Cusp loss width in multicusp negative ion source: A rigorous mathematical treatment

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Cusp loss width (CLW) is an important parameter used in designing of H^- ion source as it helps in determining the total power requirement of the source by considering particle loss at the multicusp regions. This parameter has been derived by many workers based on certain assumptions and approximations but it does not take into account the curved nature of magnetic lines of force in the cusp region[1-3]. This statement is vindicated by the fact that above method derives same expression for cusp leak width irrespective of different cusp geometries. Similarly, the final expression of CLW depends on ion acoustic velocity, magnetic field at the cusp and half length of magnetic lines of force[2,3]. The last parameter is the only geometrical parameter in the expression. However, it does not define which particular half length of magnetic lines of force has been considered, thus, leading to insensitivity to geometrical aspects of the multicusp: planar,cylindrical etc.

In the present analytical study, we report on a rigorous mathematical treatment considering geometrical aspects of the cusp leak width taking into account the appropriate geometrical factors for the cylindrical line cusp. In the present study the multicusp magnetic field in cylindrical geometry has been decomposed in to various harmonics [4]. Our results show that apart from the reported term by others, there is another term that is dependent on the geometrical aspects of the multicusp and become quite dominant in the low pressure region (< 1 mTorr) contributing nearly 90% to CLW and for region typically applicable for negative ion sources (~10 mTorr) it contributes to nearly 48%, with the assumption that particles at the cusp are lost with ion acoustic velocity (C_s) along the field line at the cusp and $D_{\|}\left(\frac{\partial n}{n\partial r}\right)_{Cusp} = C_s$. In conclusion, we define the significance of the geometrical factors in the CLW calculations.

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