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Ion beam extraction and transport for high-field electron cyclotron resonance ion sources

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Ion beam extraction and transport for high-field electron cyclotron resonance ion sources (abstract)[a]

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The next-generation, very high magnetic-field electron cyclotron resonance (ECR) ion sources, like VENUS, SERSE, or PHOENIX, strive for substantially (a factor of 10) higher extracted heavy ion beam intensities than currently achievable. Such high-intensity ion beams present significant challenges for the design and simulation of an ECR extraction and low-energy ion beam transport system. Extraction and beam formation take place in a strong (up to 3 T) axial magnetic field, which leads to significantly different focusing properties for the different ion masses and charge states of the extracted beam. Typically, beam simulations must take into account the contributions of up to 50 different charge states and ion masses. Space charge effects must be correctly included since the extraction and mass analyzing system have to be designed for a proton-equivalent current of ~25 mA at 30 kV extraction voltage. The article discusses state of the art two-dimensional and three-dimensional simulation techniques for such ion beam extraction and transport systems. Furthermore, the main contributions to the ion beam emittance are discussed: (1) The induced beam rotation due to the strong axial magnetic field, (2) the concentration of high charge state ions at the source center axis, and (3) the ion beam temperature. A novel large-gap analyzing magnet design is described which allows efficient correction of higher-order aberrations for high-intensity heavy ion beams. Such a magnet limits emittance blow up, and is necessary if the analyzed beam has to be further transported or accelerated, e.g., in a radio frequency quadrupole. [DOI: 10.1063/1.1432453]

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