Beams of charged particles are widely applied in many fields of science and technology. Ion beams are used for modification of physical and chemical properties by ion implantation, in ion thrusters and in plasma heating modules of experimental thermonuclear reactors (tokamaks, stellarators). Ion extraction and formation of ion beam of desired charge distribution, angular divergence, and ion current is the crucial point in these applications.

In this work we studied the effect of plasma meniscus surface in the ion source extraction hole, the ion beam spatial charge and ion temperature of the plasma in ion source chamber on the angular beam divergence. The estimations are based on experimentally determined dependencies of extracted ion current on extraction voltage (Fig. 1). The measurements have been performed for Ar\(^+\) beams extracted from plasma ion sources of Sidenius [1] and Nielsen type [2].

The comparison of experimental current-voltage curves to those predicted by simple theoretical model of flat electrodes (leading to Langmuir formula) resulted in definition of the extraction electrode effective surface and determination of its dependence on the extraction voltage [3]. The contribution to ion beam angular divergence from the space charge has been determined from computer simulation (Fig. 2) performed with TRQR particle-in-cell method code [4]. In calculations the assumption has been made that in the case of flat plasma meniscus its surface is equal to the surface of ion source extraction hole. Using previously calculated beam divergences and arc discharge parameters one can estimate ion thermal energies for both ion sources types from the formula

\[
\tan(\Delta\omega_p) = \frac{kT}{eU_{\text{ext}}}
\]

where \(\Delta\omega_p\) is the thermal contribution to the beam divergence.

References