3.25 A GeV/c impulsli ^{16}Op-to'qnashuvlarida kislorod yadrosi parchalanish kanallarida A ≤ 7 massa sonli fragmentlar chiqish kesimi

[1]Olimov Qosim f-m.f.d. prof., [2]Qurbonov Anvar Razzaqovich. f-m.f.b.(PhD)
[1]Fizika-texnika instituti, Toshkent sh,
[2]Jizzax Davlat pedagogika instituti, Jizzax sh.
e-mail: anvar.fizik@mail.ru

Калит сўзлар: ko'p nuklonli, α-klaster, 6-nuklonli tizimlar, 7-nuklonli tizimlar, ko'ndalang kesimi, to'qnashuv.

Annotatsiya. 3,25 A GeV/c impulsli ^{16}Op-to'qnashuvlarda 6 va 7-nuklonli sistemalar hosil bo'lgan kanallari chiqish kesimini tahlil qilish natijalari keltirilgan. Eksperimental ma'lumotlar kaskad-parchalanish bug'lanish modelining bashoratlari bilan taqqoslandi..

***

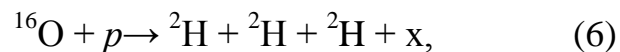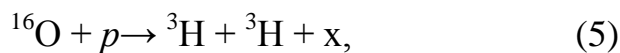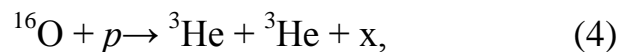*Ключевые слова: много нуклонных, α-кластерные, 6-нуклонные системы, 7-нуклонные системы, сечение, столкновение.*
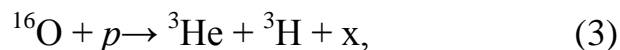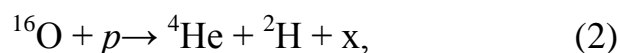
Аннотация. Представлены результаты анализа сечения выхода в каналах с образования 6- и 7- нуклонных систем в ^{16}Ор-соударениях при импульсе 3.25 А ГэВ/с. Выполнено сопоставление экспериментальных данных с предсказаниями каскадано фрагментационной испарительной модели.
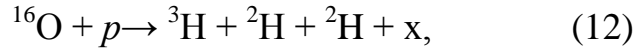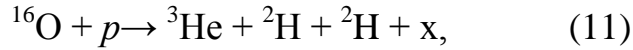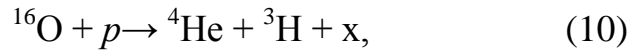
***

Key words:. Multi nucleon, α-cluster, 6-nucleon systems, 7-nucleon systems, cross section, collision.

Abstract. The results of an analysis of the exit cross section in channels from the formation of 6- and 7-nucleon systems in ^{16}Op collisions at a momentum of 3.25 A GeV/c are presented. The experimental data are compared with the predictions of the cascade-fragmentation evaporation model.

3.25 A GeV/c impulsli ^{16}Op-to'qnashuvlarida ko'p nuklonli fragmentlar tizimida olti yoki etti nuklonni o'z ichiga olgan voqealar xarakteristikalarini tahlil qilish natijalarini taqdim etadi, ya'ni quyidagi poluinklyuziv reaktsiyalar tipini:

