RADIAL ACCELERATION AND CUMULATION OF IONS BY AN INTENSE CONVERGING RING LASER PULSE

V.A. Balakirev, I.N. Onishchenko, A.I. Povrozin, A.P. Tolstoluzhsky, A.M. Yegorov
National Science Center "Kharkov Institute of Physics and Technology", Kharkov, Ukraine
E-mail: onish@kipt.kharkov.ua

Cumulation dynamics and acceleration of deuterium plasma ions by a focused ring laser pulse of the femtosecond duration are theoretically investigated. Laser pulse is focused by a dielectric lens. The spatial structure of ring laser pulse field in the vicinity of the lens focus is determined. The values of cumulation coefficient of ions, their energy, and cumulation region dimensions are obtained. Conclusions are made about the possibility of the neutron source elaboration on considered cumulation principle.

PACS: 41.75.Jv; 42.60.-v; 52.38.Kd;

INTRODUCTION

Development of a compact bright neutron sources is an actual problem of modern nuclear physics. Such sources can be used in crystal material spectroscopy, for nuclear reactions initiation, isotope production and other applications.

In [1] the method of neutron production based on the effect of dense plasma ions cumulation under influence of a focused ring laser pulse has been proposed and in [2] it was applied for so called "light trap". The essence of this method is following. Under the action of ponderomotive force on plasma electrons a charge separation in radial direction occurs. Arisen electric field of the space charge imposes to plasma ions (e.g., deuterons) the radial momentum, directed to the axis of the system. The high increase of the ion density in the axis region and ions acceleration induces thermonuclear flash along with intensive neutron flux.

In the present work the cumulation effect and acceleration of ions by the ring laser pulse focused by the lens is theoretically investigated. The work consists of two sections. In the first section a ring laser pulse focusing process of the femtosecond range duration by the double-convex lens is considered. It is shown that in the vicinity of the focal plane, as a result of diffraction divergence of the ring wave beam, the transformation of the ring wave beam into the pulse with approximately Gaussian transversal distribution of the intensity takes place. Such complicated structure of the laser pulse wave beam results in a number of peculiarities of radial cumulation process and ions acceleration by the focused laser pulse.

The second section is devoted to the study of the ion cumulation dynamics created by the focused ring laser pulse. The degree of ion cumulation in the axes region and ion energy is determined. In comparison with our previous paper [3] the effect of ions acceleration out of focal region is investigated too.

1. FIELD OF RING LASER PULSE FOCUSING BY DIELECTRIC LENS

A laser pulse is incident on thin bifocal lens with the material permittivity ε. We will describe the pulse electromagnetic field by scalar function $u(x,y,z,t)$ which can be one of electromagnetic field component. Directly before lens the function u is represented as

$$u(x_0,y_0,z=0,t)=u_0\Psi(t)\Phi(x_0,y_0)\,, \qquad (1.1)$$

where $\Psi(t)=F(t/t_L)\cos\omega_0 t$ describes dependence in time of the pulse laser field, function $F(t/t_L)$ is the pulse laser envelope, ω_0 is the carrier frequency, t_L is the characteristic pulse duration, $\Phi(x_0,y_0)$ is the function describing transversal field distribution directly immediately before lens.

According to the Fourier-transform formalism instead of (1.1) we have

$$u_\omega(x_0,y_0,0)=u_0\hat{\Psi}(\omega)\Phi(x_0,y_0)\,,$$

where

$$\hat{\Psi}(\omega)=\int_{-\infty}^{\infty}F(t/t_L)\cos(\omega_0 t)e^{i\omega t}dt\,, \qquad (1.2)$$

and

$$u(x_0,y_0,0,t)=u_0\Phi(x_0,y_0)\frac{1}{2\pi}\int_{-\infty}^{\infty}\hat{\Psi}(\omega)e^{-i\omega t}dt \qquad (1.3)$$

A thin spherical lens as a phase corrector [3] is considered. Then the field after lens can be expressed as

$$u_\omega(x_0,y_0,d)=\hat{T}u_\omega(x_0,y_0,0)\,,$$

where $\hat{T}=e^{ik_0nd-i\frac{k_0}{2f}r_0^2}$, $r_0=\sqrt{x_0^{\,2}+y_0^{\,2}}$, d is the maximal lens thickness, $n=\sqrt{\varepsilon}$, $k_0=\omega/c$, c is light velocity, f is the focal lens distance.

