Relativity — Lecture 9

- Summary of Lecture 8
- Space-Time Geometry

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100 years of living science
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Lecture 8

Revision

Remember this

For a particle of mass m, momentum p and energy E

$$\beta = \frac{pc}{E}, \qquad \gamma = \frac{E}{mc^2}.$$

Electron Gun

Electrons accelerated to $1\,\mathrm{MV}$

$$\left.\begin{array}{rcl} m_\mathrm{e} & \sim & 10^{-30}\,\mathrm{kg} \\ e & = & 1.6\cdot 10^{-14}\,\mathrm{C} \end{array}\right. \quad \rightarrow \quad \left.\begin{array}{rcl} m_\mathrm{e}c^2 & = & 9\cdot 10^{-14}\,\mathrm{J} \\ K & = & 16\cdot 10^{-14}\,\mathrm{J} \end{array}\right\} E$$

$$\beta = \frac{v}{c} = \sqrt{1-\left(\frac{m_\mathrm{e}c^2}{E}\right)^2} \simeq 0.9$$

Electron Gun

Electrons accelerated to $1\,\mathrm{MV}$

$$\left.\begin{array}{rcl} m_\mathrm{e} & \sim & 10^{-30}\,\mathrm{kg} \\ e & = & 1.6\cdot 10^{-14}\,\mathrm{C} \end{array}\right. \quad \rightarrow \quad \left.\begin{array}{rcl} m_\mathrm{e} & = & 0.5\,\mathrm{MeV}/c^2 \\ p & = & 1\,\mathrm{MeV}/c \end{array}\right\} E$$

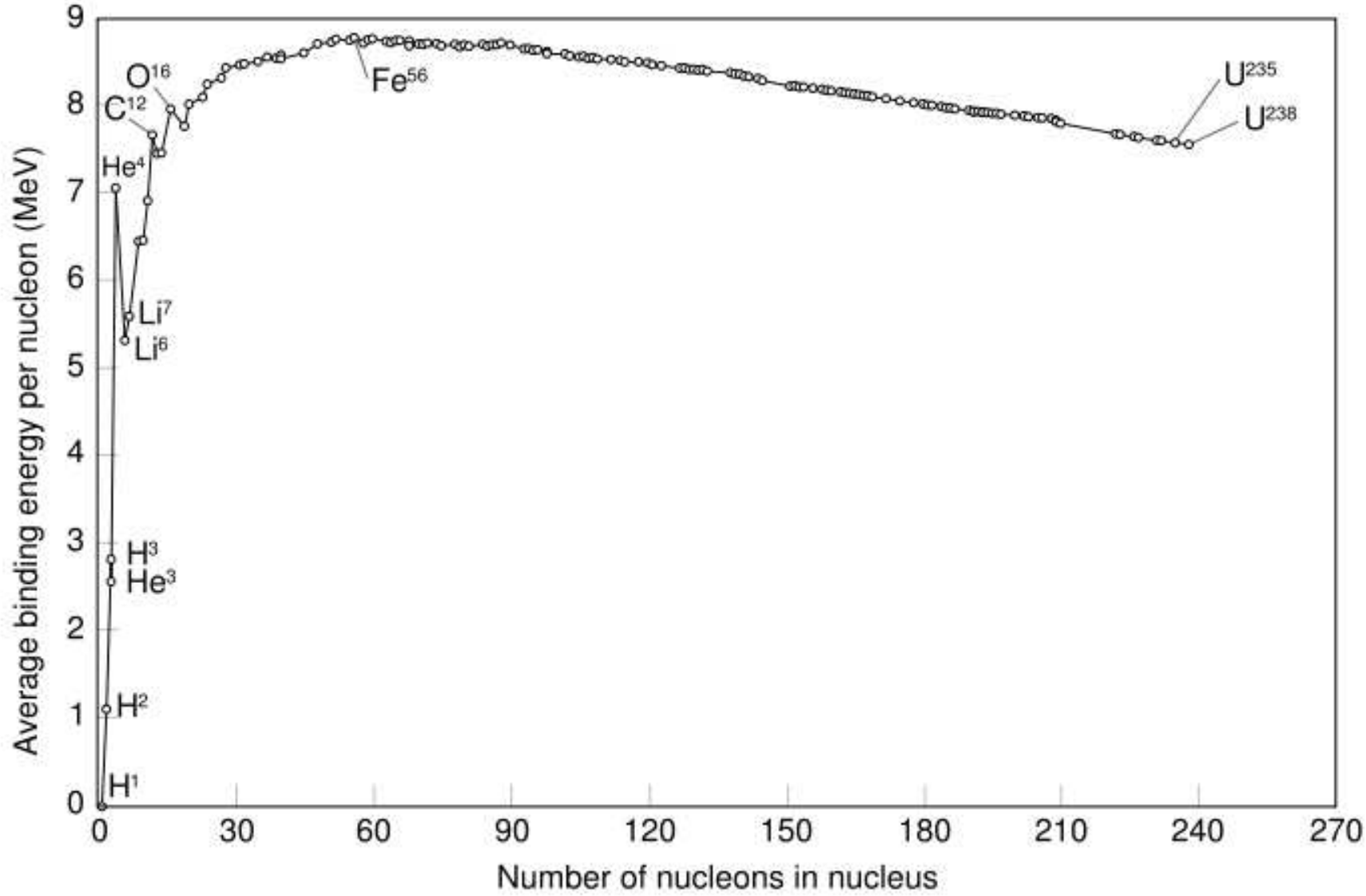
$$\beta = \frac{p}{E} = \frac{p}{\sqrt{p^2+m_\mathrm{e}^2}} = \frac{1}{\sqrt{1+\frac{1}{4}}} \simeq 0.9.$$

