Tutorial 1 - Fundamental Interactions

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1 Decay of a Relativistic Particle

A particle A of mass M has a half-life (at rest) of 10 seconds to decay into two stable particles B and C which both have mass M/4. Suppose particle A is moving at v = 3c/5.

a) What is its half-life?

When particle A decays into B and C, suppose that particle B emerges at an angle perpendicular to the direction of particle A.

b) What is the magnitude of the velocity of particles B and C in the center-of-mass reference frame?

c) What is the magnitude of the velocity of particles B and C in the original reference frame?

Suppose that particles B and C both have mass M' (instead of M/4).

d) What is the maximum value of M' such that particle B can emerge at an angle perpendicular to the direction of particle A?

e) If M' is larger than this maximum value, what is the range of possible angles (as a function of M') for particle B to emerge with respect to the direction of particle A?

2 Natural Units System

The action of a real and massive scalar field in an anharmonic potential in a Minkowski spacetime reads (in natural units)

$$S = \int d^4x \, \left[\partial_\mu \phi \, \partial^\mu \phi - m^2 \phi^2 - \frac{\lambda}{4!} \phi^4 \right]. \tag{1}$$

a) What is the dimension of the field ϕ and of the constant λ in energy units?

b) Find the Lagrangian density in the SI.