

To simplify this discussion, the concept of force is divided into two types. One type is applied force. An example of an applied force is the force you generate with your hand when throwing a ball. The second type of force is that which is generated by a field. The force of gravity would be an example of a field generated force. This discussion will only concern itself with applied forces.

The absence of analyses involving forces within relativity theory does not mean that force doesn't exist. Science knows that force exists. So, what is force? Newton's Laws define applied force in the mathematical universe. But, Newton only says what a force does and not what it is. The hypothesis here is that applied force is only the result of energy movement. And, it is the speculation of this article (and the companion article *Static Forces*) that photon movement is the only way that energy moves and is responsible for all applied forces.

A first impression of his idea may be that it ignores other types of applied forces. But, if there are other types of applied forces, then name them. Spring force? No. That comes under the classification of static force (to be explained in *Static Forces*). Acceleration force? That's a static force (due to the need to have something push on an object to accelerate it). Gas pressure on a piston? That's also a static force. All applied forces are static forces in the real universe. If static forces are forces generated by photons, the link between Newtonian applied force and photon generated force must be examined.

Mathematical Force in the Direction of Velocity

Photon generated force is the practical application of the mathematical concept of force as the result of energy movement. The traditional mathematical expression of force F is contained in Newton's Laws as expressed by (20) from the article *Force and Geometry*. For the simple case of a force applied in the direction of motion, (21a) is the result, which is stated here as:

$$F = \frac{mc}{(1 - \beta^2)^{3/2}} \frac{d\beta}{dt} \quad (52)$$

Mass m and velocity β in (52) can also be combined into an expression for the energy E of the object.

$$E = \frac{mc^2}{\sqrt{1 - \beta^2}} \quad (53)$$

Differentiating (53) gives an expression for the object acceleration:

$$\frac{d\beta}{dt} = \frac{1 - \beta^2}{\beta E} \frac{dE}{dt} \quad (54)$$

Combining (52), (53) and (54) gives:

$$F = \frac{1}{c\beta} \frac{dE}{dt} \quad (55)$$

Equation (55) states that force is a function of the change in energy of mass m . However, since the Law of Conservation of Energy states that energy cannot be created or destroyed, the only meaningful change of energy of a mass is the movement of energy into or out of the mass.

Force from Photons

Since force can be expressed as a function of energy change, consider the energy change of an experiment using pure energy (photons).



Figure 21. A photon runs into a block of matter.

Figure 21 shows a photon about to run into a block of matter. The matter is stationary in the reference frame viewing the experiment. The photon will impact the matter and give it a velocity. During this impact, the matter will feel a force causing it to accelerate. This is a version of the experiment in *Force and Time*. The energy of the photon before the impact is E_P . After the photon impacts the matter, it will be converted into heat energy contained within the matter and the amount of this energy is E_H . The matter has mass m and the velocity of the matter after photon impact is β . From the Law of Conservation of Momentum, the momentum of the system before impact is equal to the momentum after impact.

$$\frac{E_P}{c} = \frac{\left(m + \frac{E_H}{c^2}\right)c\beta}{\sqrt{1 - \beta^2}} \quad (56)$$

From the Law of Conservation of Energy, the energy of the system is equal before and after the photon impact.

$$E_p + mc^2 = \frac{\left(m + \frac{E_H}{c^2}\right)c^2}{\sqrt{1 - \beta^2}} \quad (57)$$

Plugging (57) into (56):

$$\beta = \frac{1}{1 + \frac{mc^2}{E_p}} \quad (58)$$

Combining (56), (57) and (58):

$$E_p - \frac{E_H}{\sqrt{1 - \beta^2}} = mc^2 \left(\frac{1}{\sqrt{1 - \beta^2}} - 1 \right) \quad (59)$$

Equation (59) states that the difference in the photon energy before and after the impact (relative to the stationary observing reference frame) is equal to the kinetic energy gain of the matter. The traditional interpretation of this kinetic energy gain of matter is illustrated in (14) and (15) from the article *The Acceleration Law* and is a function of the force F applied to the matter times the distance x over which the force was applied:

$$Fx = mc^2 \left(\frac{1}{\sqrt{1 - \beta^2}} - 1 \right) = E_p - \frac{E_H}{\sqrt{1 - \beta^2}} \quad (60)$$

