value of the resonance frequency accounts for 6%.

The results of the model measurements form the basis for the techical design of AS.

The work was supported by Russian Foundation of Fundamental Researches: 93-02-16718.

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EXPERIMENTAL SETUP FOR INVESTIGATION INTERNAL H^-- ION SOURCES

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The experimental setup for investigation internal H^- - ion source was design and manufactured at acceleration department of PNPI. Ion source is one of the principal units of cyclotron. The activity of many cyclotron's systems and characteristics of ion beam depend on parameters and type of the ion source. The ion source of closed type with the electrode configuration of a Philips ionization gauge, discribed by Ehlers[1], was selected as an internal H^--ion source for Gatchina Isochronous Cyclotron (GIC)[2,3]. A schematic diagram of the experimental apparatus is displayed in Fig.1 The internal ion sources operate in strong magnetic field. To model ion source in real size the magnet SP-10A was modified. Gap betveen poles was increased up to 155 mm but bottom and upper walls of the,vacuum chamber,which arranged between poles, were made from magnetic steel, so the magnitude of the magnetic field reaches 13 kGs and corresponds to one in central part of GIC. The ion source, arranged inside vacuum chamber, consist of two cathodes (hot and cold) and cylindrical anode, which axis is parallel to force lines of the magnetic field. The power supply for heating of filament with parameters $U = 5$ V and $I = 500$ A and one with $U = 3$ kV and $I = 10$ A for discharge supporting are used. The two were made by laboratory's members. Special system of calibrated feeding of working gas (hydrogen) was design for creation needed pressure inside ion source. It allowes to regulate gas flow rate Q in the limits from 0.1 to 15 cm^3/min. Vacuum system is assembled on the basis of two highvacuum pumps with effective pumping rate about 2000 l/sec and provides pressure 10^{-7} Torr in vacuum chamber without gas feeding. The extraction of the ion beam from dischage through exit slit in anode to across magnetic field is carried out by the pullers connected with dee. The extraction voltage supplies on pullers and can be as positive for extraction of negative ions so negative for extraction positive one. But there are some difficults with supplying a high positive voltage on dee

