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ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ
Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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COMPUTER SIMULATION OF RADIONUCLIDE ISOTOPE SEPARATION USED IN NUCLEAR ENERGY AND MEDICINE

Abstract. Since the radionuclide isotope radiation is widely used in medicine, in particular for diagnosis and treatment of cancer, it is extremely important to know the composition of the basic radiating materials. Method of separation of radionuclide isotopes known as mass spectrometry is applicable across diverse fields such as biochemistry, clinical chemistry, general chemistry and organic chemistry, pharmaceutics, cosmetics, perfumery, the food industry, chemical synthesis, petrochemicals and petro processing, environmental control, polymer and plastic production, medicine and forensic analysis, drug control, alcohol control, geochemistry, geology, hydrology, archeology, nuclear industry, semiconductor industry, metallurgy. Of particular interest is the isotope $^{3}_{2}He$, used in nuclear power and nuclear medicine. The article presents the results of computer simulation of separation of the following radionuclides used in geology and medicine: $^{4}_{2}He$, $^{3}_{2}He$, $^{130}_{56}Ba$, $^{138}_{56}Ba$, $^{172}_{73}Ta$, $^{181}_{73}Ta$, $^{212}_{83}Bi$, $^{215}_{83}Bi$, $^{201}_{81}Tl$, $^{205}_{81}Tl$, $^{125}_{53}I$, $^{127}_{53}I$, $^{31}_{15}P$, $^{33}_{15}P$, $^{67}_{31}Ga$, $^{71}_{31}Ga$, $^{108}_{49}In$, $^{111}_{49}In$, $^{93}_{43}Tc$, $^{99}_{43}Tc$. The suggested simulation program can also be used for separation of other isotopes.

Key words: isotope, radionuclide, geology, medicine, Matlab, computer simulation.

Introduction. The computer simulation is a powerful tool for both scientific research and education. It contributes to the development of research skills by bringing the learning process closer to scientific inquiry, which is one of the important challenges of the modern education. Such approach to the learning process creates the necessary motivation for cognitive activity and thus enhancing the quality of knowledge and research skills. Numerical modeling is an integral part of the contemporary fundamental and applied science and as important as the traditional experimental and theoretical methods. Therefore future scientists, engineers and teachers should master computer simulation technique, be able to study various physical phenomena and processes using a computer. The main idea of the computer simulation technique is creation of a mathematical model of the real process or object. Then the obtained mathematical model is studied by using the corresponding mathematical instruments that does not depend on the specific nature of the object or process.

Students of physical specialties of 5B06040 and 5B011000 of M. Auezov South Kazakhstan State University successfully master the discipline “Computer modeling of physical phenomena,” which is a logical continuation of the discipline “Information technology in physics training.” The purpose of studying these disciplines is to master the MATLAB program language [1-10], to get acquainted with its enormous potentials of modeling and visualization of physical processes. At the Department of Physics bachelor and master program students together with instructors participate in the creation of programs for solving problems of all sections of physics. Materials of research are published in journals indexed in Scopus, WOS bases and having high quartiles and percentiles [11-15].

The isotope separation simulation was carried out using Matlab software because it has a number of advantages over other software tools.

Materials and methods. Let’s consider the problem of space separation of nuclei with identical charges *q*, but of different masses *m* (i.e., mixture of isotopes). We assume that the motion of positive ions occurs *XYZ*

– coordinate system. The electric field is directed along the *X*-axis into the plane of the paper. The magnetic field is parallel to *Z*-axis directed upward. The *Y*-axis is directed to the right. From the source (ordinarily it is the velocity selector) the particles escape in the direction of *Y*-axis perpendicularly to the magnetic field. Particles escape from the selector with initial velocity identical in magnitude and in direction, and enter into a external transversal magnetic field. (The operation of the velocity selector is described in our article [13].) Here we just note that to have isotopes entering the magnetic field with identical speeds, irrespectively of their specific charges, they must pass through crossed electric and magnetic fields. In that case their speed does not depend on anything, except the ratio of the electric field to the magnetic induction, i.e. u =*E/B*).

