Answer on Question #40684, Physics, Electrodynamics

Question:

TWO BEAMS OF PROTONS MOVING WITH VELOCITY V1 AND V2 ARE ALLOWED TO ENTER PARALLEL TO EACH OTHER IN A FIELD FREE REGION.THE RATIO OF MAGNETIC FORCE TO ELECTROSTATIC FORCE IS -

1. v1v2/c2

2. c2/v1v2

3. v1/v2

4. (v1v2)1/2/c

Answer:

Coulomb's law states that the electrical force between two charged objects is directly proportional to the product of their charges (and inversely proportional to the square of the distance between them):

$$F_{el} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

where ε_0 is the permittivity of free space.

The magnetic interaction is also an inverse square law, and the law of Biot-Savart gives the field B at distance r due to a small length dL carrying current I:

$$B = \frac{\mu_0}{4\pi}\frac{IdL}{r^2}$$

where μ_0 is the permeability of space.

In this case, if the charge q covers the distance dL in time dt, then I dL may be replaced with $I\frac{dL}{dt} = q_1 v_1$. In this case, the field and the velocity of the second charge are at right angles, so the force on the second charge has the magnitude $Bq_2 v_2$, which is here attractive and:

$$F_m = \frac{\mu_0}{4\pi}\frac{q_1 q_2 v_1 v_2}{r^2}$$

So, the ratio of forces:

$$\frac{F_m}{F_{el}} = v_1 v_2 \mu_0 \varepsilon_0$$

But $\mu_0 \varepsilon_0 = \frac{1}{c^2}$, therefore:

$$\frac{F_m}{F_{el}} = \frac{v_1 v_2}{c^2}$$

Answer: 1. $\frac{v_1 v_2}{c^2}$