SCALING LAWS FOR ELECTRON LOSS

FROM ION BEAMS*

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Heavy Ion Fusion requires accelerating intense beams of low-charge-state, heavy ions to high energies, transporting them over long distances, and focusing them on a small target in a target chamber. All along the beam path interactions between the beam particles and background gases generate charge and energy straggled beam components which are lost to the walls. This degrades the beam quality, erodes vacuum walls or lens elements, and increases radiation levels. Minimizing such problems requires information about interaction probabilities, particularly for single and multiple electron loss from fast, low-charge-state, heavy ions interacting with many-electron targets. Unfortunately, direct experimental information is not possible since existing acclerators cannot provide low-charge-state heavy ion beams at the high energies of interest. Therefore, available information must be extrapolated to the regions of interest. Theory can be used for this purpose but is complicated since multi-electron transitions resulting from intereactions between two highly complex particles must be modeled.

To aid in this problem we have used available experimental information to extract empirical scaling laws for projectile electron loss resulting from collisions with a many-electron target. It was found that a single universal curve can be used to fit single and multiple electron loss from virtually any projectile. The same curve can be used for loss from negative ions, neutral particles, and singly or multiply charged positive ions. We have applied the scaling to projectiles ranging from hydrogen to uranium and collision energies ranging from sub keV/u to hundreds of MeV/u. At high energies, existing data are consistent with a v^{-1} impact velocity dependence for scaled velocities less than 10. Above 10, limited data imply that the velocity dependence becomes v^{-2}. Using our fitted curve and a few input parameters such as the ionization potentials and number of outer shell electrons, absolute cross sections can be extracted for single and multiple electon loss from any arbitrary ion; from these total loss cross sections and the average number of electrons lost can be determined. Examples and predictions for electron loss from several possible ions of interest to the HIF program will be presented.

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