It is necessary to carry out calculation and visualization of the motion trajectory of nuclei with identical charges but different masses, i.e. isotopes in the mixture. The charged particles escaping the velocity selector further move under the action of the Lorentz force.

The differential equations of motion of charged particles in the magnetic field are known [13]. Therefore, we do not give them in this article, just note only that it is necessary to take their *X-,Y-, Z-* components and solve them using solvers of the Matlab system by previously bringing the system of second-order differential equations into the system of first-order equations.

To solve these differential equations (DE), we created an m-file called Lorentz.m. The listing of the m-file f = Lorenz (t, z) and the codes of the calculation and visualization program are given in an article published by us in the journal News of NAS RK, series of geology and technical sciences, V.5 (431), 2018, pages 218-225 [13], so we will not repeat them here.

The present article presents the results of computer simulations of isotopes separation used in medicine: ${}^{4}_{2}He$, ${}^{3}_{2}He$, ${}^{130}_{56}Ba$, ${}^{138}_{56}Ba$, ${}^{172}_{73}Ta$, ${}^{181}_{73}Ta$, ${}^{212}_{83}Bi$, ${}^{215}_{83}Bi$, ${}^{201}_{81}Tl$, ${}^{205}_{81}Tl$, ${}^{125}_{53}I$, ${}^{127}_{53}I$, ${}^{31}_{15}P$, ${}^{33}_{15}P$, ${}^{67}_{31}Ga$, ${}^{71}_{31}Ga$, ${}^{108}_{49}In$, ${}^{111}_{49}In$, ${}^{93}_{43}Tc$, ${}^{99}_{43}Tc$.

Results and discussion.

1. Helium-3 is extremely popular today - in particular, in medicine (in magnetic resonance imaging is used to get the picture of lungs).

The program for calculation and visualization of isotopes ${}^{3}_{2}He$, ${}^{4}_{2}He$

```
>> global B; % input the global variable
>> B=[0 0 1]; % input the elements of matrix
>> x0=0; y0=0; z0=0; % input the initial coordinates of particles
>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles
>> m1=3; q1=2; м2=4; q2=2; % input the charges and masses of the particles
>> [t,R]=ode45('Lorenz',[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE
>> plot3(R(:,1)*m1/q1,R(:,3)*m2/q2,R(:,5)*m/q,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=2; m1=3, 3/2He)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> grid on; % input the coordinate grid
>> hold on; % drawing the next picture
>> plot3(R(:,1)*m1/q1,R(:,3)*m2/q2,R(:,5)*m/q,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q2=2; m2=4, 4/2He,)
>> view([0 0 100]); % drawing the trajectory on the plane
>> gtext('q1/m1=2/3'); % input the text at a chosen place
>> gtext('q2/m2=2/4'); % input the text at a chosen place
```

The result is shown in figure 1.

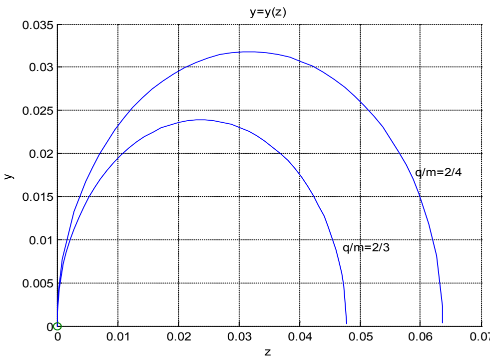

Figure 1. The motion trajectories of isotopes ${}^{3}_{2}He$, ${}^{4}_{2}He$ on the plane

2. Barium-130 is used for producing the radiopharmaceutical preparation “Proxelan caesium-131” applied in urology for oncological therapy (prostate cancer).

