IONS LOSSES IN MULTISLIT ELECTROMAGNETIC TRAP "JUPITER 2M"*

O.A.Lavrent'ev, V.A.Maslov, M.G.Nozdrachev, V.P.Oboznyj
Institute of Plasma Physics, National Scientific Center "Kharkov Institute of Physics and Technology", Kharkov, Ukraine, <lavr@ipp.kharkov.ua>, tel. 0572 35 64 38

The results of ions losses researches through magnetic slits and axial holes of a multislit electromagnetic trap "Jupiter 2M" are submitted. Plasma potential in the central area of a trap and potential depression in a ring magnetic slit are experimentally measured. The potential barriers to ions in ring magnetic slits are determined. It is shown, that the ions losses in the axial holes make no more than 4 % of total ions losses from the trap. The reason of low ions losses in axial holes is the additional forces arising at plasma interaction with crossed electrical and magnetic fields.
*The research described in this publication was made possible in part by Grant #1341 from STCU
PACS: 52.55.-s

The plasma in the electromagnetic traps is created by the neutral gas ionization with the help of high-energy electron injection. Electrons are confined by magnetic field of the multipole structure, and in the ring slits and axial holes - by electric field, ions are confined in the potential well of electron's space charge [1]. Such configuration of electric and magnetic fields is the main criteria ensuring the stability of plasma.

The experimental researches of ion losses in ring magnetic slits and axial holes were carried out on installation "Jupiter 2M"[2] - multislit electromagnetic trap of high-temperature plasma with axisymmetric magnetic field geometry.

It was experimentally shown, that the channels of electrons and ions losses in electromagnetic traps are divided in space. Under enough high negative potentials locking magnetic slits, electrons can leave a trap only as a result of cross transfer through a magnetic field. The ions, being kept in a potential well of a volumetric electrons charge, leave a trap only through magnetic slits (in systems with axisymmetric magnetic field geometry - through ring magnetic slits and axial holes), where the potential barrier is reduced because of potential depth in a slit. It allows to make separate registration of electron and ion losses flows from plasma and to compare them with theoretical models. The ion losses from a trap are coordinated on a charge with electron losses. The balance of currents $I^{\Sigma}_{i} + I_{ek} = I^{\Sigma}_{e\perp}$, is carried out, where I^{Σ}_{i} - total losses of ions from a trap through magnetic slits, I_{ek} - current of high energetic electrons injection and $I^{\Sigma}_{e\perp}$ - total electron losses from a trap across a magnetic field.

Plasma confinement in axial holes is basic question of the research program of axisymmetric traps. The conditions for ions confinement in ring magnetic slits essentially differ from conditions in axial holes. The plasma flow in ring magnetic slits is limited by anode diaphragm and has the cross size of 4 mm. Electrostatic division of plasma components and their confinement by longitudinal electrical field is possible in this case. The magnetic flow, which is limited by anode diaphragm in a ring slit, passes through an axial hole, being condensed in a beam of circular section. The sizes of electron circulation area in an axial hole grow in many times, increasing sagging of a volumetric charge potential. The electrostatic division of plasma components in the area of an axial hole and its confinement by a longitudinal electrical field become impossible.

The experiments for definition of ions losses ratio (through ring magnetic slits and axial holes) were carried out in the following way: electron injection was made through one of the edges of a trap, and opposite injector was used as a locking electrode and receiver of ions. The system of the automatic collection, processing and storage of the experimental information, which is made on the basis of a digital transformation SDI-AD12-128H card, allowed to register electron losses on each of 17 electrodes (anodes and limiting diaphragms), limiting area of plasma accumulation, simultaneously during one pulse of injection and ion losses in each of 7 ring slits and axial hole. The total ion losses (top curve), total electron losses (bottom curve) and flow of ions in an axial hole (average curve) are given in fig. 1 at injection from the left gun (a) and from the right gun (в). The current of ions in an axial hole from fig. 1a in increased scale is given in fig. 1c. The results of comparison of electrons and ions flows on electrodes of electrostatic system and restrictive diaphragms with total electrons and ions losses allow to make a conclusion that plasma accumulation, heating and confinement process in a trap does not depend on the fact, which electron injector works at the moment (left, right or they work both simultaneously). It is visible from the fig.1, that the ion flow in each of axial holes does not exceed 2 % from total ion losses through magnetic slits. It is possible to make a conclusion, that ion losses through axial holes, despite of their large size (d = 26 мм) and absence of a potential barrier, do not exceed 4 % of total losses of ions through magnetic slits. This very important result for axisymmetric traps is explained by action on ions of the additional forces arising at plasma interaction with crossed electrical and non-uniform magnetic fields. It will be well coordinated to results of theoretical accounts of charged particles losses through axial holes in a multislit electromagnetic trap [4].