Useful units

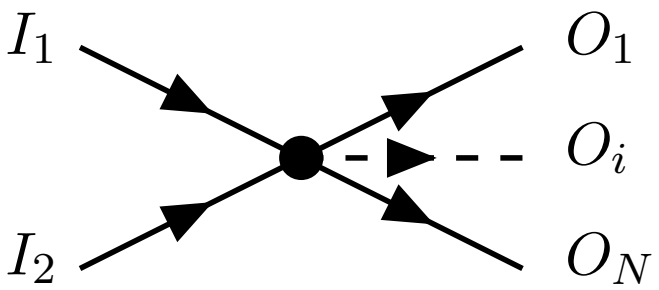
- Express energies in eV
- Express momenta in eV/c
- Express masses in eV/c^2

$$1\,\mathrm{GeV}/c^2 = 10^9 \frac{1\mathrm{V}\cdot e}{c^2} = \frac{10^9 \cdot 1.6 \cdot 10^{-19}}{9 \cdot 10^{16}} \simeq 2 \cdot 10^{-27}\,\mathrm{kg}$$

Binding Energy



Particle Collisions



$$\sum_i \boldsymbol{p}_i = \sum_o \boldsymbol{p}_o$$

$$\sum_i \boldsymbol{E}_i = \sum_o \boldsymbol{E}_o$$

with $E^2_{(i,o)} = p^2_{(i,o)}c^2 + m_{(i,o)}c^4$

Lorentz Transforms

Lorentz Transformations $(\boldsymbol{x}, ct)$

$$\begin{aligned} x' &= \gamma\left(x - \beta ct\right) \\ y' &= y \\ z' &= z \\ ct' &= \gamma\left(ct - \beta x\right) \end{aligned}$$

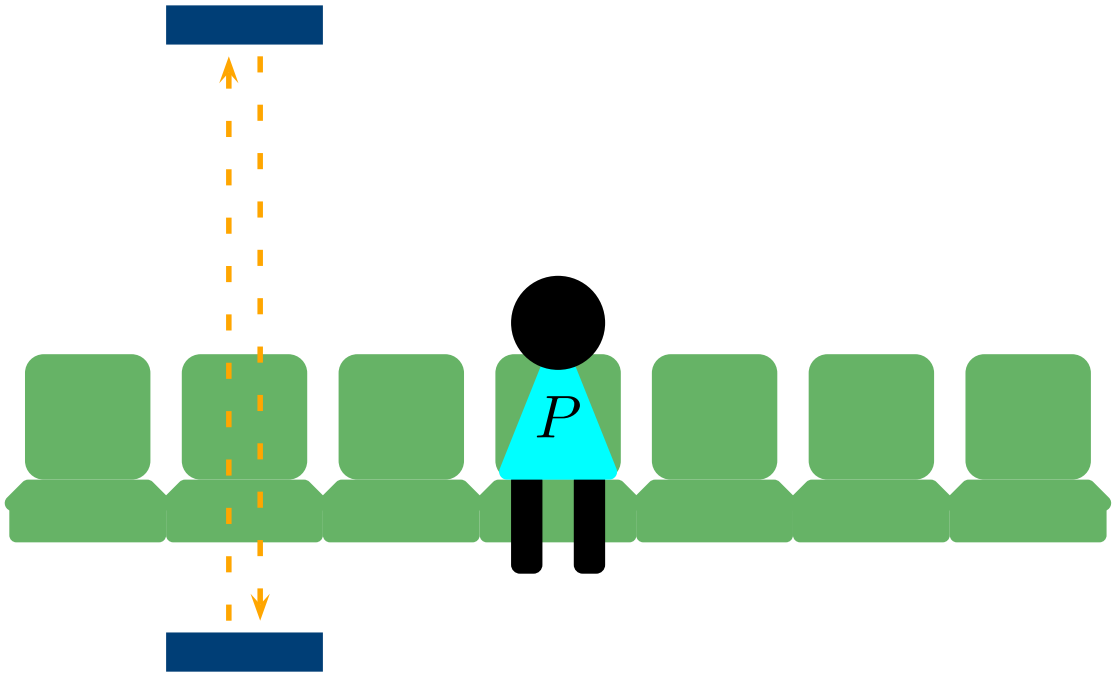
Lorentz Transformations $(\boldsymbol{p}, E)$

