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Research on the optimal shape of radioactive materials based on greedy algorithm

Abstract:

In order to find the shape of the material with the largest total energy released by the proton in the material (hereinafter referred to as S_value). Two models , $f_1(x)$ and $f_2(x)$, are established to describe the relationship between the energy release rate of the proton and its propagation distance in the material by using the triangle function and cosine function.

Based on these two models, greedy algorithm is used to find the material shape hat maximizes S_value(hereinafter referred to as O_Shape). Then compare the S_value of O_Shape with other materials in the same volume, such as cube, cuboid, hemispherical, double hemispherical. The S_value of O_Shape is larger, and the results verify the correctness and feasibility of the model and algorithm. By comparing $f_1(x)$ with $f_2(x)$, it can be concluded that $f_2(x)$ is better than $f_1(x)$ in describing the S_value of a given radioactive shape.

Moreover，we find that the change of model parameters will cause the change of O_Shape, so we use the control variable method to study the influence of the change of parameters in $f_2(x)$ on O_Shape. It is worth mentioning that. If influence of model parameters on O_shape is known, when we need to calculate the O_Shape of a material, we can directly abstract the Bragg peak function of the material to be the model proposed in the paper, obtain the model parameters, and then predict the O_Shape of the material.

Finally, we try to segment O_Shape, and find that segmentation will reduce S_value normally, which also supports our hypothesis that O_Shape should be solid.

Key words:

Greedy Algorithm； Radioactive Material Shape； Bragg peak curve； Energy Maximization

Contents

I. Introduction

In order to indicate the origin of problems, heat from radioactivity, the following background is worth mentioning.

1.1 Background

Radioactive material refers to the decay of atomic nuclear energy of certain substances, which can only be detected by special instruments, and can not be seen or felt by the naked eye. This property of matter is called radioactivity. Radioactive materials are those that can naturally radiate energy and emit radiation. Generally, they are metals with high atomic mass, such as plutonium, uranium, etc. Radiation emitted by radioactive materials mainly includes alpha rays, protons, neutrons, neutrinos and other particles[1]. Radioactive substances have a strong destructive effect on human health and electronic components, and usually use special labels for warning, as shown in Figure 1. Among them, proton radiation is a kind of particle radiation, which is composed of proton (hydrogen nucleus) with certain energy. It is common in space radiation, and its common energy is 1-1000 MeV. It is an important part of galactic cosmic rays (GCR), solar particle events (SPE). Proton radiation can ionize the molecules or atoms of the affected substances. When it acts on the human body or organism, it can cause the changes of atoms or molecules in the tissue cells, kill or mutate the irradiated cells, resulting in various health hazards to the human body. Research shows that the incidence of cancer, cataracts, blindness, growth retardation, fertility reduction and other diseases in people who have been exposed to radioactive pollution for a long time is much higher than that in ordinary people [2] . In order to avoid the harm of proton radiation to human health, we need to reduce the intensity of proton radiation. There are two ways to avoid proton radiation. One is to coat protective materials on the surface of the radiation materials, the other is to change the shape of the radiation materials, so that most of the energy released by the particles in the materials, which is also the content of this paper, by changing the radioactive materials The shape of the proton maximizes the total energy released in the material.

Figure 1 Radioactive material sign

II. The Description of the Problem

2.1 Problem Restatement

We make a piece of radioactive material with a long half-life into a specific shape. The time it takes for the nucleus of a radioactive element to decay to half of its original number is called half-life. In this material, the nucleus releases a proton in a random direction as it decays. We assume that the energy of the proton carrying is a constant. Protons, when they pass through the dense material itself, release the energy they carry and convert it into heat. The relationship between the proton's energy release rate and its travel distance in the material is in accordance with the Bragg peak curve1, that is, most of the energy is released when it travels to a certain constant distance. We put this material in water, and we can assume the Bragg peak curve of the proton in water is the same as in the material, as shown in Figure 2.1. The question is what shape is the material made to maximize the total energy released by the proton in the material?

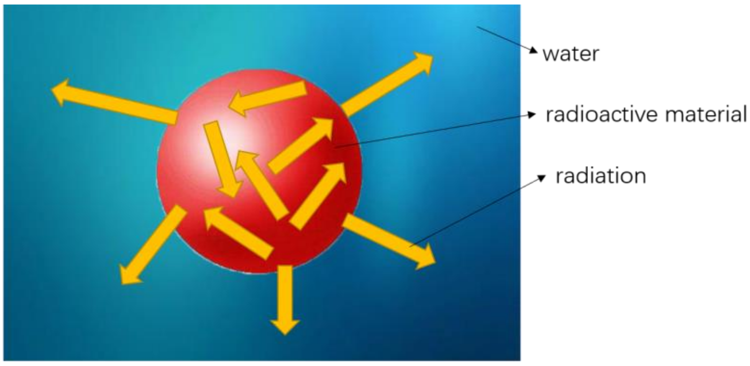


Figure 2.1 Radioactive materials in water

2.2 Problem Analysis

The Bragg peak curve has the following characteristics: in a certain distance, the energy release rate of the proton changes slowly, when the proton propagates to a certain distance, most of the energy is released. According to the characteristics of the Bragg peak curve of the proton in the air given in the title, we use the triangle function and cosine function to establish two models to describe the relationship between the energy release rate of the proton and its propagation distance in the material, and then use the established model to find the O_Shape. Through comparative analysis, the correctness and feasibility of the model are proved, and then the influence of the change of the parameters of the model on the O_Shape is studied.

III. Models

3.1 Notation and Assumptions

3.1.1 Notation

Table 1 Notation in the paper

Notation	Definition
$f_1(x)$	The first model established
$f_2(x)$	The second model established
S_value	Total energy released by all protons in radioactive materials
A	Cube consisting of 1000 coordinate points
B	Cuboid consisting of 1000 coordinate points
C	Hemisphere consisting of 1000 coordinate points
D	Double hemisphere consisting of 1000 coordinate points
O_Shape	Shape of the material that maximizes the total energy released by protons in the material
a	Constant value of proton energy release rate in Bragg peak curve
b	The distance at which the rate of proton energy release reaches a maximum in the Bragg peak curve
c	Peak width in the Bragg peak curve
k	Coefficient of Bragg peak in the Bragg peak curve
Blk_point	Coordinate points in the material body, represented by black points
Yew_point	Coordinate point around material body, indicated by yellow point
Red_point	Coordinate point of material section, indicated by red point
Npoint	The number of coordinate point that make up the material

P.s. Other symbols instruction will be given in the text.

3.1.2 Assumptions

Assume1：The Bragg peak curve of the proton in water is the same as in the material.

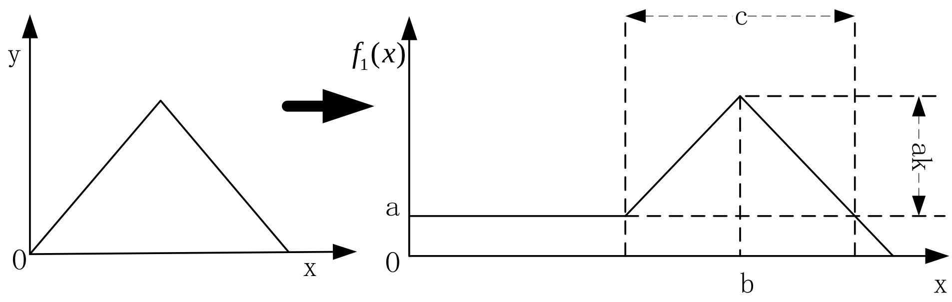
Assume2：The shape of the material that maximizes the total energy released by protons in the material is solid(not hollow).