The field over the space after the lens can be expressed through the Green function

$$u_\omega(x,y,z)=\int_S dx_0dy_0u_\omega(x_0,y_0,d)G_\omega(x-x_0,y-y_0,z)\,. \qquad (1.4)$$

Here

$$G_\omega(x-x_0,y-y_0,z)=\frac{k_0}{2\pi iz}e^{ik_0z+i\frac{k_0}{2z}[(x-x_0)^2+(y-y_0)^2]}$$

is Green function of the parabolic equation [3]. Pass in (1.4) into cylindrical system of coordinates. As result instead of (1.4) we obtain

$$u_\omega=u_0\frac{k_0}{iz}\hat{\Psi}(\omega)e^{ik_0(z+nd)+ik_0\frac{r^2}{2z}}\int_0^a r_0dr_0\Phi(r_0)J_0(\frac{k_0rr_0}{z})e^{i\frac{k_0r_0^2}{2\zeta}}\,, \qquad (1.5)$$

where a is the lens radius, $\frac{1}{\zeta}=\frac{1}{z}-\frac{1}{f}$.

Accordingly for the field of laser pulse we have the following expression

$$u(r,z,t)=\frac{u_0}{2\pi icz}\int_{-\infty}^{\infty}\omega d\omega\widehat{\Psi}(\omega)e^{-i\omega T}\int_0^a r_0dr_0\Phi(r_0)J_0(\frac{k_0rr_0}{z})e^{i\frac{k_0r_0^2}{2\zeta}},$$

$T=t-\frac{1}{c}(z+nd)-\frac{r^2}{2zc}$. For the pulse with Gaussian envelope $F(t/t_L)=\exp(-t^2/t_L^2)$ we have

$$\widehat{\Psi}(\omega)=\frac{\sqrt{\pi}}{2}t_L[e^{-\frac{1}{4}(\omega-\omega_0)^2t_L^2}+e^{-\frac{1}{4}(\omega+\omega_0)^2t_L^2}].$$

Let's consider the following model transversal profile of the ring laser pulse

$$\Phi(r_0)=e^{-r_0^2/r_1^2}-e^{-r_0^2/r_2^2},\ r_1\succ r_2.$$

This function turns to zero at $r=0$ and reaches the maximal values at the point

$$r_{\max}=r_2\sqrt{\frac{\ln(1/s^2)}{1-s^2}},\ s=r_2/r_1.$$

Edge effects caused by lens aperture finiteness, can be neglected if $a\gg r_1$. In this limit case in the integral (1.5), the upper limit can be replaced with the infinity. As a result we obtain the standard integral, which calculation gives the following expression for the laser pulse field

$$u(r,z,t)=\frac{u_0}{4\pi icz}\int_{-\infty}^{\infty}\omega d\omega\widehat{\Psi}(\omega)B(\omega,r,z)e^{-i\omega T},\ (1.6)$$

where

$$B(\omega,r,z)=\frac{r_1^2}{1-il_1/\zeta}e^{-\frac{l_1^2}{z^2}\frac{r^2}{r_1^2}\frac{1}{1-il_1/\zeta}}-\frac{r_2^2}{1-il_2/\zeta}e^{-\frac{l_2^2}{z^2}\frac{r^2}{r_2^2}\frac{1}{1-il_2/\zeta}},$$

$$l_{1,2}=k_0r_{1,2}^2/2.$$

Further we explore the expression for the laser pulse field. First of all we shall note that at the focal plane case $z=f$ the integral (1.6) can be calculated exactly. Accordingly, for the laser pulse field we have the following expression

$$u(z=f,r,t)=\frac{u_0}{\omega_0}\frac{d}{dt}\left[\frac{l_1}{f}\frac{t_L}{\tau_1}e^{-\frac{l_1^2}{f^2}\frac{t_L^2}{\tau_1^2}\frac{r^2}{r_1^2}-\frac{T^2}{\tau_1^2}}\cos(\omega_0T\frac{t_L^2}{\tau_1^2})-\frac{l_2}{f}\frac{t_L}{\tau_2}e^{-\frac{l_2^2}{f^2}\frac{t_L^2}{\tau_2^2}\frac{r^2}{r_2^2}-\frac{T^2}{\tau_2^2}}\cos(\omega_0T\frac{t_L^2}{\tau_2^2})\right].\ (1.7)$$

Here $\tau_{1,2}^2=t_L^2+r^2r_{1,2}^2/c^2f^2$.