$$\begin{aligned} p'_x &= \gamma\left(p_x - \beta\frac{E}{c}\right) \\ p'_y &= p_y \\ p'_z &= p_z \\ \frac{E'}{c} &= \gamma\left(\frac{E}{c} - \beta p_x\right) \end{aligned}$$

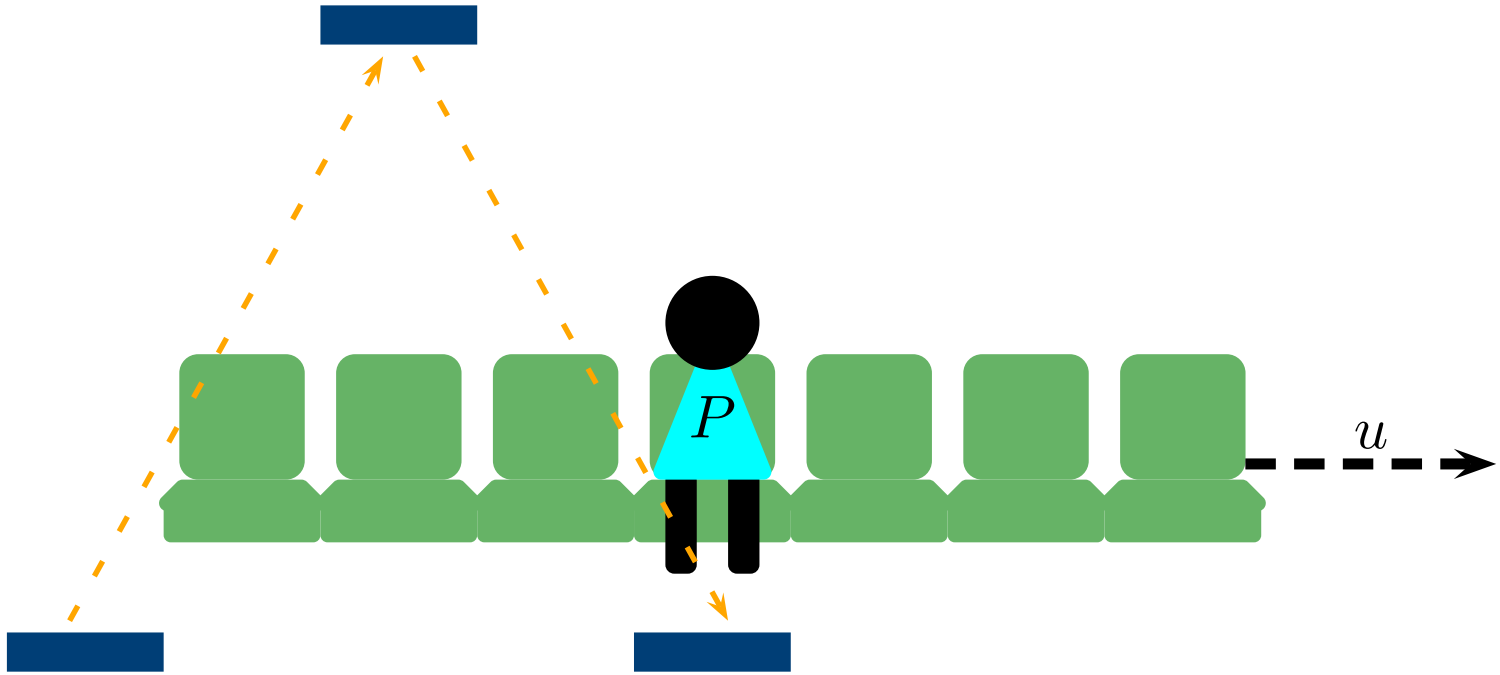
p transforms like x and E/c like ct.

Lecture 9

Clock on a Train



Clock on a Train



Invariance