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Abstract

The Michelson-Morley experiment and its resolution by the special theory of relativity form a foundational truth in modern physics. In this paper we examine and generalise the geometry of the sequence of events within a standard MM interferometer to arrive at a simple, yet curious geometry that compels deeper exploration.

Keywords— Michelson-Morley, Circle, Pythagoras Theorem

1 Introduction

The aim of this paper is to conduct an in-depth theoretical re-visitation of the paradigm shifting Michelson-Morley (MM) experiment and its famous null result [1]. We will examine arguments that show that the event sequence within an MM interferometer may be theorised by the rest frame in an unconventional fashion. This approach will demonstrate that under inertial conditions and independent of its orientation or its relative velocity with respect to the rest frame, the locus of all points in space where a reflection event can occur within an MM interferometer is a stationary circle in space.

2 Euclidean Geometry

On a flat surface, we draw any angle θ at origin Q bounded by two equal length line segments $QB = QB' = h$. We join points B and B' to points A and C such that the line segment AC is perpendicular to QB and centred at Q. We will restrict our arguments to the domain $x < h$. Fig. 1 illustrates.

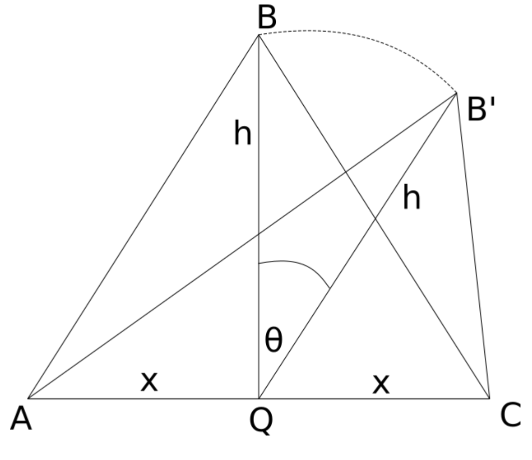

Figure 1: Triangles ABC and $AB'C$ rendered on a flat surface.

From fig. 1, we posit the following:

1. If $x > 0$, physical measurements will verify the theoretical statement $AB + BC \neq AB' + B'C$ remains true for all $\theta \neq 0, \pi, 2\pi...$
2. Since h is constant, curve BB' will take the form of a circle as $0 \leq \theta \leq 2\pi$ independent of x.
3. If $x > 0$, physical measurements will verify the theoretical statement $\angle AB'Q \neq \angle QB'C$ remains true over all $\theta \neq 0, \pi/2, \pi...$

3 A Template of the MM Experiment

Now we turn to theoretical aspects of relativistic optical interferometry to demonstrate that the geometry and sequence of events within an MM interferometer always templates to that of fig. 1.

3.1 Frames of Reference

Consider two imaginary euclidean reference frames that are in relative motion with respect to each other. Let us arbitrarily assume one of these frames is at rest and the other moves with some velocity v with respect to the rest frame. Accordingly we refer to fig. 1 and declare,

1. A rest frame I_0 centered at point Q.
2. A moving frame I_1 that translates from point A to point C with some velocity v relative to rest frame I_0.

3.2 Geometry and Sequence of Events

Now let us consider the structure of an MM interferometer [1](see fig. 2). By fixing $\angle B_1' Q B_2' = \pi/2$, line segments QB_1' and QB_2' form the arms of the interferometer. Mirrors B_1 and B_2 are aligned perpendicular to their respective arms. The apparatus may be rotated about its source and consequently each arm subtends its own angle θ_i measured from a perpendicular to line segment AC. Let us affix moving frame I_1 to the source of the interferometer. Now let us imagine this interferometer moving through space under inertial rules such that,

1. v remains constant ($AQ = QC$).
2. The interferometer orientation (θ_i) with respect to line segment AC remains constant.

