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THE NEW **ECR** ION SOURCE **DECRIS-4**
(Project)

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I. INTRODUCTION

The development of a new ECR ion source was started with the aim of solving two problems in the nearest future using the U-400 cyclotron.

a) The new ion source will be used as a "charge breeder'. The use of secondary beams of radioactive nuclei strongly extends the possibilities for the investigation of properties of atomic nuclei and nuclear reactions. In accordance with the plan of the FLNR (JINR) development, the production of exotic nucleus beams is one of the main scientific lines of research. At the second stage of the DRIBs (**D**ubna **R**adioactive **I**on **B**eams) project[1,2] it is planned to use a primary electron beam from the Microtron MT-25 for the production of radioactive neutron-rich nuclei (^{238}U photo-fission fragments). The beam of single-charged radioactive ions can be turned to the low-energy laboratory or post-accelerated in the cyclotron U-400. For this purpose single-charged ions will be transported into the ECR ion source and then extracted with the n^+ charged state required for the acceleration.

b) The ^{48}Ca ion beam has been the most frequently accelerated beam (more than 70 % of the operation time) at the U-400 cyclotron within the past few years.

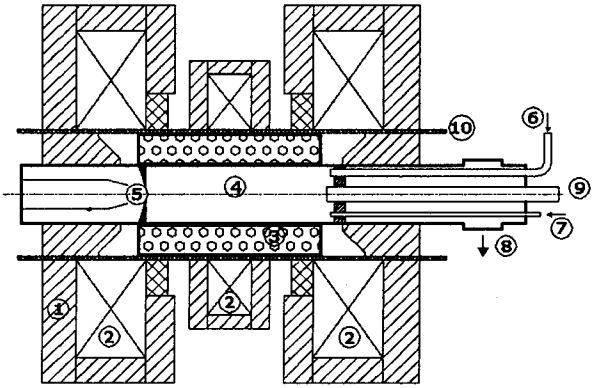

FIG.1. Magnetic structure of the ion source DECRIS-4. 1: Iron yoke. 2: Three independent coils. 3: Hexapole. 4: Plasma chamber. 5: Extraction electrodes. 6: UHF input. 7: Gas feeding. 8: Pumping. 9: Bias electrode. 10: Isolator

The improvement in the efficiency and the "lifetime" of the source are also important goals of this design.

As a result the new ECR ion source DECRIS-4 was constructed as a "charge breeder" for the second phase of the DRIBs project. After a simple modification of the injection side this ion source can also be used as an injector of heavy multiple-charged ions for the U-400 cyclotron.

II. DESIGN OF THE ION SOURCE

The design of the magnetic structure of the source was based on the idea of the so-called "magnetic plateau" in the center of the source suggested by Alton and Smithe[3] and successfully realized by the Münster University team.[4] A cross-sectional view of the ion source DECRIS-4 is shown in Figure 1. The main design parameters are collected in Table 1.

TABLE I: The design parameters of DECRIS-4

Main parameters	
UHF frequency	14 GHz
B_{inj}	1.29 T
B_{ext}	1.29 T
L_{mirror}	29 cm
Max. coil current	1000 A
Water cooling ΔP	15 bar
Plasma chamber internal diameter	74 mm
Hexapole field on the wall of plasma chamber	>1.0 T
Max. extraction voltage	30 kV

The axial magnetic field is formed by 3 independent solenoids enclosed in separated iron yokes. An enlarged resonance zone can be created with the help of the

