An Experiment to Determine Whether Electromagnetic Waves have Mass

by Mark A. Newstead and Stephen C. Newstead

email: mark.newstead@alumni.lboro.ac.uk

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In previous papers we have proposed that the mass of an electromagnetic wave is dependent upon its speed. This relationship is such that when the wave is travelling at the speed of light it has no mass, but its mass monotonically increases as the wave slows down (i.e. the wave has mass when it is passing through a medium). In this paper we propose an experiment that would be able to determine whether electromagnetic waves have mass when they are not travelling at the speed of light. Also the experiment would be able to determine whether the wave's frequency affects the wave's mass for a given speed.

1 Introduction

We have previously proposed that not only do electromagnetic waves have mass, but also that their mass changes inversely proportional to their velocity [9, 10]. This relationship between mass (m) and velocity (v) is given by

$$m = \frac{hf}{c^2}\sqrt{1 - \frac{v^2}{c^2}}, \tag{1}$$

where h is Planck's constant, c is the speed of light (in a vacuum) and f is the frequency of the wave. Thus the mass of an electromagnetic wave is zero when it is travelling at the speed of light, but monotonically increases as the wave slows down, until it stops (i.e. impacts something) when the maximum mass is obtained. Although many experiments have already been done to determine what the mass of an electromagnetic wave is, they have all considered the wave as a particle that may have mass [11]. Thus, if the wave did have mass then it would have a rest mass, which would then increase with velocity, in the same way the mass of the particle increases [2, 4]. Some of these experiments (observations) have been extra-terrestrial, i.e. looking for the effects a wave with mass would have on objects or the dispersion of starlight [11]. However from our definition of the mass of an electromagnetic wave, it would be zero since the waves were travelling in a vacuum, which correlates with the results. The terrestrial experiments are measuring waves within air and/or using radio waves [11]. From our description these waves would only produce extremely minute amounts of mass, due to their lower frequency and/or their speed of propagation, which again correlates with the experimental results.

Hence in this paper we propose a different experiment, which uses high frequency waves travelling at very slow speeds. Thus according to our description these should produce a detectable amount of mass, assuming sufficient number of waves are used simultaneously.

2 The Experiment

We have stated that mass and velocity are inversely proportional to each other, as described by equation (1). Therefore in order to best detect whether electromagnetic waves have mass, we should slow the waves down as much as possible, as this "generates" more mass. In fact over the last couple of decades scientists have been able to purposely slow electromagnetic waves to several miles an hour in various experiments [7, 5]. For example the Rowland Institute for Science slowed these waves down to 38 mph in 1999. Even though scientists can significantly slow down the wave speed, the mass of a bunch of electromagnetic waves is still minute. Therefore we propose that in order to measure this minute mass, a very sensitive balance scale is used, as shown in Figure 1. Moreover, since the mass of the wave is proportional to frequency then gamma rays should be used. These will then cause the greatest unbalancing of the scales for a given wave speed.

