

MULTISLIT ELECTROMAGNETIC TRAP “JUPITER F”

O.A. Lavrent'ev, V.A. Maslov, N.A. Krutko, V.P. Oboznyi

IPP, National Science Center “Kharkov Institute of Physics and Technology”, Kharkov, Ukraine

The construction of multislit electromagnetic trap “Jupiter F” with application of ferromagnetic materials to strengthening of a magnetic field, the results of calculations, and the results of experimental investigations of the magnetic field configuration are presented.

PACS: 52.55.-s

The basic peculiarity of electromagnetic traps is a shell character of plasma confinement. The plasma confining magnetic field is formed by conductors or coils with alternating polarity of currents and is characterized by a deep magnetic well. The magnetic field intensity is equal to zero in the center of a trap and rises steeply to the periphery. In the central part of the trap, where magnetic field is absent, the plasma is in force-less and thermally equilibrium condition.

The plasma in electromagnetic traps is produced by ionization of working gas with injected electrons. Electrons injected into the trap are accumulated and confined between magnetic surfaces by an acute-angled magnetic field, and in the circular magnetic slits and axial holes – by external electrical field. The ions are accumulated and confined in the potential well of a volumetric charge of electrons.

The construction of electromagnetic traps magnetic system allows to apply ferromagnetic materials to strengthening a magnetic induction both in toroidal, and in axisymmetric electromagnetic traps. The application of ferromagnetic materials can result in significant decrease of the energy consumption for creation of confining magnetic field in electromagnetic traps.

The application of ferromagnetic materials allows to create a magnetic configuration ensuring conditions for Brillouin injection of electrons through the axial apertures and through the ring slits. In the plasma volume the chaotization of electrons injected in such a way takes place as adiabatic invariant for them does not conserve. The application of ferromagnetic materials can considerably simplify the electrostatic “locking” system in circular magnetic slits and increase the energy of electron injection.

For validation of these assumptions the device “Jupiter F” was built up (Fig. 1). When assembling device “Jupiter F”, the magnetic coils, skeleton and vacuum chamber of the multislit electromagnetic trap “Jupiter 2M” [1] were used. In Fig. 2 the circuit of installation is shown. The central part of the device consists of four pairs of magnetic coils (1) with alternating polarity of current, which create three large ring slits. From both sides to them back-to-back small coils (2), forming 2 slits, are adjoined. These coils are interfaced a magnetic field of the central part of the trap to field of the coils (3), located at the ends of device. All magnetic coils are installed in screens of an ARMCO - steel. The radial part of screens (4) is made of a sheet ARMCO - steel with

thickness 20 mm with end caps directed inside of a slits, for concentration of magnetic field.

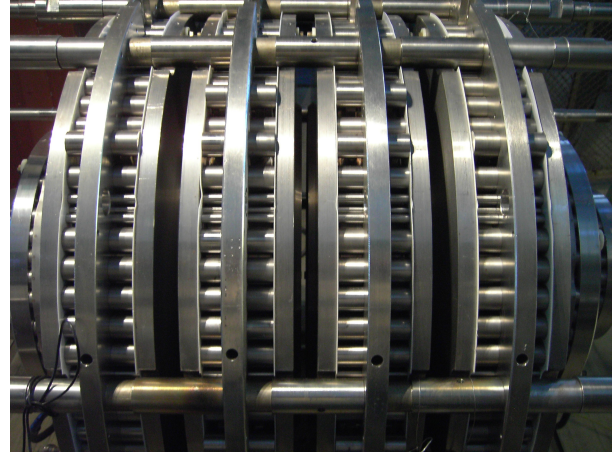


Fig. 1

The external part of cores (5) is made from an ARMCO – steel rod with diameter of 25 mm. In axial apertures concentrators of a magnetic field (6) also are located.

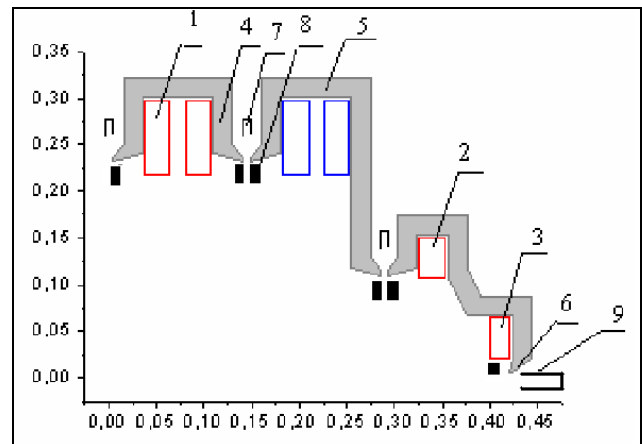


Fig. 2

The length of magnetic system between axial holes is 86 cm, the diameter of the ring magnetic slits in the central part - 45 cm, the small ring slits - 22 cm, the width of every gap between end caps in ring slits – 0.8 cm, the diameter of axial holes – 1.2 cm.