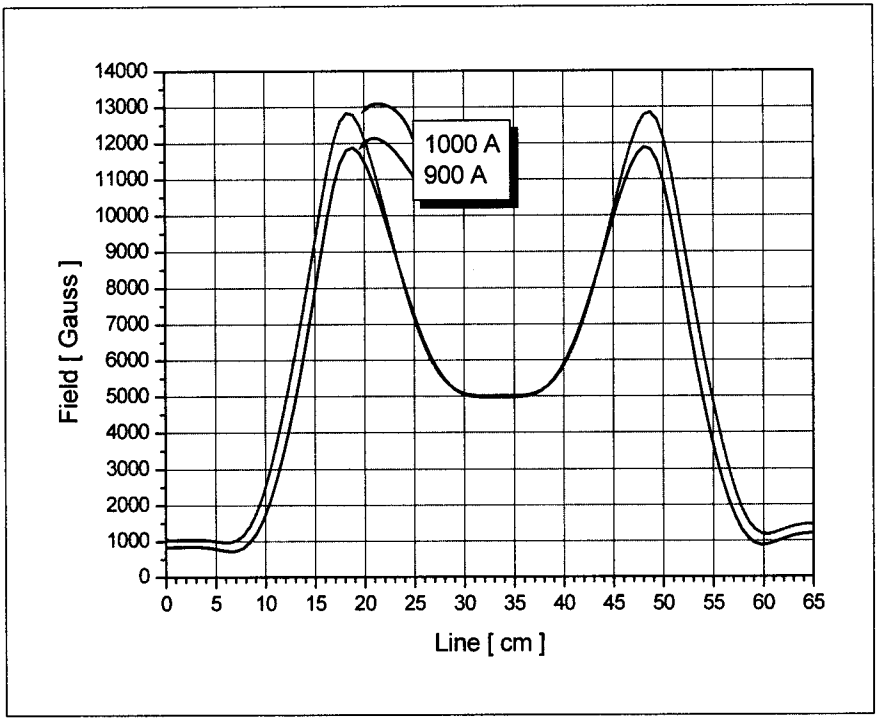

FIG.2. Axial magnetic field distribution

middle coil and two movable soft iron rings (in Figure 1 they are shown by hatching). The position of the rings depends on the coil current and will be assigned experimentally. The maximal magnetic field at the axis is about 1.3 T on both sides which provides a mirror ratio of higher than 2.5. The hexapole for the radial confinement has a Halbach structure. It consists of 24 permanent magnet identical sectors. The outer diameter is 160 mm, the inner one - 80 mm. The desired magnetic field on the plasma chamber wall is about 1 T. The superposition of the coils and hexapole magnetic fields (three-dimensional view) is shown in Figure 3, and the magnetic field contour map is shown in Figure 4. It is easy to see the enlarged resonance volume in both figures. The whole magnet structure is moveable along the axis with respect to the plasma chamber to optimize the plasma electrode position during the source operation.

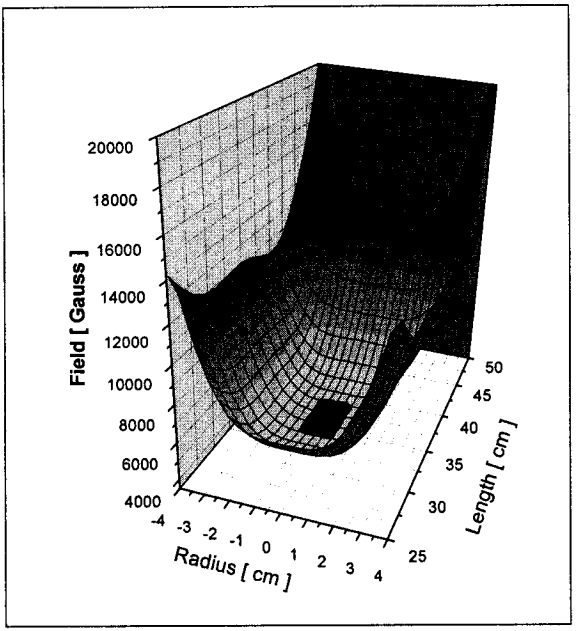

FIG. 3. Three-dimensional distribution of magnetic field. The dark area in the centre corresponds to the enlarged resonance zone

