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Finding the domain of cascade – probabilistic functions for light particles

In the paper the calculations of cascade-probabilistic functions depending on number of interactions and depth of penetration of particles are considered and we get a real area of finding the results. The regularities of behavior of the area of results and a step for calculation depending on the various factors have been found. The results of calculations were presented in the form of diagrams and tables.
Key words: domain, particle, aluminum, iron, boron, nitrogen.

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Нахождение области определения каскадно-вероятностных функций для легких частиц

В работе рассматриваются расчеты каскадно-вероятностных функций в зависимости от числа взаимодействий и глубины проникновения частиц, в связи с чем находится реальная область нахождения результата. Найдены закономерности поведения области результата и шага для расчета в зависимости от различных факторов. Результаты расчетов представлены в виде графиков и таблиц.
Ключевые слова: область, частица, алюминий, железо, бор, азот.

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Жеңіл бөлшектер үшін каскадты-ықтималдылық қызметін анықтау аумағын табу

Бұл зерттеу жұмысында бөлшектердің ішіне бойлай енуін және өзара әсерлесу санына тәуелді каскадты-ықтималдылық қызметін, нәтижелердің нақты орналасқан аймағын есептеуді қарастырады. Әртүрлі факторларға қатысты есептеу қадамы мен нәтижелердің көріну аймағы үшін заңдылықтар табылды. Есептеу нәтижелері сызбанұсқа түрінде және кесте түрінде келтірілген.
Түйін сөздер: аумағы, бөлшектер, аллюминий, темір, бор, азот.

Introduction

The constructional materials envelop a set of the different materials applied to manufacture the details of constructions, machines and technical products. Possibility of creation of any construction and its working capacity depends on existence of materials with suitable mechanical properties.

The work was performed within a cascade-probabilistic method. As a target ferrous alloys are taken. The essence of the cascade-probability method is to obtain and further use of the cascade-probability functions, having the meaning of the probability to reach a particle a certain depth h after the n-th number of collisions.

In this connection, it is necessary to calculate these functions, find the domain of definition of the result and choose the step for the calculation. It is necessary to reveal the regularities arising in the calculation of these functions depending on the various factors.

Experiment

To calculate cascade-probabilistic function taking into consideration energy losses for ions depending on number of interactions, it is necessary to find the domain of result. In the found area CPF at first increases, reaching a maximum, and then starts decreasing. Let's note some regularities of behavior of area of result at change of number of interactions of particles.

1. Finding the value of parameter $h/l \approx n$. With a small nuclear weight of the impinging particle and small depths, the maximum value of CPF is reached approximately at *h/l*. With increasing the depth of supervision the area of result starts being displaced to the left from the corresponding *h/l* and starts being narrowed.

2. With reduction of initial energy with the same depth the area of result also is narrowed and displaced to the left.

3. Dependence of value of the maximum of CPF on supervision depth is a decreasing, on energy with the same depth for any impinging particle and any target also decreasing.

Results and Discussion

Results of calculations are presented in the form of schedules (figure 1-3) and in table 1.

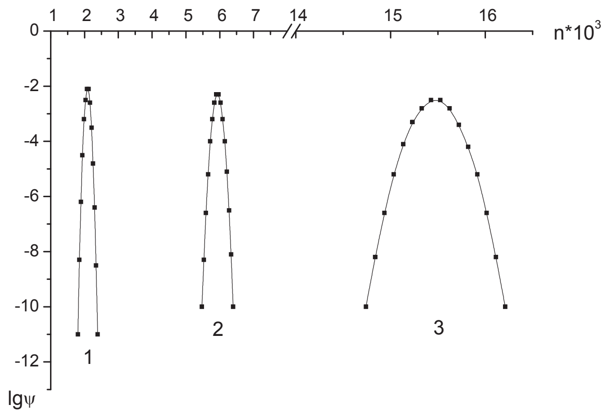

Figure 1 – CPF dependence for aluminum in iron on number of interactions for E_0= 500 keV and h=0,1*10^{-3}; 0,2*10^{-3}; 0,3*10^{-3} (cm) (1-3)

