Laboratory astrophysics based on nuclear burning at the deep potential well of virtual cathode at nanosecond vacuum discharge

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Neutrons from DD microfusion at the interelectrode space of a table-top low energy nanosecond vacuum discharge (NVD) with deuterium-loaded Pd anode has been demonstrated earlier [1]. The particle-in-cell (PIC) simulation of the discharge experimental conditions have been developed using a fully electrodynamic code. The principal role of virtual cathode(VC) and the corresponding deep quasistationary potential well (PW) formed in the interelectrode space are recognized [2]. PIC modeling allowed to identify the scheme of small-scale experiment as variant of inertial electrostatic confinement fusion (IECF) [3-5]. Deuterons are accelerating at PW up to the energies of few tens keV that provides DD nuclear synthesis under their head-on collisions (at the moments of deuteron collapses at PW bottom). In particular, ions in the potential well may undergo high frequency (~80 MHz) harmonic oscillations ( like POPS [5]) accompanied by a corresponding regime of oscillatory DD neutron yield [6]. Ironically, the presented IECF scheme that heats ions to thermonuclear temperatures during the compression phase also cools them to cryogenic temperatures when the plasma expand and become strongly nonideal one [5]. Meanwhile, the data accumulated along experiment with NVD with deuterium-loaded Pd anode allow to assume that nuclear burning at PW imitates some features of stellar nucleosynthesis also. In fact, any ions of other elements like He, C, O, Si (main elements of different shells in the star) even with low charges Z being placed at PW edge have to be accelerated also up to the head-on collisions energies which are corresponding formally to the temperatures of ignition Tign ~ 1 -300 keV for different stellar shells [7] (remark, the energy of ions at the bottom of PW will be ~ ZU, where U is PW depth). The experimental data obtained at NVD are recognizing the appearing and accumulating of C, O, Na, Mg, Al, Si, S, Cl, K, Ca, and other light elements. In particular, component analysis shows that characteristic X-rays radiation from anode surface contains strong new lines of Si and S. Beyond of other elements, the surface of cathode edge contains Fe and Mn also. The relation of concentrations Mn/Fe > 1 at any cathode area would be explained by capture of DD neutrons by iron, Fe(n,p)Mn, along the large number of discharge shots. We conclude that hypothesis on imitation of some stages of stellar nucleosynthesis by nuclear burning at potential well of virtual cathode in vacuum discharge [8] seems reasonable and stimulating in the future study of complex element burning including advanced fuel like р- B11.

References

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