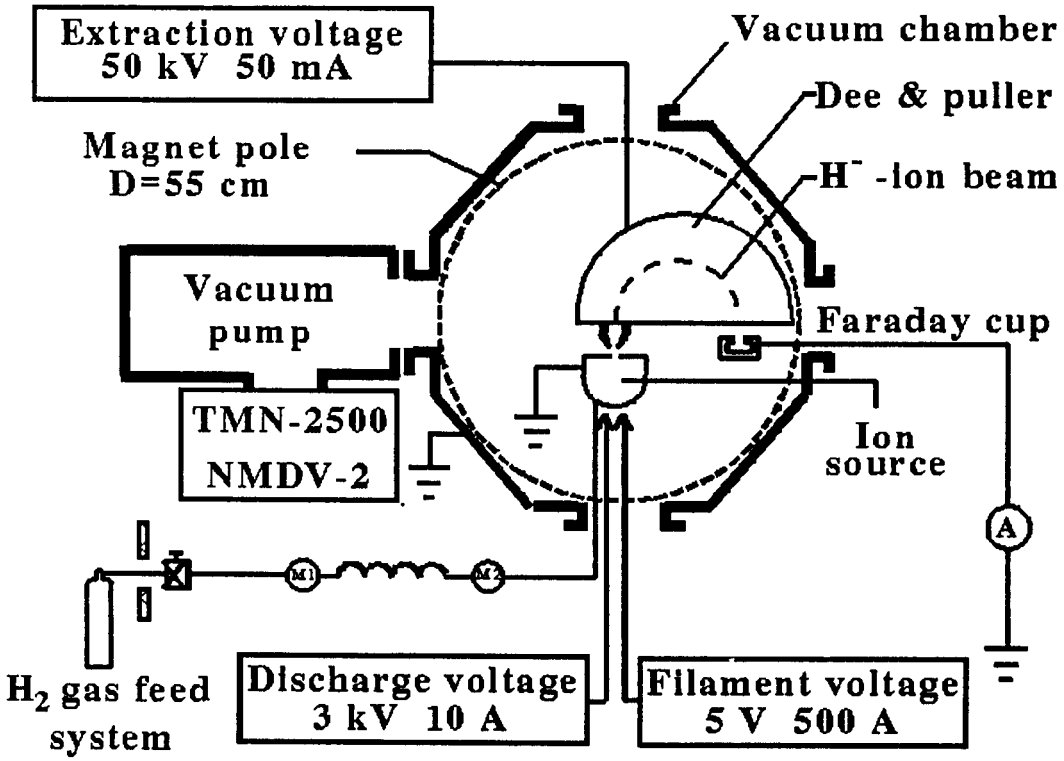

Fig.1. Schematic diagram of the experimental apparatus

in the presence of magnetic field on account of arising parasitic Penning discharge inside vacuum chamber. For this reason the impulse power supply for providing extraction voltage with impulse duration $\tau = 20\mu s$ - 1ms, period T=100 μs - 10ms and amplitude $U = 12$ kV was disigned and manufactured. After extraction from discharge the ion beam penetrates trough pullers and comes into 180^0-dee where it is rotated on 180^0 by magnetic field and is registrated after exiting from dee by movable Faraday cup. That means that arrangement works as mass-spectrometer. The capacity of the registration system is illustrated by the mass spectra of positive ions extracted at different discharge parameters (Fig.2). But after analisis of this system the supposition that not whole beam reaches Faradey cup on account of bracking electrical field between dee and detector was made. So the new detector under dee potential consisting of series of the immovable electrodes was realised. At present the negative hydrogen ions beam with intensity 1.2 mA (current density 25 mA/cm^2 that corresponds average value for this type of ions sources) was obtained and the works for optimization ion source constraction are continued. The intensity of ions beams and also its rellative mass composition (for positive ions) depends strongly on discharge parameters (see Fig.2,3). To understand these dependenses the program for calculation of the particle concentrations in dischage plasma on the basis of solution of the balance equations system was written. Prelimenary calculations are qualititivly in according to experimental results.

The work was supported by Russian Fondation of Fundamental Researches, 93-02-16718.

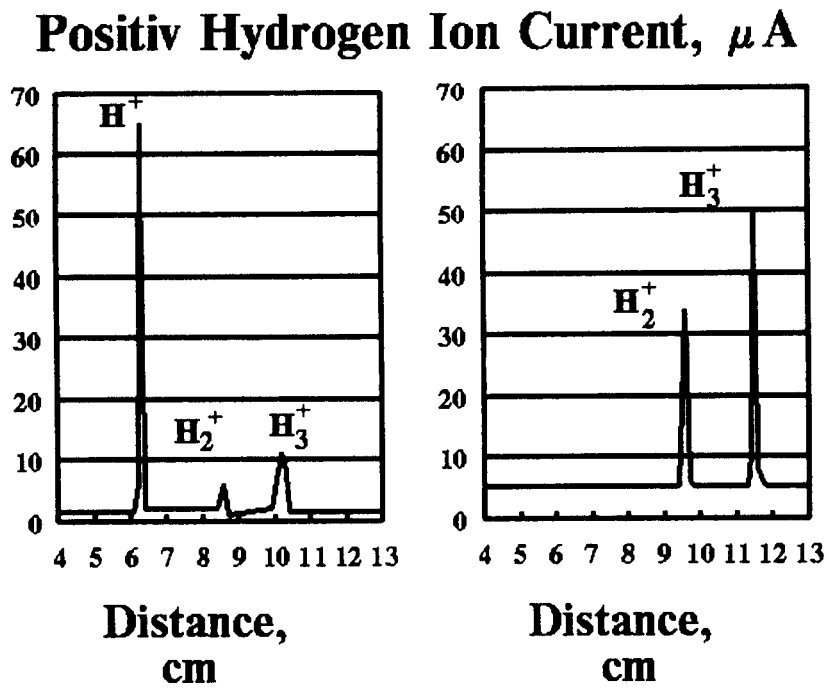

Fig.2. Mass spectra of the positive ions registred by Faradey cup. Mass spectra recieved at different dischage current , gas flow rate into ion source and different extraction voltages. Distance was measured between exit slit of the source and beam registration point