3.2 Model Establishment and Analysis

According to the Bragg peak curve, as shown in Figure 2.1.It can be seen that when protons pass through the material, they will release the energy they carry and convert it into heat. Within a certain distance, the rate of energy released by protons is basically constant.So we abstract the rate of proton energy release in this distance as a constant.When the proton propagates to a certain distance, most of the energy is released and Bragg peak appears.According to the appearance of Bragg peak, we choose trigonometric wave function and cosine function which are similar to the shape of Bragg peak curve to build two models. Next, we build $f_1(x)$ and $f_2(x)$.

3.2.1 Model 1

We set the rate value when the rate of proton energy release changes slowly to constant a. When the proton propagation distance is set to b, most of the energy is released. Select trigonometric wave function similar to the shape of Bragg peak curve to build the model. Set the peak width to *c* and the peak value to *a* (1 + *k*),as shown in Figure 3.1(b).



(a) Trigonometric wave function (b) $f_1(x)$

Figure 3.1 Trigonometric wave function and $f_1(x)$

So, The mathematical expression of model 1 is：

$$f_1(x)=\begin{cases} a, x<b-\dfrac{c}{2} \\ a+\dfrac{2ak}{c}(x-b+\dfrac{c}{2}), b-\dfrac{c}{2}\leqslant x<b \\ a(1+k)-\dfrac{2ak}{c}(x-b), b\le x\le b+c\dfrac{k+1}{2k} \\ 0, x=others \end{cases} \tag{1}$$

3.2.2 Model 2

We abstract the rate of proton energy release into a constant a.It is also stipulated that most energy is released when the propagation distance of proton is B.We choose cosine function cos(wx+φ) which is similar to the shape of Bragg peak curve to build the model.The peak width is set to C, the peak value is set to $a(1+k)$, as shown in Figure 3.2

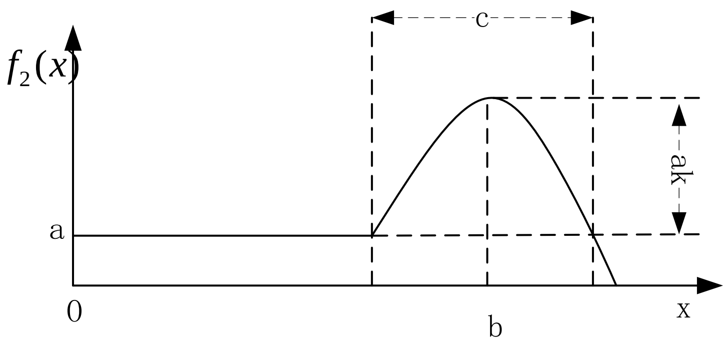


Figure 3.2 Curve of $f_2(x)$

Then, the mathematical expression of model 2 is：

$$f_2(x)=\begin{cases} a, x<b-\dfrac{c}{2} \\ a(1+k)\cos(\dfrac{c}{2}x-\omega b), b-\dfrac{c}{2}\le x\le\dfrac{\pi}{2\omega} \\ 0, x=others \end{cases} \tag{2}$$

3.1.3 Model Simulation

Set parameters a=1,b=3.5,k=1.3,c=0.5,$NPiont$=1000 in model 1 and model 2.It should be noted that the change of parameter a in the model does not affect the O_shape; obviously, it is positively related to the volume of radioactive materials. Therefore, in order to facilitate the simulation calculation, we make a = 1 and NPiont = 1000 in the following analysis of the paper. Use simulation software to simulate the curve of model 1 and model 2, as shown in Figure 3.3, the result is that they conform to the change rule of Bragg peak curve. Related codes See Appendix I.

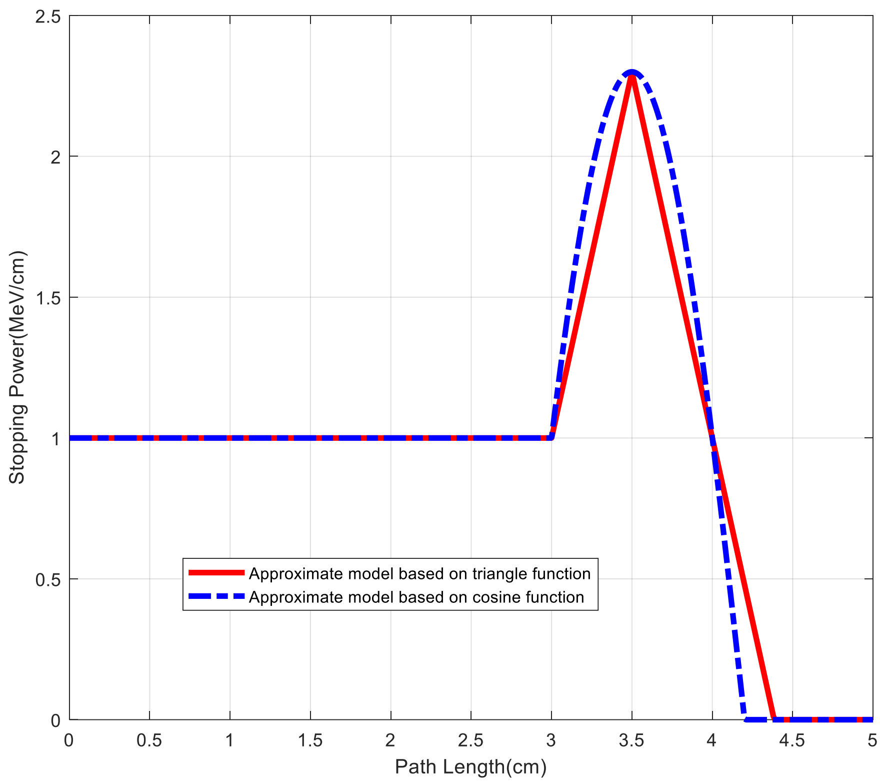


Figure 3.3 $f_1(x)$ and $f_2(x)$ simulation diagram

3.3 Optimal Shape Algorithm based on Established Model

3.2.1 Greedy Algorithm

Greedy choice means that the global optimal solution of the problem can be achieved through a series of local optimal choices, namely greedy choice[3]. This is the first basic element of the feasibility of greedy algorithm and the main difference between greedy algorithm and dynamic programming algorithm. Greedy choice is to make successive choices from top to bottom and iteratively. Each greedy choice simplifies the problem to a smaller sub problem. For a specific problem, to determine whether it has the property of greedy choice, we must prove that every step of greedy choice can ultimately get the optimal solution of the problem. Generally, it can be proved that a global optimal solution of the problem starts from greedy selection, and after greedy selection, the original problem is simplified to a smaller similar subproblem. Then, it is proved by mathematical induction that through every greedy choice, a global optimal solution of the problem can be obtained, as shown in Figure 3.4.