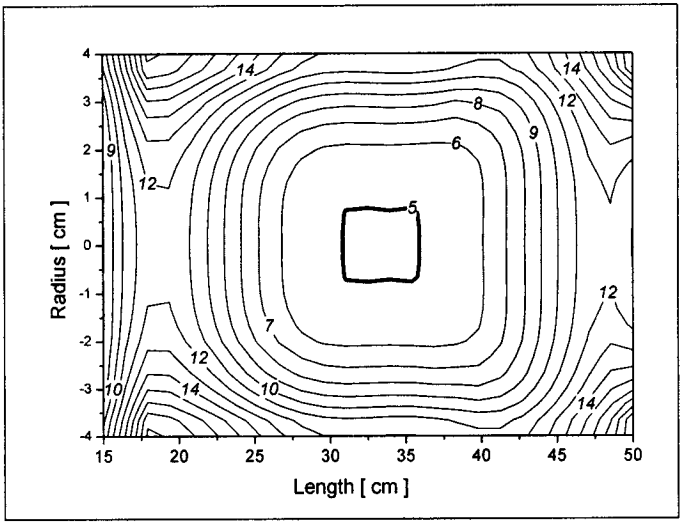

FIG. 4. Schematic view of surfaces of magnetic equipotentials. The thick line in the center shows the enlarged resonance surface.

For the ECR heating we can use a single 14 GHz and 2 kW klystron or a few frequencies produced by independent oscillators which are mixed and amplified by a TWT.

As compared with the previous versions of DECRIS, the new ion source has some more innovations, such as a bigger size plasma chamber, a movable bias electrode for precise cavity tuning, UHF coupling fed by the standard waveguide instead of coaxial feeding and so on. The injection side of the source has more room for the installation of a new high temperature oven with temperature control and a bigger size crucible. This allows us to increase the efficiency and time of nonstop operation during the ^{48}Ca ion beam production.

III. CONCLUSION

The new ion source DECRIS-4 for the U-400 cyclotron was designed. The source is dedicated to improve the efficiency of the ^{48}Ca ion beam production and to be a "charge breeder" for the DRIBs project. We are planning to finish the assembly of the source at the end of 2004.

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Новый ионный ЭЦР-источник DECRIS-4
(проект)

Новый источник многозарядных ионов DECRIS-4 планируется построить в Лаборатории ядерных реакций (ОИЯИ). Источник может быть использован как инжектор тяжелых многозарядных ионов в циклотрон У400 или как «charge breeder» («$1^+ \rightarrow n^+$»-метод) для второй стадии проекта DRIBs. Главной особенностью ионного источника является создание расширенной резонансной зоны в относительно компактном ЭЦР-источнике. Для этой цели распределение осевого магнитного поля сформировано с плоским минимумом. Суперпозиция осевого магнитного поля с полем NdFeB-гексаполя позволяет создать относительно большой резонансный объем. В данном случае электроны могут быть нагреты более эффективно. Максимум плотности плазмы расположен около оси, откуда главным образом извлекаются многозарядные ионы. Для нагрева плазмы будет использоваться частота 14 ГГц. Описана предварительная конструкция источника DECRIS-4 и обсуждаются особенности и перспективы его применения.

Работа выполнена в Лаборатории ядерных реакций им. Г. Н. Флерова ОИЯИ.

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The New ECR Ion Source DECRIS-4
(Project)

A new ion source DECRIS-4 for the production of multiplicity charged ions is planned to be built at the FLNR (JINR). The source can be used as an injector of heavy multiply charged ions for the U400 cyclotron, as well as a «charge breeder» («$1^+ \rightarrow n^+$» method) for the second phase of the DRIBs project. The main feature of the ion source design is the creation of the extended resonance zone in a comparatively compact ECRIS. For this purpose the axial magnetic field distribution is formed with a flat minimum. Superposition of the axial magnetic field with the field of the permanent magnet hexapole, made of NdFeB, allows one to create a large resonance volume. In this case the electrons can be heated more efficiently. The maximum of the plasma density is situated near the axis, where ions are mainly extracted from. For the plasma heating a microwave frequency of 14 GHz will be used. A preliminary design of the source is described. Also the features and prospects for the application of this source are discussed.

The investigation has been performed at the Flerov Laboratory of Nuclear Reactions, JINR.

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