Reference frame I_1 (affixed to the source) translates with constant velocity v from point A to point C. From the perspective of the rest frame I_0, a discrete event cycle begins with the source at point A marking the simultaneous emission of a pair of photons (wavelength=λ). As the entire apparatus moves with some constant ($AQ = QC$) velocity v relative to origin Q along line segment AC, the photons are emitted at point A, reflect from mirrors B_1 and B_2 to finally arrive simultaneously (in phase with each other) at point C. This geometry and sequence of events remains true over all possible orientations θ of an MM interferometer [2] and over all $0 \leq v < c$ where c represents the velocity of light in free space [3].

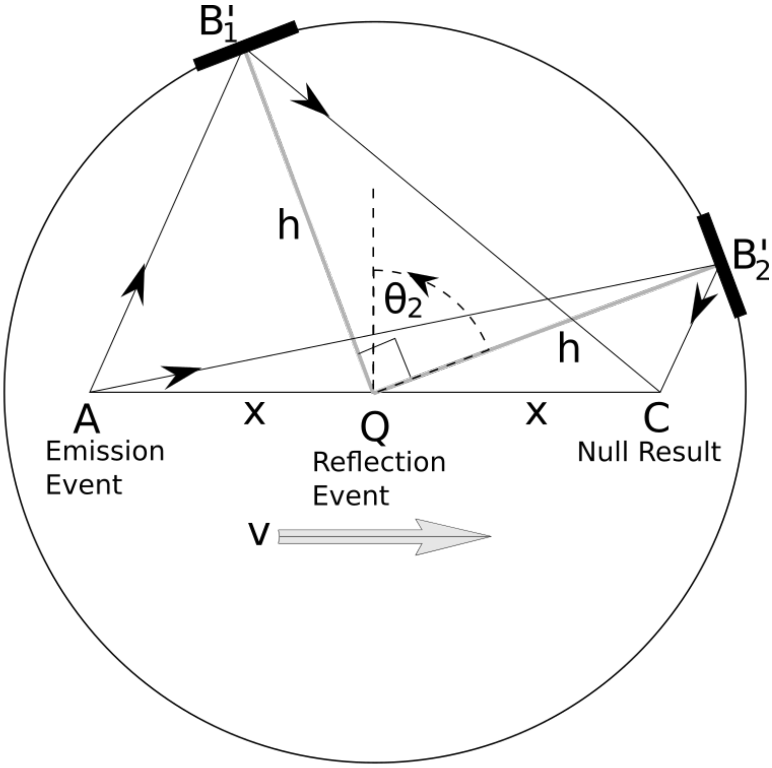

Figure 2: Geometry of the Michelson-Morley experiment depicting the general case $v \neq 0$ and $\theta_i \neq 0, \pi/2, \pi....$ Point Q is chosen as the origin. Only the events within the interferometer that are relevant to relativistic discussion are shown. Independent of the orientation of the interferometer, we find triangle $AB_i'C$ is a generalisation of triangle $AB'C$ in fig. 1. Identical to fig.1, physical measurements of the geometry of events will confirm that $AB_i'+B_i'C \neq AB_j'+B_j'C$ for all $\sin\theta_i \neq \sin\theta_j$ (inequality in path lengths) and $\angle AB'Q \neq \angle QB'C$ (inequality in angles of incidence and reflection) for all $\theta_i \neq 0, \pi/2, \pi...$ By setting $v = 0$ ($x = 0$), the figure represents the observational perspective of moving frame I_1. By setting $v > 0$ ($x > 0$), the figure represents the observational perspective of rest frame I_0. It is evident from fig. 1 that curve BB' will take the form of a stationary circle of radius h about point Q independent θ_i and v i.e. frame of reference.

4 Conclusion

Traditionally, the MM problem is reconciled by selecting point A as the origin followed by the application of special relativity [4]. But we have seen that by selecting instead point Q as the origin, rest frame I_0 and moving frame I_1 are both assured that over all $0 \leq \theta \leq 2\pi$ and $0 \leq v < c$, the locus of all points in space where a reflection event can occur is a common stationary circle of radius h about point Q [5]. This curious intermediate truth is presented for scrutiny.

5 Statements and Declarations

The author has no competing interests to declare that are relevant to the content of this article. There are no data associated with this article.

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