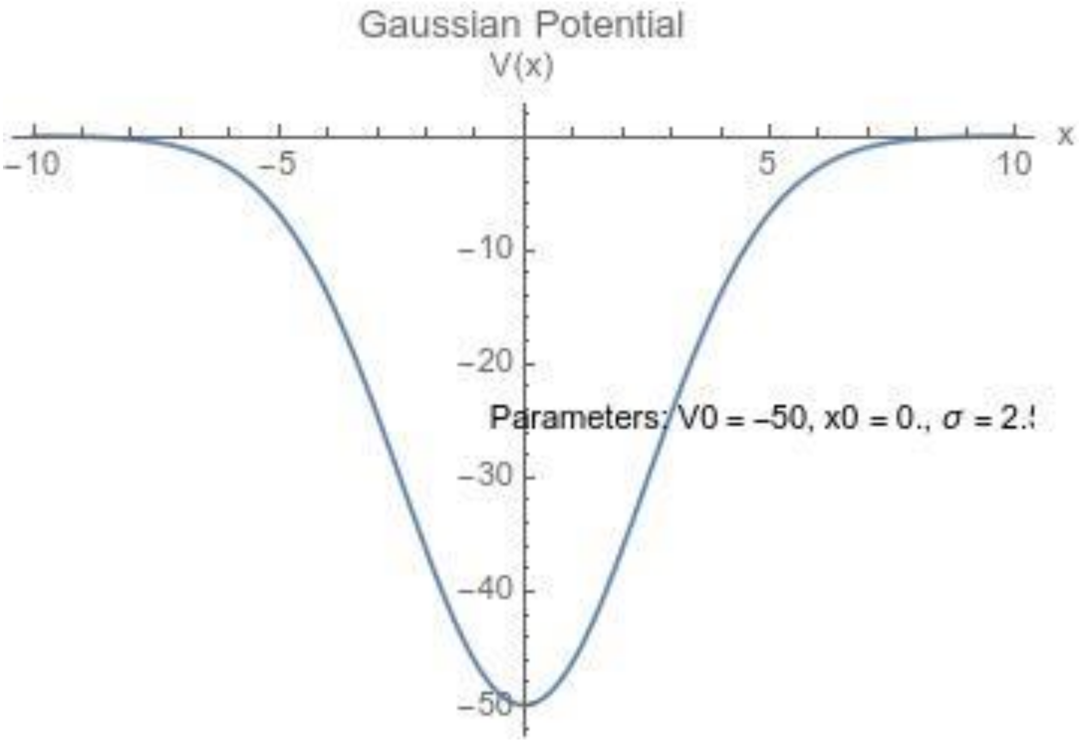
$$\overline{V}_C = \frac{4}{3}\frac{Z_C Z_d e^2}{R} \approx 2.59 \text{ MeV}. \tag{5}$$

Deytron va uglerod orasidagi yadro va Kulon potensiallarini baholaymiz:

$$\frac{\overline{V}_C}{V_{yad}} = \frac{2.59 \text{ MeV}}{50 \text{ MeV}} \approx 0.0518 = 5.18\ \%.$$

Demak, Kulon potensiali yadro potensialining taxminan 5 foizini tashkil qiladi, shuning uchun $r < R$ masofalarda faqat yadro potensialini hisobga olib, Shredinger tenglamasini yechamiz. Umumiy holda, ikki yadroning ta'sirlashuv potensial energiyasi quyidagiga teng ekan:

$$V = \begin{cases} -V_0 + \overline{V}_C, & r < R \\ \dfrac{Z_C Z_d e^2}{r}, & r > R \end{cases} \quad (6)$$



1.1-rasm. Yadroviy potensialning ko'rinishi.

$r < R$ masofalarda yadro kuchlari o'zaro tortishadi, shuning uchun manfiy, $r > R$ masofalarda esa ikkita yadro bir xil ishorali zaryadlanganligi uchun itarishadi, shuning uchun musbat bo'ladi.[2,3]