The program for calculation and visualization of isotopes $^{130}_{56}\boldsymbol{Ba}$, $^{138}_{56}\boldsymbol{Ba}$

m1=130; q1=56; m2=138; q2=56;

>> global B; % input the global variable

>> B=[0 0 1]; % input the elements of matrix

>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles

>> vx=0; vy=0.1; vz=0; % input the initial velocities of particles

>> [t,R]=ode45(‘Lorenz’,[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE

>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,’o’,’MarkerSize’,6);

% drawing trajectory in three-dimensional space (for q1=56; m1=130, $^{130}_{56}\boldsymbol{Ba}$)

>> view ([0 0 100]); % drawing the trajectory on the plane

>> grid on; % input the coordinate grid

>> hold on; % drawing the next picture

>> plot3(R(:,1)*m2/q2,R(:,3)*m2/q2,R(:,5)*m2/q2, x0,y0,z0,’o’,’MarkerSize’,6);

% drawing trajectory in three-dimensional space (for q2=56; m2=138, $^{138}_{56}\boldsymbol{Ba}$)

>> view ([0 0 100]); % drawing the trajectory on the plane

>> gtext (‘q1/m1=56/130’); % input the text at a chosen place

>> gtext (‘q2/m2=56/138’); % input the text at a chosen place

The result is shown in figure 2.

3. Tantalum is used in medicine for manufacture of prostheses, orthopedic constructions and other fracture splicing devices which are subsequently subject to removal.

The program for calculation and visualization of isotopes $^{172}_{73}\boldsymbol{Ta}$, $^{181}_{73}\boldsymbol{Ta}$

m1=172; q1=73; m2=181; q2=73;

>> global B; % input the global variable

>> B=[0 0 1]; % input the elements of matrix

>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles

>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles

>> [t,R]=ode45(‘Lorenz’,[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE

>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,’o’,’MarkerSize’,6);

% drawing trajectory in three-dimensional space (for q1=73; m1=172, $^{172}_{73}\boldsymbol{Ta}$)

>> view ([0 0 100]); % drawing the trajectory on the plane

>> grid on; % input the coordinate grid

>> hold on; % drawing the next picture

>> plot3(R(:,1)*m2/q2, R(:,3)*m2/q2, R(:,5)*m2/q2, x0,y0,z0,’o’,’MarkerSize’,6);

% drawing trajectory in three-dimensional space (for q1=73; m1=181, $^{181}_{73}\boldsymbol{Ta}$)

>> view ([0 0 100]); % drawing the trajectory on the plane

>> gtext (‘q1/m1=73/172’); % input the text at a chosen place

>> gtext (‘q2/m2=73/181’); % input the text at a chosen place

The result is shown in figure 3.

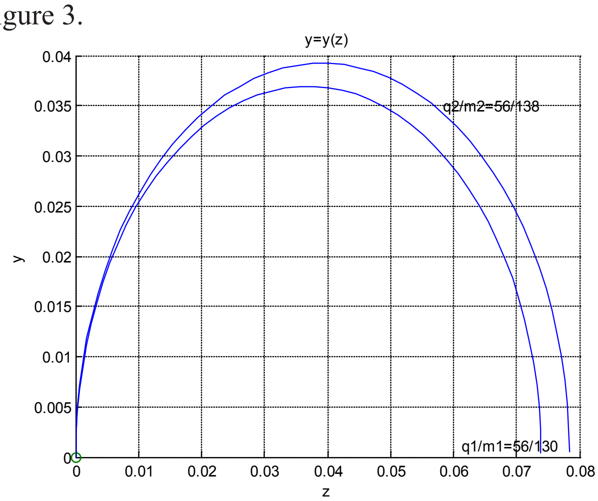

Figure 2. The motion trajectories of isotopes $^{130}_{56}\boldsymbol{Ba}$, $^{138}_{56}\boldsymbol{Ba}$ on the plane

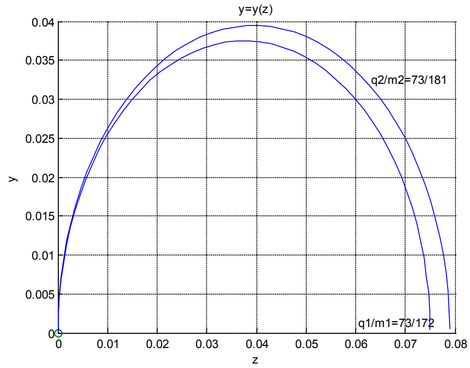

Figure 3. The motion trajectories of isotopes $^{172}_{73}Ta$, $^{181}_{73}Ta$ on the plane

4. In radio-immunotherapy $^{212}_{83}Bi$, $^{215}_{83}Bi$ are considered to be promising alpha-emitting isotopes for producing drugs.