$$^{16}O + p \rightarrow {}^{6}Li + x, \qquad (1)$$

$$^{16}O + p \rightarrow {}^{4}He + {}^{2}H + x, \qquad (2)$$

$$^{16}O + p \rightarrow {}^{3}He + {}^{3}H + x, \qquad (3)$$

$$^{16}O + p \rightarrow {}^{3}He + {}^{3}He + x, \qquad (4)$$

$$^{16}O + p \rightarrow {}^{3}H + {}^{3}H + x, \qquad (5)$$

$$^{16}O + p \rightarrow {}^{2}H + {}^{2}H + {}^{2}H + x, \qquad (6)$$

6-nuklonli tizimlar va yadrolar hosil bo'lishi va

$$^{16}O + p \rightarrow {}^{7}Li + x, \tag{7}$$

$$^{16}O + p \rightarrow {}^{7}Be + x, \tag{8}$$

$$^{16}O + p \rightarrow {}^{4}He + {}^{3}He + x, \tag{9}$$

$$^{16}O + p \rightarrow {}^{4}He + {}^{3}H + x, \tag{10}$$

$$^{16}O + p \rightarrow {}^{3}He + {}^{2}H + {}^{2}H + x, \tag{11}$$

$$^{16}O + p \rightarrow {}^{3}H + {}^{2}H + {}^{2}H + x, \tag{12}$$
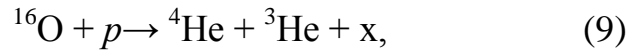
7-nuklonli tizimlar va yadrolar hosil bo'lishi. X-sifatida $A \leq 3$ massa sonli bir- yoki ikki-zaryadli fragment, tepki proton yoki pion bo'lishi mumkin. Shunday qilib, ya'ni $A \geq 4$ massa sonli hamroh yadrolar tug'iladigan tizimlar hosil bo'lishi mumkin bo'lgan boshqa kanallar muhokama qilinmagan.

6- va 7-nuklonli tizimlar ko'ndalang kesimi KFIM bo'yicha hisoblanganda 29.98 ± 0.67 mbn va 34.27 ± 0.72 mbn ga tengligi ko'rinadi, xuddi shunday ularning eksperimental qiymati munosib 42.18 ± 1.34 mbn va 39.55 ± 1.30 mbn ga teng bo'ladi. Bu kesimlardagi farq KFIMda 6- hamda 7-nuklonli tizimlar va yadrolar hosil bo'lishi eksperimentga nisbatan etarli darajada baholanmasligini ko'rsatadi. Shuningdek, KFIM da 7- nuklonli tizimlar hosil bo'lishi 6- nuklonlilar bilan solishtirilganda aftidan, ehtimolligi yuqoriligi, xuddi shunday eksperimentda teskari, 6- nuklonli tizimlar hosil bo'lishi ehtimolli yuqoriligi ko'rinadi [16-18].

1-jadval.

(1−6) reaktsiyalarning yig'indi zaryadi (Q) va chiqish kesimi (σ_y)

Sistema tipi	Reaksiya tartib nomeri	Yig'indi zaryadi, Q	Reaktsiya kesimi σ_y, mbn	
			Eksp.	KFIM
^{6}Li	1	3	3.67±0.36	7.00±0.33
$^{4}He+{}^{2}H$	2	3	23.83±1.03	12.22±0.44
$^{3}He+{}^{3}H$	3	3	5.55±0.48	2.93±0.21
$^{3}He+{}^{3}He$	4	4	3.67±0.39	4.11±0.25
$^{3}H+{}^{3}H$	5	2	2.64±0.36	2.53±0.20
$^{2}H+{}^{2}H+{}^{2}H$	6	3	2.81±0.37	1.20±0.13

1- va 2- jadvallarda yig'indi zaryad (Q) va ko'ndalang kesimi (σ_y) mos ravishda (1-6) reaktsiyalar uchun 6 nuklonli tizim va yadro hosil bo'lishi, shuningdek, (7-12) reaktsiyalar uchun esa 7-nuklonli tizim va yadrolar hosil bo'lishi KFIM bashoratlari bilan taqqoslangan holda keltirilgan[19-21].

(7−12) reaktsiyalarning yiqindi zaryadi (Q) va chiqish kesimi (σ_y)

| Sistema tipi	Reaksiya tartib nomeri	Yig'indi zaryadi, Q	Reaktsiya kesimi σ_y, mbn	
			Eksp.	KFIM
^{7}Li	7	3	2.72±0.31	6.36±0.31
^{7}Be	8	4	3.43±0.39	10.65±0.41
^{4}He+^{3}He	9	4	13.77±0.26	7.88±0.35
^{4}He +^{3}H	10	3	13.22±0.75	6.26±0.31
^{3}He + ^{2}H+^{2}H	11	4	3.21±0.37	1.69±0.16
^{3}H + ^{2}H+^{2}H	12	3	3.21±0.40	1.43±0.15

