A Miniature Dual-anode Electron Beam Ion Trap to Generate Highly Charged Ions with Low Ionization Threshold

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In addition to their importance in hot plasma diagnostics, recent theoretical studies indicate that certain highly charged ions (HCIs), such as Pr^{9+} and Nd^{10+}, are potentially useful for such applications as the development of next-generation atomic clocks, quantum information processing, or the search for variation in the fine-structure constant [1]. Highly-stripped heavy ions have been studied in an electron beam ion trap (EBIT) with a strong magnetic field (~ 3 T). However, there are many interesting charge states that are not generated efficiently in an EBIT because of their low ionization threshold; in such cases, a lower magnetic field and more compact geometry are better suited for abundantly producing the above-mentioned examples, as well as other ions with relatively low ionization thresholds (50 eV to 1000 eV). We present a room-temperature miniature EBIT (mini-EBIT) with a dual-anode electron gun, which has been developed to alleviate the space-charge effects in propagating an electron beam at lower energy. This work discusses the tests and new capabilities of the mini-EBIT apparatus for the production and extraction of highly charged ions with low ionization thresholds. Time-of-flight spectra of extraction of noble gas HCIs (ions of Ne, Ar, Kr, Xe gases) are analyzed for the identification of ion species and the ion counts. Progress on the extraction of charge-state-selected HCI species via a Wien filter unit is presented. Preliminary design work for the re-trapping and isolation of HCIs in a permanent magnet Penning trap with a trap center magnetic field (~ 0.72 T) is also presented.

References

[1] M. Safronova, *et al.*, PRL **113**, 030801 (2014).