The program for calculation and visualization of isotopes $^{212}_{83}Bi$, $^{215}_{83}Bi$
m1=212; q1=83; m2=215; q2=83;
>> global B; % input the global variable
>> B=[0 0 1]; % input the elements of matrix
>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles
>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles
>> [t,R]=ode45('Lorenz',[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE
>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=83; m1=212, $^{212}_{83}Bi$)
>> view([0 0 100]); % drawing the trajectory on the plane
>> grid on; % input the coordinate grid
>> hold on; % drawing the next picture
>> plot3(R(:,1)*m2/q2,R(:,3)*m2/q2,R(:,5)*m2/q2, x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=83; m1=215, $^{215}_{83}Bi$)
>> view([0 0 100]); % drawing the trajectory on the plane
>> gtext('q1/m1=83/212'); % input the text at a chosen place
>> gtext('q2/m2=83/215'); % input the text at a chosen place
The result is shown in figure 4.

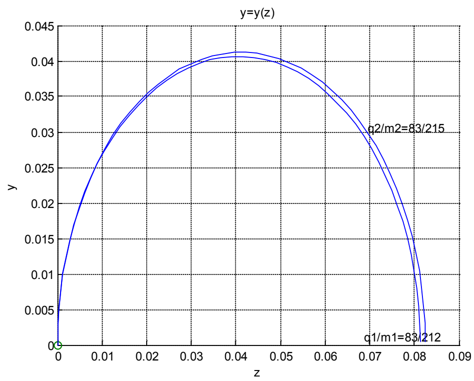

Figure 4. The motion trajectories of isotopes $^{212}_{83}Bi$, $^{215}_{83}Bi$ on the plane

5. Thallium isotope $^{201}_{81}Tl$ is used in Auger therapy - the youngest direction in radiation therapy.

The program for calculation and visualization of isotopes $^{201}_{81}Tl$, $^{205}_{81}Tl$
m1=201; q1=81; m2=205; q2=81;
>> global B; % input the global variable
>> B=[0 0 1]; % input the elements of matrix
>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles
>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles

>> [t,R]=ode45('Lorenz',[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE
>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=81; m1=201, $^{201}_{81}\boldsymbol{Tl}$)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> grid on; % input the coordinate grid
>> hold on; % drawing the next picture
>> plot3(R(:,1)*m2/q2,R(:,3)*m2/q2,R(:,5)*m2/q2, x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=81; m1=205, $^{205}_{81}\boldsymbol{Tl}$)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> gtext ('q1/m1=81/201'); % input the text at a chosen place
>> gtext ('q2/m2=81/205'); % input the text at a chosen place
The result is shown in figure 5.

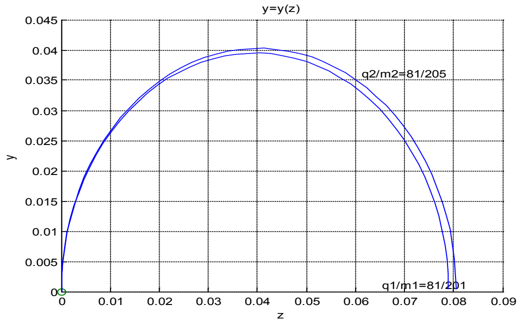

Figure 5. The motion trajectories of isotopes $^{201}_{81}\boldsymbol{Tl}$, $^{205}_{81}\boldsymbol{Tl}$ on the plane

6. Phosphorus isotope $^{31}_{15}\boldsymbol{P}$ is used in application brachytherapy and angioplasty after establishing a stent in the places of plaque accumulation.

