VISIBLE LIGHT PLASMA DIAGNOSTICS OF ELECTRON CYCLOTRON RESONANCE ION SOURCE

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The JYFL 6.4 GHz and 14 GHz Electron Cyclotron Resonance (ECR) ion sources are used to produce highly charged ion beams for the JYFL K130 cyclotron. In min-B configured ECR ion sources [1] the plasma heating is based on the energy transfer from microwaves to electrons via electron cyclotron resonance in external magnetic field. As a result of the efficient plasma heating the energy of electrons is sufficient to produce highly charged ions via electron impact ionization. The performance of ECR ion sources, in terms of ion beam intensity and charge state, has to be improved in order to meet the requirements set by the nuclear physics community and industrial and medical applications. The energy of the beam accelerated by the cyclotron is proportional to square of the charge state of ion. Intensity of beam depends on production rate of ions and the efficiency of ion beam formation and transport. To be able to make development to increase the charge state and its production rate, the plasma inside the source has to be studied and understood.

Invasive plasma diagnostic methods cannot be used as they disturb especially the high charge states of interest. In addition to electron impact ionization, responsible to increase charge state of ions, also the electron impact excitation occurs in plasma. Due to the spontaneous emission of excited states, visible light is emitted opening a possibility to study physics of ECR plasma with non-invasive method called optical emission plasma spectroscopy [2]. Plasma spectroscopy can be used to identify particle species in the plasma. Also it can give insight on how different methods for example two-frequency heating method and different ECR parameters for example microwave power, neutral pressure and magnetic field affects on light intensity emitted by high charge states. Light intensity depends on ion density and electron energy distribution function.

In this presentation methods to measure and analyze visible light spectrum emitted by the ECR plasma will be discussed. Particle species identification will be presented from the measured argon plasma spectrum. Also the change of light intensity emitted by neutral argon $3s^2 3p^5 4p\ 2\mathrm{p}_5 \rightarrow 1\mathrm{s}_4$ transition and argon 10+ ion $2s^2 2p^4\ 3P_1 \rightarrow 3P_2$ transition at 50 W and 400 W plasma heating power will be presented as an example.

[1] D. Hitz, "Recent Progress in High Frequency Electron Cyclotron Resonance Ion Sources," *Advances in Imaging and Electron Physics*, vol. 144, pp. 1-164, 2006.

[2] U. Fantz, "Basics of plasma spectroscopy," *Plasma Sources Science and Technology*, 2006.