Particle-in-Cell (PIC) kinetic simulations
09. Electromagnetic field solver

Chun-Sung Jao (饒駿頌)
Assistant Research Scholar,
Institute of Space Science and Engineering,
National Central University, Taiwan

University of São Paulo, 2019.11.25-12.06

www.slido.com code: #B194

Maxwell's equations (1D)

$$\frac{\partial}{\partial y}=\frac{\partial}{\partial z}=0$$

$$\nabla\cdot\vec{E}=\frac{\rho_c}{\varepsilon_0} \qquad \frac{\partial E_x}{\partial x}=\frac{\rho_c}{\varepsilon_0}$$

$$\nabla\cdot\vec{B}=0 \qquad \frac{\partial B_x}{\partial x}=0 \qquad B_x=const$$

$$\nabla\times\vec{E}=-\frac{\partial\vec{B}}{\partial t} \qquad -\frac{\partial E_z}{\partial x}=-\frac{\partial B_y}{\partial t} \qquad \frac{\partial E_y}{\partial x}=-\frac{\partial B_z}{\partial t}$$

$$\nabla\times\vec{B}=\mu_0\vec{J}+\frac{1}{c^2}\frac{\partial\vec{E}}{\partial t} \qquad -\frac{\partial B_z}{\partial x}=\mu_0 J_y+\frac{1}{c^2}\frac{\partial E_y}{\partial t} \qquad \frac{\partial B_y}{\partial x}=\mu_0 J_z+\frac{1}{c^2}\frac{\partial E_z}{\partial t}$$

Maxwell's equations (2D)

$$\nabla \cdot \vec{B} = 0$$

$$\frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y} = 0$$

$$\frac{\partial}{\partial z} = 0$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\frac{\partial E_z}{\partial y} = -\frac{\partial B_x}{\partial t}$$

$$-\frac{\partial E_z}{\partial x} = -\frac{\partial B_y}{\partial t}$$

$$\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y} = -\frac{\partial B_z}{\partial t}$$

$$\nabla \times \vec{B} = \mu_0 \vec{J} + \frac{1}{c^2} \frac{\partial \vec{E}}{\partial t}$$

$$\frac{\partial B_z}{\partial y} = \mu_0 J_x + \frac{1}{c^2} \frac{\partial E_x}{\partial t}$$

$$-\frac{\partial B_z}{\partial x} = \mu_0 J_y + \frac{1}{c^2} \frac{\partial E_y}{\partial t}$$

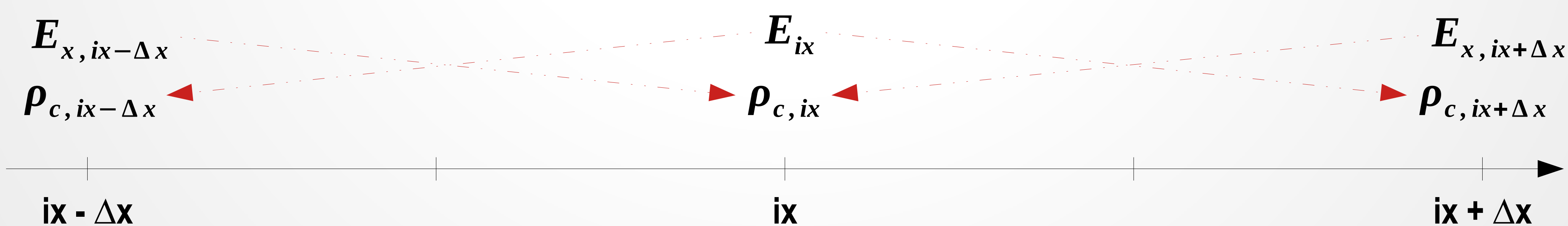
$$\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y} = \mu_0 J_z + \frac{1}{c^2} \frac{\partial E_z}{\partial t}$$

Maxwell's equations (1D)

$$\frac{\partial E_x}{\partial x} = \frac{\rho_c}{\varepsilon_0}$$

$$\frac{\partial}{\partial y} = \frac{\partial}{\partial z} = 0$$

$$\frac{E_{x,ix+\Delta x} - E_{x,ix-\Delta x}}{2\Delta x} = \frac{\rho_{c,ix}}{\varepsilon_0}$$