The program for calculation and visualization of isotopes $^{31}_{15}\boldsymbol{P}$, $^{33}_{15}\boldsymbol{P}$
m1=31; q1=15; m2=33; q2=15;
>> global B; % input the global variable
>> B=[0 0 1]; % input the elements of matrix
>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles
>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles
>> [t,R]=ode45 ('Lorenz',[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE
>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=15; m1=31, $^{31}_{15}\boldsymbol{P}$)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> grid on; % input the coordinate grid
>> hold on; % drawing the next picture
>> plot3(R(:,1)*m2/q2,R(:,3)*m2/q2,R(:,5)*m2/q2, x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=15; m1=33, $^{33}_{15}\boldsymbol{P}$)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> gtext ('q1/m1=15/31'); % input the text at a chosen place
>> gtext ('q2/m2=15/33'); % input the text at a chosen place
The result is shown in figure 6.

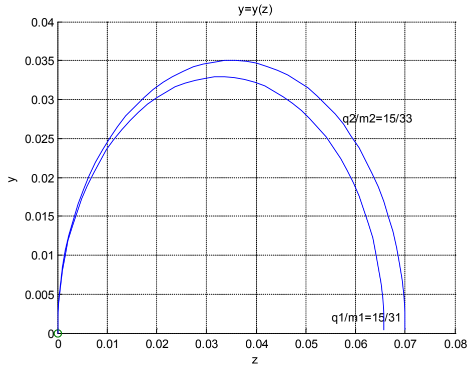

Figure 6 -The motion trajectories of isotopes $^{31}_{15}\boldsymbol{P}$, $^{33}_{15}\boldsymbol{P}$ on the plane

7. Gallium isotope ${}^{67}_{31}Ga$ as well as ${}^{201}_{81}Tl$ is used in Auger therapy - the youngest direction in radiation therapy.

The program for calculation and visualization of isotopes ${}^{67}_{31}Ga$, ${}^{71}_{31}Ga$

```
m1=67; q1=31; m2=71; q2=31;
>> global B; % input the global variable
>> B=[0 0 1]; % input the elements of matrix
>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles
>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles
>> [t,R]=ode45 ('Lorenz',[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE
>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=31; m1=67, 67/31 Ga)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> grid on; % input the coordinate grid
>> hold on; % drawing the next picture
>> plot3(R(:,1)*m2/q2,R(:,3)*m2/q2,R(:,5)*m2/q2, x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=31; m1=71, 71/31 Ga )
>> view ([0 0 100]); % drawing the trajectory on the plane
>> gtext ('q1/m1=31/67'); % input the text at a chosen place
>> gtext ('q2/m2=31/71'); % input the text at a chosen place
```

The result is shown in figure 7.

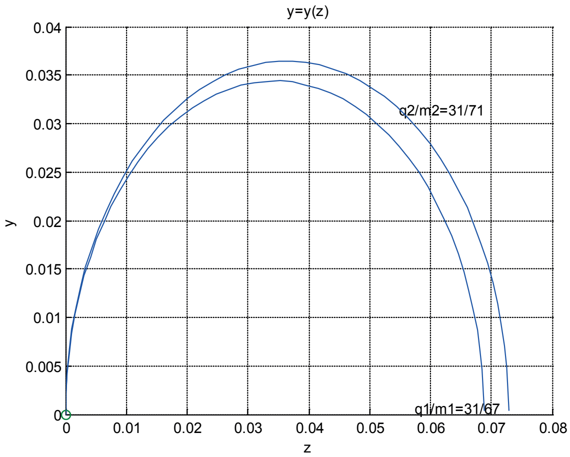

Figure 7. The motion trajectories of isotopes ${}^{67}_{31}Ga$, ${}^{71}_{31}Ga$ on the plane

8. Iodine isotopes ${}^{121}_{53}I$, ${}^{131}_{53}I$ are used in Auger therapy.

The program for calculation and visualization of isotopes ${}^{121}_{53}I$, ${}^{131}_{53}I$

```
m1=121; q1=53; m2=131; q2=53;
>> global B; % input the global variable
>> B=[0 0 1]; % input the elements of matrix
>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles
>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles
>> [t,R]=ode45('Lorenz',[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE
>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=53; m1=121, 121/53 I)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> grid on; % input the coordinate grid
>> hold on; % drawing the next picture
>> plot3(R(:,1)*m2/q2,R(:,3)*m2/q2,R(:,5)*m2/q2, x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=53; m1=131, 131/53 I)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> gtext ('q1/m1=53/121'); input the text at a chosen place
>> gtext ('q2/m2=53/131'); input the text at a chosen place
```

The result is shown in figure 8.