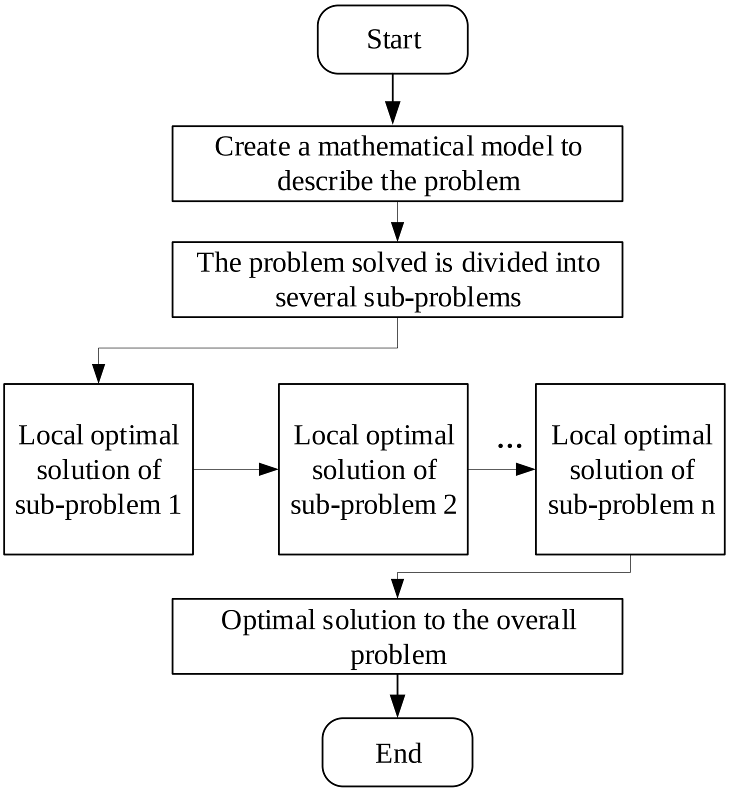


Figure 3.4 Greedy algorithm basic flow chart

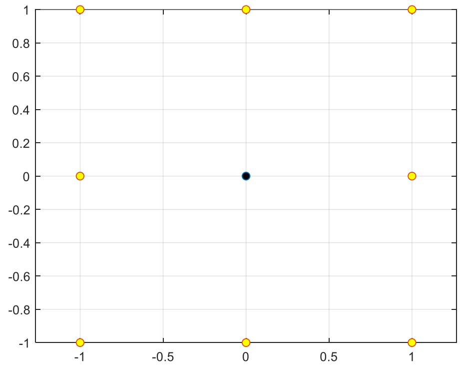
3.2.2 Find the optimal shape based on greedy algorithm

In order to calculate the maximum value of S_value, each proton in the material releases as much energy as possible, so that the total energy released by all protons in the material is the maximum. We use greedy algorithm to calculate the total energy released by all protons in the material. The specific steps of the algorithm in two-dimensional space are as follows (the same in three-dimensional space):

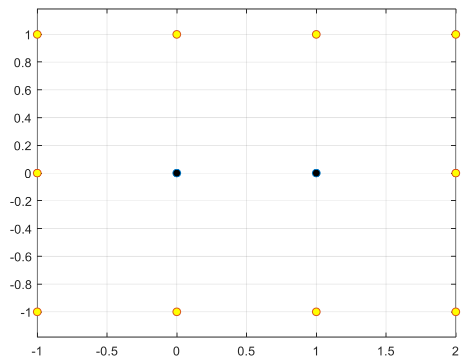
- First, set the parameters of model $f_1(x)$ as a=1, b=3.5, k=1.3, c=0.5, *NPiont*=1000;
- Set the 2D coordinate of the initial Yew_point to (0,0), Then set it to Blk_point, and set the points around Blk_point to Yew_ points, as shown in Figure 3.5 (a);
- Using the model $f_1(x)$, the energy of each Yew_point propagating to

Blk_point(0,0) is calculated. Select Yew_point with the largest propagation energy and closest to Blk_point, and set it as the second Blk_point. And set the current points around all Blk_points to Yew_ points as shown in Figure 3.5 (b);

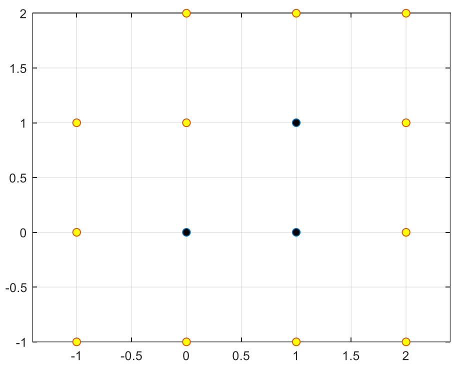
- Using the model $f_1(x)$, the total energy of each Yew_point propagating to Blk_point (0,0) and Blk_point (1,0) is calculated. Select Yew_point with the largest total energy and the smallest distance, set it as the third Blk_point, and set the points around all current Blk_ points as Yew_points. As shown in Figure 3.5 (c);
- Similarly, the coordinate point of the fourth Blk_point. As shown in Figure 3.5 (d).
- Cycle through and add new Blk_points until the number of Blk_points equals Npoints.



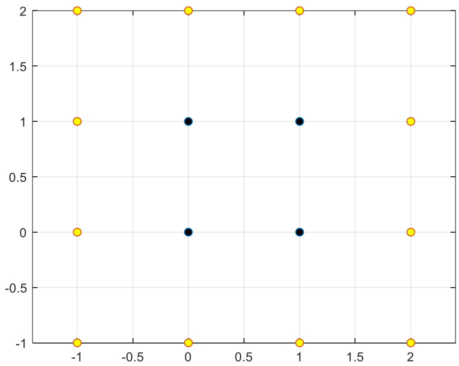
(a) Coordinate point of the first Blk_point



(b) Coordinate point of the second Blk_poin



(c) Coordinate point of the third Blk_point



(d) Coordinate point of the fourth Blk_point

Figure 3.5 The coordinate points of the 1st-4th Blk_points obtained by model $f_1(x)$

The algorithm flow chart is shown in Figure 3.6:

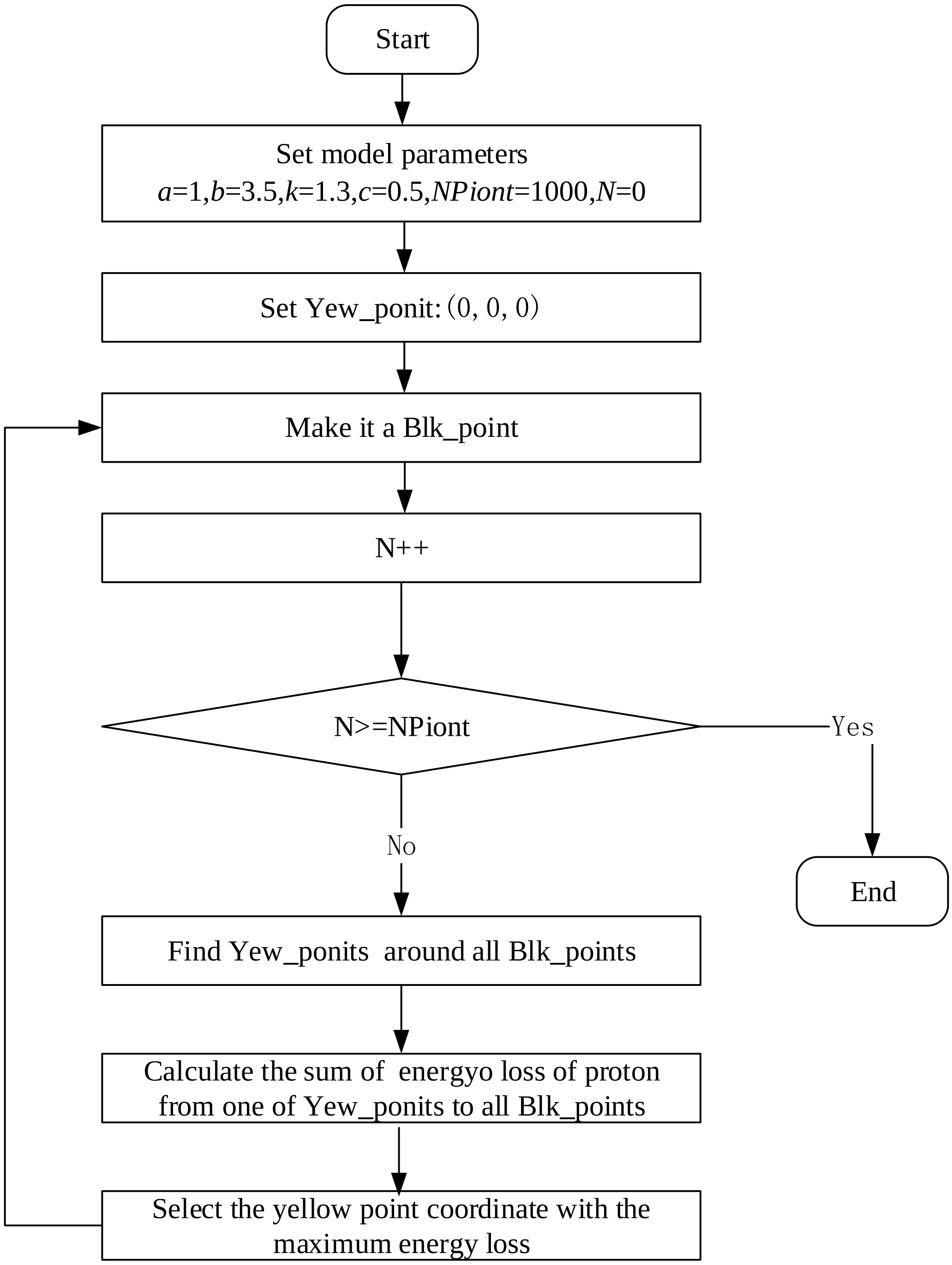


Figure 3.6 Flow chart of Optimal shape algorithm

Similarly, we set model $f_2(x)$parameters, a=1,b=3.5,k=1.3,c=0.5,$NPiont$=1000. Through the appeal algorithm, we calculated the 2D figure of O_ shape corresponding to models $f_1(x)$, $f_2(x)$, as shown in Figure 3.7. For comparison, we paint them in different colors.

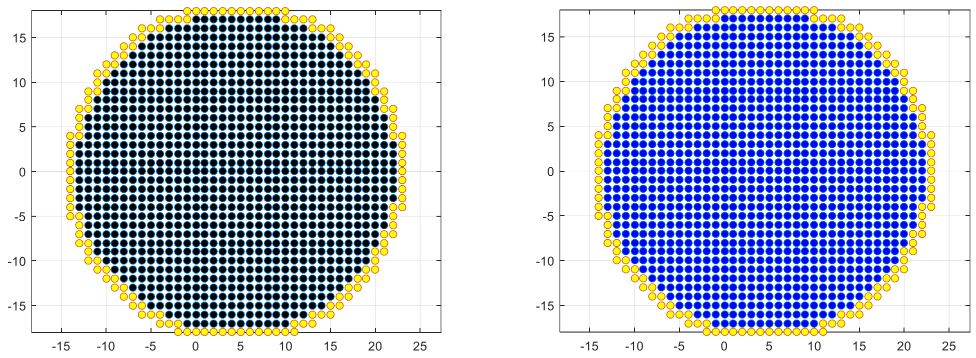


Figure 3.7 Using the $f_1(x)$ (left) and $f_2(x)$ (right) to calculate the 2D shape of O_shape

We use the same algorithm to get O_ shape by using the model $f_1(x)$ and $f_2(x)$. For a clear comparison, we paint them in different colors.

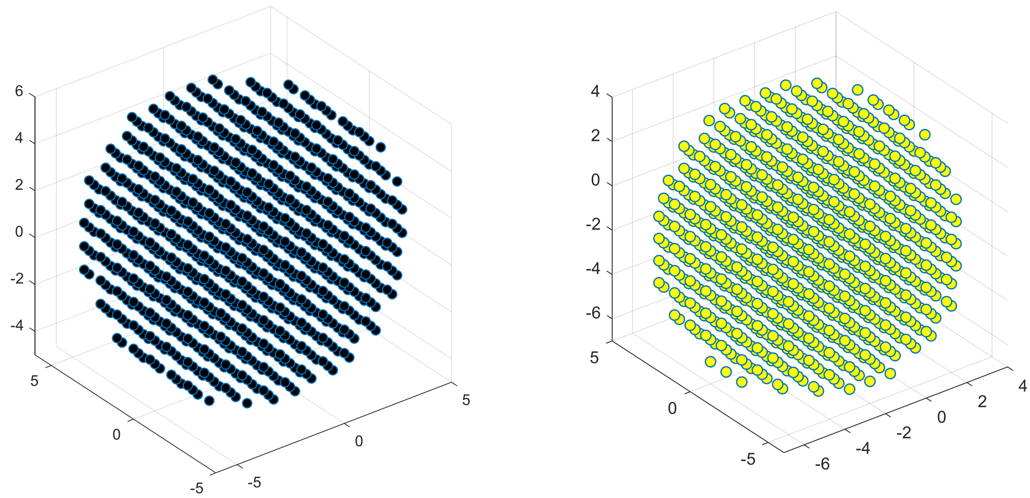
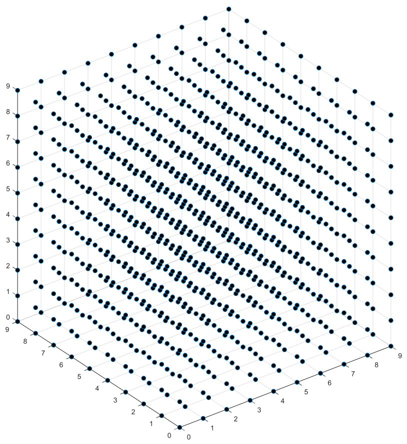


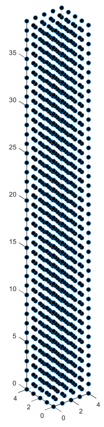
Figure 3.8 Using the $f_1(x)$ (left) and $f_2(x)$ to calculate the 3D shape of O_shape

3.4 Prove the Established Model

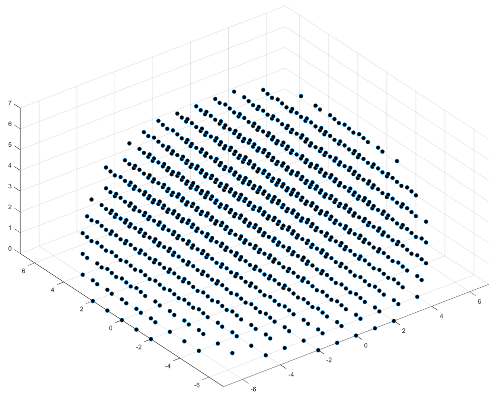
In order to prove the correctness and feasibility of the established model, We have chosen four other shapes of the same volume as the O_Shape obtained above, A,B,C,D, as shown in Figure 3.9. Calculate the S_value of the four materials and compare them with the S_value of O_Shape above. See Appendix 2 for the codes.



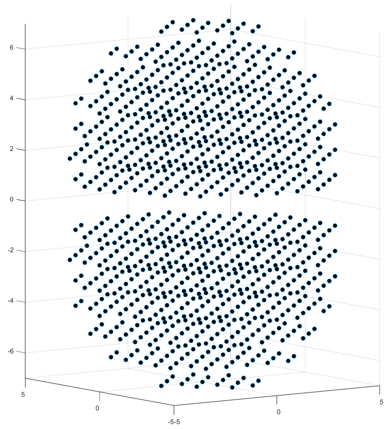
(a) A



(b)B



(c)C



(dD

Figure 3.9 Simulation diagram of different shapes of radioactive materials

The calculation results are shown in Table 2. From the data, we can see that the S_value of O_shape calculated by $f_1(x)$ or $f_2(x)$ is significantly greater than that of other four shape materials.This shows that $f_1(x)$, $f_2(x)$ is correct and feasible.

