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ION INITIAL AZIMUTHAL SPEED INFLUENCE UPON ISOTOPES SEPARATION IN THE PRESENCE OF CONSTANT AXISYMMETRIC RADIAL-ELECTRIC AND AZIMUTHAL-MAGNETIC FIELDS, THE STRENGTHS OF WHICH IS INVERSELY PROPORTIONAL TO THE DISTANCE FROM THE AXIS

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A new method of the electromagnetic separation of isotopes in the presence of constant axisymmetric radial-electric and azimuthal-magnetic fields, the strength of which in inversely proportional to the distance r from the axis z (r, a, z-are cylindrical coordinates) is considered in the paper [1-3]. At the calculation of these trajectories it was suppoused that at the moment of start from the source the fluctuations of initial isotope velocity components dv_r, dv_a and dv_z are equal on magnitude and are small in compared with initial velocity v_{0z}. Moreover the azimuthal velocity fluctuations dv_a were neglected at the computations of isotope trajectories in the (rz) plane .

In the present work the lithium and uranium isotope trajectories in the (rz) and (ra) planes with the consideration of dv_a are presented.

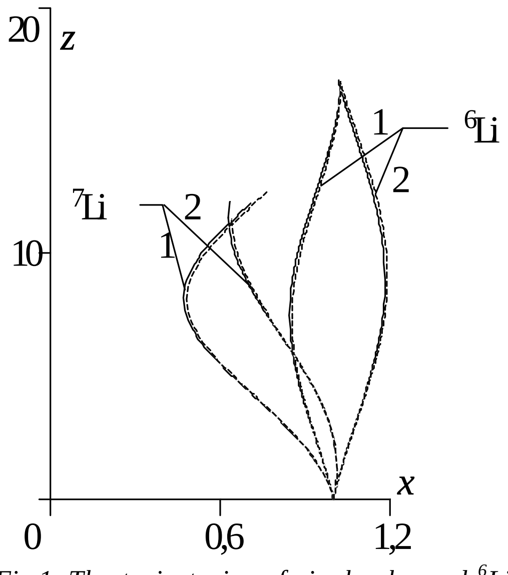

Fig.1- The trajectories of singly charged ^{6}Li and ^{7}Li ions in the plane (rz) at $d_a = 0$ (solid lines, see [1]) and $d_a \neq 0$ (dashed lines); 1) $d_r = d_z = -0{,}02$, 2) $d_r = d_z = 0{,}02$

The projections of trajectories of lithium and uranium isotopes on the plane (rz) (trajectories in the plane (rz)) are represented on Fig.1 and Fig.2., respectively. The movement of ions in this plane is described in dimensionless coordinates $x = \frac{r}{a}$ and $z = \frac{z}{a}$, and the point of the ions start from a source has coordinates $x = 1$, $z = 0$. The solid lines correspond to trajectories at $d_a \equiv \frac{dv_a}{v_{0z}} = 0$ (see [1] and [2], respectively), dashed lines correspond to trajectories

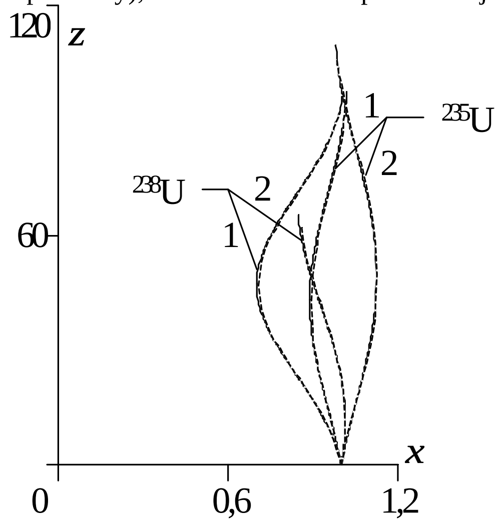

Fig.2- The trajectories of singly charged ^{235}U and ^{238}U ions in the plane (rz) at $d_a = 0$ (solid lines, see [2]) and $d_a \neq 0$ (dashed lines); 1) $d_r = d_z = -2{,}5\cdot10^{-3}$, 2) $d_r = d_z = 2{,}5\cdot10^{-3}$

calculated at $d_a \neq 0$. Comparison of the respective trajectories shows, that both for isotopes of an easy element, and for isotopes of a heavy element the trajectories in the plane (rz), calculated at $d_a \neq 0$, practically do not differ from trajectories calculated at $d_a = 0$. Thus, with the large degree of accuracy at calculation of isotope trajectories in the plane (rz) it is possible may be take $d_a = 0$, and that considerably simplifies calculations. It is necessary note, that separated beams of isotopes are focused in planes (rz) in different points, distance between which it is enough for clean separation.

