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Flux of multiple charged metal ions from plasma of a low voltage laser-induced vacuum discharge

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The process of ions emission from the plasma of the fast laser-induced vacuum discharge has been studied experimentally. Parameters of the discharge with the aluminum cathode were as follows, current amplitude was up to 1.7 kA, current rise rate was near 7.5×10^{9} A/s and the capacitor voltage was of 2.3 kV. The discharge has been induced by the laser pulse with duration 30 ps, energy less than 10 mJ and power density of 5×10^{11} W/cm^2 which irradiates the cathode.

The discharge was shown to be an effective source of accelerated and highly charged ions of the cathode material. The aluminum ions production has been observed definitely at the instant when the discharge current rise rate attains its peak and the plasma pinching occurs at the front of the cathode jet expanding into the inter-electrode gap. Ion energy distributions were characterized by the presence of a significant non-Maxwellian tail of the accelerated ions. The typical maximum ion charge and energy per a charge unit were equal to +8 and 14 keV/Z, respectively. The energy of ions exceeded the potential of current source for the value of not less than 5Z times.

The performed qualitative analysis of ion beam characteristics under the conditions of initiating laser pulse energy variation has shown that formation of the micro-pinch structures in the cathode plasma jet (achievable by means of optimizing the laser pulse energy) enhances the maximum charge of the beam ions. The exceeding of average energies of the ions emitted from the discharge plasma over the average energies of ions emitted from the laser produced plasma (without discharge) under the essentially more powerful laser irradiation of aluminum target (27 ps, 400 mJ, 2×10^{13} W/cm^2) has been shown. Furthermore, discharge ions energies are comparable with the maximum ion energies observed in this kind of laser produced plasma.

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Effect of magnetic field on ablatively driven Richtmyer – Meshkov instability induced by interfacial nonlinear structure

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In an Inertial Confinement Fusion (**ICF**) situation, laser driven ablation front of an imploding capsule is subjected to the fluid instabilities like Rayleigh-Taylor (RT), Richtmyer-Meshkov (RM) and Kelvin-Helmholtz (KH) instability. In this case dense core is compressed and accelerated by low densityablating plasma. During this process laser driven shocks interact the interface and hence it becomes unstable due to the formation of nonlinear structure like bubble and spike. The nonlinear structure is called bubble if the lighter fluid pushes inside the heavier fluid and spike, if opposite takes place. R-M instability causes non-uniform compression of ICF fuel pellets and needs to be mitigated. Scientists and researchers are much more interested on RM instability both from theoretical and experimental points of view. In this article, we have presented the analytical expression for the growth rate and velocity for the nonlinear structures due to the effect of magnetic field of fluid using potential flow model [1]. The magnetic field is assumed to be parallel to the plane of two fluid interfaces. If the magnetic field is restricted only to either side of interface the R-M instability can be stabilized or destabilized depending on whether the magnetic pressure on the interface opposes the instability driving shock pressure or acts in the same direction. An interesting result is that if both the fluids are magnetized, interface as well as velocity of bubble and spike will show oscillating stabilization and R-M instability is mitigated. All analytical results are also supported by numerical results. Numerically it is seen that magnetic field above certain minimum value reduces the instability for compression the target in ICF.

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Laser induced ablatively driven interfacial nonlinear fluid instabilities in multilayer targets

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High power laser driven shock waves in condensed matter have important application for studying equation of state (EOS) and high pressure physics. This is an important phenomenon in fuel compression for Inertial Confinement Fusion (ICF) experiments where multilayer targets of differing shock impedance are interacted by laser induced shocks. The interface between the two fluid becomes unstable when driven by the impulsive force (Richtmyer-Meshkov) due to such a shock wave or a continuously acting force e.g., gravity (Rayleigh-Taylo). In the nonlinear stage, the fluid interface is found to develop structures having finger-like shapes. The structures resemble a bubble (spike) accordingly as a lighter (heavier) fluid pushes in a heavier (lighter) fluid. These effects need to be mitigated for efficient compression in ICF experiment. We have studied the effect of density variation on R-T and R-M instability on the temporal development of nonlinear two fluid interfacial structures like bubble and spike. It is shown that the velocity of bubble or spike decreases leading to stabilization if the density of the fluids leads to lowering of the Atwood number. The Atwood number $A = \dfrac{\rho_a - \rho_b}{\rho_a + \rho_b}$ changes to $A^* = \dfrac{\rho_a^* - \rho_b^*}{\rho_a^* + \rho_b^*}$ where $\rho_m^* = \rho_m\left(1 - \dfrac{1}{\gamma_m}\right)$, $m = [a, b]$, assuming $\rho_a > \rho_b$.

It has been seen that the stabilization or destabilization (depending on the algebraic sign of the gradient) will be proportional to the pressure p_0 at the interface [1].

The set of equation describing the dynamics of the bubbles and spikes in presence of fluid density variation are not analytically intergrable in closed form. All the results are derived by numerical methods and are represented and interpreted. Analytical calculations are performed (not presented here) to modify the dynamical boundary condition between the two fluids and we have finally arrived at the following expression for the asymptotic bubble velocity $v_b^2 = \dfrac{2(r^*-1)}{3r^*} gk + \left(\dfrac{\alpha}{3}\sqrt{\dfrac{C_{a0}C_{b0}}{(\gamma_a - 1)(\gamma_b - 1)}}\dfrac{\sqrt{r^*}}{\gamma_a} KL\right)$; where $r^* = \dfrac{\rho_a^*}{\rho_b^*}$,

k = wave number,

g = gravity factor.

Here L denotes the density gradient inhomogeneity scale length and L>0 or <0 accordingly as density is increasing or decreasing while $\sqrt{C_{a0}C_{b0}}$ is proportional to p_0 and $\alpha = 0(1)$ $[C_{a0} = \gamma_a p_0 / \rho_a]$. Clearly instability is reduced if the bracketed term is negative. The opposite occurs when it is positive.

We have obtained the conditions for stabilization of the fluid instabilities for various conditions of density variations of heavier fluid and or lighter fluid. It is interesting to note that compression of lighter fluid and decompression of heavier fluid leads to stabilize the two fluid interfaces which is desirable for ICF target design.