Table 2 Comparison of S-value of different shapes of radioactive materials

Model	Shape	S_value($MeV \cdot 10^4$)
$f_1(x)$	O_Shape	12.37
	A	11.710
	B	8.6506
	C	11.358
	D	11.830
$f_2(x)$	O_Shape	166.79
	A	161.27
	B	58.876
	C	146.99
	D	151.59

3.5 Comparison and Analysis of Models

The data in Table 2 shows that the S_values of different shapes obtained by using $f_1(x)$ are significantly smaller than those obtained by using $f_2(x)$.

This shows that the model $f_2(x)$based on cosine function is better than the$f_1(x)$ bas ed on triangle function in describing the S_value of different shapes.Therefore, in the following analysis of the influence of model parameter changes on O_shape, we only use the better model $f_2(x)$ for analysis.

3.6 Influence of Model Parameters on Material Shape

The Bragg peak curve formed by different parameters is actually the absorption curve of proton energy released by different materials. According to the above analysis, we can know that the parameters that affect the O_shape include b , c , k .In this chapter, the control variable method is used to calculate the S_value with the model $f_2(x)$ to get the O_shape. Observe how the change of parameters will make the O_shape change, and analyze the reasons.In order to observe the change of the internal shape of the material, we use matlab simulation software to segment the figure, and the points on the segmentation surface are painted red.

3.6.1 Impact of parameter *b*

First, set the quantitative parameters: a=1; c=0.5; k=2; then make B equal to 5 and 6 respectively. The response of parameter B's change band is shown in Figure 3.10. It can be seen that O_shape is a sphere.

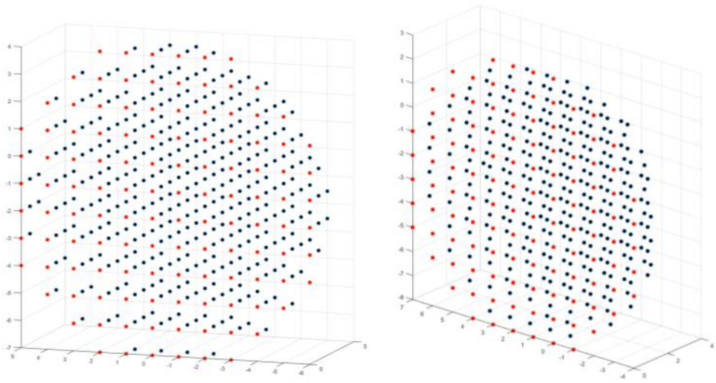


Figure 3.10 O_shape half section when b = 5 (left), 6 (right)

Set b as 7, 8 and 9 respectively. With the increase of b, the change of O_shape is shown in Fig. 3.11. It can be observed that there are cavities in the center of the material, and the cavities increase with the increase of b.

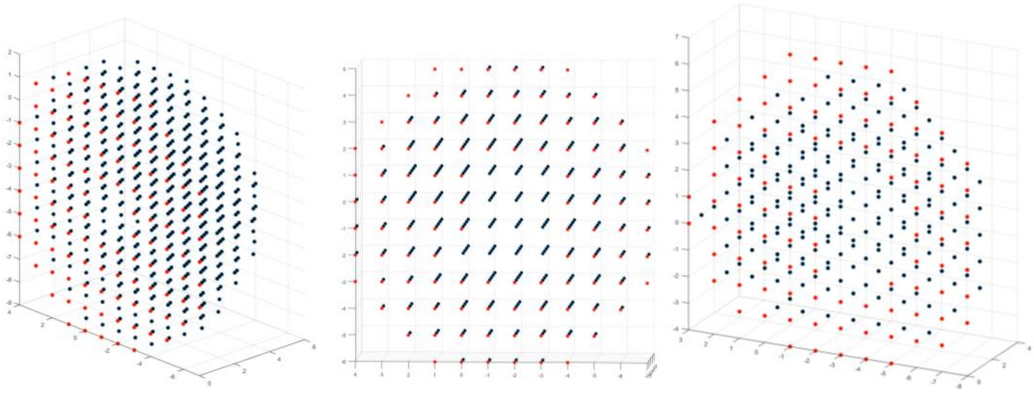


Figure 3.11 O_shape half section when *b*= 7 (left), 8 (middle), 9 (right)

When *b* = 10,12,13, with the increase of *b*, the shape of O_shape changes as shown in Fig. 3.12, the holes in the center of O_shape are penetrated, and with the increase of *b*, the O_shape splits.

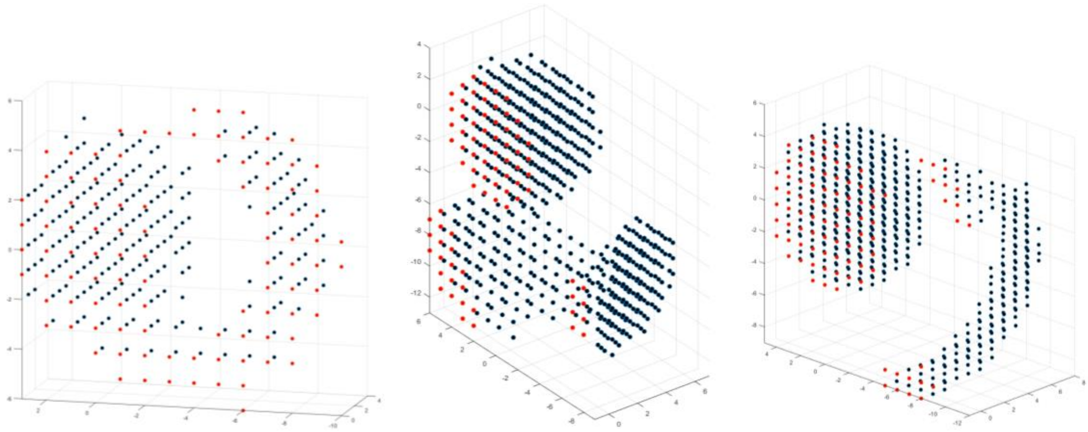


Figure 3.13 the O_shape half section body when *b*= 10 (left), 12 (middle), 13 (right).

Set *b* = 14,15. it can be seen from figure 3.14 that O_shape converges into a ball with the increase of *b*.

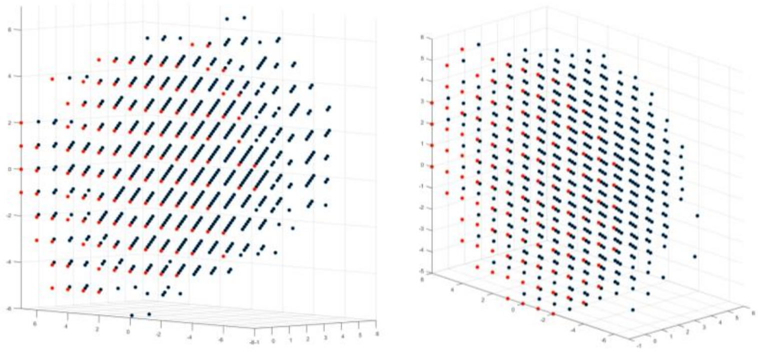


Figure 3.14 O_shape half section when *b* = 14 (left), 15 (right)

By analyzing the phenomenon of appeal, we can get the following conclusions:

(1) when the value of *b* is small, O_shape is a sphere. The reason is that in the process of O_Shape formation, the closer each Yew_poin to most Blk_points, the greater the energy release rate, so the Yew_point closest to Blk_points becomes a new

Blk_point, and then the materials gather into a sphere.