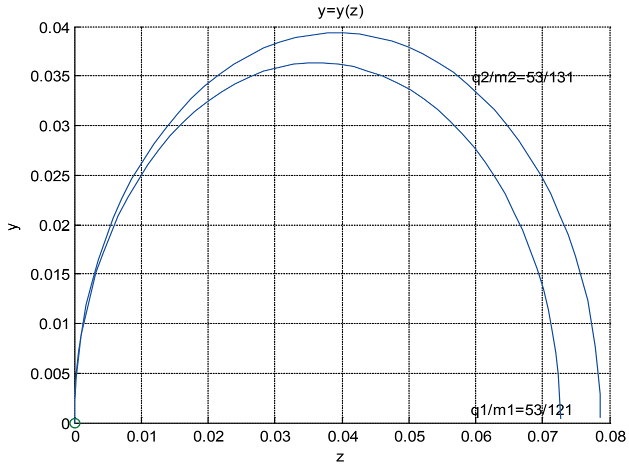

Figure 8. The motion trajectories of isotopes $^{121}_{53}I$, $^{131}_{53}I$ on the plane

9. Indium radio-nuclides $^{108}_{49}In$, $^{111}_{49}In$ is used in Auger therapy as radiopharmaceuticals. $^{111}_{49}In$ is also used in leukocyte scanning for search of hidden infections. The electromagnetic separation method (mass spectrometer) allows collecting a sufficient amount of the necessary radio-nuclides for their use as radiopharmaceuticals.

The program for calculation and visualization of isotopes $^{108}_{49}In$, $^{111}_{49}In$

```
m1=108; q1=49; m2=111; q2=49;
>> global B; % input the global variable
>> B=[0 0 1]; % input the elements of matrix
>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles
>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles
>> [t,R]=ode45('Lorenz',[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE
>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=49; m1=108, 108/49 In)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> grid on; % input the coordinate grid
>> hold on; % drawing the next picture
plot3(R(:,1)*m2/q2,R(:,3)*m2/q2,R(:,5)*m2/q2, x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=49; m1=111, 111/49 In )
>> view ([0 0 100]); % drawing the trajectory on the plane
>> gtext ('q1/m1=49/108'); input the text at a chosen place
>> gtext ('q2/m2=49/111'); input the text at a chosen place
```

The result is shown in figure 9.

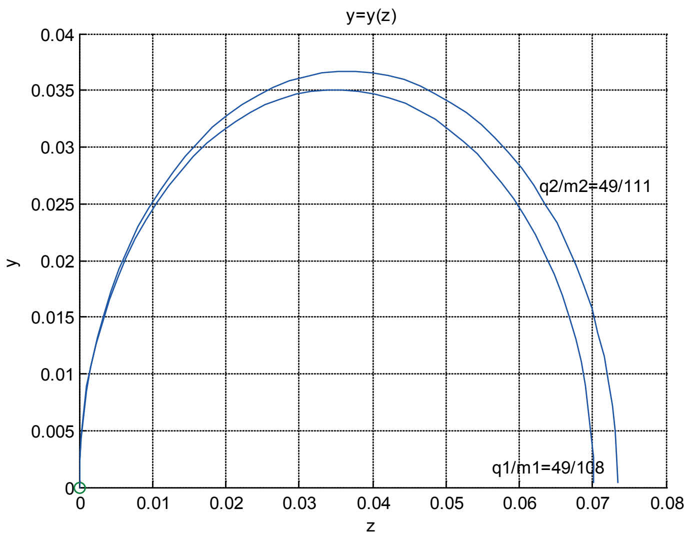

Figure 9. The motion trajectories of isotopes $^{108}_{49}In$, $^{111}_{49}In$ on the plane

10. Technetium isotope $^{99}_{43}Tc$ is used to diagnose diseases of the liver, thyroid, kidneys and adrenal glands, spleen, respiratory system, brain, spinal cord and marrow, salivary glands, digestive system, bones and joints, as well as to study the physiological functions of the heart and blood system, lymphatic and urological systems, to study the rate of glomerular filtration and plasma volume.