For paraxial region $t_Lcf/r_1\gg r$ expression for the pulse field (1.7) is simplified. As a result for averaging over carrier frequency intensity $I=\langle u^2\rangle$ we find

$$I=I_0e^{-2\frac{T^2}{t_L^2}}F(r),$$

$$F(r)=\left(\frac{l_1}{f}e^{-\frac{l_1^2}{f^2}\frac{r^2}{r_1^2}}-\frac{l_2}{f}e^{-\frac{l_2^2}{f^2}\frac{r^2}{r_2^2}}\right)^2.\ (1.8)$$

The function $I(r)$ has two maxima at points

$$r_{\max 1}=0,I(0)=I_0\frac{l_1^2}{f^2}(1-s^2)^2,$$

$$r_{\max 2}=\sqrt{2}r_*,r_*=\frac{2f}{k_0r_1}\sqrt{\frac{\ln(1/s^2)}{1-s^2}},I(r_{\max 2})=I_0\frac{l_1^2}{f^2}s^{-4}e^{-4\frac{\ln(1/s^2)}{1-s^2}}$$

and one minimum at the point

$$r_{\min}=0,I(r_{\min})=0.$$

The ratio of maximal intensity values is equal to

$$\frac{I(0)}{I(r_{\max 2})}=s^4e^{4\frac{\ln(1/s^2)}{1-s^2}}\gg 1.$$

The value of intensity in the first maximum always exceeds intensity of the second maximum. Thus, originally ring laser pulse in the focal plane is transformed into a continuous pulse.

For the quasi-monochromatic laser pulse

$$\omega_0t_L\gg 1\qquad(1.9)$$

integral (1.6) can be calculated approximately and in that way to find the pulse field distribution all over the space. For this purpose we transform the integral (1.6) to the form

$$u=\frac{u_0}{4\pi cz}\frac{dS}{dt},$$

$$S=\frac{\sqrt{\pi}}{2}t_L\int_{-\infty}^{\infty}e^{-i\omega T-\frac{1}{4}\omega^2t_L^2}Q(\omega,r,z,t)d\omega,\quad(1.10)$$

$$Q(\omega,r,z,t)=e^{-i\omega_0T}B(\omega+\omega_0,r,z)+e^{i\omega_0T}B(\omega+\omega_0,r,z).$$

The main contribution to the integral (1.10) gives the vicinity of the point $\omega=0$. The approximate calculation of the integral in this limit case gives the following expression

$$S(r,z,t)=\pi Q(0,r,z,t)=e^{-i\omega_0T}B(\omega_0,r,z)+e^{i\omega_0T}B^*(\omega_0,r,z).$$

In the limit case (1.9) for laser pulse intensity we have the following expression

$$I(r,z,t)=I_0e^{-2T^2/t_L^2}F(r,z),\qquad(1.11)$$

$$F(r,z)=\left\{(1+\frac{l_1^2}{\zeta^2})R_1^2+(1+\frac{l_2^2}{\zeta^2})R_2^2-2R_1R_2\left[(1+\frac{l_1}{\zeta}\frac{l_2}{\zeta})\cos(\theta_1-\theta_2)+(\frac{l_1}{\zeta}+\frac{l_2}{\zeta})\sin(\theta_1-\theta_2)\right]\right\},$$

$$R_\alpha=\frac{l_\alpha}{z}\frac{1}{1+l_\alpha^2/\zeta^2}e^{-\frac{\rho_\alpha^2}{1+l_\alpha^2/\zeta^2}},\ \rho_\alpha=\frac{l_\alpha}{z}\frac{r}{r_\alpha},$$

$$\theta_\alpha=\rho_\alpha^2\frac{l_\alpha/\zeta}{1+l_\alpha^2/\zeta^2},\ \alpha=1,2.$$

At the focal plane $z=f$, from expression (1.11) the expression (1.8) follows. Let's analyze obtained expression for some limit cases. First of all we will give distribution of laser pulse intensity along the axis of the system $r=0$

$$I=I_0e^{-2T^2/t_L^2}\frac{z^2(l_1-l_2)^2}{(z^2+l_1^2\Delta z^2/f^2)(z^2+l_2^2\Delta z^2/f^2)},\ (1.12)$$

$$\Delta z=f-z.$$

The intensity increases on the axis and reaches maximum value in the focus $z=f$.