(2) with the increase of *b*, O_shape appears hole or even split from the center. Because in the process of O_shape formation, the farther each Yew_point is to most Blk_ points, the greater the energy release rate, so the Yew_point closest to Blk_points becomes a new Blk_points, and then the material appears hole phenomenon.

(3) with the further increase of *b*, the O_ Shape of the material is a sphere, because in the process of O_ Shape formation, most Yew_point energy release rates are equal to a, so the Yew_point closest to Blk_points becomes a new Blk_point. The material is then restored to a sphere.

3.6.2 Impact of parameter *c*

First, set the quantitative parameters: a=1;b=7; k=10; then make C equal to 2, and the response of parameter *c* change band is shown in Figure 3.14. It can be seen that the O_shape is a sphere.

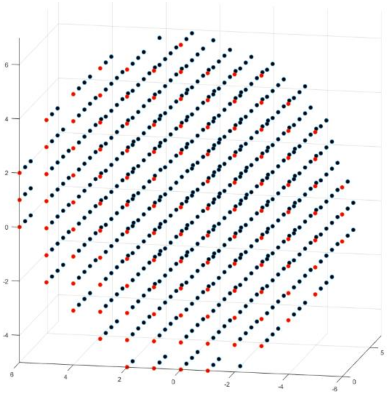


Figure 3.14 Half section of O_shape when c=2.

Then set c to 2.5. With the increase of *c*, the change of O_shape is shown in Fig.3.13. It can be observed that there are holes in the center of the material.

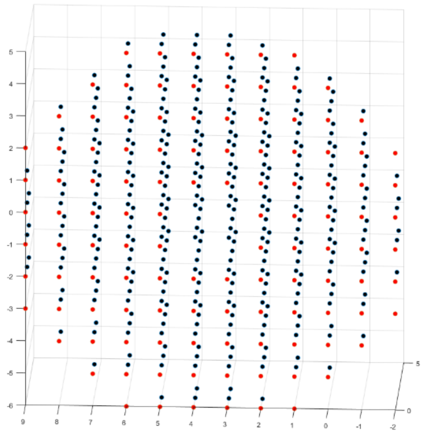


Figure 3.15 Half section of O_shape when c=2.5.

Then set c to 3 and 3.5 respectively. With the increase of *c*, the change of O_shape is shown in Figure 3.16, and it is restored to a sphere.

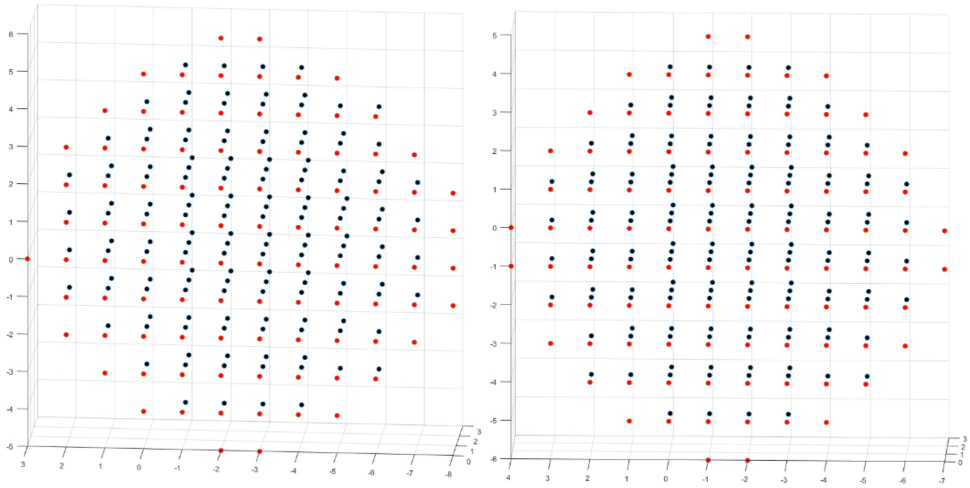


Figure 3.16 O_shape half section when c = 3(left), 3.5 (right)

Then set c to 4, with the increase of c, the change of O_shape is shown in Fig.3.17, and the hole appears again.

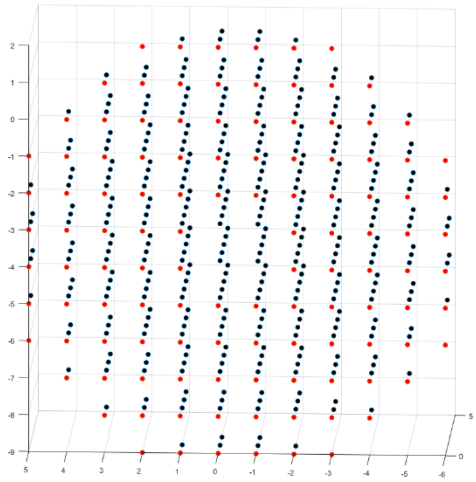


Figure 3.17 Half section of O_shape when c=4.

Then set c to 4.5 and 5 respectively. With the increase of c, the change of O_shape is shown in Figure 3.18, and it is restored to a sphere.

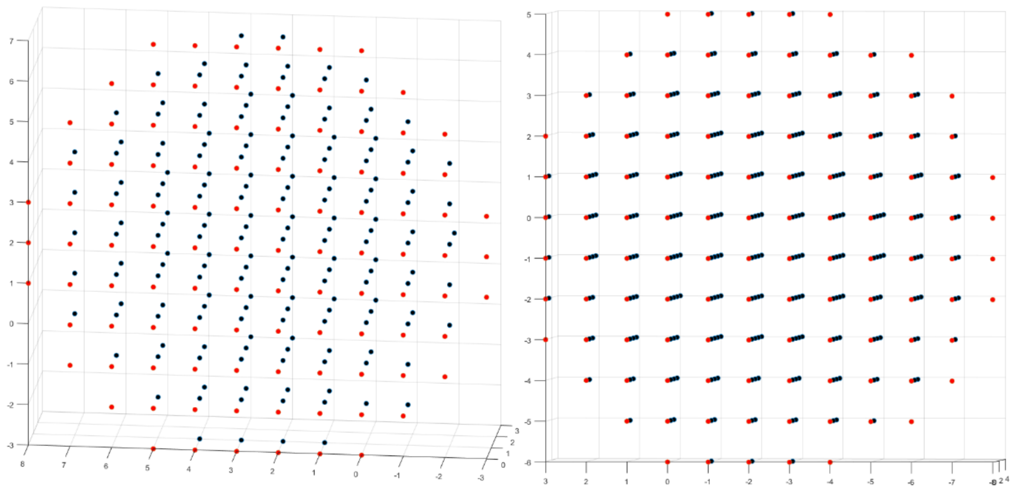


Figure 3.18 Half section of O_shape when c=4.5(left),5.5(rigth)

By analyzing the phenomenon of appeal, we can get the following conclusions:

(1) when the value of c changes to a certain extent, the closer each Yew_poin is to most Blk_points, the greater the loss value. Therefore, the Yew_poin closest to Blk_points becomes a new Blk_point, and then the materials gather into a sphere

(2) when the value of c changes to a certain extent, the further away each Yew_poin is from most Blk_points, the larger the loss value is. Therefore, the Yew_poin closest to the Blk_point becomes a new Blk_point. Then the hole phenomenon appears in O_shape

(3) when the value of c changes to a certain extent, the further away each Yew_poin is from most Blk_points, the loss value is equal to a, so the Yew_poin closest to Blk_points becomes a new Blk_point, and then the O_shape is restored to a sphere.

