Speed of Microwave in Standing Wave

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A standing wave consists of two identical waves moving in opposite direction. A frequency detector moving toward the standing wave will detect two different frequencies. One is blueshifted, the other is redshifted. The distance between two adjacent nodes in the standing wave is equal to half of the wavelength of both waves. Consequently, the wave detector will detect different speeds from both waves due to the same wavelength and the different frequencies. The calculation of speed is demonstrated with a typical household microwave oven which emits microwave of frequency range around 2.45 GHz and wavelength range around 12.2 cm.

I. INTRODUCTION

Two identical waves can form a standing wave if they move toward each other. As a result of superposition, the position where total amplitude is constant is called node. The nodes are stationary. However, the standing wave is not stationary in all reference frames. For any observer moving relative to the stationary nodes, the standing wave becomes a moving wave to the observer. What is the speed of each wave in the standing wave if the standing wave is moving? This paper will examine the detail of wave interaction and calculate the speed of both waves.

II. PROOF

Consider one-dimensional interaction.

A. Difference In Frequency

A standing wave is formed by two identical waves moving in opposite direction. Both waves have the same frequency, wavelength and amplitude. The distance between two adjacent nodes in this standing wave is equal to half of the wavelength of both waves.

Let this standing wave be stationary in reference frame F_1. Let a wave detector be stationary in reference frame F_2. If F_1 is stationary relative to F_2. the detector will detect identical frequency and identical wavelength from both waves in this standing wave.

The harmonic formation of the standing wave depends solely on two colliding waves and is independent of the existence and the motion of the wave detector. Put F_2 under acceleration relative to F_1. The formation of nodes exist in both F_1 and F_2 The distance between two adjacent nodes is equal to half of the wavelength of both waves respectively in both F_1 and F_2.

According to Doppler Effect, this wave detector will detect higher frequency in the wave moving toward the wave detector. The frequency of wave moving away from the wave detector will be lower to the wave detector.

Therefore, a stationary wave detector in F_2 detects different frequencies in both waves while a stationary wave detector in F_1 detects identical frequency in both waves

The speed of a wave is equal to its frequency multiplied by its wavelength. **Due to the same wavelength but different frquencies, the speeds of both waves differ in F_2 but remains identical in F_1.**

B. Wave Cavity

A standing wave can be formed inside an optical cavity such as laser or a microwave cavity such as microwave oven.

Consider the standing wave inside a typical household microwave oven. The wavelength of the microwave emitted by the microwave oven is typically between 12 cm and 12.7 cm. The distance between two adjacent nodes can be visibly measured to be about 6.2 cm on a layer of chocolate or cheese.

Let a wave detector move relatively to the microwave oven at a speed of V. According to Doppler Effect, the time for a single wavelength to pass through the detector is

$$\frac{L}{C+V} \tag{1}$$

for W_+, and is

$$\frac{L}{C-V} \tag{2}$$

for W_-

where

W_+ is the wave moving toward the detector

W_- is the wave moving away from the detector

C is the speed of both W_+ and W_-

L is the wavelength of both W_+ and W_-

C. Speed of Microwave

Let the microwave oven be stationary in reference frame F_1. Let the wave detector be stationary in reference frame F_2. Let F_2 move at a speed V relatively to F_1.

In F_1, $T_+ = \frac{L}{C+V}$ is the time for W_+ to pass a single wavelength through the detector. $T_- = \frac{L}{C-V}$ is the time for W_- to pass a single wavelength through the detector.

Both T_+ and T_- are independent of reference frame[1]. L is also independent of reference frame[2].

The speed of each wave detected by a stationay wave detector in F_2 can be calculated as

$$V_+ = \frac{L}{T_+} = C + V \tag{3}$$

for W_+, and

$$V_- = \frac{L}{T_-} = C - V \tag{4}$$

for W_-

The speed of microwave depends on the reference frame. It is identical to the speed of light in F_1. It is either greater or smaller than the speed of light in F_2.

III. CONCLUSION

The speed of microwave in a standing wave is a relative value. It depends on the relative motion between the standing wave and the wave detector. To the wave detector, microwave can be faster or slower than the speed of light.

Consequently, the wave detector is stationary relatively to the standing wave only if both waves in the standing wave are detected to move at the same speed.

[1] Eric Su: Reflection Symmetry and Time. viXra: Relativity and Cosmology/1704.0187 (2017), http://vixra.org/pdf/1704.0187v1.pdf

[2] Eric Su: Translational Symmetry and FitzGerald-Lorentz Contraction. viXra: Relativity and Cosmology/1703.0169 (2017), http://vixra.org/pdf/1703.0169v2.pdf