Far from the focus

$$|\Delta z|\gg 2zf/k_0r_2^2\qquad(1.13)$$

spatial distribution of the intensity is described by the expression

$$I(r,z,t) = I_0 e^{-2T^2/t_L^2} F(r,z),$$
$$F(r,z) = \frac{f^2}{\Delta z^2}\left(e^{-\frac{r^2}{r_1^2}\frac{f^2}{\Delta z^2}} - e^{-\frac{r^2}{r_2^2}\frac{f^2}{\Delta z^2}}\right)^2. \qquad (1.14)$$

In the space region given by (1.13) focusing of the pulse occurs with the initial ring configuration. The ring pulse radius decreases with approaching towards the focus according to the low

$$r_{\max} = |\Delta z| \frac{r_2}{f}\sqrt{\frac{\ln(1/s^2)}{1-s^2}}.$$

Note that the laser pulse energy flow in the process of focusing is conserved

$$\int_0^\infty r dr I(r,z,t) = \int_0^\infty r dr I(r,z=0,t).$$

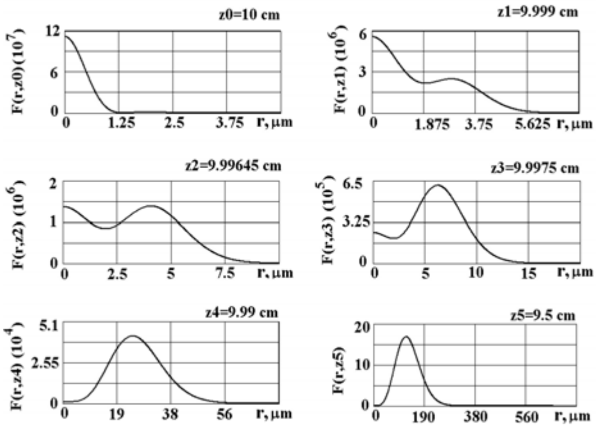

Fig.1. Radial profiles of laser pulse

Fig.1 shows radial laser pulse profiles at different distances from the focus, calculated using the formula (1.11). Numerical calculations were performed for the lens with the focal distance f=10 cm, laser pulse wavelength $\lambda = 1.05\mu m$, and geometrical parameters $r_1 = 3$ cm, $r_2 = 2$ cm.

In the plane of the lens $(z = 0)$ the radius of ring laser pulse is $r_{\max} = 2.4$ cm. According to the formula (1.14), at large distances from the focus the pulse has a ring transversal structure (Fig.1,z4,z5). With approaching to the focus, diffraction diffusion of the ring pulse increases and, it transforms gradually into a continuous pulse. According to formula (1.8), in the focal plane $z = f$ (Fig.1,z0) near the axis region the transversal pulse profile has a similar to the Gaussian shape.

Fig.2 shows longitudinal coordinate intensity dependences for various radius values. Near the axis region (Fig.2,r0,r1), in the focus, the intensity increases greatly. With moving away from the axis in a focal plane, intensity minimum is formed (Fig.2,r2,r3). With moving away from the axis in a focal plane, intensity minimum is formed (Fig.2,r2,r3). The curve of the longitudinal coordinate intensity dependence is two-humped one. For the large radius values (Fig.2,r4,r5) in the focus region the intensity decreases practically to zero.

