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KUMULYATIV PROTONLARNING INKLYUZIV KESIMLARI VA INVARIANT TUZILISH FUNKSIYALARI BO‘YICHA TAQSIMOTLARI

¹*Qurbonov Anvar Razzaqovich, ²Mixliev Jaloliddin*

¹*f.m.f.b.(PhD), dotsent, ²magistr 2-kurs,*

^{1,2}*Jizzax davlat pedagogika universiteti, Jizzax sh., O‘zbekiston*

e-mail: anvar.fizik@mail.ru

Калит сўзлар: *kumulyativ jarayon, to‘qnashuv, kumulyativlik soni, impuls, inklyuziv ko‘ndalang kesim, barionli tizimlar, pionlar*

Аннотация. *Yuqori energiyali zarralar va yadrolar to‘qnashuv jarayonida hosil bo‘lgan kumulyativ protonlarni o‘rganish yadro xususiyatlarini ochib berishda yuqori samara beradi. Ushbu ish juda keng qamrovli bo‘lib 3.25 A GeV/c li ¹⁶Op-to‘qnashuvlarida, 40 GeV/c li π^- C-to‘qnashuvlari, 4.2 va 9.9 GeV/c li pC-to‘qnashuvlarida, 4.2 A GeV/c li ⁴HeC- va CC-to‘qnashuvlarida, hamda 300 GeV/c li pNe-to‘qnashuvlarida kumulyativ protonlar hosil bo‘lishini ilk bor tizimli tadqiq qilish hamda kumulyativ jarayonlarni tavsiflashga bag‘ishlangan hodisalarning tahlil natijalari keltirilgan.*

Ключевые слова: *кумулятивный процесс, столкновение, кумулятивное число, импульс, инклюзивное сечение, барионные системы, пионы*

Аннотация. *Изучение кумулятивных протонов, образующихся при столкновении частиц высоких энергий с ядрами, весьма эффективно для выявления ядерных свойств. Эта работа очень обширна по столкновениям ¹⁶Op при 3,25 ГэВ/с, столкновениям pC при 40 ГэВ/с, столкновениям pC при 4,2 и 9,9 ГэВ/с, 4,2 А ГэВ/с первое систематическое исследование кумулятивного образования протонов в ⁴HeC - представлены и CC-столкновения с c, и pNe-столкновения с 300 ГэВ/с и анализ явлений, посвященный описанию кумулятивных процессов.*

Key words: *cumulative process, collision, cumulative number, momentum, inclusive cross section, baryon systems, pions*

Abstract. *The study of cumulative protons produced by the collision of high-energy particles with nuclei is very effective for revealing nuclear properties. This work is very extensive on ¹⁶Op collisions at 3.25 GeV/c, pC collisions at 40 GeV/c, pC collisions at 4.2 and 9.9 GeV/c, 4.2 A GeV/c first systematic study of cumulative proton production in ⁴HeC - both CC-collisions with c and pNe-collisions with 300 GeV/c and an analysis of the phenomena devoted to the description of cumulative processes are presented.*

40 GeV/c li π^- C- va 4.2 A GeV/c li CC-o‘zarota’sirlarida kumulyativ protonlar inklyuziv ko‘ndalang kesimlarining kumulyativlik soni β bo‘yicha taqsimotini solishtirish bu jarayonlarning har birida hosil bo‘lgan kumulyativ protonlar hosil bo‘lishi haqida muhim ma’lumotlar olishimiz mumkin. Misol tariqasida 40 GeV/c li π^- C- va 4.2 A GeV/c li CC-to‘qnashuvlarida kumulyativ

protonlar inklyuziv ko‘ndalang kesimlarining kumulyativ soni β bo‘yicha taqsimoti $\beta > 1.2$ sohalar uchun ko‘rsatishimiz mumkin. Bundan tashqari 300 GeV/c li $p^{20}\text{Ne}$ -to‘qnashuvlar va 3.25 A GeV/c li ^{16}Op -to‘qnashuvlari uchun kumulyativ protonlar invariant strukturaviy funksiyasining kumulyativlik soni β bo‘yicha taqsimotlari keltirilgan. To‘g‘ri uzluksiz chiziqlar orqali tajribaviy taqsimotlarga quyidagi ifoda

$$f(\beta) = a \exp(-b\beta), \quad (1)$$

bilan yaqinlashish natijalari ko‘rsatilgan.