The program for calculation and visualization of isotopes $^{93}_{43}Tc$, $^{99}_{43}Tc$

```
m1=93; q1=43; m2=99; q2=43;
>> global B; % input the global variable
>> B=[0 0 1]; % input the elements of matrix
>> x0=0; y0=0; z0=0.04; % input the initial coordinates of particles
>> vx=0;vy=0.1; vz=0; % input the initial velocities of particles
>> [t,R]=ode45('Lorenz',[0:10/1024:0.5],[x0 vx y0 vy z0 vz]); % solution of DE
>> plot3(R(:,1)*m1/q1,R(:,3)*m1/q1,R(:,5)*m1/q1,x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=43; m1=93, 93/43 Tc)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> grid on; % input the coordinate grid
>> hold on; % drawing the next picture
>> plot3(R(:,1)*m2/q2,R(:,3)*m2/q2,R(:,5)*m2/q2, x0,y0,z0,'o','MarkerSize',6);
% drawing trajectory in three-dimensional space (for q1=43; m1=99, 99/43 Tc)
>> view ([0 0 100]); % drawing the trajectory on the plane
>> gtext ('q1/m1=43/93'); input the text at a chosen place
>> gtext ('q2/m2=43/99'); input the text at a chosen place
```

The result is shown in the figure 10.

Conclusion. Method of separation of radionuclide isotopes known as mass spectrometry is applicable across diverse fields of science, industry and medicine.

In medicine the radionuclide isotope radiation is widely used for diagnosis and treatment of cancer. Thus, the calculation and visualization of isotope separation processes from mixtures becomes extremely relevant. The article offers the programs for calculation and visualization of the separation process of various isotopes applied in medicine. The mathematical model of motion of charged particles in the magnetic field is developed using the package of MatLab applied programs. To solve the system of differential equations of the second order it is converted into the system of differential equations of the first order and previously m-file is created under the name Lorenz.m, which is addressed from the command line. The equations are solved by using the procedure ode45 of the MatLab system. Results of calculations are presented in figures 1-10 in the form of motion trajectories of isotopes as a function of their specific charges. It is seen that isotopes with different specific charges are separated and move along different circular trajectories. The less is the specific charge the more is the revolution radius or the more is the mass number of the isotope the greater is its radius of revolution.

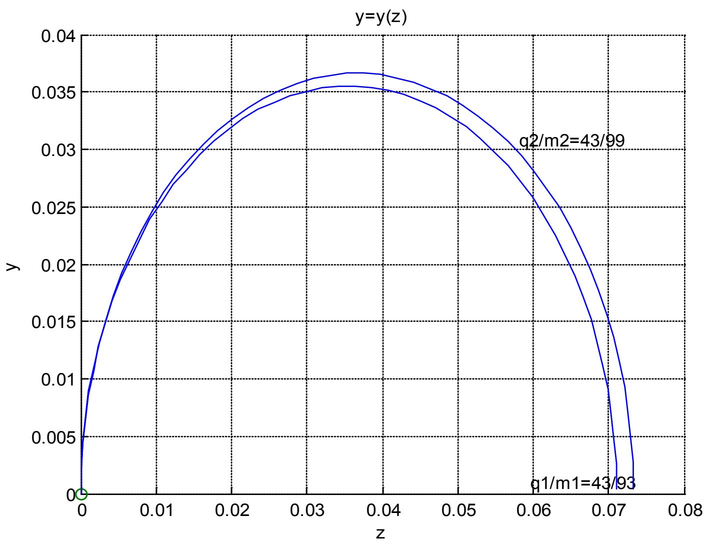

Figure 10-The motion trajectories of isotopes $^{93}_{43}Tc$, $^{99}_{43}Tc$ on the plane

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ЯДРОЛЫҚ ЭНЕРГЕТИКА МЕН МЕДИЦИНАДА ПАЙДАЛАНЫЛАТЫН РАДИОНУКЛИДТЫ ИЗОТОПТАРДЫ БӨЛУ ПРОЦЕСІН МОДЕЛЬДЕУ