3.6.3 Impact of parameter *k*

First, set quantitative parameters:a=1;b=7; c=1.5; Set k = 0,1,2, and the simulation results show that the O_Shape is a sphere , as shown in Figure 3.19.

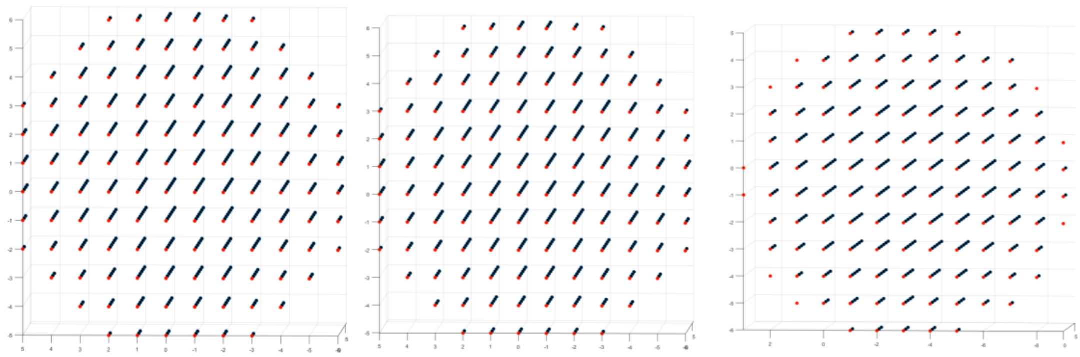


Figure 3.19 O_shape half section when k = 0,1,2

Then let k = 3,4,5,6. With the increase of k, there is a hole in the center of the material, as shown in Figure 3.20.

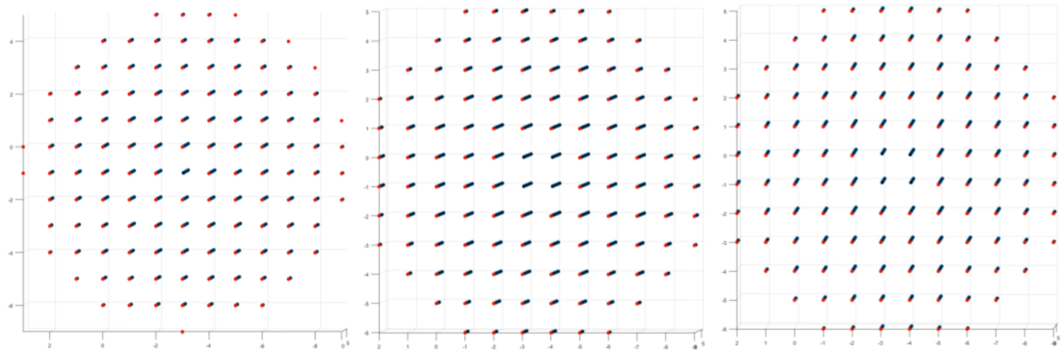


Figure 3.20 O_shape half section when k = 3,6,7

Set k = 7,8,9, with the increase of b, when the hole is small, the shape of the material polymerizes to form an ellipsoid, as shown in Figure 3.21.

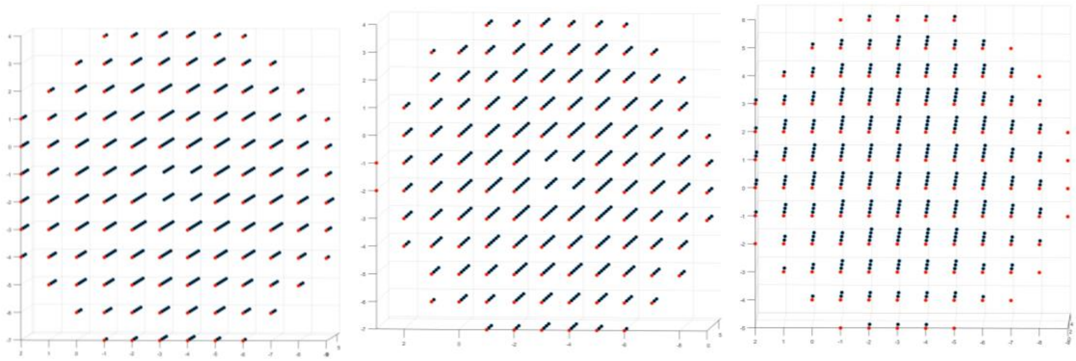


Figure 3.21 O_shape half section when k = 7,8,9

Conclusion:

(1) When the value of k is small, the O_shape of the material is a sphere, because in the process of O_shape formation, the closer each Yew_poin is to most Blk_points, the greater the energy release rate, so the Yew_poin closest to Blk_points becomes a new Blk_point, and then the material is gathered into a sphere.

(2) With the increase of k, O_ Shape appears hole or even split from the center, because in the process of O_ Shape formation, the farther each Yew_poin is to most Blk_points, the greater the energy release rate is, so the Yew_poin nearest to Blk_points becomes a new Blk_point, and then the hole phenomenon appears in the material.

(3) With the further increase of K, the O_ shape of the material is a sphere, because in the process of O_ shape formation, most Yew_poin energy release rates are equal to a, so the Yew_poin closest to Blk_point becomes a new Blk_point. The material is then restored to a sphere.

3.7 O_Shape Segmentation

In order to study the influence of segmented materials on S_value, we have drawn specific O_shapes, four spheres with volume of 200 points, 500 points, 1000 points and 2000 points respectively, as shown in Figure 3.22. Calculate the s value of the four

O_shapes. for calculation procedure in appendix 2.

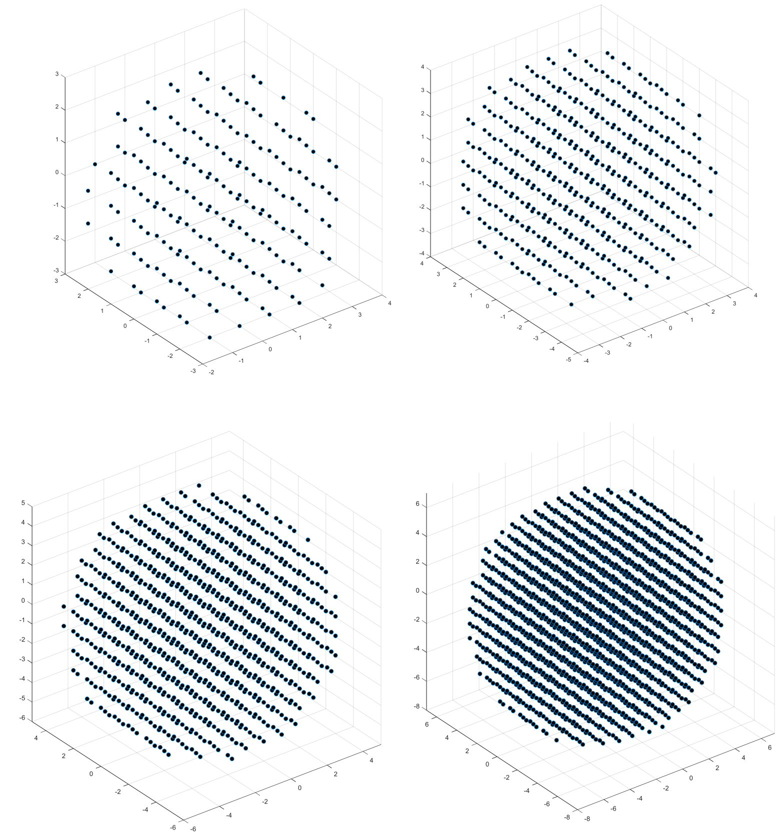


Figure 3.22 Simulation diagram of O_shape segmented according to different scales

The calculation results are shown in Table 2. It is not difficult to see from the data that the sum of S_values of ten 200 point balls is smaller than that of one 2000 point ball. Therefore, the conclusion is that, in general, segmentation will reduce S_values. This also supports our hypothesis that O_shape should be solid.

