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New Progress of High Current Gasdynamic Ion Source

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The experimental and theoretical research carried out at the Institute of Applied Physics (IAP RAS, Nizhniy Novgorod, Russia) resulted in development of a new type of ECR sources – gasdynamic ECR ion sources. The ideas underlying development of such sources were borrowed from the field of conventional ECR sources of multicharged ions, as well as from investigations of problems of fusion in mirror traps (FMT). The gasdynamic ECR ion sources differ from the Geller sources by the mechanism of plasma confinement in a magnetic trap. It is the quasi-gasdynamic mechanism similar to that is used in FMT.

Experimental studies of gasdynamic ECR ion sources were performed at SMIS 37 facility. In these experiments plasma was created by 37.5 GHz gyrotron radiation with power up to 100 kW. Such high frequency of microwaves allowed to create and sustain plasma with significantly higher density (up to $2\cdot10^{13}$ cm^{-3}) and at the same time to maintain the main advantages of conventional ECRIS such as high ionization degree and low ion energy. Reaching such high plasma density relies on the fact that the critical density for the microwave radiation grows with the frequency squared. Using high microwave power allowed to keep the average electron energy on a high enough level (50-300 eV) for efficient ionization even in the case of so-called quasi gasdynamic regime of plasma confinement at neutral gas pressure range of $1\cdot10^{-4}$ - $1\cdot10^{-3}$.

Gasdynamic ECR ion source demonstrated a good performance for production of high current (100-300 mA) multicharged ion beams with moderate average charge (4-5 for Argon). Especially effective gasdynamic ion sources appeared to be for formation of hydrogen or deuterium beams. In recent experiments a possibility of beam extraction with proton current up to 500 mA and current density 600 – 700 mA/cm^2 was demonstrated. One of the main advantages of such systems is extremely low emittance of extracted beams. It was shown that normalized RMS emittance of 500 mA proton beam is below 0.07 $\pi\cdot$mm$\cdot$mrad.