Endi biz zarrachaning markaziy maydonda sochilish muammosini ko'rib chiqamiz, bunda potentsial $V(r)$ faqat masofa r moduliga bog'liq bo'ladi. Bu masalani yechish Shredinger tenglamasining musbat energiya uchun quyidagi chegaraviy shartni qanoatlantiradigan yechimini topishga olib keladi: to'lqin funksiya tushayotgan va sochilayotgan to'lqinlar yig'indisi ko'rinishida bo'ladi:[4]

$$\tilde{u}_l(r) = C\sin(k_0 r), \quad r < R \quad (7)$$

$r > R$ sohalarda ikki yadro faqat Kulon potensiali orqali ta'sirlashishadi.[5,6,7]

$$u_l(r) = 4\pi i^l e^{i\delta_l}\cos\delta_l[F_l(kr) - tg\delta_l G_l(kr)] \quad (8)$$

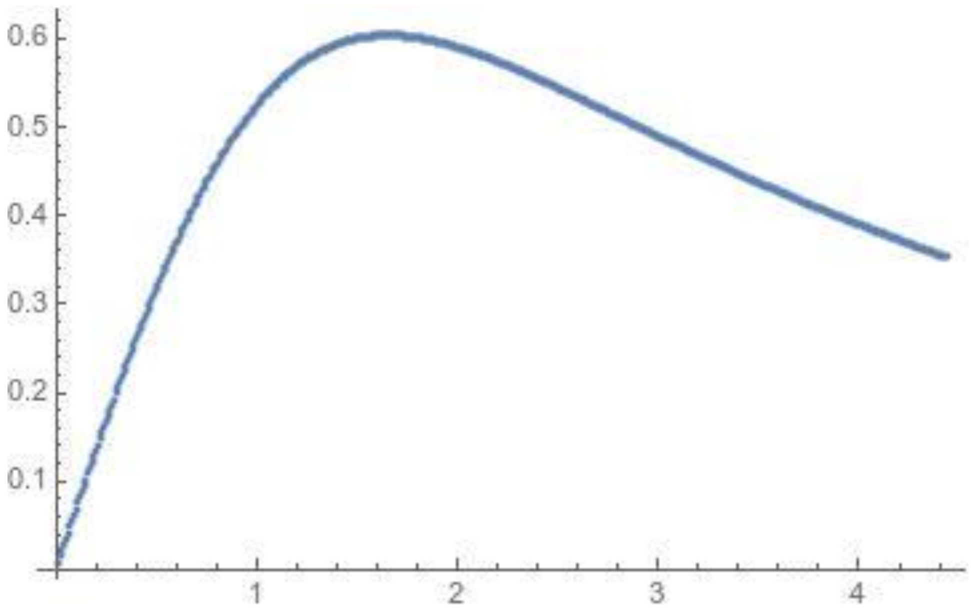
Chegaraviy shartlardan foydalanib, ya'ni o'zaro ta'sir chegarasida to'lqin funksiyalari va ularning hosilalari uzluksiz bo'lishidan $(r = R)$ δ_l − sochilish fazasini aniqlaymiz:

$$\frac{\tilde{u}_l'(r)}{\tilde{u}_l(r)} = \frac{u_l'(r)}{u_l(r)}, \qquad r = R. \tag{9}$$

$$D = \frac{k_0}{k}\frac{\cos(k_0R)}{\sin(k_0R)} \tag{10}$$

$$tg\delta_l = \frac{F_l'(kR) - DF_l(kR)}{G_l'(kR) - DG_l(kR)} \tag{11}$$

Yuqoridagi formula zarracha energiyasi va potensial yama parametrlaridan sochilish fazasini aniqlaydi.



Kichik energiyada sochilish amplitudasining asosiy hissasi $l = 0$ to‘lqin tomonidan amalga oshiriladi ($s -$ sochilish).

$$f(\theta) = \frac{1}{k}e^{i\delta_0}\sin\delta_0 \tag{12}$$

$$d\sigma = \frac{1}{4k^4}e^{2i\delta_0}\sin^2\delta_0 d\Omega \tag{13}$$

$$\sigma = \frac{4\pi}{k^2}\sin^2\delta_0 \tag{14}$$

Sochilish energiyasi nolga yaqin bo‘lsa, samarali radius nazariyasi qo‘llanilishi mumkin, ya’ni $\frac{k}{tg\delta_0} = \frac{1}{a} -$ deb belgilash kiritsak, δ_0 ning kichik qiymatlarida, $tg\delta_0 \approx \sin\delta_0$ bo‘ladi va to‘la kesim:

$$\sigma = \frac{4\pi}{k^2}\sin^2\delta_0 = \frac{4\pi}{k^2}a^2k^2 = 4\pi a^2 \tag{15}$$

$a -$ kattalik sochilish uzunligi deyiladi. [3]

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