Table 3 Comparison of s value after O_shape segmentation

NPoint	Volume split scale	S_value(MeV·10^4)	S_value Proportion
200	1	9.884	1.000
500	2.5	34.61	3.501
1000	5	81.61	8.257
2000	10	18.36	18.580

IV. Conclusions

4.1 Solutions of the problem

In order to find the material shape that can maximize the total energy released by the proton in the material, we first use the triangle function and cosine function to establish two models to describe the relationship between the energy release rate of the proton and its propagation distance in the material, that is, $f_1(x)$ and $f_2(x)$, and prove the correctness and feasibility of the model. Based on the better model $f_2(x)$, using greedy algorithm, we find that the O_shape is a sphere under certain parameters. However, we find that the change of model parameters will cause the change of O_shape, so we use the control variable method to study the influence of the change of $f_2(x)$ parameters on O_shape, and draw the following conclusions.

- When the parameters of the model are small, the closer each Yew_point is to most of the Blk_ points, the greater the energy release rate. Therefore, the Yew_point which is closest to the Blk_ points and has the largest total energy release becomes a new Blk_ point, and then the materials gather into a sphere.
- With the increase of each parameter value of the model, the farther each Yew_point is to most of the Blk_ points, the greater the energy release rate. Therefore, the distance between Yew_points, which can release the most total energy, and Blk_ points is far away from the Blk_ points, and then the hole phenomenon appears in the material.
- When the parameters of the model are large enough, the energy release rate of most Yew_points is equal to a in the process of O_shape formation. Therefore, Yew_point, the nearest to Blk_ points, becomes a new Blk_ point, and then the material is restored to a sphere.

Finally, we try to segment O_shape and find that segmentation will reduce s'value, which also supports our hypothesis that O_shape should be solid.

4.2 Methods used in our models

We use greedy algorithm in the model to calculate the energy released by each Yew_point, and select the Yew_point that releases the most energy as Blk_point. Every Blk_point we find is the coordinate point that releases the most energy in the current state. Every time we calculate it, we get the local optimal solution, and finally form the O_shape we want to find.

4.3 Applications of our models

We study the influence of model parameters on O_shape. In practical application, if it is necessary to calculate the O_shape of a material, the Bragg peak function of the material can be directly abstracted from the model proposed in this paper. By getting the parameters of the model, the O_shape of the material can be predicted.

V. Future Work

5.1 Better Models

Because of time, this paper uses triangle function and cosine function to build two models $f_1(x)$ and $f_2(x$. In the future work, we can use more function graphs, such as sawtooth function and bell function, to build more models to describe the relationship between proton energy release rate and its distance in materials, as shown in Figure 4.1.

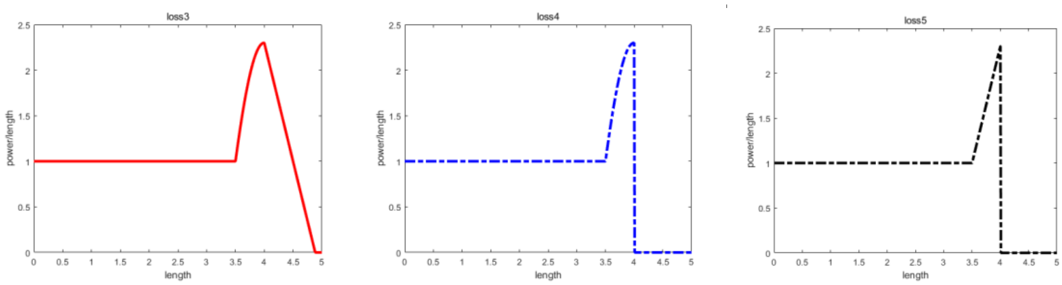


Figure 4.1 Other models simulation curves

5.2 Better Optimal Shape Algorithms

Greedy algorithm always makes the best choice in solving problems. Generally speaking, greedy algorithm is an efficient and unstable algorithm. However, it has certain limitations in solving problems. It can only find the range of feasible solutions that meet certain constraints. The algorithm is not considered from the overall optimization, and the choice made is only in a certain sense When the greedy algorithm is faced with a problem with multiple optimal solutions, it can not find all the optimal solutions

We can try to use particle swarm optimization algorithm [4], simulated annealing algorithm [5], ant colony algorithm [6], etc. to calculate O_shape, or we can improve the greedy algorithm [7] .

5.3 Another Works

The volume of the material is set to NPiont = 1000. With the increase of npiont, the shape of the simulation becomes more vivid, but at the same time, the amount of calculation increases sharply. Due to the limitation of the computer performance used in the simulation, we have not added the npoont of materials. In the future, we can use better equipment to generate more precise simulation results.

VI. References

[1] Zheng Junzheng. Orientation and connotation of the discipline of ionizing radiation protection [J]. Radiation protection communication, 2015, 35 (3): 1-5.

[2] Yuan Tao, Wang Xiaoyu, Li Zaixin, et al. Approach to nuclear waste treatment [J]. Science and technology and engineering, 2004, 4 (10): 861-867.

[3] Ye Dongyi, Huang Cuiwei, Zhao Bin. A greedy algorithm for attribute reduction in rough sets [J]. Systems engineering and electronic technology, 2000 (09): 64-66

[4] Huang Zhen, pan Ying, Cao Xiaoli. Basic theory and improvement of particle swarm optimization algorithm [J]. Silicon Valley, 2014 (5): 37-37.

[5] Jiang long Cong, Liu Jiang Ping. Simulated annealing algorithm and its improvement [J]. Journal of Engineering Geophysics, 2007, 4 (2): 135-140.

[6] Wang Xiaoting, Qian Qian. Ant colony algorithm based on search concentration and dynamic pheromone update [J]. Electronic measurement technology, 2019 (9)

[7] Liu Jun, Yi Jing. An improved greedy algorithm based personalized dormitory allocation method for college students [J]. Information communication, 2019 (05): 35-37

VII. Appendix

Appendix I

```
%Loss 1
function value1=loss1(long,a,b,k,kuan)
    if(long<b-kuan)
        value1=a;
    elseif(long>=(b-kuan) && long<b)
        value1=(k/kuan)*a*(long-b+kuan)+a;
    elseif(long>=b && long<b+(1+1/k)*kuan)
        value1=(1+k)*a-(k*a/kuan)*(long-b);
    else
        value1=0;
    end
end
%Loss 2
function value1=loss2(long,a,b,k,kuan)
     w=acos(1/(1+k))/kuan;
    if(long<b-kuan)
        value1=a;
    elseif(long>=b-kuan && long<b+pi/(2*w))
        value1=(1+k)*a*cos(w*(long-b));
    else
        value1=0;
    end
end
```

Appendix II

```
%Loss_calcu
function loss_calcu(A,a,b,k,kuan)
[m,~]=size(A);
ivalue=0;
% a=1;
% b=1000;
% k=2;
% kuan=0.5;
for i=1:m
```

```
    jvalue=0;
    for j=i+1:m
        long=sqrt((A(i,1)-A(j,1))^2+(A(i,2)-A(j,2))^2+(A(i,3)-A(j,3))^2);
        loss_point=loss1(long,a,b,k,kuan);
        jvalue=jvalue+loss_point;
    end
    ivalue=ivalue+jvalue;
end
ivalue
end
```