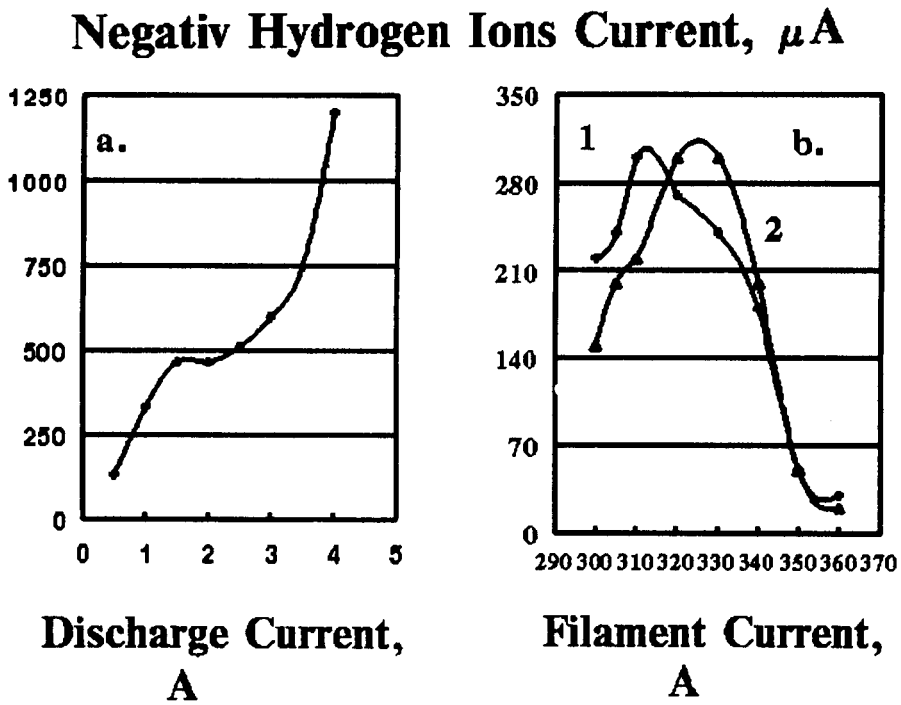

Fig.3. Intensity extracted negative hydrogen ions beam versus discharge parameters. The curves 1 and 2 (Fig.3b) were obtained at different gas flow rate

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CALCULATION OF THE BEAM DYNAMICS IN THE CENTRAL REGION OF THE CYCLOTRON GIC

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As is well known, the central region of a cyclotron determines to a great extend intensity and quality of a beam. In this connection the large attention is being given to the analysis of the beam dynamics in the central region and optimum design.

The calculation of particles dynamics was carried out by using the program similar that was successfully applied to design of the central region with an internal source [1]. Program has been modernised to calculate dynamics in a cyclotron with external injection. Main input data for calculation are electrical and magnetic fields. The magnetic field is described by the formula:

$$B(r,\varphi) = \bar{B}(r) + A_4(r) \times \cos\left(4 \times (\varphi + \eta\ (r))\right)\ ,$$

where $\bar{B}(r)$ – the average magnetic field is planning to be found as a result of calculation, and the amplitude $A_4(r)$ and phase $\eta(r)$ of a main harmonic have been measured on model 1:8. On Fig.1 and Fig.2 the amplitude $A_4(r)$, phase $\eta(r)$ and parameters of an average magnetic field $\bar{B}(r)$ are indicated. The electrical field in an accelerating gap is described in a 2-D approximation and presented as a Gauss distribution similarly to how it has been offered in [1-3]. Following input data have been used in calculations:

Injection energy	20 keV
Number of dee	2
Dee voltage amplitude	60 kV
Harmonic f_{rf}/f_{ion}	2
Dee apperture	±15 mm
Angular dee extension	90°
Accelerating gap	20 mm

Correctly designed central region should provide:

- isochronous acceleration of particles with a high gain of energy per turn;
- good centring of a beam, i.e. small value of coherent oscillations of a beam as a whole;
- focusing in an axial plane;
- small free oscillations of particles in the horizontal region.