The measurements of plasma potential and potential depth in a slit are carried out for finding - out of ions losses character through a ring magnetic slit. Plasma potential was measured with the help of single lengmure probe. The method of potential depth measurement is based on measurement of volt-ampere characteristic of an overbarrier ions current. The ions from a tail of power distribution overcome a potential barrier, leave through an aperture in a locking electrode and get on the negatively charged collector, if potential of a collector is more than potential depth on absolute value. The grid was established before collector.

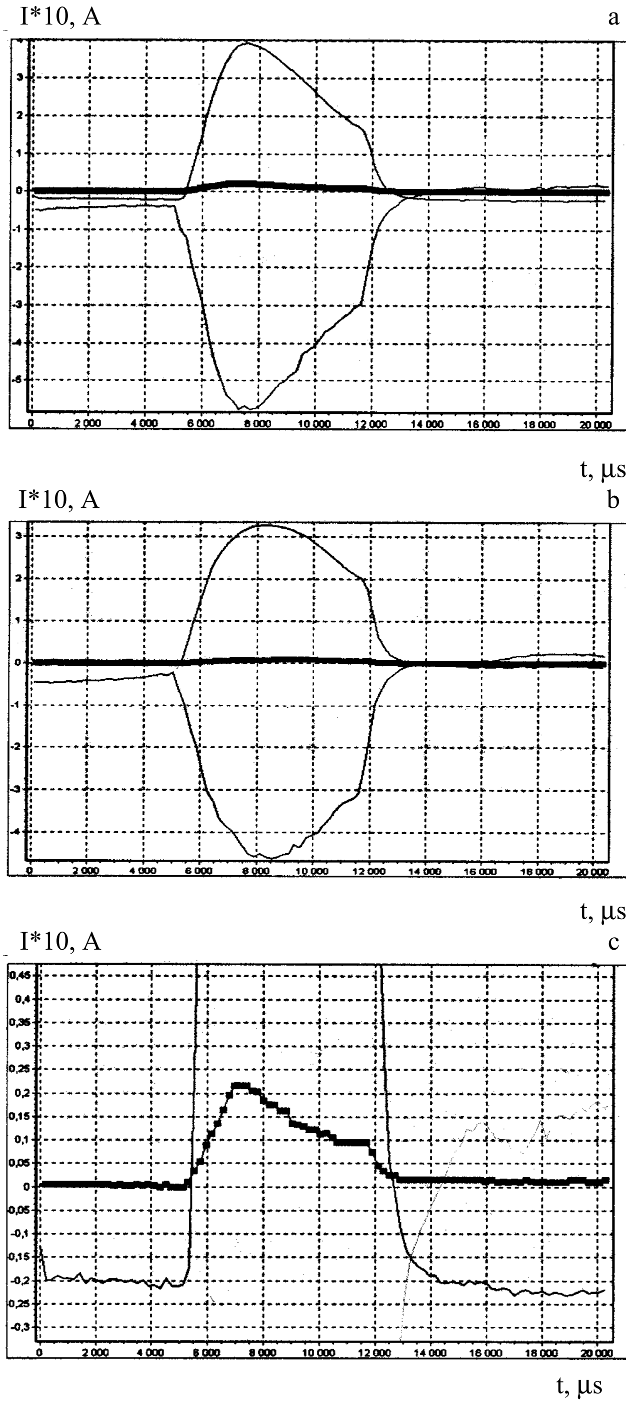

Fig. 1

Analyzing voltage close to a sawtooth one fed on this grid. Analyzing potential, at which measured ion current begins to decrease, determines value of potential depth for given magnetic slit. Oscillograms of plasma potential Φ_p, analyzing potential Φ_{an} and current of ions on a probe I_p are given in fig. 2.

Volt-ampere characteristics of ions flow in a ring magnetic slit are given in fig. 3.

The value of a potential barrier for ions in a ring magnetic slit was determined from a ratio $\Phi_i = \Phi_p - \Delta\Phi$. It was noticed that the potential depth grows with plasma density growth. Plasma potential changed within the limits of 40 - 200 V, and the value of a potential barrier for ions achieved 70 V depending on mode of installation operations.