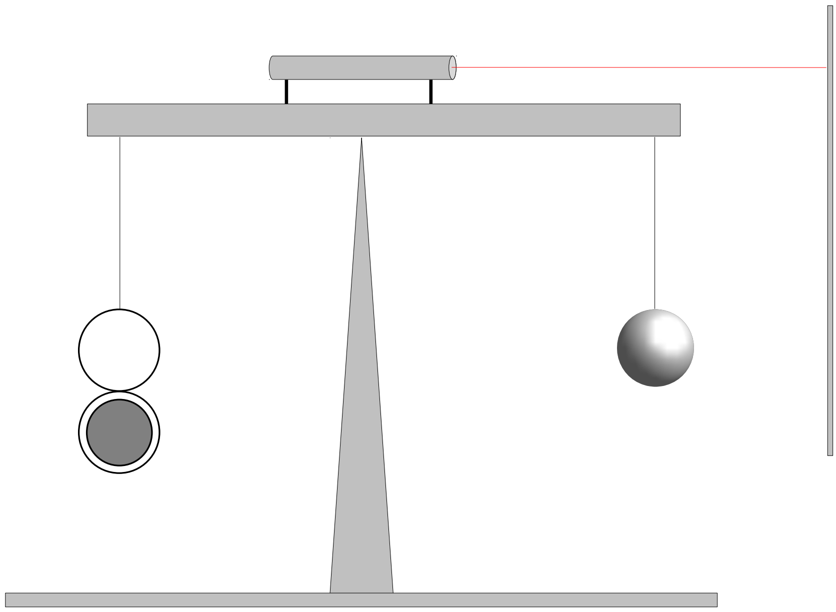

Figure 1: *A schematic diagram for an experiment that would be able to test whether electromagnetic waves have mass as we have proposed, or not. Moreover, it should be able to determine whether the mass of an electromagnetic wave is proportional to its frequency and inversely proportional to its velocity.*

Figure 1 shows a schematic diagram of an experiment that should be able to test whether electromagnetic waves have mass. On the left hand side of the balance are two closed tubes (represented by the white and grey circles) that the gamma rays will pass through. The ball on the right hand side is the counterbalance weight, which is sufficiently heavy to balance the scales when no gamma rays (or any other electromagnetic waves) are passing through either of the left hand tubes. The reason for having two tubes on the left hand side is that they contain different mediums. The top white tube contains a vacuum, and thus when the waves pass through it, the balance scale should remain level. We note that the balance will only remain level if a very thin material, which has a minimal affect on the speed of electromagnetic waves, is used on the two ends of the tube. Otherwise the mass "generated" by the gamma rays as they pass through the ends of the tub will be sufficient to unbalance the scales. The bottom grey circle (tube) on the left hand side contains the medium that significantly slows electromagnetic waves down. Hence by only changing which tube the electromagnetic waves pass through, determines whether the balance is balanced (i.e. in the case of the vacuum tube) or not (i.e. in the case of the grey tube). Also some of the waves maybe absorbed by the medium in the grey tube, as they pass it producing heat which may affect the results. Therefore we propose that as much as possible of the tube is covered in a reflective surface, such that the minimum amount of energy is lost externally, along the tube. This reflective surface may require multiple layers to retain the maximum amount of energy. These reflective surface(s) are represented by the black circle, which surrounds the grey one. Additionally, as this is such a fine experiment, we have added a laser to the top of the balance beam. Therefore any movement in the beam is amplified by the movement of the laser dot on the screen (shown on the far right hand side). Moreover, the further the screen is from the balance the greater the amplification of any movement, allowing the minute mass "generated" by the electromagnetic waves to be detected.

Furthermore we note that gamma rays can also destroy atomic nuclei and may therefore cause the apparatus to lose mass, since the nuclei will be heavier than the resulting electromagnetic waves [3, 1, 6, 8]. However as the mass of the electromagnetic waves should "instantly" become non-zero as they enter the medium slowing the wave down, then the experiment should be able to detect the change in weight almost immediately. Thus the experiment should not need to run for a long time, which has the side effect of limiting the number of atoms destroyed by the gamma rays. Overall though, if the experiment is set up carefully enough, then it should be able to detect the mass of an electromagnetic waves, as well as having the possibility of measuring it.

3 Conclusions

In this paper we have proposed a new experiment to detect whether electromagnetic waves have mass or not. This new experiment is based upon our previous proposals that the mass of an electromagnetic wave is proportional to its frequency and inversely proportional to its velocity, such that at the speed of light the wave has no mass [9, 10]. Moreover, all current experiments correlate with our proposal, since they have returned results implying that the mass of an electromagnetic wave is zero [11]. However these experiments have tried to measure the mass of a wave that is travelling at or very close to the speed of light. This new experiment though would be able to detect the minute mass of a high frequency, slow travelling wave. It should also be able to determine whether the wave's mass is proportional to its frequency and inversely proportional to its velocity, as we have proposed.

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