All magnetic slits are closed by electrostatic locking system - electrodes with high negative potential. The electrostatic system in each slit consists of the central locking electrode (7), lateral locking electrodes (end caps of a radial part of screens (4)) and grounded anodes (8)

limiting the area of plasma accumulation in ring slits and in axial holes. Width of a slit between anodes is 0.4 cm. Thus the lateral locking electrodes are located in "shadow" of anodes and are protected from the plasma radiations.

The plasma in the trap is created by ionization of working gas with electrons injected from cathodes (9), located in axial apertures. The central locking electrodes (7) are made as hollow cathodes. If the negative potential of lateral locking electrodes exceeds the potential of central electrodes, it will result in suppression of secondary electronic emission from the central electrodes. In opposite case the flow of secondary electrons can be used for additional electron injection in a trap through the ring slits. The cathodes in axial apertures and central locking electrodes in ring slits are located behind end caps - concentrators, where the magnetic field is equal to zero. Such magnetic configuration ensures the conditions for Brillouin injection of electrons through the axial apertures and through the ring slits. Injected electrons turn out in the central part of the trap, where the magnetic field practically is absent and are accumulated there.

The energy supply of magnetic system is realized using the condensers of total capacity $C = 0.033$ F. Fig. 3 shows the oscillogram of magnetic field in the trap.

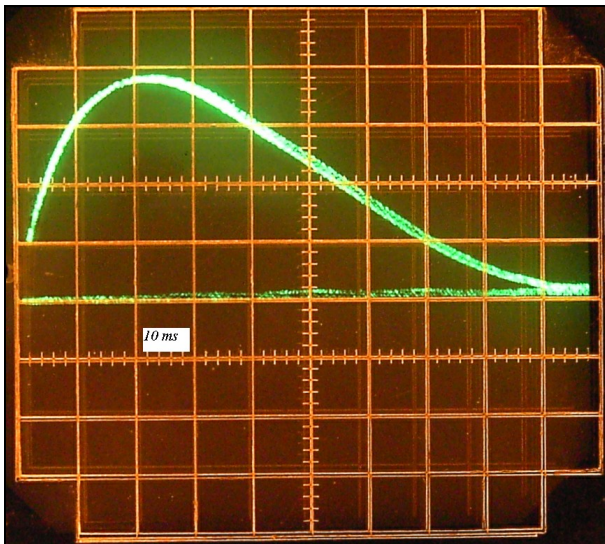


Fig. 3

The pulse duration of magnetic field is 90 ms; the plateau of field strength $\tau_m \geq 10$ ms ($\Delta B/B = \pm 2\%$).

The spatial distribution of magnetic field intensity in the region of plasma accumulation is characterized by a deep magnetic well. In Figs. 4 and 5 the experimental and calculating distributions of magnetic field radial components in the central magnetic slit and axial components along the axis of the trap are given at a current in magnetic coils $I = 600$ A. In the central area of the trap the magnetic field is zero, and starts to grow sharply to the periphery. The discrepancy between absolute meanings of calculating and experimental distributions of a magnetic field is because for

calculations the tabular data of ARMCO - steel magnetization were used [2].