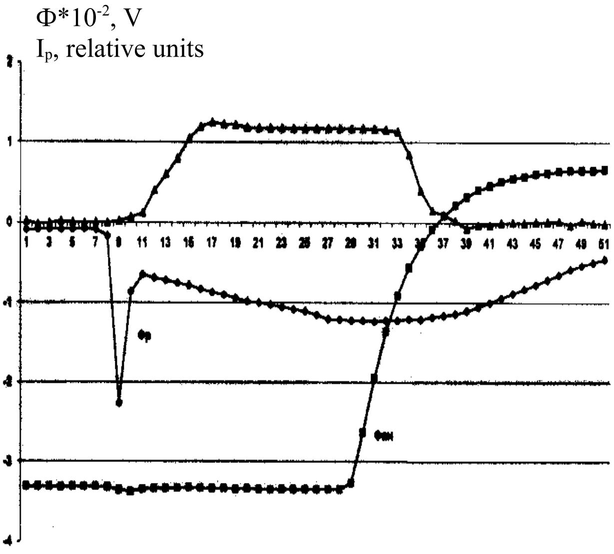

Fig. 2

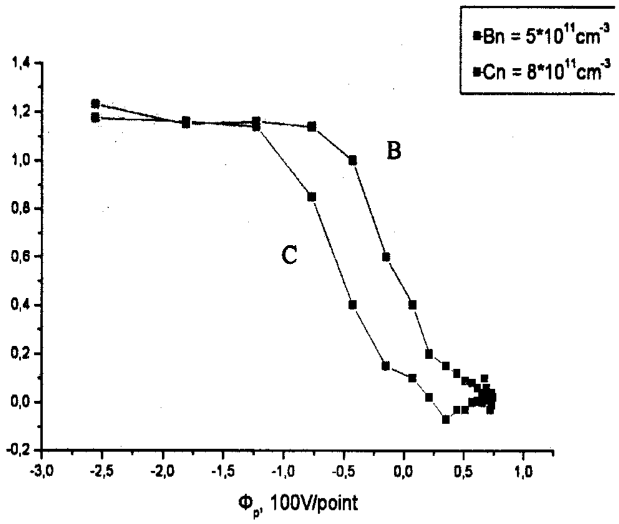

Fig. 3

The received results allow to make a conclusion about existence of potential barrier for ions in ring magnetic slits. They will be well coordinated with results of theoretical accounts of the charged particles losses through ring magnetic slits in a multislit electromagnetic trap [4].

REFERENCES

1. O. A. Lavrent'ev. Research of an electromagnetic trap. *Magnitnye lovushki.* , Kiev, "Naukova dumka", 1968, Vyp.3, p.77-147.
2. S.A. Vdovin, O.A. Lavrent'ev, V.A. Maslov, M.G.Nozdrachov, V.P. Oboznyj, N.N. Sappa. Plasma storage in the multislit electromagnetic trap "Jupiter 2M".//*Voprosy Atomnoj Nauki i tekhniki, Ser: Termoyadernyj Sintez/* Moskow, N3,1989, p. 40-45.
3. O.A. Lavrent'ev, V.A. Maslov, S.V. Germanova, M.G.Nozdrachev, V.P. Oboznyi. Neutral gas influence on plasma heating and confinement in the multislit electromagnetic trap «Jupiter 2M»// *Problems of Atomic Science and Technology, Ser: Plasma Physics/* Kharkov,(5), 2000, №.3, p. 48-50.
4. O.A.Lavrent'ev. *The theory of plasma heating and confinement in a multislit electromagnetic trap.*

ВТРАТИ ІОНІВ В БАГАТОЩІЛИННІЙ ЕЛЕКТРОМАГНІТНІЙ ПАСТЦІ “ЮПІТЕР 2М”

О. О. Лаврентьєв, В. О. Маслов, М. Г. Ноздрачов, В. П. Обозний

В роботі представлені результати досліджень втрат іонів через магнітні щілини та осьові отвори багатощілинної електромагнітної пастки “Юпітер 2М”. Експериментально виміряні потенціал плазми в центральній області пастки та провисання потенціалу в кільцевих магнітних щілинах. Визначені потенційні бар’єри для іонів в кільцевих магнітних щілинах. Показано, що втрати іонів через осьові отвори не перевищують 4% загальних втрат іонів з пастки. Причиною малих втрат іонів через осьові отвори є додаткові сили, що виникають при взаємодії плазми з схрещеними електричним та магнітним полями.

ПОТЕРИ ИОНОВ В МНОГОЩЕЛЕВОЙ ЭЛЕКТРОМАГНИТНОЙ ЛОВУШКЕ «ЮПИТЕР 2М»

О. А. Лаврентьев, В. А. Маслов, М. Г. Ноздрачев, В. П. Обозный

В работе представлены результаты исследования потерь ионов через магнитные щели и осевые отверстия многощелевой электромагнитной ловушки «Юпитер 2М». Экспериментально измерены потенциал плазмы в центральной области ловушки и провисание потенциала в кольцевых магнитных щелях. Определены потенциальные барьеры для ионов в кольцевых магнитных щелях. Показано, что потери ионов в осевые отверстия не превышают 4% общих потерь ионов из ловушки. Причиной малых потерь ионов через осевые отверстия являются дополнительные силы, которые возникают при взаимодействии плазмы со скрещенными электрическим и магнитным полями.