Magnetic Mirror Effect in Magnetron Plasma:

Modeling of Plasma Parameters

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1. Lorentz Force

Lorentz force

$$\frac{d\mathbf{v}}{dt} = \frac{q}{m}\left(\mathbf{E} + \mathbf{v} \times \mathbf{B}\right) \tag{1}$$

$$\frac{d\mathbf{x}}{dt} = \mathbf{v} \tag{2}$$

Discretized Lorentz force

$$\frac{\mathbf{v}_{k+1} - \mathbf{v}_k}{\Delta t} = \frac{q}{m}\left[\mathbf{E}_k + \frac{(\mathbf{v}_{k+1} + \mathbf{v}_k)}{2} \times \mathbf{B}_k\right] \tag{3}$$

$$\frac{\mathbf{x}_{k+1} - \mathbf{x}_k}{\Delta t} = \mathbf{v}_{k+1} \tag{4}$$

2. Boris Algorithm

Boris Algorithm

$$
\begin{aligned}
\mathbf{v}^{-} &= \mathbf{v}_k + q'\mathbf{E}_k \\
\mathbf{v}^{+} &= \mathbf{v}^{-} + 2q'\left(\mathbf{v}^{-} \times \mathbf{B}_k\right) \\
\mathbf{v}_{k+1} &= \mathbf{v}^{+} + q'\mathbf{E}_k \\
\mathbf{x}_{k+1} &= \mathbf{x}_k + \Delta t \ \ \mathbf{v}_{k+1}
\end{aligned}
\tag{5}
$$

where $q' = \frac{q}{m}\frac{\Delta t}{2}$.

References

Qin, H., Zhang, S., Xiao, J., & Tang, W. M. (April, 2013). *Why is Boris algorithm so good?*. Princeton Plasma Physics Laboratory, PPPL-4872.