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45° Ion Motion in an RFQ: a Study of SIMION 8.1 for Modeling Isobar Separator Beam Dynamics in AMS

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Radiofrequency multipoles (RFM's) are a promising new technology in accelerator mass spectrometry (AMS) for contributing to the removal of atomic and molecular isobars when combined with appropriate gases. The motion of charged particles in vacuo through the hyperbolic RFQ version are governed by the Mathieu functions for which convenient algebraic solutions exist for direct, continuous calculation of position, velocity and energy of a particle over a range of initial conditions and RF inputs for the continuous RFQ. Though the Mathieu solutions for the RFQ are well known, the ability to model reliably cation and anion trajectories in a general isobar separator column for AMS remains incompletely explored. This difficulty is due to issues inherent to matching an RFM to particle beams from AMS sputter-ion sources, i.e.: (1) large time-dependent phase-space variations of the beams into the RFQ, (2) space-charge effects, (3) the effect of (residual) gas collisions during deceleration, reactions and final re-acceleration, and (4) geometric impedances associated with an RFM column. A key reason for using the software SIMION extensively is to assist the designs of such devices, thus it is highly desirable to ensure SIMION results are reliable by comparing it to purely algebraic solutions. Here we report one such comparable case: the study of the ion motion in an RFQ for the extreme 45°-limit between the hyperbolic poles under vacuum conditions. Particle positions, trajectories and energies for the RFQ ions initially at $\pm 45^\circ$ are compared with the "direct"Mathematica calculations and those obtained by SIMION "simulations". We confirm that SIMION results are trustworthy for assisting RFM device designs.

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