Electrodynamics, lecture 11, 2019

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Electrical and information technology

Last lecture

- Relativistic energy and momentum
- Relativistic dynamics

Energy and momentum

Relativistic 4-vector for the momentum of particle with mass m and velocity $\boldsymbol{v}$

$$p^{\mu} = \begin{pmatrix} \gamma mc \\ \gamma m v_x \\ \gamma m v_y \\ \gamma m v_z \end{pmatrix}$$

Einstein identified $p^0 c$ as the relativistic energy

$$E \equiv m\gamma c^2 \tag{1}$$

Equation of motion

$$\boldsymbol{F} = \frac{d\boldsymbol{p}}{dt} \tag{2}$$

where $\boldsymbol{p}$ is the relativistic momentum.

Equation of motion

Example: Circular motion in a constant $\boldsymbol{B}$-field
$R =$ radius of circle
Nonrelativistic radius

$$F = \frac{mv^2}{R} \tag{3}$$

$$F = qvB \tag{4}$$

$$R = \frac{mv^2}{F} = \frac{mv}{qB} \tag{5}$$

The relativistic expression of the radius is

$$R = \frac{m\gamma v}{qB} = \frac{p}{qB} \tag{6}$$

Einstein quote

"Everything Should Be Made as Simple as Possible, But Not Simpler"

Today

- Relativistic electrodynamics
- Tensor notation