Ko'rilganlarni tasdiqlash maqsadida 1- va 2- rasmlarda reaktsiya turlaridan 6- va 7- nuklonli tizim va yadrolar chiqish kesimining eksperiment va KFIM dagi bog'liqligi keltirilgan. 1a -rasmda 6- nuklonli tizim va yadrolar eksperimentdagi va KFIM bo'yicha hisoblangan kesim qiymatlari munosib farqini to'ldirib ko'rsatilgan.
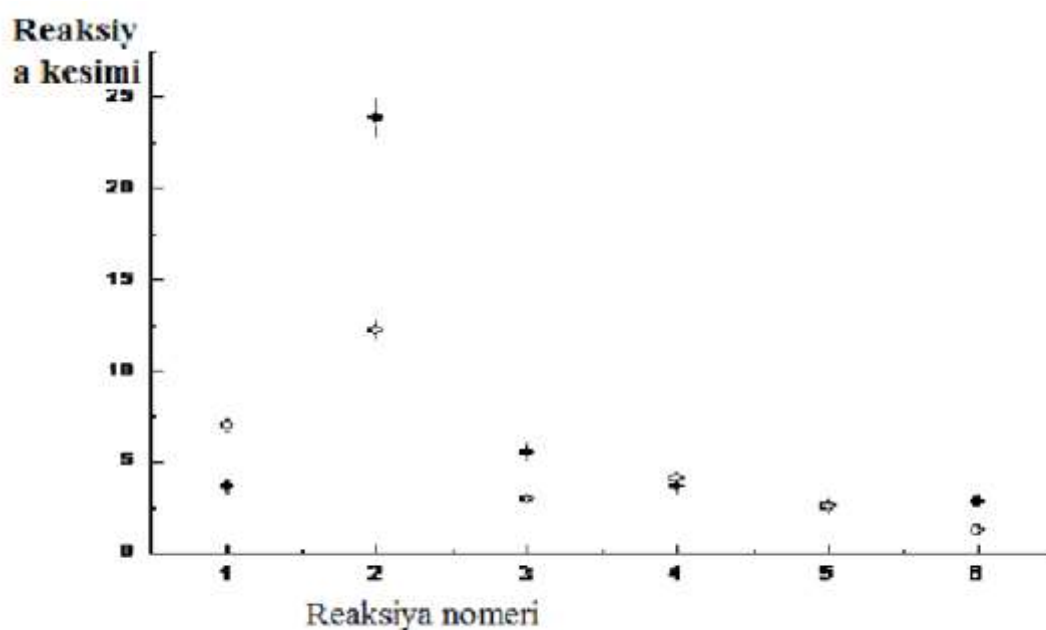
1 - rasm. (1−6) reaktsiyalarda 6- nuklonli tizimlar chiqish kesimi. Nuqta: ● – eksperiment, ○ –KFIM bo'yicha hisob.

