ION CONFINEMENT IN ECR ION SOURCES

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The charge state distribution of heavy ions produced in an ion source depends on the relative electron-ion velocity and on the product of the ion confinement time and the electron density. In the present paper we analyse the confinement of multiply charged heavy ions in the multipole-mirror magnetic field and ambipolar potential well of an ECR ion source. Provided the variation of the magnetic field in the frame of the particle's motion is slow (adiabatic motion) and the pressure is sufficiently low ($p \leqslant 10^{-7}$mbar), the loss of trapped particles is essentially determined by multiple weak interaction of particles which results in a diffusion in velocity space. Contrarily to the conventional mirror devices in the ECR ion source heavy ions escape through the mirror throat with much smaller velocity than the (remaining) hot electrons. Using the procedure of derivation of an approximate solution of the Fokker-Planck equation in a square well potential [1] , we have obtained analytical expressions for the collisional losses of particles. In deriving these expressions we have assumed that the escaping species has a much smaller velocity. The maximum ambipolar potential is determined as a solution of a transcedental equation obtained by equating the total electronic and ionic currents at the mirror throat. For the parameters of the ECR ion source VINIS we found that the ratio of the ambipolar potential to the ion energy is $z_{eff}\, e\phi_{max} / T_i = 4.7$. The ion confinement time exceeds largerly the ion-ion 90° scattering time ($\tau_i \simeq 1$ ms).

[1] V.P.Pastukhov, Nucl. Fusion 14(1974)3.