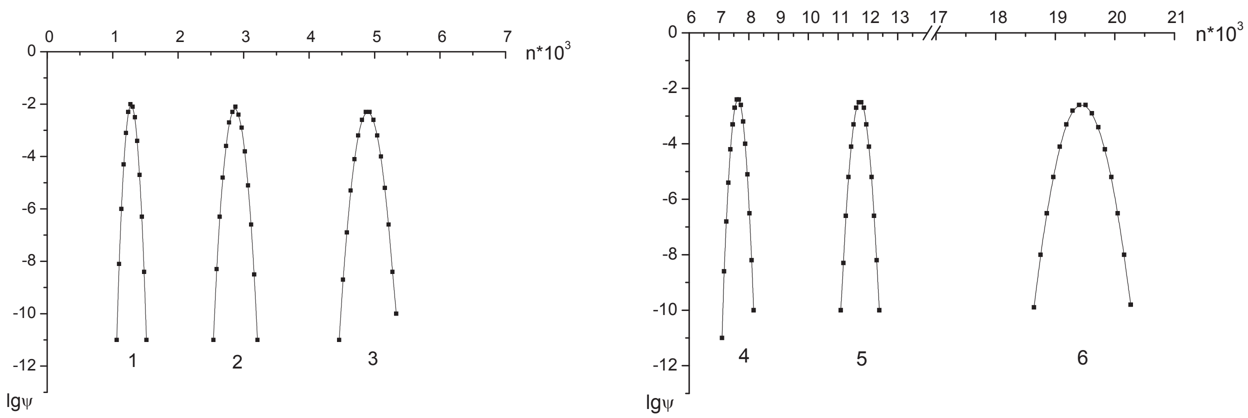

Figure 2 – CPF dependence for aluminum in iron on number of interactions for E_0= 100 keV and h=0,1*10^{-4}; 0,2*10^{-4}; 0,3*10^{-4}; 0,4*10^{-4}; 0,5*10^{-4}; 0,6*10^{-4} (cm) (1-6)

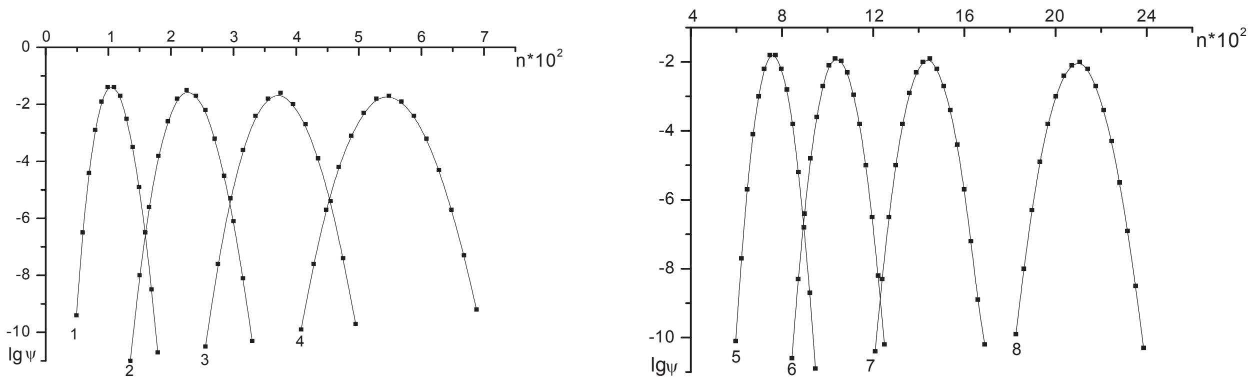

Figure 3 – CPF dependence for boron in iron on number of interactions for
E_0= 1000 keV and *h* = 1,0×10^{-4}; 2,0×10^{-4}; 3,0×10^{-4}; 4,0×10^{-4}; 5,0×10^{-4}; 6,0×10^{-4}; 7,0×10^{-4}; 8,0×10^{-4} (cm) (1-8)

Table 1 – Dependence of percent of displacement of the left and right borders of result area on number of interactions for aluminum in iron for a) E_0 = 1000 keV; b) E_0 = 500 keV; c) E_0 = 100 keV;

*h**10^4, см	B_1,%	B_2,%	N_n	B_3,%
1	46	8	17	54
2	48	-22	27	26
3	54	-38	34	16
4	60,5	-51,5	46	9
5	69,5	-64,5	60	5
6	83	-81	90	2

a)

*h**10^4, см	B_1,%	B_2,%	N_n	B_3,%
1	34	-12	45	22
2	49,3	-40,3	62	9
3	72,55	-69,7	98	2,85

b)

*h**10^5 см	B_1,%	B_2,%	N_n	B_3,%
1	25	9	35	34
2	28,5	-9,5	48	19
3	36	-23	58	13
4	45,5	-37	71	8,5
5	57,5	-52,5	86	5
6	74,03	-71,7	108	2,33

c)

As *h/l* can be very big (tens of millions), the values of CPF calculated with a step 1, practically will not differ from each other and the counting duration will be very big (more than two hours). Value N_n is taken as a step for calculation, that is added to the current n and CPF is calculated at n, n+ N_n, n+2 N_n. . . Thus, for calculation of CPF it is necessary to find not only domain of result, but also to choose a step.

