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Application and Effects of Introducing Low Frequency Electromagnetic Waves in Electron Cyclotron Resonance Ion Source

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We have been experimentally measuring the charge state distribution of the multiply-charged ion current generated and extracted from an electron cyclotron resonance (ECR) ion source (ECRIS), and plasma parameters in the ECRIS, and then investigating the correspondence between them. According to the accessibility conditions of wave propagation in the magnetized ECRIS plasma, it is speculated that the essential factor that determines the limitations in the multiply charged ion current in the current ECRIS is not simply the ordinary wave cutoff, nor the right-hand polarization wave cutoff density, but rather the higher density limit one, i.e., the left-hand polarization wave cutoff density where electromagnetic waves no longer can exist. In addition to the conventional method of simply increasing the frequency to establish the magnetic field strength, it is necessary to overcome this limit and to stabilize instabilities that appears in them. As a new strategy, we applied electromagnetic waves with much lower frequency than ECR's ones, which essentially has no density limit. Typical examples include the introduction of ion cyclotron resonance (ICR) and lower hybrid resonance (LHR). In this paper, we will mainly report on the former, and will report the results obtained by improving the efficiency of multiply charged ion generation based on selective heating by ICR of low mass number element ions during low mass number element gas mixing. In particular, it was found that the effect of low-frequency electromagnetic waves was large when introducing light Z gases such as Ar and He into the Xe operating gas, and the corresponding changes in various parameters were measured. We will also discuss the preparation status of the LHR experiment, as well as strategies for applying low-frequency electromagnetic waves to relieve and stabilize possible instabilities caused by the peaking phenomenon of spatial parameters due to the already mentioned density limit.

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