

## The Light Clock Experiments and the Law of Reflection

Pavle I. Premović

Laboratory for Geochemistry, Cosmochemistry and Astrochemistry, University of Niš, P.O. Box 224,  
18000 Niš, Serbia

### 1. Introduction

Elementary classical physics tell us that when a ray of light strikes a plane mirror, the light ray reflects off the mirror. According to the law of reflection, the angle of incidence equals the angle of reflection.

One of the most important results of Special relativity (SR) is the effect of time dilation [1]. This phenomenon has apparently been demonstrated in many experiments, including muon experiment [2] and the experiment of synchronising two atomic clocks [3].

Many physics textbooks deal with the subject of time dilation. This phenomenon can be depicted using a device known as a light clock [4]. In this note it will be considered relation between various light clock experiments and the law of reflection.

### 2. Discussion and Conclusions

The light clock usually consists of two plane parallel mirrors  $M_1$  and  $M_2$  that face each other and are separated by a proper distance  $d$ , Fig. 1a. A light signal (or photon) originating from mirror  $M_1$  is reflected back by mirror  $M_2$  and finally returns to the location of mirror  $M_1$ , Fig. 1a. The light pulse traces out a path of length  $2d$ . Of course, the angles of light signal incidence and reflection are equal zero.

Now allow the same light clock to be moving with a certain relative speed  $v$  horizontally in the direction of positive  $x$ -axis. In this case, a stationary observer who is watching the light clock could design a following diagram, Fig. 1b. As previously, the light signal of mirror  $M_1$  reaches mirror  $M_2$  and reflects back to mirror  $M_1$ , Fig. 1a. Clearly, light signal will now travel a larger distance  $2D$ . The stationary observer concludes that this signal again follows the law of reflection i. e., the angle of light signal incidence ( $\alpha_I$ ) is equal to its angle of reflection ( $\alpha_R$ ), Fig. 1b.

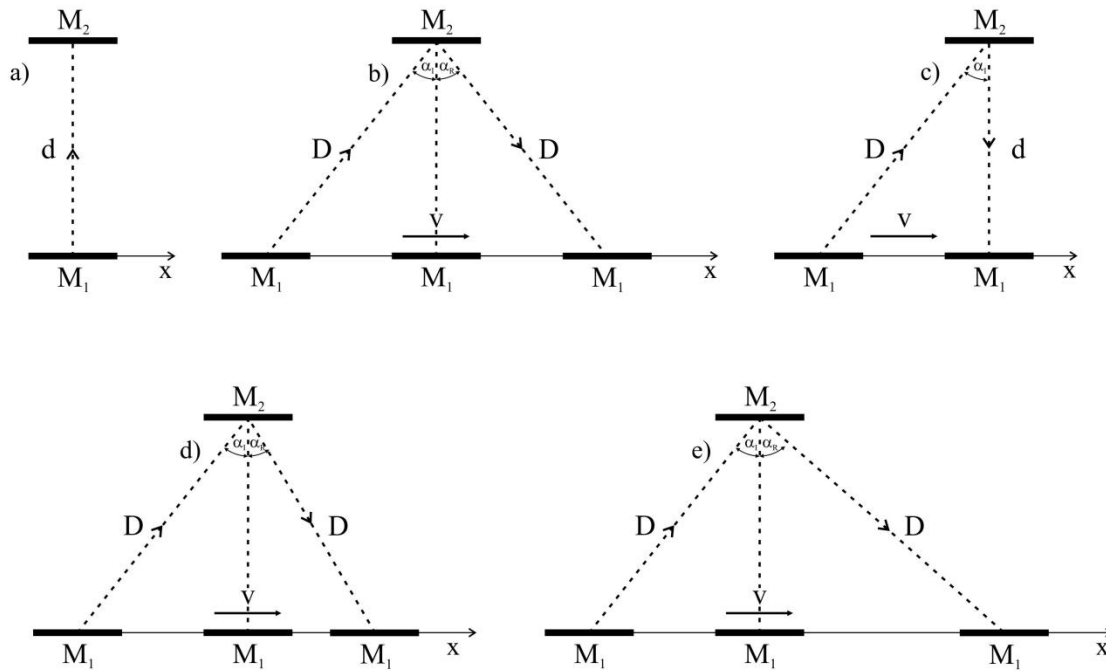


Fig. 1. Measurements and analysis for the light clock made in different frames.

(a): No relative motion; (b) – (e): the light clock moving at speed  $v$ .

Let us assume that the light clock makes full stop when the light signal reaches mirror  $M_2$ . The stationary observer determines that the light signal angle of incidence  $\alpha_I$  is greater than zero but its angle of reflection  $\alpha_R$  is zero degree, Fig. 1c. Of course, this observation disagrees with the law of reflection. In addition, if we are dealing with a single photon as the light signal any process of its detection at the mirror  $M_2$  leads to its annihilation.

If the speed of the light clock after the light signal reaching mirror  $M_2$  is lower than  $v$  then the angle of reflection  $\alpha_R$  will be smaller than the angle of incidence  $\alpha_I$ , Fig. 1d. In the opposite case, if this speed is higher than  $v$  the angle of incidence  $\alpha_I$  will be lower than the angle of reflection  $\alpha_R$ , Fig. 1e. Similar effects would be observed if the light signal after reaching mirror  $M_2$  travels at a speed lower (“slow light”) or higher (“fast light”) than  $c$ , for some reason.

All these observations also disagree with the law of reflection. My friends-physicists argue that this disagreement is a result of changing one inertial frame to another frame; though I am uneasy with this explanation. Indeed, SR states that “the velocity  $c$  of light in vacuum is the same in all inertial frames of reference in all directions and depends neither on the velocity of the

source nor on the velocity of the observer” [Einstein, 1905]. It sounds rather strange that the direction of motion of light depends of the inertial frame.

### **References**

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