Standing Wave And Doppler Effect

Eric Su
eric.su.mobile@gmail.com
https://sites.google.com/view/physics-news/home
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The harmonic mode of standing wave requires the number of nodes to be conserved in all inertial reference frames. The half wavelength is proportional to the width of the microwave cavity. The same cavity width is observed by all stationary observers in the same inertial reference frame. All observers observe the same wavelength from the standing wave in a moving cavity. According to the Doppler effect, the observer will detect a higher frequency if the microwave cavity is approaching. The observer will detect a lower frequency if the microwave cavity is receding. With the same wavelength but different frequency, the speed of microwave in the standing wave is different for different observer.

I. INTRODUCTION

The standing wave is a resonance created by constructive interference of two waves which travel in opposite directions. The waves change phase upon reflection from a fixed end. The modes of superposition associated with resonance have characteristic patterns. A node is where the superposition vanishes at all time. There is no node in the fundamental harmonic mode. There is one node in the second harmonic mode.

The harmonic mode is conserved in all inertial reference frames. This property allows the wavelength in other inertial reference frame to be determined accurately. The frequency can be determined accurately from the Doppler effect[1].

Consequently, the speed of the wave can be determined from the product of the wavelength and the frequency in a particular inertial reference frame.

II. PROOF

Consider one-dimensional motion.

A. Wavelength

A microwave cavity is in harmonic mode if the width of the cavity is proportional to half of the wavelenght of the microwave. Consider a cavity in the second harmonic mode. There is one node in the cavity. The width is equal to one wavelength.

Let the microwave cavity be stationary relative to a reference frame F_1. The width of the cavity is D_1. The standing wave is the superposition of two waves, W_1^+ and W_1^-. W_1^+ travels in the positive x direction with wavelength λ_1^+. W_1^- travels in the negative x direction with wavelength λ_1^-.

The second harmonic mode requires that

$$\lambda_1^- = D_1 = \lambda_1^+ \tag{1}$$

Let another reference frame F_2 move at a constant velocity of -V relative to F_1. The second harmonic mode is conserved in all inertial reference frames. The mode requires

$$\lambda_2^- = D_2 = \lambda_2^+ \tag{2}$$

$$\lambda_2^- = \lambda_2^+ \tag{3}$$

Identical wavelength for both W_2^+ and W_2^- in F_2.

B. Doppler Effect

Let two observers, P_+ and P_-, be stationary relative to F_2. Let the microwave cavity moves between P_+ and P_-. The cavity moves toward P_+ and away from P_-.

The detected frequency of W_2^+ is f_2^+ for P_+. The detected frequency of W_2^- is f_2^- for P_-. According to the Doppler Effect,

$$f_2^+ > f_2^- \tag{4}$$

The speed of W_2^+ for P_+ is

$$c_2^+ = f_2^+ * \lambda_2^+ \tag{5}$$

The speed of W_2^- for P_- is

$$c_2^- = f_2^- * \lambda_2^- \tag{6}$$

From equations (3,4,5,6),

$$c_2^+ > c_2^- \tag{7}$$

The microwave appears to move faster for an observer if the cavity is approaching this observer.

III. CONCLUSION

The speed of microwave depends on the relative motion between the microwave cavity and the microwave detector.

For two detectors sharing the same rest frame, both will detect an identical wavelength from the standing wave. However, the detected frequencies for these two detectors are different according to the Doppler effect. Consequently, the detected speed of the microwave is different for different observer.

The speed of microwave depends on the rest frame of the microwave detector.

[1] Possel, Markus (2017). "Waves, motion and frequency: the Doppler effect". Einstein Online, Vol. 5. Max Planck Institute for Gravitational Physics, Potsdam, Germany. Retrieved September 4, 2017.

[2] Eric Su: List of Publications, http://vixra.org/author/eric_su