1 va 2-jadvallardan ko'rinadiki, 6- va 7-nuklonli tizimlarda maksimal kesim reaktsiyalarda ^{4}He yadrolarning hosil bo'lishi bilan kuzatiladi. 6-nuklonli tizim uchun eksperimentda α-zarralar hosil bo'lishi kesimi 23.83 ± 1.03 mbn ni tashkil qiladi, 7-nuklonlilar uchun esa 26.99 ± 1.15 mbn. Mos ravishda KFIMda
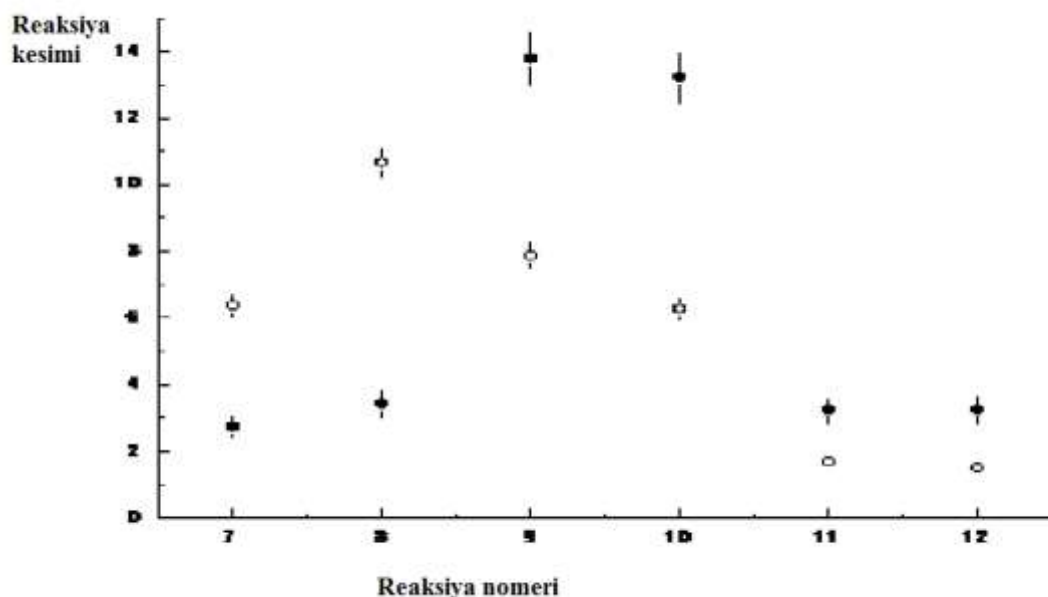
hisoblangan kattaliklar 6-nuklonli tizim uchun 12.22 ± 0.44 mbn va 7-nuklonlilar uchun 14.14 ± 0.49 mbn ni tashkil qiladi, ya'ni eksperimentdagidan KFIMda o'rtacha 1.93 marta kichik. Bu holat, bizning nazarimizda, KFIM-da hisobga olinmaydigan parchalanadigan kislorod yadrosi α-klasterli tuzilishining namoyon bo'lishidan guvohlik beradi. Bu xususiyat eksperiment va KFIM-da 6-nuklonli tizimlar hosil bo'lishi kesimlari qiyosi keltirilgan 1-rasmda yaxshi ko'rinib turibdi. Haqiqatan, eksperiment va KFIM da 6-nuklonli tizim chiqish kesimlaridagi asosiy farq aynan α-zarralar chiqish kanalida kuzatiladi, qolgan reaktsiyalarning chiqish kesimlari yig'indisi esa eksperimentda 18.87 ± 0.85 mbn ni va KFIMda 17.77 ± 0.65 mbnni tashkil qilib, amalda bir-biriga mos keladi[6-9].
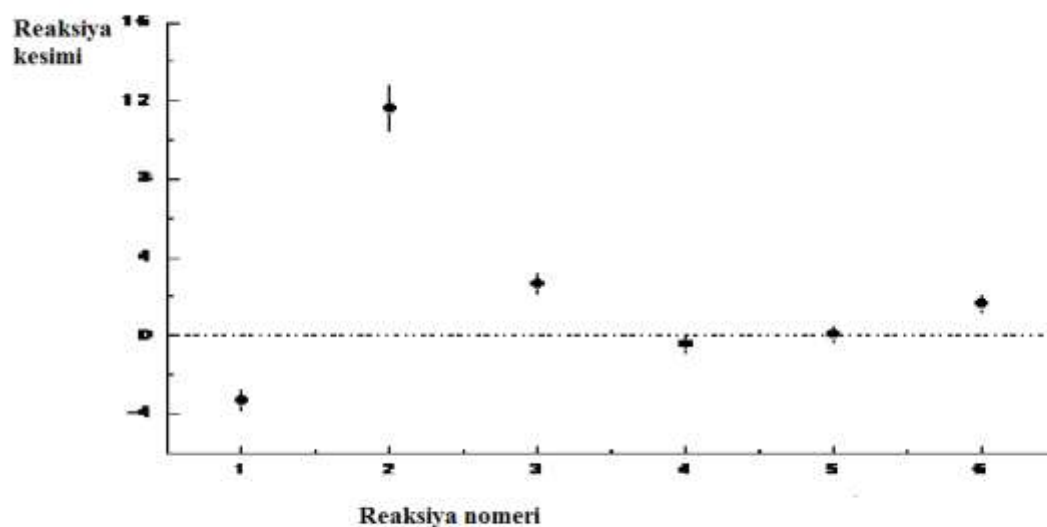
1a - rasm. Eksperiment va KFIM bo'yicha hisoblangan kesim qiymatlaridagi farq, poluinklyuziv reaktsiyalar tipidan bog'liqligi.