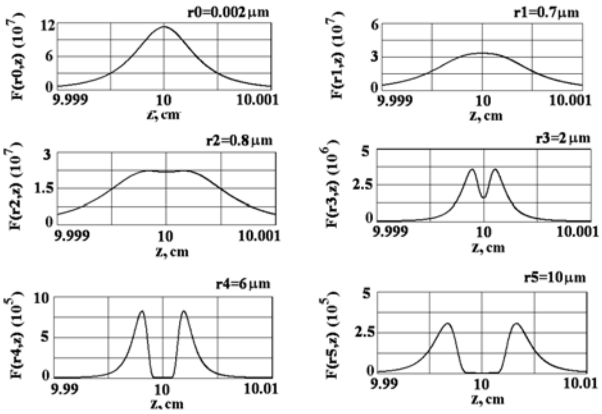

Fig.2. Longitudinal distribution of the intensity

2. ION CUMULATION BY RING LASER PULSE

Let's consider cumulation of ions by the focused ring laser pulse in the uniform homogeneous cylindrical plasma column, located symmetrically to the right and left side of the lens focus. Axes of the plasma column and the lens coincide.

In the previous section it has been shown that the laser pulse conserves its original ring profile in the focal region at distances from the focus $|\Delta z| \ll f^2\lambda/(\pi r_2^2)$. For the given lens and laser pulse parameters this inequality is equivalent to the inequality $|\Delta z| \ll 6\mu m$. In this area the transversal laser pulse structure is more favorable for the paraxial cumulation of ions. The intensity maximum is located on the axis, near the focus; therefore defocusing force will influence on plasma electrons and accordingly also on plasma ions, removing plasma from the axis to the periphery.

Under the laser pulse influence, the ponderomotive force will affect plasma electrons

$$\vec{F}_p = -mc^2\nabla\Phi_p,$$

where m is the electron mass, $\Phi_p = \sqrt{1 + a^2/2}$ is the ponderomotive potential, $a^2 = e^2 I/(mc\omega)^2$. A numerical value of the dimensionless value a can be written down in the form $a = 0.85\cdot 10^{-9}\lambda(\mu m)\sqrt{I(W/cm^2)}$. Under the influence of the ponderomotive forces in plasma the displacement of electrons relatively to ions will occur. As a result, in plasma the polarization electric field $\vec{E}$ will arise. The equation of motion for plasma electrons has the form

$$\frac{d\vec{p}_e}{dt} = -e\vec{E} - mc^2\nabla\Phi_p,$$

where $\vec{p}_e$ is the electron momentum. In the electric field of the space charge plasma ions will begin to move too. We have the following equation of motion for ions

$$M\frac{d\vec{v}_i}{dt} = e\vec{E},$$

M is the ion mass, $\vec{v}_i$ is their velocity. Plasma electrons will be in equilibrium state at the polarized electric field value

$$\vec{E} = -\frac{mc^2}{e}\nabla\Phi_p .$$

Correspondingly, the equation of motion of ions in this approximation has the form [1]

$$\frac{d\vec{v}_i}{dt} = -\frac{m}{M}c^2\nabla\sqrt{1+a^2/2}. \qquad (2.1)$$

Thus, the laser pulse influences on plasma ions through the space charge field, arising as a result of a charge separation in plasma.

Taking into account the very short time of the laser pulse action on ions, the displacement of ions can be neglected. In this approximation the ions acquire finite velocity, and then they move uniformly and rectilinearly by inertia. Integrating the equations of motion over the time of the laser pulse influence, we find velocity, acquired by the ions during the pulse propagation [2]

$$v_{ir} = -\frac{m}{2M}c^2\sqrt{\frac{\pi}{2}}t_L a_0^2\frac{\partial F(r_0,z_0)}{\partial r_0},$$

$$v_{iz} = -\frac{m}{2M}c^2\sqrt{\frac{\pi}{2}}t_L a_0^2\frac{\partial F(r_0,z_0)}{\partial z_0}, \qquad (2.2)$$

where r_0, z_0 are the initial coordinate values. These relations for velocity components are obtained for a comparatively low laser intensity $a^2/2 \ll 1$. In the opposite limit case $a^2/2 \gg 1$ instead of (2.2) we have

$$v_{ir} = -\frac{m}{M}c^2\sqrt{\frac{\pi}{2}}t_L a_0\frac{\partial\sqrt{F(r_0,z_0)}}{\partial r_0},$$

$$v_{iz} = -\frac{m}{M}c^2\sqrt{\frac{\pi}{2}}t_L a_0\frac{\partial\sqrt{F(r_0,z_0)}}{\partial z_0}. \qquad (2.3)$$

Cumulation process and acceleration of deuterium ions by the focused ring laser pulse were investigated numerically by solution of motion equation for ions (2.1).

