Doppler Effect In Relativity

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The frequency of sound is always different in a different inertial reference frame. The Doppler effect for sound wave and electromagnetic wave is not identical. The main difference is the transmission medium. The wavelength changes if the rest frame of the wave source is different from the rest frame of the transmission medium. Without the medium, the wavelength is invariant in inertial reference frames. The Doppler effect for sound, water, and electromagnetic wave depends on the transmission medium.

I. INTRODUCTION

Doppler effect[1] was proposed by Christian Doppler in 1842. The hypothesis was tested for sound waves by Buys Ballot in 1845. The sound pitch was confirmed to be higher than the emitted frequency when the sound source approached. However, sound transmission is different from light transmission.

Woldemar Voigt published a paper[2], "On Doppler's Principle", in 1887. Voigt speculated the homogeneous wave equations to be covariant in inertial reference frames. In order to apply Doppler effect to the wave equations, Voigt proposed the invariance of the velocity of light in inertial reference frames. His resulting space-time transformation was mostly ignored.

Voigt's speculation on Doppler effect was indeed a mistake. Unwittingly, Einstein copied the erroneous speculation from Voigt into the theory of relativity without knowing its dire consequence.

II. PROOF

A. Stationary Wave

A stationary wave displays no frequency nor velocity to a stationary observer. To a moving observer the same wave will appear to move and exhibit frequency.

The relative motion between the rest frame of the wave and the rest frame of the observer determines both the velocity and the frequency of the wave. Let F_1 be the rest frame of the stationary wave. Let F_2 move at the velocity of -V relative to F_1.

Table I shows the observation of the stationary wave by a stationary observer in each frame.

TABLE I. Stationary Wave

Frame	**Velocity**	**Frequency**	**Wavelength**
F_1	0	0	λ
F_2	V	$\mid \frac{V}{\lambda} \mid$	λ

The wavelength is invariant in both F_1 and F_2 but the frequency varies with the reference frame.

B. Water Wave

A wave can be formed on the surface of water by the vertical vibration of a buoy.

Let F_1 be the rest frame of both water and the buoy. The velocity of the wave is a function of the density and the depth of the water and is independent of the vertical vibration of the buoy.

Let V_w be the horizontal velocity of the wave. The wavelength is λ_0. The frequency of the wave to any stationary observer relative to F_1 is

$$f_0 = \mid \frac{V_w}{\lambda_0} \mid \tag{1}$$

The frequency is determined by the vertical vibration but not the horizontal movement of the buoy. Let the buoy move at the horizontal velocity of V_s relative to F_1. The wavelength becomes

$$\lambda = \mid \frac{V_w - V_s}{f_0} \mid \tag{2}$$

The wavelength has changed because the rest frame of the wave source becomes different from the rest frame of the transmission medium. From equations (1,2), the new frequency appears to be

$$f_1 = \mid \frac{V_w}{\lambda} \mid = f_0 \mid \frac{V_w}{V_w - V_s} \mid \tag{3}$$

However, the wavelength is independent of the movement of the observer[3]. Let F_2 be the rest frame of the observer and move at the velocity of V_o relative to F_1. The relative velocity of the wave to the observer according to velocity transformation[3] is

$$V = V_w - V_o \tag{4}$$

From equations (2,4), the new frequency to the observer is

$$f_2 = \mid \frac{V}{\lambda} \mid = f_0 \mid \frac{V_w - V_o}{V_w - V_s} \mid \tag{5}$$

Table II shows the observation of the water wave by a stationary observer in each frame. This is known as Doppler effect proposed by Christian Doppler and verified with sound wave.

TABLE II. Buoyancy Wave

Frame	Velocity	Frequency	Wavelength
F_1	V_w	$f_0 \mid \frac{V_w}{V_w - V_s} \mid$	λ
F_2	$V_w - V_o$	$f_0 \mid \frac{V_w - V_o}{V_w - V_s} \mid$	λ

C. Electromagnetic Wave

Unlike water wave which requires water for transmission, the electromagnetic wave requires no transmission medium.