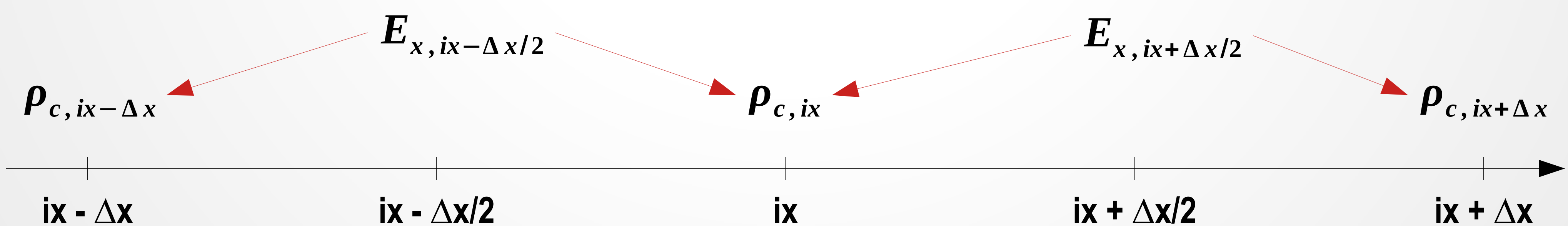


Maxwell's equations (1D)

$$\frac{\partial E_x}{\partial x} = \frac{\rho_c}{\varepsilon_0}$$

$$\frac{\partial}{\partial y} = \frac{\partial}{\partial z} = 0$$

$$\frac{E_{x,ix+\Delta x/2} - E_{x,ix-\Delta x/2}}{\Delta x} = \frac{\rho_{c,ix}}{\varepsilon_0}$$



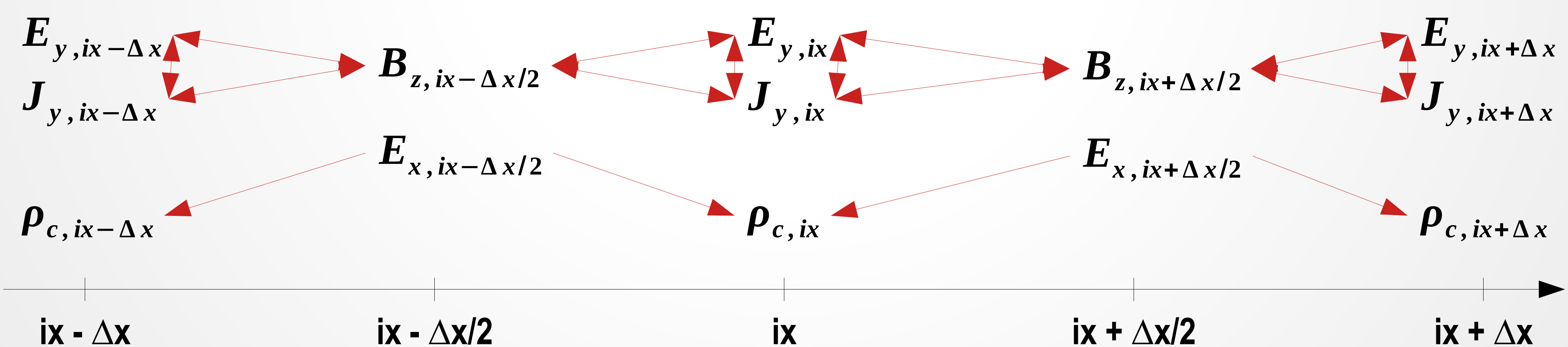
Maxwell's equations (1D)

$$\frac{\partial}{\partial y}=\frac{\partial}{\partial z}=0$$

$$\frac{\partial E_x}{\partial x}=\frac{\rho_c}{\varepsilon_0}$$

$$-\frac{\partial B_z}{\partial x}=\mu_0 J_y+\frac{1}{c^2}\frac{\partial E_y}{\partial t}$$

$$\frac{\partial E_y}{\partial x}=-\frac{\partial B_z}{\partial t}$$



Maxwell's equations (1D)

$$\frac{\partial}{\partial y}=\frac{\partial}{\partial z}=0$$

$$\frac{\partial E_x}{\partial x}=\frac{\rho_c}{\varepsilon_0}$$

$$-\frac{\partial B_z}{\partial x}=\mu_0 J_y+\frac{1}{c^2}\frac{\partial E_y}{\partial t} \qquad \frac{\partial E_y}{\partial x}=-\frac{\partial B_z}{\partial t}$$

$$\frac{\partial B_y}{\partial x}=\mu_0 J_z+\frac{1}{c^2}\frac{\partial E_z}{\partial t} \qquad -\frac{\partial E_z}{\partial x}=-\frac{\partial B_y}{\partial t}$$