At a choice of a step the following regularities take place.

1. For the small nuclear weight of the impinging particle and small depths the step is small (about 10-20), with increase of depth of supervision it starts increasing.

2. With increase of nuclear weight of the impinging particle the step respectively increases, reaching several hundreds and even thousands.

3. With energy reduction (the impinging particle and a target are the same) the step also increases.

4. Dependence of a step on supervision depth for any impinging particle and any target is increasing.

For CPF calculation taking into consideration energy losses depending on h it is also necessary to find function's domain. Let's note some regularities arising at finding real domain.

1. As calculations show, with a small nuclear weight of the impinging particle and small depths the area of result of CPF depending on *h* is near *h*, which corresponds to *h*/l. With increase of depth of supervision the area of result is displaced and narrowed.

2. With reduction of initial energy of the particle (the impinging particle and a target are the same) with the same depth of supervision the area of result is displaced to the right and narrowed.

3. With increase of depth of supervision for any impinging particle and any target the area of result is displaced to the right and the percent of internal area decreases. The percent of shift of the left border of area decreases, sometimes on the end of run increases a little. The right border of area fluctuates, on the end of run decreases, however the percent of internal area of result always decreases.

4. Dependence of value of the maximum of CPF on depth of supervision is decreasing function. With reduction of initial energy of the particle value of function in a maximum point for the same depths decreases.

Let's note some regularities in the behavior of a step.

1. For the small nuclear weight of the impinging particle the step is small, with increase of depth of supervision it increases, and on the end of run it increases very strongly.

2. With reduction of initial energy of the particle with the same depth of supervision (the impinging particle and a target are the same) a step also increases.

3. With increase of nuclear weight of the impinging particle for the same depth of supervision the step increases at first gradually, then very sharply.

4. With increase of depth of supervision for any impinging particle and any target the step increases.

The results of calculations are presented in figures 4,5 and in tables 2,3.

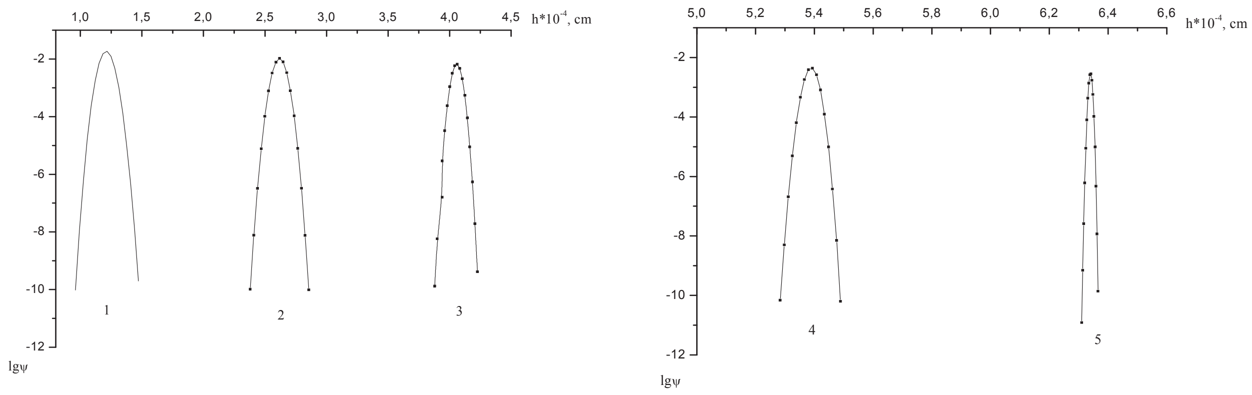

Figure 4 – CPF dependence for aluminum in iron on *h* for E_0= 1000 keV and *h/l*= 462, 1479, 3516, 7765, 18430.