The force on the matter can be expressed as a function of the energy change of the photon. Because the photon is pure energy, this experiment demonstrates a conversion of energy into force (and displacement x). Equation (60) is similar to the equation stating that the energy of a photon is related to its momentum P_p :

$$F = \frac{dP_p}{dt} = \frac{d(E_p / c)}{dt} = \frac{1}{c} \frac{dE_p}{dt} \quad (61)$$

Equation (60) is the matter view of the experiment and (61) is the photon view. One final point should be made about the interaction of photons with matter. If (57) and (58) are blended together, the result is:

$$\frac{E_H}{E_p} = \sqrt{\left(1 + \frac{mc^2}{E_p}\right)^2 - 1} - \frac{mc^2}{E_p} \quad (62)$$

The conversion efficiency of energy E_p into E_H (or into force) is dependent on the mass

of the matter that is impacted. The larger m is, the larger E_H is. Force production efficiency is specifically tied to experimental system properties.

Mathematical Force Perpendicular to the Direction of Velocity

Figure 22 shows a version of the experiment in *Force and Geometry*.

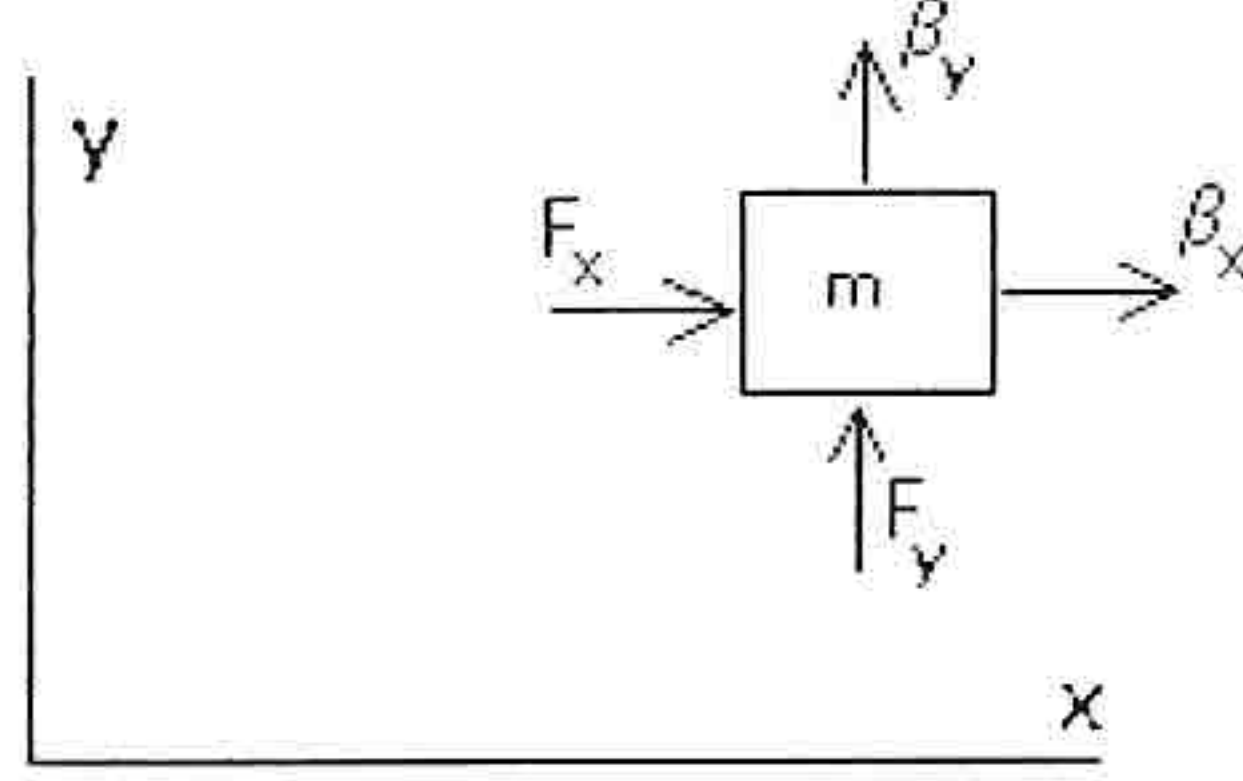


Figure 22. Forces applied to mass m which is moving in the x and y directions.