Belgilaymizki, 6-nuklonli tizimlar hosil bo'lishning eksperiment va hisobdagi kesimlari mos kelishi faqat aynan o'xshash ikkilamchi yadrolar (^{3}He + ^{3}He) va (^{3}H + ^{3}H) uchun o'rinli ekanligini kuzatish mumkin. ^{4}He + ^{2}H tizim va ^{6}Li yadrosi hosil bo'lishi kanallari kesimini taqqoslash qiziqarli bo'ladi. Eksperimentda olingan ^{4}He + ^{2}H tizim va ^{6}Li yadrosi hosil bo'lishi ko'plamchiligi nisbati 6.5 ni tashkil qiladi, bu holda modelda hisoblangani mos ravishda 1.7 ga teng. Agar ^{6}Li yadrosining hosil bo'lishi ^{4}He va ^{2}H yadrolar qo'shilishi hisobiga yuz bersa, u holda koalestsentsii modeli [138] doirasida bunday ustunlikni zaruriy nisbiy impulslar hamda ^{4}He va ^{2}H yadrolarning fazoviy yaqinligi kabi faktorlar bilan tushuntirish mumkin. Xuddi shunday mulohazani ^{7}Li ядроси va ^{4}He + ^{3}H tizimlariga, shuningdek, ^{7}Be yadrosi va ^{4}He + ^{3}He tizimlari chiqish kesimlari o'zaro nisbatiga nisbatan keltirish mumkin. 2 rasmda eksperimentda va KFIM da 7- nuklonli tizimlar va yadrolar chiqish kesimi ko'rsatilgan. 2-rasmdan ko'rinadiki, xuddi shunday 6- nuklonli tizimlar kabi kesimning maksimal qiymatiga ^{4}He

yadrolarning hosil bo'lishi kanallarida erishadi, bu kislorod yadrosi α-klaster tuzilishining ustunligidan guvohlik beradi. Ayni paytda KFIM da maksimal chiqish kesimi ^{7}Be yadrosi hosil bo'lish kanaliga mos keladi. Bundan tashqari modelda ^{4}He+^{3}He va ^{4}He+^{3}H chiqish kesimlaridagi farq kuzatiladi, birinchi tizim chiqish kesimi oxirgisiga nisbatan 1.3 marta katta. Bu, chamasi, shu bilan bog'liqki, modelda engil «ko'zgu» yadrolar shakllanishida proton-nishon zaryadi protonlari ortiqcha bo'lgan yadrolarning kesimini neytronlari ortiqcha yadrolarga nisbatan oshirgan holda ishtirok etadi[1-7].

2 - rasm. (7-12) reaktsiyalarda 7- nuklonli tizimlar chiqish kesimi. Nuqta: ● – eksperiment, ○ –KFIM bo'yicha hisob.

Belgilaymizki, 6-nuklonli tizimlar hosil bo'lishning eksperiment va hisobdagi kesimlari mos kelishi faqat aynan o'xshash ikkilamchi yadrolar (^{3}He + ^{3}He) va (^{3}H + ^{3}H) uchun o'rinli ekanligini kuzatish mumkin. ^{4}He + ^{2}H tizim va ^{6}Li yadrosi hosil bo'lishi kanallari kesimini taqqoslash qiziqarli bo'ladi. Eksperimentda olingan ^{4}He + ^{2}H tizim va ^{6}Li yadrosi hosil bo'lishi ko'plamchiligi nisbati 6.5 ni tashkil qiladi, bu holda modelda hisoblangani mos ravishda 1.7 ga teng. Agar ^{6}Li yadrosining hosil bo'lishi ^{4}He va ^{2}H yadrolar qo'shilishi hisobiga yuz bersa, u holda koalestsentsii modeli [6-9] doirasida bunday ustunlikni zaruriy nisbiy impulslar hamda ^{4}He va ^{2}H yadrolarning fazoviy yaqinligi kabi faktorlar bilan tushuntirish mumkin. Xuddi shunday mulohazani ^{7}Li ядроси va ^{4}He + ^{3}H tizimlariga, shuningdek, ^{7}Be yadrosi va ^{4}He + ^{3}He tizimlari chiqish kesimlari o'zaro nisbatiga nisbatan keltirish mumkin. 2 rasmda eksperimentda va KFIM da 7- nuklonli tizimlar va yadrolar chiqish kesimi ko'rsatilgan. 2-rasmdan ko'rinadiki, xuddi shunday 6- nuklonli tizimlar kabi kesimning maksimal qiymatiga ^{4}He yadrolarning hosil bo'lishi kanallarida erishadi, bu kislorod yadrosi α-klaster