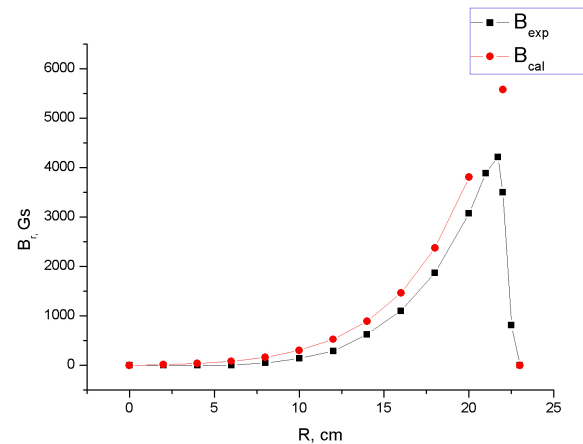


Fig. 4

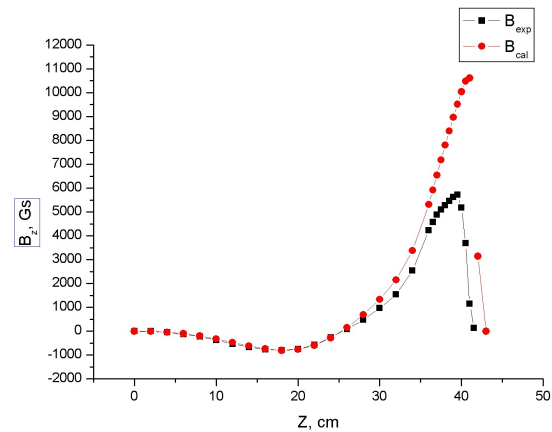


Fig. 5

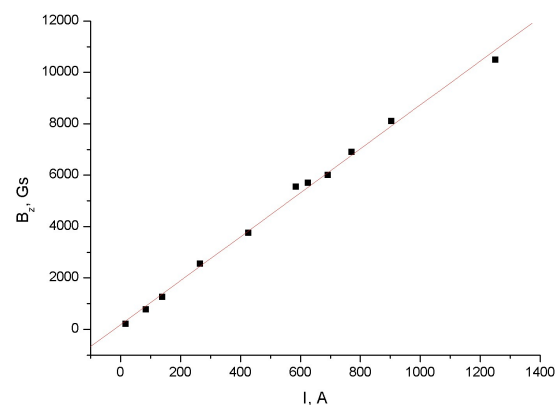


Fig. 6

In Figs. 6, 7 the dependences of the maximal values of magnetic field in the central ring slit upon the current in magnetic coils are shown. It is seen that in a quite wide

range, the magnetic field rises linearly with increasing the coil current.

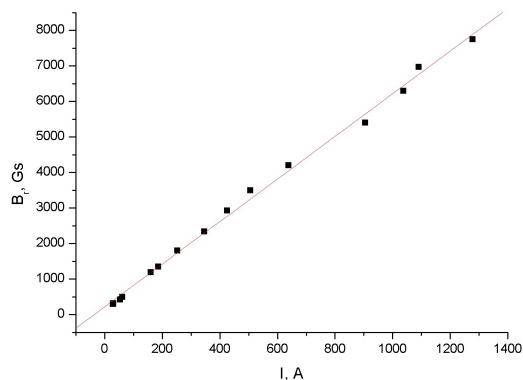


Fig. 7

In Fig. 8 the experimentally measured radial distribution of magnetic field in the central ring slit and the calculated one for magnetic system without ferromagnetic screen is given at the current in magnetic coils 600 A. The application of the ferromagnetic screen increases the magnetic field more than two times in front of the slit but at the same time decreases it to zero just behind the end caps. Thus the magnetic field distribution meets the requirements for Brillouin injection through the ring magnetic slits.

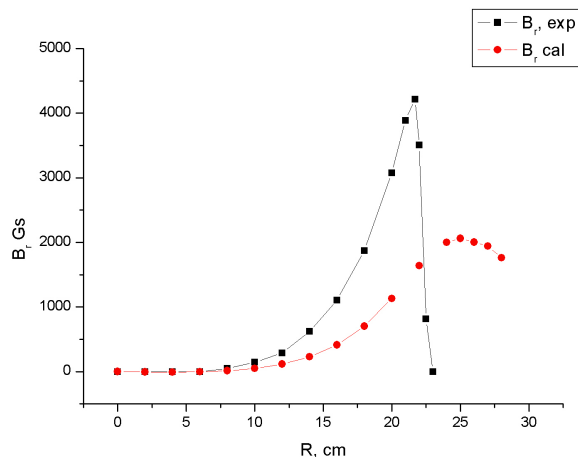


Fig. 8

REFERENCES

1. S.A. Vdovin, O.A. Lavrent'ev, V.A. Maslov, M.G. Nozdrachov, V.P. Oboznyj, N.N. Sappa. Plasma confinement in the multislit electromagnetic trap "Jupiter 2M" // *Voprosy Atomnoj Nauki i Tekhniki. Seriya "Termoyadernyj Sintez" (3)*. Moscow. 1988, p. 40-45 (in Russian).
2. D.D. Mishin. Magnetic materials. Moscow: "Vysshaya shkola", 1981, p. 175 (in Russian).

Article received 30.09.08.

МНОГОЩЕЛЕВАЯ ЭЛЕКТРОМАГНИТНАЯ ЛОВУШКА "ЮПИТЕР Ф"

О.А. Лаврентьев, В.А. Маслов, Н.А. Крутько, В.П. Обозный

Представлены конструкция многощелевой электромагнитной ловушки "Юпитер Ф" с применением ферромагнитных материалов для усиления магнитного поля, результаты расчетов и экспериментальных исследований конфигурации магнитного поля.

БАГАТОЩЕЛИННА ЕЛЕКТРОМАГНІТНА ПАСТКА "ЮПІТЕР Ф"

О.О. Лаврентьев, В.О. Маслов, Н.О. Крутько, В.П. Обозный

Представлено конструкцію багатощеливної електромагнітної пастки "Юпітер Ф" з використанням ферромагнітних матеріалів для підсилення магнітного поля, результати розрахунків та експериментальних досліджень конфігурації магнітного поля.