

# **Magnetic Mirror Effect in Magnetron Plasma:**

## Modeling of Plasma Parameters

---

January 20, 2022

# 1. Lorentz Force

## Lorentz force

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

$$\frac{d\mathbf{x}}{dt} = \mathbf{v} \quad (2)$$

## Discretized Lorentz force

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

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

## 2. Boris Algorithm

### Boris Algorithm

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

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.