The calculated plasma region is shown in Fig.3 ($\tau = 0$). Left boundary of the area is at the distance of 39 μm from the focus, the region length is 13 μm, and its radius is 12.7 μm. Deuterium plasma of density ~10^{20}cm^{-3} is simulated by $N_i = 2.3\cdot10^5$ ion macroparticles. Ions were placed in the calculated region accordingly to the random low. Each red and blue point in Fig.3 ($\tau = 0$) corresponds to the initial position of ions. Laser pulse parameters are as follows: wavelength $\lambda = 1.05\,\mu m$, pulse duration $t_L = 400 fs$, $r_1 = 3cm$, $r_2 = 2cm$. Maximum power density of the laser radiation at the entrance plasma boundary is $I_{\max} = 1.2\cdot10^{19} W/cm^2$, i.e. the laser pulse parameter is $a \approx 4.7$.

Fig.3 shows ion planes r, z at the different points of dimensionless time $\tau = t/t_L$. At first in plasma the thin compacting shell of conical configuration is formed, which moves to the system axis and at moment $\tau = 5.806$ it reaches the left plasma boundary, where laser pulse is the most focused. The radial size of cumulation region is equal to one micron. Further, the ions reach the axis, and begin to move away in the radial direction, and the cumulation region spreads into plasma.

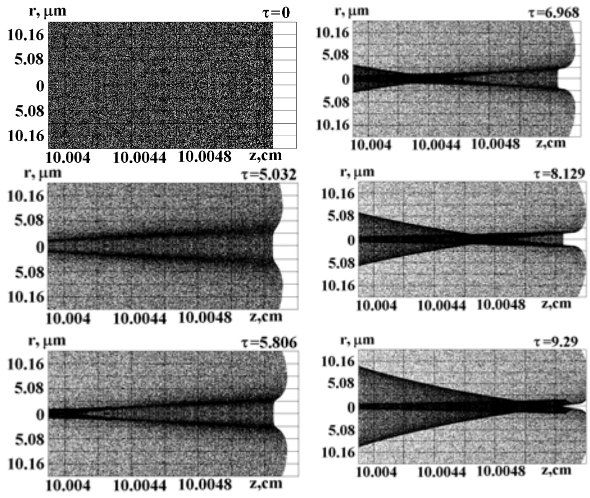

Fig.3. Ion plane r, z at different moment of dimensionless time

In other words, the laser pulse divergence results in a cumulation wave formation in plasma, which moves along the longitudinal direction of the field decreasing. With the wave propagation its velocity decreases. It is caused, firstly, by decreasing of radial ion velocity during removing apart from the left plasma boundary and, secondly, by increasing of shell radius. It should be note that the longitudinal movement of ions is very slow and practically it does not influence on radial cumulation.

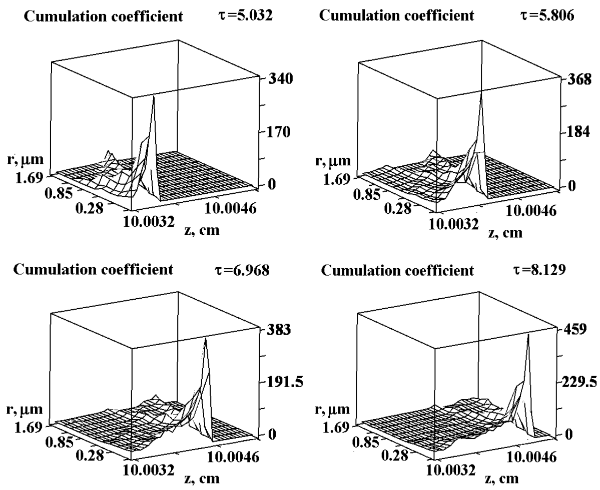

Fig.4. Distributing of cumulation ion factor in plane r , z at different moments of time

Fig.4 shows the coordinates $K(r,z)$ dependences of the cumulation coefficient at various points of time. The cumulation coefficient was determined as a ratio of ion density at the current moment of time at given point to the initial density. It is seen from the figures that in complete accordance with previous Fig.3 the effective cumulation region moves deep into plasma. At the same time the peak value of cumulation coefficient increases in the process of cumulation wave propagation deep into plasma. It is caused by increase of the ring laser pulse radius, and consequently the number of ions entrained in the process of ionic shell cumulation is increased too.