In Figure 22, a mass m has velocity β_x in the x -direction and β_y in the y -direction. The energy E of this mass is:

$$E = \frac{mc^2}{\sqrt{1 - \beta_x^2 - \beta_y^2}} \quad (63)$$

The change in this energy with time is:

$$\frac{dE}{dt} = \frac{mc^2}{(1 - \beta_x^2 - \beta_y^2)^{3/2}} \left(\beta_x \frac{d\beta_x}{dt} + \beta_y \frac{d\beta_y}{dt} \right) \quad (64)$$

This mass is under the influence of forces F_x in the x -direction and F_y in the y -

direction. Specify that β_x is constant ($\frac{d\beta_x}{dt} = 0$) for this experiment. This condition is put into (64). It is also put into (20a) from the article *Force and Geometry*, which gives:

$$F_x = \frac{mc}{(1 - \beta_x^2 - \beta_y^2)^{3/2}} \beta_x \beta_y \frac{d\beta_y}{dt} \quad (65)$$

When (64) and (65) are combined, the result is:

$$F_x = \frac{\beta_x}{c} \frac{dE}{dt} \quad (66)$$

In order to maintain the condition $\frac{d\beta_x}{dt} = 0$, F_x as specified by (66) is required. This force is proportional to the change in energy of mass m . Mass m has no x-direction acceleration, so it has no gain in energy due to F_x . But the y-direction acceleration is adding kinetic energy to the mass. F_x is needed to accelerate this y-direction energy up to velocity β_x . F_x is the reaction to the movement of energy.

Perpendicular Force from Photons

Figure 23 shows a photon traveling in the y-direction in stationary frame B. This photon will impact frame A which is moving in the x-direction with velocity β . This photon represents a flow of energy from frame B to frame A, just as force F_y in the experiment of Figure 22 was the source of energy flow in that experiment. The emission of this photon from frame B resulted in a y-directed force F_B on frame B.