Shuni ta’kidlash kerakki, kumulyativ protonlarning na faqat invariant strukturaviy funksiyalarining β -ga bog‘liqligi hatto ular inklyuziv ko‘ndalang kesimlarining ham kumulyativlik soniga bog‘liqligi eksponensial qonuniyatga bo‘yso‘nar ekan.

Ushbu ishda 300 GeV/c li $p^{20}\text{Ne}$ - va 3.25 A GeV/c li ^{16}Op -to‘qnashuvlarida kumulyativ protonlar invariant ko‘ndalang kesimlarining kumulyativlik soni bo‘yicha taqsimotini 1-jadvaldan ko‘rishimiz mumkin. To‘g‘ri chiziqlar tajribaga (1) ifoda bilan yaqinlashish natijalarini 300 GeV/c li $p^{20}\text{Ne}$ - to‘qnashuvlarida kumulyativ protonlarning soni 4990 tani tashkil qiladi va 3.25 A GeV/c li ^{16}Op -to‘qnashuvlarida hosil bo‘ladigan kumulyativ protonlar soni 12367 tani tashkil qiladi[1-5].

Kumulyativ protonlarning kumulyativlik soni β bo‘yicha barcha taqsimotlarga (1) ifoda bilan yaqinlashish natijalari 1-jadvalda keldirilgan.

1-jadvaldan ko‘rinib turibdiki, qiyalik parametrlarning qiymatlari qaralangan barcha turdagi o‘zarota’sirlar va birlamchi energiyalar uchun statistik xatoliklar chegarasida bir-biriga teng va hamma ansambllar bo‘yicha uning o‘rtacha qiymati 8.1 ± 0.1 ni tashkil qiladi[4-5].

1-jadval

(2) ifoda bilan yaqinlashish bo‘yicha qiyalik parametrlari, to‘qnashuv turlari va voqealar soni

‘zarota’sir turi, $R_0(\text{GeV}/c)$	Voqealar soni	qiyalik parametri, b	$\chi^2/\text{e.d.s.}$
$\pi^-C, 40.0$	16657	8.18 ± 0.26	1.1
$pC, 4.2$	6901	8.09 ± 0.49	1.0
$pC, 9.9$	18325	8.10 ± 0.25	0.9
$^4\text{HeS}, 4.2 A$	12326	8.00 ± 0.28	1.2
$CC, 4.2 A$	20530	8.14 ± 0.20	0.4
$^{16}\text{Op}, 3.25 A$	12367	8.13 ± 0.21	0.4
$p^{20}\text{Ne}, 300$	4990	7.99 ± 0.18	0.8

Shunday qilib, aytish mumkinki, kumulyativ protonlar hosil bo’lish mexanizmi birlamchi zarracha turiga hamda energiyaga bog’liq emas.

Kumulyativ protonlarning kumulyativ $^{16}\text{O}p$ - va $p^{20}\text{Ne}$ -to’qnashuvlaridagi o’rtacha soni mos ravishda 1.11 ± 0.02 va 1.16 ± 0.3 larga tengdir, π^- -mezonlar, protonlar, α -zarrachalar va uglerod yadrolarining uglerod yadrolari bilan o’zaro ta’sirlarida bu kattalik 1.05 ± 0.01 ni tashkil qiladi. 4.2 A GeV/c impulsli CTA-o’zarota’sirlarini dastlabki tahlilida kumulyativ protonlarning kumulyativ hodisalardagi o’rtacha soni 1.79 ± 0.06 ga teng chiqdi. Shunday qilib, aytish mumkinki, kumulyativ protonlarning o’rtacha soni parchalanuvchi yadro massa soni o’sishi bilan sekin ortib boradi[5-9].

Kumulyativ protonlar o’rtacha ko’plamchiligining parchalanuvchi yadro massa soniga bog’liqligini o’rganish uchun unga quyidagi ifoda $\langle n_{\text{cum}} \rangle = a + A^\alpha$ bilan yaqinlashdik. Bu erda A – parchalanuvchi yadro massa soni, a – va α – yaqinlashish parametrlari. Yaqinlashish natijasida 99 foizli ehtimollikda parametrlarning qiymatlari quyidagilarga $a = -0.41 \pm 0.01$ va $\alpha = 0.15 \pm 0.01$ teng chiqdi. Tajriba natijalariga $\langle n_{\text{cum}} \rangle = a + Z^\alpha$ ifoda bilan (bu erda Z – yadro zaryadi) yaqinlashganda esa 99 foizdan ko’proq ehtimol bilan parametrlar qiymatlari $a = -0.32 \pm 0.01$ va $\alpha = 0.17 \pm 0.01$ larga teng chiqdi.