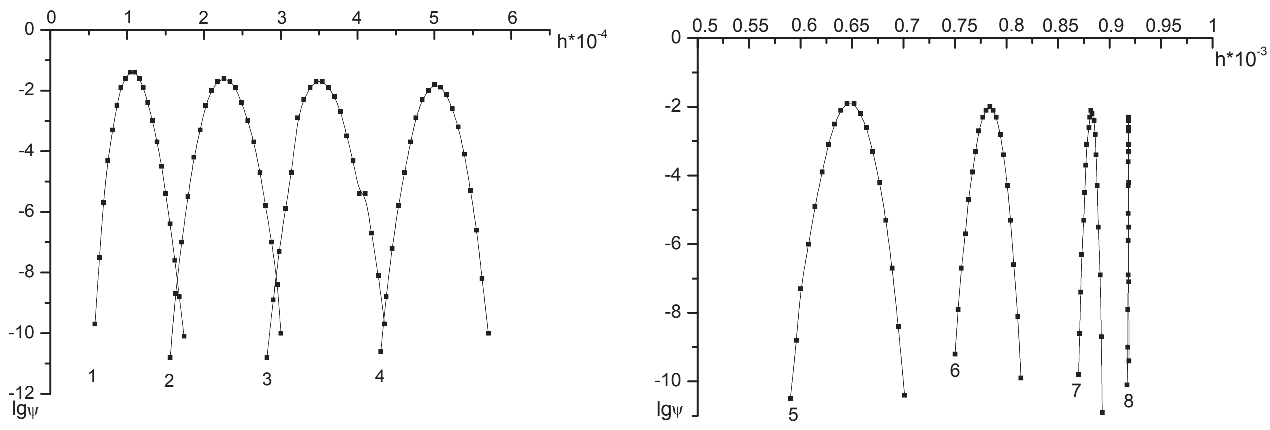

Figure 5 – CPF dependence for boron in iron on depth of penetration for E_0= 1000 keV and *n*= 113; 264; 471; 768; 1217; 1961; 3404; 7301 (1–8).

Table 2 – Dependence of percent of displacement of the left and right borders of result area on depth of penetration for aluminum in iron for E_0 = 1000 keV

$h*10^4$, см	h/λ	C_1,%	C_2,%	N_h	C_3,%
1	462	4	48	30	52
2	1479	-19	44	80	25
3	3516	-29,3	41	190	11,7
4	7763	-32,1	37,45	386	5,35
5	18430	-26,2	27,4	1800	1,2

Table 3 – Dependence of percent of displacement of the left and right borders of result area on depth of penetration for nitrogen in iron for a) E_0 = 1000 keV; b) E_0 = 800 keV; c) E_0 = 500 keV; d) E_0 = 100 keV

$h*10^4$, см	h/λ	C_1,%	C_2,%	N_h	C_3,%
1	237	30	56	15	86
2	553	12	42	30	54
3	987	-2	38	55	36
4	1613	-13	38	85	25
5	2578	-22	37	150	15
6	4240	-26,5	33,5	335	7
7	7718	-22,9	24,4	1500	1,5

a)

$h*10^4$, см	h/λ	C_1,%	C_2,%	N_h	C_3,%
1	287	25	47	20	72
2	693	6	40	40	46
3	1296	-9	38	70	29
4	2265	-20	37	130	17
5	4047	-26,4	33,9	320	7,5
6	8302	-21,85	22,95	2000	1,1

b)

*h**10^4, см	*h*/λ	C_1,%	C_2,%	N_h	C_3,%
1	522	15	39	30	54
2	1404	-8	37	70	29
3	3149	-23	36	200	13
4	8020	-23	25,67	1250	2,67

c)

*h**10^4, см	*h*/λ	C_1,%	C_2,%	N_h	C_3,%
1	176	36	58	13	94
2	391	20	44	25	64
3	655	9	40	35	99
4	989	-1	40	45	39
5	1421	-10	38	65	28
6	2002	-17	37	90	20
7	2824	-23	36	180	13
8	4068	-26	33.7	310	7.7
9	6172	-24.9	28	720	3.1

d)

Conclusion

In the paper the calculations of cascade-probability functions depending on the depth of penetration of the particles and the number of interactions were conducted. It was found the area location of the result and a step for calculating.

It was revealed the regularities of the domain of the result and the step depending on the atomic number of the incident particle, target, the initial energy of the primary particle and the depth of observation.

References

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