tuzilishining ustunligidan guvohlik beradi. Ayni paytda KFIM da maksimal chiqish kesimi ^{7}Be yadrosi hosil bo'lish kanaliga mos keladi. Bundan tashqari modelda ^{4}He+^{3}He va ^{4}He+^{3}H chiqish kesimlaridagi farq kuzatiladi, birinchi tizim chiqish kesimi oxirgisiga nisbatan 1.3 marta katta. Bu, chamasi, shu bilan bog'liqki, modelda engil «ko'zgu» yadrolar shakllanishida proton-nishon zaryadi protonlari ortiqcha bo'lgan yadrolarning kesimini neytronlari ortiqcha yadrolarga nisbatan oshirgan holda ishtirok etadi.

Eksperimentda 7-nuklonli holatlarda α-zarralar hosil bo'lmaydigan reaktsiyalarida kanallar kesimi statistik xatoliklar chegarasida mos kelishini belgilash qiziqarli, xuddi shunday KFIM bo'yicha hisoblangan faqat bir xil zaryadli holatlar ^{7}Li va ^{4}He + ^{3}H hosil bo'lish kesimi mos kelishi, hamda har xil zaryadli ^{2}H + ^{2}H + ^{3}He va ^{2}H + ^{2}H + ^{3}H uch zarrali tizimlar chiqish kesimi mosligi kelib chiqadi. Oxirgi natijaga ko'ra aftidan, ko'rib chiqilayotgan modelda yadroning α-klaster tuzilishi hisobga olinmaydi. Oxirgi holatda, ko'rinishidan, $A = 3$ massa sonli engil "ko'zgu" yadrolarning aynan o'xshash shakllanish mexanizmlari bilan bog'liq yig'indi zaryadlari farqlanuvchi ^{6}Li va ^{3}He + ^{3}He 6-nuklonli tizimlar shuningdek, ^{4}He + ^{3}He va ^{4}He + ^{3}H 7-nuklonli tizimlar eksperimental chiqish kesimlari mos kelishiga e'tibor qaratamiz[1-8]. Engil parchalanuvchi yadrolar α-klasterli tuzilishini hisobga olish zaruriyati KFIMda ^{6}Li, ^{7}Li va ^{7}Be yadrolarning chiqish kesimlari eksperimentga qaraganda sezilarli yuqori bo'lishidan kelib chiqadi[9-13].

Adabiyotlar

1. Olimov K. et al. Formation of multinucleon systems and nuclei with mass numbers of 6 and 7 in ^{16}Op-interactions at a momentum of 3.25 GeV/c per nucleon //Physics of Atomic Nuclei. – 2009. – T. 72. – №. 4. – C. 596-600.
2. Olimov K. K., Sattarov A. R., Kurbanov A. Correlation effects in production of stable isotopes containing 2-7 nucleons in {sup 16} Op-interactions at the momentum 3.25 GeV/s per nucleon; – 2008.
3. Olimov K. et al. Production of mirror nuclei ^{7}Li and ^{7}Be in ^{16}Op- interactions at a momentum of 3.25 GeV/c per nucleon //Physics of Atomic Nuclei. – 2011. – T. 74. – №. 2. – C. 268-271.
4. Olimov K. et al. Formation of six-nucleon systems and nuclei in ^{16}Op- collisions at a momentum of 3.25 GeV/c per nucleon //Physics of Atomic Nuclei. – 2014. – T. 77. – №. 3. – C. 325-329.
5. Olimov K. K. et al. ABOUT CROSS-SECTIONS OF YIELD OF EXCITED ^{6}Li∗, ^{7}Li∗, ^{9}B∗ AND ^{10}B∗ NUCLEI AND THEIR CONTRIBUTIONS TO FORMATION OF MULTINUCLEON SYSTEMS INVOLVING 4 He NUCLEI IN ^{16}Op COLLISIONS AT 3.25 A GeV/c //International Journal of Modern Physics E. – 2013. – T. 22. – №. 08. – C. 1350057.