Shunisi qiziqki, har ikkala yaqinlashishda ham daraja ko’rsatkichlari statistik xatoliklar chegaralirida bir-biriga teng va 1/6 ga juda yaqindir. Bu qiymat esa hamma protonlar sonining massa soniga bog’lanish ko’rsatgichi (2/3)dan 4 marta kichikdir.

2-jadvalda kumulyativ hodisalar ulushining birlamchi zarracha turiga va massasiga bog’liqligi to’g’risidagi ma’lumotlar keltirilgan. 2-jadvaldan shuni ko’rish mumkinki, berilgan parchalanuvchi yadro uchun kumulyativ hodisalar ulushi birlamchi zarracha ,ki yadro massa soniga (proton ,ki barionlar tizimi) bog’liq emas. Bu holat kumulyativ protonlar «sovuq» model bashorati orqali vujudga kelishiligini to’la-to’kis tasdiqlaydi. Ikkinchidan, bu kattalik birlamchi zarracha turiga (pion ,ki proton) bog’liq.

Birinchi holatdan foydalanib $p^{12}\text{C}$ -, $\alpha^{12}\text{C}$ - va $^{12}\text{C}^{12}\text{C}$ -to’qnashuvlari bo’yicha kumulyativ hodisalarning o’rtacha ulushini topishimiz mumkin. Bu kattalik $10.0 \pm 0.1\%$ ga teng. Kumulyativ protonli hodisalar ulushinig birlamchi barionlar tizimiga bog’liq bo’lmasligi birlamchi zarrachalarning fluktonlar bilan bir karrali to’qnashuvlari ustivor ekanligini ko’rsatadi. Fluktonlar soni esa berilgan parchalanuvchi yadro uchun «sovuq» model bashorati bo’yicha o’zgaras kattalikka ega. Flukton va zarrachalar to’qnashuvlarida zarrachaning turi, ya’ni kvarkli tarkibi muhim ahamiyatga ega. Shu jihatdan barionli tizimlar va pionlar to’qnashuvlarida hosil bo’lgan kumulyativ hodisalar ulushlari nisbati diqqatga

sazovordir, bu kattalik 0.66 ± 0.02 ga teng, bu esa statistik xatoliklar chegaralarida 2/3ga tengdir, ya’ni piondagi valent kvarklar soni (2)ning protondagi valent kvarklar soni(3)ga nisbatiga aynan tengdir. Demak kumulyativ protonlar hosil bo’lishi kvark-parton darajalarida amalga oshar ekan[6-8].

2-jadval

Kumulyativ protonli hodisalar ulushlarining birlamchi zarracha turiga bog’liqligi

O’zarota’sir turi, $R_0, \text{ GeV/c}$	Hodisalarning to’liq soni	Kumulyativ protonli hodisalar soni	Kumulyativ protonli hodisalar ulushlari, %
$\pi^{-12}\text{C}, 40.0$	16657	1097	6.6 ± 0.2
$p^{12}\text{C}, 4.2$	6901	699	10.1 ± 0.4
$p^{12}\text{C}, 9.9$	18325	1825	10.0 ± 0.2
${}^4\text{Ne}^{12}\text{C}, 4.2 A$	12326	1211	9.8 ± 0.3
${}^{12}\text{C}^{12}\text{C}, 4.2 A$	20530	2070	10.1 ± 0.2
${}^{16}\text{Op}, 3.25 A$	12367	1496	12.1 ± 0.4
$p^{20}\text{Ne}, 300$	4990	728	14.6 ± 0.6
CTa, 4.2	2440	1013	41.5 ± 1.5

Shunday qilib, xulosa qilish mumkinki, kumulyativ protonlar hosil bo’lish invariant inklyuziv ko’ndalang kesimlarining kumulyativlik soni β ga bog’liqligi universal xarakterga ega bo’lib birlamchi zarracha turiga, parchalanuvchi yadro massa soniga va birlamchi energiyaga bog’liq emas. Kumulyativ zarrachalar hosil bo’lishi bilan boshqa zarrachalar ko’plamchiligi orasidagi bog’lanishlarni tahlil shuni ko’rsatdiki, ular orasida bog’lanish mavjud bo’lib, u kumulyativ protonlar kumulyativlik darajasiga bog’liq emas ekan. Boshqacha qilib aytganda, bu ikkala jarayonlar mexanizmlari orasida hech qanday bog’lanish mavjud emas.

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