

## A REBUTTAL TO AJAY SHARMA'S PAPER ON $E = Amc^2$

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In a seminal paper published in 1905 [1] Einstein produced a very original derivation of the variation of mass depending of the variation of a body's energy. The conclusion of Einstein's paper [1] is that "If a body gives off the energy  $L$  in the form of radiation, its mass diminishes by  $L/c^2$ ". Einstein derives this very interesting relationship by applying the results of his other 1905 seminal paper[2] to a body that emits[2] "two plane waves of light" of equal energy  $L$ , arranged to be at  $180^\circ$  with respect to each other such that there is no recoil for the emitting body after the radiation was emitted. In the following note we will refute the errors in the Ajay Sharma [3] paper that claims that the result of electromagnetic radiation can be "mass increase" under certain circumstances (see equations (13) and (14) at the beginning of paragraph 4 ). In the following we will be using Einstein notation employed in [1].

## 1 The Mass Variation and the Recoil Energy

As in the original Einstein paper[1], we will consider a body at rest in an inertial frame  $S$  that emits only one light wave of energy  $L$  in a direction making an angle  $\phi$  with the positive  $x$  axis. The results will be analyzed from the inertial frame  $S'$  in relative motion with speed  $v$  with respect to  $S$ . According to [2], in  $S'$ :

$$L' = L\gamma(1 - \beta\cos\phi), \quad (1.1)$$

hence:

$$H_0 = H_1 + L' = H_1 + L\gamma(1 - \beta\cos\phi), \quad (1.2)$$

$H_0$  and  $H_1$  are the energy of the body in  $S'$ , before and after the emission,  $v$  is the relative speed between  $S$  and  $S'$ .

The conservation of energy in  $S'$  gives:

$$H_0 - H_1 = L\gamma(1 - \beta\cos\phi). \quad (1.3)$$

The conservation of energy in  $S$  gives:

$$E_0 - E_1 = L, \quad (1.4)$$

where  $E_0$  and  $E_1$  are the energy of the body in  $S$ , before and after the emission. Therefore the kinetic energy variation is:

$$\begin{aligned} K_0 - K_1 &= (H_0 - E_0) - (H_1 - E_1) = (H_0 - H_1) - (E_0 - E_1) \\ &= L\gamma(1 - \beta\cos\phi) - L = 0.5\frac{Lv^2}{c^2} - L\gamma\beta\cos\phi \end{aligned} \quad (1.5)$$

or:

$$K_1 - K_0 = -0.5\frac{Lv^2}{c^2} + L\gamma\beta\cos\phi. \quad (1.6)$$

The above shows that a body emitting the radiation energy  $L$  experiences a mass **decrease** by  $\frac{L}{c^2}$  and a kinetic energy increase due to recoil  $L\gamma\beta\cos\phi$ . By contrast (equations (13) and (14)) Mr. Sharma concluded[3] that the body experiences a “mass **increase** by the factor  $\frac{L}{c^2}$ ”. We could trace the origin of the error to his incorrect application of the energy conservation equations.

## 2 Conclusion

Einstein's derivation stands. Ajay Sharma's derivation is refuted.

## References

- [1] A. Einstein, “Does the Inertia of a Body Depend upon its Energy-Content”, *Annalen der Physik* 18, (1905)
- [2] A. Einstein, “On the Electrodynamics of Moving Bodies”, *Annalen der Physik* 17, (1905)
- [3] A. Sharma, “The Basis of the Generalization of  $E = mc^2$  to  $E = Amc^2$  and its Justification in Physical Phenomena”, *Concepts of Physics*, 4 (2006) 351.