6. Abror Q. Development of Magnetic Characteristics of Power Transformers //Fazliddin, A., Tuymurod, S., & Nosirovich, OO (2020). Use Of Recovery Boilers At Gas-Turbine Installations Of Compressor Stations And Thyristor Controls. The American Journal of Applied sciences. – 2020. – Т. 2. – №. 09. – С. 46-50.

7. Юлдашев Б. С. и др. Некоторые особенности образования зеркальных семинуклонных систем и ядер в ^{16}Op-соудрениях при 3.25 A ГэВ/с //Узбекский физический журнал. – 2017. – Т. 19. – №. 2. – С. 120-123.

8. Olimov K. et al. Contributions of excited ^{6}Li and ^{7}Li nuclei to the production of ^{4}He+ ^{2}H and ^{4}He+ ^{3}H systems in ^{16}O p collisions at a momentum of 3.25 GeV/c per nucleon //Physics of Atomic Nuclei. – 2013. – Т. 76. – №. 7. – С. 881-882.

9. Kurbanov A. R., Petrov V. I., Yuldashev A. A. The formation seven-nucleon mirror systems and nuclei in ^{16}Op collisions at 3.25 A GeV/c. – 2013.

10. Qurbonov A. 3.25 A GeV/c impulsli ^{16}Op-to'qnashuvlarida ko'zguli (^{3}H, ^{3}He, ^{7}Li, ^{7}Be) yadrolar va mezonlar (π^{+}, π^{-}) ning birgalikda hosil bo'lishi //Физико-технологического образование. – 2020. – №. 1.

11. Olimov K. et al. Comparative analysis of properties of channels of deuteron and tritium production in ^{16}Op- collisions at a projectile momentum of 3.25 GeV/c per nucleon //Physics of Atomic Nuclei. – 2014. – Т. 77. – №. 12. – С. 1456-1462.

12. Olimov K. et al. The formation of six-nucleon systems and nuclei in {sup 16} Op collisions at 3.25 A GeV/s; Obrazovanie shestinuklonnykh sistem i yader v {sup 16} Op-soudareniyakh pri 3.25 A GeV/s. – 2013.

13. Olimov K. K., Sattarov A. R., Kurbanov A. Correlation effects in formation of stable isotopes with 2-7 nucleons number in ^{16}Op-collisions at 3.25 GeV/s impulse on nucleon. – 2008.

14. Olimov K. K. et al. About Transverse Momentum Distributions of Negative Pions in p^{12}C and π^{-12}C Collisions at High Energies //Ukrainian Journal of Physics. – 2020. – Т. 65. – №. 2. – С. 97-97.

15. Olimov K. et al. The formation of six-nucleon systems and nuclei in ^{16}Op collisions at 3.25 A GeV/c. – 2013.

16. Olimov K. et al. Contributions of excited [sup. 6] Li and [sup. 7] Li Nuclei to the production of [sup. 4] He+[sup. 2] H and [sup. 4] He+[sup. 3] H systems in [sup. 16] Op collisions at a momentum of 3.25 GeV/c per nucleon //Physics of Atomic Nuclei. – 2013. – Т. 76. – №. 7. – С. 881-883.

17. Olimov K. et al. Cross sections of semi inclusive channels with formation of 6-and 7-nucleon systems and nuclei's in ^{16}Op-reactions at 3.25 A GeV/s. – 2012.

18. Olimov K. et al. Average multiplicities of fragments with A≤ 3, associated with formation of 6-and 7-nucleon systems and nuclei in ^{16}Op-collisions at 3.25 A GeV/s. – 2012.

19. Olimov K. et al. Disintegration of ^{16}O nuclei with 3.25 A GeV/s impulse in the interactions with protons on light fragments of A= 3 and 4. – 2010.

20. Olimov K. et al. Singularities of mirror nuclei {sup 7} Li and {sup 7} Be production in {sup 16} Op-interactions at 3.25 A GeV/s. – 2009.

21. Olimov K. et al. Singularities of mirror nuclei ^{7}Li and ^{7}Be production in ^{16}Op-interactions at 3.25 A GeV/s. – 2009.