As for the ion energy in the cumulation region (see Fig.5) it is decreases continuously with time. Thus, if at the moment of time $\tau = 5.032$ maximal ion energy value equals to about 230 keV at the cumulation coefficient value $K = 340$, then at the moment of time $\tau = 8.129$ ion energy decreases to 100 keV with cumulation coefficient increase up to the value of $K = 460$.

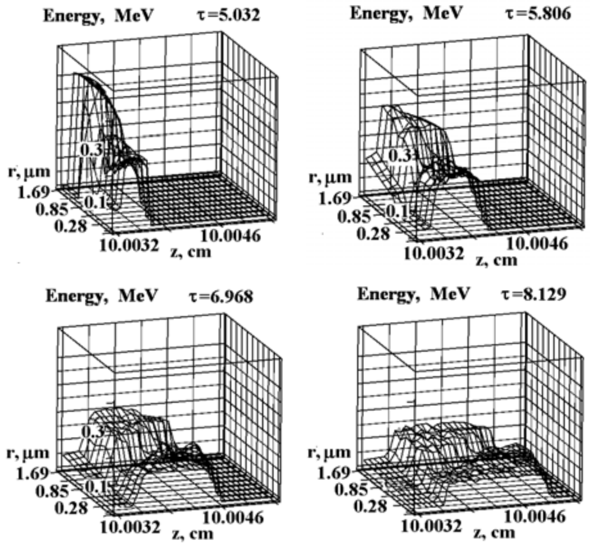

Fig.5. Distributing of ion energy in plane r , z at different moments of time

As it follows from the relations (2.2) and (2.3) radial ion velocity and consequently energy too, is proportional to the influencing force. Since after the lens the ring pulse radius increases quickly then the radial force and consequently accelerated ion energy decreases.

3. IONS ACCELERATION IN THE FOCAL REGION

Let's examine now a case, when the region in the vicinity of the dielectric lens focus, i.e. $f + L \le z \le f - L$ ($2L$ = 80μ is the length of the focal region), is also included into consideration. The numerical analysis of ions dynamics in the laser pulse field have been examined for $f + L_p \le z \le f - L_p$, where $2L$ = 120 μ is the length of the plasma column. In Fig.6 the obtained configurational space (r_i, z_i) is shown for the various moments of time.

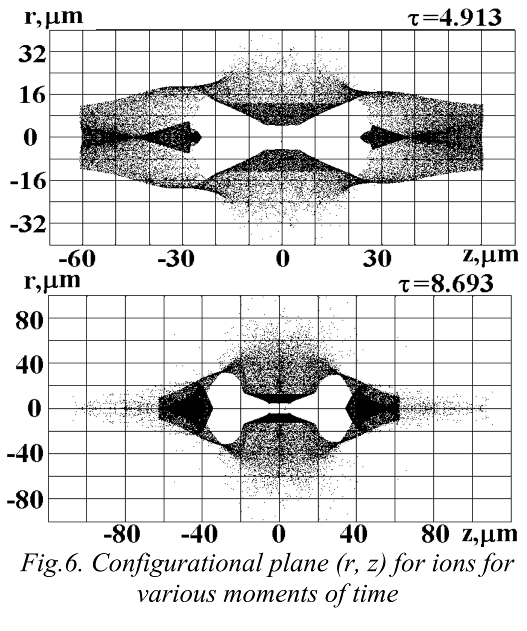

Fig.6. Configurational plane (r, z) for ions for various moments of time

In the focal region, ions are experienced strong defocusing radial and longitudinal forces. Action of these forces leads to leaving of ions from the focal region (Fig.6, τ = 4.913). As a result a cavity is formed in plasma. Further the size of the cavity increases (Fig.6, τ = 8.693). Ions, which initially were located in the vicinity of the focal plane, are experienced strong acceleration in radial direction. So the energy of a main bulk of ions reaches 6 MeV. A small group of ions gains energy up to 23 MeV. It should be noted, that, as it is shown in the previous section, far enough from the focal plane, where the laser pulse has ring radial structure, cumulation of ions and their radial acceleration directed to plasma column axis takes place.