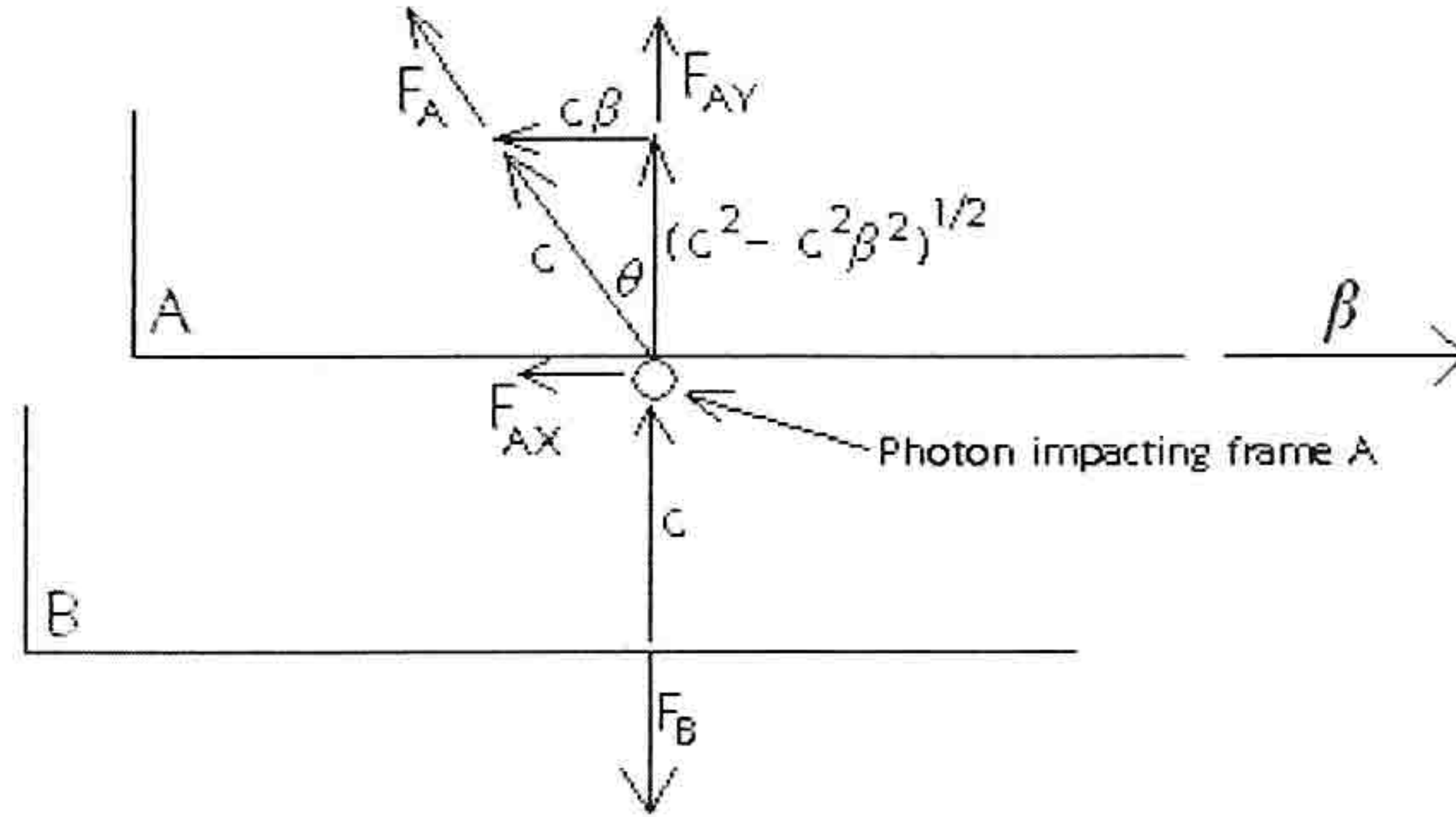


Figure 23. Photon from frame B impacts frame A.

The photon has velocity c in frame B and also in frame A. But, in frame A, the photon velocity is now at an angle θ . The frame A photon velocity has x and y components as indicated in Figure 23. Photon energy E is determined by its frequency and the frequency in this case is approximately determined by the relative time flow rates in frame A and frame B (as long as θ is relatively small). The photon frequency during emission is $1/t_B$ and the photon frequency during impact is $1/t_A$. Frequency f is the reciprocal of the period and h is Planck's Constant.

$$t_A = t_B \sqrt{1 - \beta^2} \quad E = hf = \frac{h}{t}$$

$$E_A = \frac{E_B}{\sqrt{1 - \beta^2}} \quad (67)$$

It is now useful to examine the photon in more detail. Figure 24 shows the photon as seen by frame A and frame B (for a small angle θ).

