Track3P

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Introduction

Track3P is a 3D parallel particle tracking code for multipacting and dark current simulations. Track3P provides unprecedented capabilities for modelling complex structures with fast turn-around times and has been successfully used to predict multipacting phenomena in many accelerator components such as the ILC ICHIRO cavities, TTFIII coupler and its components, SNS coupler and cavities,...

Multipacting procedure

Run Multipacting Code Do Post-Process 1. Field level scan: different 1. Impact energy range combination of transmission 2. SEY curve Step1: Construct MP and reflection coefficients susceptible zone 2. Launching location scan: MP susceptible zone: space and phase 3. Launching energy: 2ev-5ev 1. Field level 4. Scan variable external B field, DC bias ... 2. Location 3. Reflection coefficient, external B field, ... After both MP field level and Step2: Trace out location are determined, Plot the trajectory of space trajectory and find calculations are repeated to and phase MP order trace out the trajectory of MP electrons and to find out the time of flight between impacts

Mathematical Modeling

Motion equations and Numerical scheme

$$\begin{split} \frac{d\vec{p}}{dt} &= e(\vec{E} + \frac{1}{c} \left[\vec{v} \times \vec{B} \right] \right), \vec{p} = m \gamma \vec{v}, \gamma = \frac{1}{\sqrt{1 - v^2 / c^2}} \\ \vec{r}_{n+1} &= \vec{r}_1 + (\vec{v}_n + \vec{v}_{n+1}) \frac{\Delta t}{2}, \vec{r}_1 = \vec{r}_n + \frac{1}{2} \vec{v}_n \Delta t \\ \vec{p}_{n+1} &= \vec{p}_2 + \vec{E}(r_1, t_n) \Delta t \qquad f_2 = 2 \frac{f_1}{1 + f_1^2 |\vec{B}^2|} \\ \vec{p}_2 &= \vec{p}_1 + f_2(\vec{p}^2 \times \vec{B}) \qquad f_1 = f_{\mathcal{E}} t g f_{\mathcal{E}}^2 |\vec{B}^2| \\ \vec{p}_1 &= \vec{p}_n + \vec{E}(r_1, t_n) \Delta t \qquad f_{\mathcal{E}} = \frac{ec \Delta t}{2\sqrt{\vec{p}^2 + mc^2}} \end{split}$$

Omega3P fields interpretation

$$\overline{E}(x, y, z, t) = s \sum_{i} \overline{E}_{i}(x, y, z) \sin(w_{i}t + \psi_{i})$$

$$\overline{B}(x, y, z, t) = \mu_{0}s \sum_{i} \overline{H}_{i}(x, y, z) \cos(w_{i}t + \psi_{i})$$

$$\mathbf{E}_{i}, \mathbf{H}_{i} - \text{Eigen modes}$$

$$\omega_{i} = 2\pi F_{i} - \text{Eigen frequencies}$$

$$\psi_{i} - \text{Initial oscillation phases}$$

$$s = \frac{eU_{accel}}{\varepsilon_{started}} - \text{scale factor.}$$

Field emission

Fowler-Nordheim law:
$$J(r,t) = 1.54 \times 10^{\left(-6 + \frac{4.52}{\sqrt{\varphi}}\right)} \frac{(\beta E)^2}{\varphi} e^{\left(\frac{-6.53 \times 10^9 \varphi^{1.5}}{\beta E}\right)}$$
$$v_0 = \sqrt{\frac{2|e|\varphi}{m}}$$

φ - Work function of the metal (i.e., 4.4 for Cu)

β - Field enhancement factor (300 typical)

E - Magnitude of external electric field

m - Mass of an individual particle

Secondary emission

$$\begin{split} &I_{secondary} = I_{primary} \, \sigma(\phi, \epsilon), \\ &\sigma = \delta + \eta + r, \end{split}$$

where

 δ - Coefficient of elastic scattering

 $\boldsymbol{\eta}$ - Coefficient of non-elastic scattering

r - Coefficient for true secondary electrons

Past Accomplishments