CONCLUSIONS

The cumulation of deuterium ions and ion acceleration process induced by the femtosecond focused laser pulse was investigated. Focusing is accomplished by the means of double-convex lens. By the solution of the corresponding quasioptical problem the spatial distribution of intensity after the lens was obtained. It was shown that when the ring laser pulse approaches to the lens focus it is transformed to the pulse with transversal profile that is similar to the Gaussian one. The effective ion cumulation region was determined.

The results of the numerical simulation of the ion cumulation process in plasma located near the lens focus are presented. Divergence (convergence) of the focused laser pulse results in a cumulation wave formation in plasma, which propagates in the direction of the pulse intensity decrease.

The cumulation coefficient increases when cumulation wave propagates deep into plasma, and maximal ion energy in the cumulation region decreases. The obtained cumulation coefficient and ion energy values give the basis for the development of a compact neutron sources based on a nuclear fusion reaction in effective ion cumulation region. The main feature of the proposed neutron source is the removability of the neutron generation region in plasma volume.

In the focal region, strong defocusing radial and longitudinal forces influence on ions, that leads to leaving of ions from the focal region and to formation a cavity in plasma.

REFERENCES

1. G.S. Sarkisov, V.Yu. Bychenkov, V.T. Tichonchuk, et al. // *JETP Letters*. 1999. v.69, №1, p.20.
2. V.A. Balakirev, A.N. Dovbnya, A.M. Yegorov, et al. // *Problems of Atomic Science and Technology. Series «Nucl. Phys. Investigations» (42)*. 2004, №1, p.41-44.
3. V.A. Balakirev, I.N. Onishchenko, A.I. Povrozin, A.P. Tolstoluzhsky A.M. Yegorov // *Problems of Atomic Science and Technology. Series «Nucl. Phys. Investigations» (50)*. 2007, №5, p.126-130.
4. B.Z. Katsenlenbaum. *High-frequency electrodynamics*. M.: "Nauka", 1966.

Статья поступила в редакцию 27.05.2008 г.

РАДИАЛЬНОЕ УСКОРЕНИЕ И КУМУЛЯЦИЯ ИОНОВ ПРИ ВЗАИМОДЕЙСТВИИ С ПЛАЗМОЙ ФОКУСИРУЕМОГО КОЛЬЦЕВОГО ЛАЗЕРНОГО ИМПУЛЬСА

В.А. Балакирев, И.Н. Онищенко, А.И. Поврозин, А.П. Толстолужский, А.М. Егоров

Исследована динамика кумуляции и ускорения ионов дейтериевой плазмы сфокусированным кольцевым лазерным импульсом фемтосекундной длительности. Определена пространственная структура поля кольцевого лазерного импульса в окрестности фокуса линзы. Получены значения коэффициента кумуляции ионов, их энергии и размеры области кумуляции. Сделаны выводы относительно возможности разработки нейтронного источника, основанного на рассматриваемом принципе кумуляции.

РАДІАЛЬНЕ ПРИСКОРЕННЯ І КУМУЛЯЦІЯ ІОНІВ ПРИ ВЗАЄМОДІЇ З ПЛАЗМОЮ ФОКУСУЄМОГО КІЛЬЦЕВОГО ЛАЗЕРНОГО ІМПУЛЬСУ

В.А. Балакірєв, І.М. Онищенко, А.І. Поврозін, О.П. Толстолужський, О.М. Єгоров

Досліджена динаміка кумуляції і прискорення іонів дейтерієвої плазми сфокусованим кільцевим лазерним імпульсом фемтосекундної тривалості. Визначена просторова структура поля кільцевого лазерного імпульсу поблизу фокуса лінзи. Отримані значення коефіцієнта кумуляції іонів, їх енергії та розміри області кумуляції. Зроблені висновки відносно можливості розробки нейтронного джерела на принципі кумуляції, що розглядається.