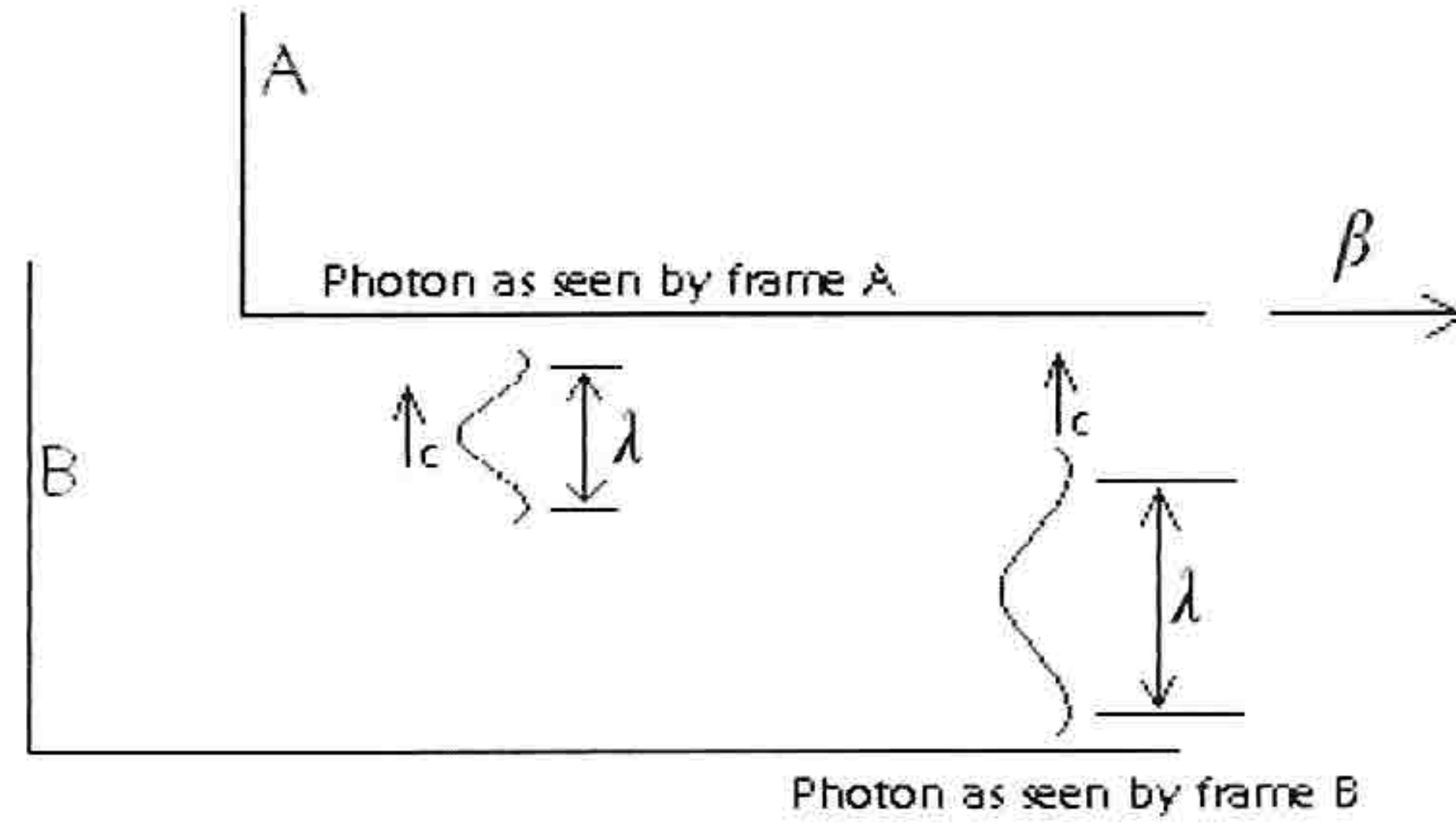


Figure 24. How the two reference frames see the same photon.

Frame B sees a lower frequency for the photon and a longer wavelength $\lambda = c/f$. Since the velocity of both photons is the same, Figure 24 indicates that the time interval needed for the photon to pass frame B (emit from frame B) or pass frame A (impact frame A) will also be longer for frame B. If the photon consists of only one wavelength of light, then the time for emission or impact would also be the period t . The photon force is F_A on frame A and F_B on frame B and is given by (65).

$$F_B = \frac{1}{c} \frac{E_B}{t_B} \quad F_A = \frac{1}{c} \frac{E_A}{t_A}$$

$$F_A = \frac{F_B}{(1 - \beta^2)} \quad (68)$$

From (68), the impact force is greater than the emission force. The photon frequency is higher and the time period for impact is less. Simple geometry in frame A gives:

$$F_{AY} = F_A \cos(\theta) = F_A \sqrt{1 - \beta^2} = \frac{F_B}{\sqrt{1 - \beta^2}} \quad (69)$$

Equation (69) is the force enhancement result (23b) from *Force and Geometry*. Also:

$$F_{AX} = F_A \sin(\theta) = F_A (-\beta)$$

$$\frac{F_{AX}}{F_{AY}} = \frac{-\beta}{\sqrt{1 - \beta^2}} \quad (70)$$

Equation (70) is the same as (32) except that $\beta_{YB} = 1$ for a photon.

Summary

The three inertial principles of the Special Theory of Relativity are founded upon experiments examining photon movement between a moving reference frame and a stationary reference frame. It should not be surprising to discover that the fourth principle of relativity (force enhancement) is also defined by these same experiments. Force can be interpreted as a reaction to the movement of energy and the movement of energy can be interpreted as the movement of photons. It is more difficult to prove that the movement of photons is the only way that energy moves, but that is the speculation of this article. This idea is also examined further in the article *Static Forces*.

Note that the definition of force given here does not contradict Newton's Laws. Newton's Laws are used for this analysis. It is the interpretation of what is happening during the experiment that is providing the new insights.