Аннотация. Сәулеленген радионуклидтердің медицинада кеңінен қолдануына байланысты, атап айтқанда онкологиялық ауруларды диагностикалау мен емдеуде бастапқы материалдардың құрамын білу өте маңызды. Адамзаттың іс-әрекетінде масс-спектрометрияның қолданылмайтын саланы елестету қиын. Айталық: геология, геохимия, биохимия, клиникалық химия, жалпы химия және органикалық химия, биология, физика, фармацевтика, косметика, парфюмерия, тамақ өнеркәсібі, мұнай химиясы и мұнай өндіруі, ортаны қорғау, минералогия, петрография археология, ядролық энергетика и ядролық медицина, т.б. Ядролық энергетика мен ядролық медицинада гелий ($^{3}_{2}He$), изотопының алатын орны ерекше. Мақалада келесі радионуклидтерді $^{4}_{2}He$, $^{3}_{2}He$ $^{130}_{56}Ba$, $^{138}_{56}Ba$, $^{172}_{73}Ta$, $^{181}_{73}Ta$, $^{212}_{83}Bi$, $^{215}_{83}Bi$, $^{201}_{81}Tl$, $^{205}_{81}Tl$, $^{31}_{15}P$, $^{33}_{15}P$, $^{67}_{31}Ga$, $^{71}_{31}Ga$, $^{121}_{53}I$, $^{131}_{53}I$ $^{108}_{49}In$, $^{111}_{49}In$, $^{93}_{43}Tc$, $^{99}_{43}Tc$ масс-спектрометриялық ажырату үдерісінің компьютерлік моделдеуінің нәтижелері ұсынылған. Ұсынылған моделдеу программасын басқа да изотоптарды ажыратуда қолдануға болады.

Түйінді сөздер: Изотоп, радионуклид, геология, медицина, Matlab, компьютерлік модельдеу.

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МОДЕЛИРОВАНИЕ ПРОЦЕССА РАЗДЕЛЕНИЯ РАДИОНУКЛИДНЫХ ИЗОТОПОВ, ИСПОЛЬЗУЕМЫХ В ЯДЕРНОЙ ЭНЕРГЕТИКЕ И МЕДИЦИНЕ

Аннотация. В связи с широким использованием излучений радионуклидных изотопов в медицине, в частности диагностики и лечении онкологических заболеваний, чрезвычайно важно знать состав исходных материалов. Трудно представить область человеческой деятельности, где не нашлось бы места масспектрометрии. Ограничимся просто перечислением: биохимия, клиническая химия, общая химия и органическая химия, фармацевтика, косметика, парфюмерия, пищевая промышленность, химический синтез, нефтехимия и нефтепераработка, контроль окружающей среды, производство полимеров и пластиков, медицина и криминалистика, допинговый контроль, контроль наркотических средств, контроль алкогольных напитков, геохимия, геология, гидрология, петрография, минералогия, геохронология, археология, ядерная промышленность и энергетика, полупроводниковая промышленность, металлургия. Особый интерес представляет изотоп гелия ($^{3}_{2}He$), используемый в ядерной энергетике и ядерной медицине. Представлены результаты компьютерного моделирования разделения нижеследующих радионуклидов, используемые в медицине:

$^{4}_{2}He$, $^{3}_{2}He$ $^{130}_{56}Ba$, $^{138}_{56}Ba$, $^{172}_{73}Ta$, $^{181}_{73}Ta$, $^{212}_{83}Bi$, $^{215}_{83}Bi$, $^{201}_{81}Tl$, $^{205}_{81}Tl$, $^{31}_{15}P$, $^{33}_{15}P$, $^{67}_{31}Ga$, $^{71}_{31}Ga$,

$^{121}_{53}I$, $^{131}_{53}I$, $^{108}_{49}In$, $^{111}_{49}In$, $^{93}_{43}Tc$, $^{99}_{43}Tc$ Программа позволяет моделировать разделение и других изотопов.

Ключевые слова: изотоп, радионуклид, геология, медицина, Matlab, компьютерное моделирование.

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