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Evolution of Transverse Phase-Space Distribution of Highly Charged Heavy Ion Beams through LEBT

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We studied how the transverse phase-space distribution (PSD) of heavy-ion beams extracted from an ECR ion source (ECRIS) changes as a function of the extraction current I_{ext} through the LEBT. Heavy ion beams produced by ECRIS are distributed over a certain range of charge, so that the total current extracted from the ion source I_{ext} is an order of magnitude larger than that of the target ion beam. Therefore, when aiming for higher intensity ion beams than the now, the I_{ext} will also increase, and the emittance increase due to the space-charge effect (SCE) of I_{ext} is expected to become a serious problem. From the view point, it is necessary to clarify how the transverse PSD changes with changes in the extraction current I_{ext}.
The emittance of Ar beams with several charges extracted from the 28-GHz superconducting ECRIS at the RIKEN was measured with a pepper-pot type emittance meter installed after the magnetic analyzer. The Ar beam was tuned to a few 10 μA to avoid significant SCE of its own. The I_{ext} was varied from 1.4 mA to 7.0 mA, mainly by adjusting the amount of N_2-support gas and microwave power for ECR heating.
It is found that the x and y emittances of $Ar^{10+,11+,13+}$ increase with increasing values of I_{ext}. Furthermore, it is found that the x-y distribution at the analyzing slit does not spread in a similar shape. These Ar beams, which are annularly distributed (hollow beam) up to I_{ext} ~ 2 mA, but from I_{ext} ~ 3mA, are gradually concentrated in a few localized spots. Finally, at 7 mA, the beams no longer have annular structure. These changes in the beam distribution are not distributions that can be simply predicted from the beam spread due to SCE only. We will discuss whether the combination of the SCE and aberrations during LEBT transport can explain these changes in the transverse PSD, or whether we need to include phenomena inside the ECRIS.

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Yes

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