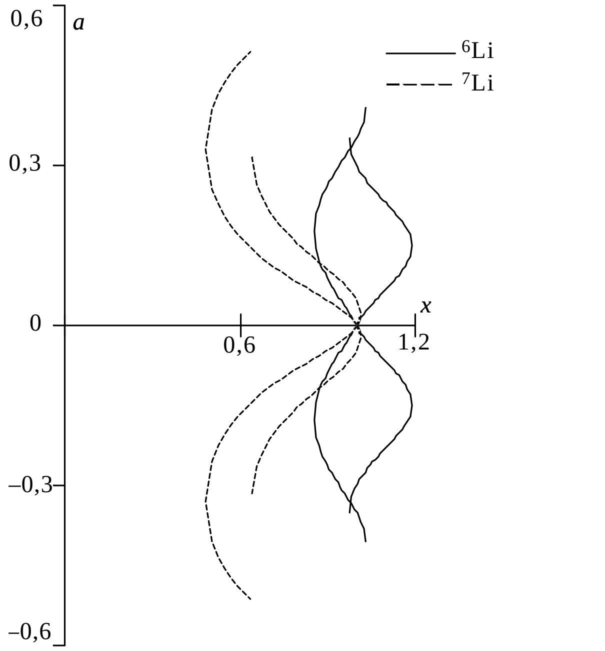

Fig. 3-The trajectories of singly charged ^6Li and ^7Li ions in the plane ($r\alpha$). The left isotope trajectories are obtained at $d_r = d_z = -0,02$, right- at $d_r = d_z = 0,02$

The curves determining dependence an azimuthal angle a from x at movement of lithium and uranium isotopes are respectively represented on Fig.3 and Fig.4.. These curves represent projections of isotope trajectories on the plane ($r\alpha$). If azimuthal angle of a start of isotopes from the source to accept equal to zero, irrespective of sign d_r and d_z at $d_a > 0$ an isotope will move in a plane ($r\alpha$) in the direction of unit vector $\vec{e}_a$ (increment of an angle a is positive at change r), at $d_a < 0$ -against a direction unit vector $\vec{e}_a$ (increment of an angle a is negative at change r). Both curves are mirrorly symmetric to each other, as it is visible on Fig.3 and Fig.4.

Represented on Fg.1-4 trajectories enable to choose optimum position for receivers of separating isotope beams. From Fig. 1 follows, that the isotopes ^{6}Li are focused near the point $x = 1{,}02$; $z = 16{,}66$. At $a = 11{,}6$ ñm. it corresponds to coordinates $r = 11{,}88$ ñm, $z = 193{,}2$ ñm. On Fig.3 at $x \approx 1$ have $\alpha \approx 0{,}3$. Thus, the centre of ring of the receiver for ions ^{6}Li has coordinates (at $a = 11{,}6$ cm): $r \approx 11{,}9$ cm, $z \approx 193$ cm and angular size - $-0{,}3 \le \alpha \le 0{,}3$ at $-0{,}02 \le d_a \le 0{,}02$ (the isotopes which taken of from a source with $d_a = 0$ in the plane $\alpha = 0$, will fly further in the plane $\alpha = 0$).

By analogy from same Fig.1 and Fig.3 we find, that the centre of ring of the receiver for ions ^{7}Li has coordinates $x = 0{,}63$ ($r = 7{,}3$ ñm), $z = 11{,}2$ ($z = 129{,}7$ ñm) and angular size - $-0{,}52 \le \alpha \le 0{,}52$ at $-0{,}02 \le d_a \le 0{,}02$.

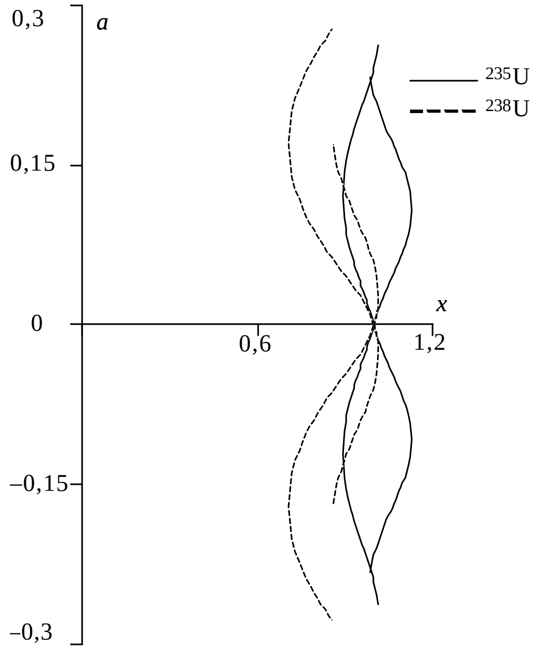

Fig.4-The trajectories of singly charged ^{235}U and ^{238}U ions in the plane (ra). The left isotopes trajectories are obtained at $d_r = d_z = -2{,}5 \cdot 10^{-3}$, right - at $d_r = d_z = 2{,}5 \cdot 10^{-3}$

From Fig.2 and Fig.4 we find, that $a = 6{,}65$ cm, $|d_a| \le 2{,}5 \cdot 10^{-3}$ the centre of ring of the receiver for ions ^{235}U has $x = 1{,}02$ ($r = 6{,}75$ ñm), $z = 60$ ($z = 399$ ñm), and angular size - $0{,}23 \le \alpha \le 0{,}23$, and for ions ^{238}U - $x = 0{,}84$ ($r = 5{,}59$ ñm), $z = 70$ ($z = 465{,}5$ ñm) and $-0{,}28 \le \alpha \le 0{,}28$.

We see, that the account of movement of isotopes in the plane (ra) results in the final angular sizes separating of ions beams and, respectively, requires the final angular sizes of ring of receivers of these beams. It is important that this movement does not influence on trajectories in the plane (rz) (see Fig.1, 2) and, therefore, an efficiency of isotope separating on coordinates r and z does not break.

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