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Ion Beam Focusing with Cone Optics for WDM Experiments

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Ion beam focusing using cone optics has recently been examined experimentally [1] and numerically [2] and its applicability to accelerator-driven warm dense matter (WDM) experiments is one of the issues to be discussed. This beam-focusing scheme is based on small angle scattering of incident ions by the solid wall of a conical tube. Since the ion scattering depends strongly on various physical quantities such as the scattering angle, the incident ion species and energy, and the atomic composition of the tube wall, systematic investigation over a wide range of these parameters is necessary to understand beam transport physics in the cone optics. The aim of this study is to systematically examine the ion transport through the cone optics by numerical simulations and clarify the potential of this focusing method in the beam parameter ranges relevant to the WDM experiments.

The numerical investigation in this study used a three-dimensional Monte Carlo code, which takes into account only elastic scattering between incident ions and target atoms as a stochastic process. The energy loss of the incident ions in the tube wall was calculated using SRIM stopping power data. The beam focusing efficiency was evaluated for various combinations of beam parameter and conical tube material and shape. We found that the use of cones with parabolic wall shapes drastically improves the focusing efficiency although it degrades the output beam quality. The simulation results also showed that the heavier wall material leads to higher focusing efficiency. However, its dependency on the atomic number of the wall material was much weaker than expected from the scattering cross section, indicating that the ion stopping process inside the wall might dominate the overall focusing efficiency of the cone optics. From the results of the systematic investigation, the cone optics designs were optimized for the beam parameters that will be achieved in the future WDM experiments.

[1] F.M. Bieniosek, et al., Laser and Particle Beams 28, 209-214 (2010).
[2] J. Hasegawa, et al., Journal of Applied Physics, 110, 044913-044919 (2011).

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