Let F_1 be the rest frame of the electromagnetic wave. The wave displays no frequency nor velocity to a stationary observer in F_1. The relative motion between the rest frame of the wave and the rest frame of the observer determines the velocity and the frequency of the wave to the observer.

However, the wavelength of a stationary wave is independent of the movement of the observer[3]. Let the wavelength be λ.

Let F_2 be the rest frame of the observer and move at the velocity of V relative to F_1. The frequency to a stationary observer in F_2 is

$$f_2 = \frac{\mid 0 - V \mid}{\lambda} = \mid \frac{V}{\lambda} \mid \tag{6}$$

Let another inertial reference frame F_3 move at the velocity of $-V_c$ relative to F_1. The frequency to a stationary observer in F_3 is

$$f_3 = \frac{\mid 0 - (-V_c) \mid}{\lambda} = \mid \frac{V_c}{\lambda} \mid \tag{7}$$

The relative velocity between F_3 and F_2 is $V_c + V$ according to velocity transformation[4].

Table III shows the observation of the electromagnetic wave by a stationary observer in each frame.

TABLE III. Electromagnetic Wave

Frame	Velocity	Frequency	Wavelength
F_1	0	0	λ
F_2	$-V$	$\mid \frac{V}{\lambda} \mid$	λ
F_3	V_c	$\mid \frac{V_c}{\lambda} \mid$	λ

In modern physics, all electromagnetic waves are emitted at the velocity of V_c in F_3, the rest frame of the wave source.

D. Error In Relativity

The wavelength changes only if the rest frame of the wave source becomes different from the rest frame of the transmission medium. For example, sound and water wave. The wavelength can not change if there is no transmission medium. For example, light and electromagnetic wave.

All 3 tables show that the wavelength is invariant in inertial reference frames while the velocity and the frequency vary with the reference frame.

In 1887, Voigt made a mistake by assuming the velocity of sound to be invariant in inertial reference frames. He applied the same mistake to light by assuming that light travels at constant speed through some incompressible medium which was called ether[5] by the contemporary.

In 1905, a copycat known as Albert Einstein copied Voigt's idea of invariant velocity of light into his paper, "Zur Elektrodynamik bewegter Krper"[6]. By assuming the velocity of light is invariant in all inertial reference frames, Einstein attempted to derive Lorentz transformation. The derivation was achieved because Voigt had already proved it.

Few scientists understand that invariant velocity of light originates from Voigt, not from Einstein. Voigt's misunderstanding of Doppler effect was copied by Einstein into the theory of relativity and all the way into modern physics.

III. CONCLUSION

Sound wave transmits through air. The rest frame of air can be different from the rest frame of the sound source. Hence, the wavelength can be changed by the motion of the wave source. Electromagnetic radiation requires no transmission medium. Hence, the wavelength of light can not be changed by the motion of the light source.

Voigt had mistakenly identified sound transmission with light transmission. He did not understand that the wavelength can vary only if the rest frame of the wave source is different from the rest frame of the transmission medium.

Voigt's mistake was copied by Einstein into the theory of relativity. Until 2020, the mistake still remains in modern physics. Few physicists realize that the velocity of light depends on the choice of inertial reference frame[3]. The legend of this mistake started with Voigt's misunderstanding of Doppler effect.

Without any verification, physicists and astronomers continue to assume a new wavelength from the Doppler effect for light.

[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] Voigt, W. (1887), "Ueber das Doppler'sche Princip (On the Principle of Doppler)", Gttinger Nachrichten (7): 4151; Reprinted with additional comments by Voigt in Physikalische Zeitschrift XVI, 381386 (1915).
[3] Su, Eric: Error in Modern Astronomy. viXra: Relativity and Cosmology/1908.0005 (2019). http://vixra.org/abs/1908.0005
[4] Su, Eric: Velocity Transformation in Reference Frame. viXra: Relativity and Cosmology/1801.0108 (20189). http://vixra.org/abs/1801.0108
[5] Lorentz, H. A.: De relatieve beweging van de aarde en den aether. Zittingsverlag Akad. v. Wet. 1, 74 (1892), English trans. The relative motion of the earth and the aether. In: Zeeman, P., Fokker, A. D. (eds.) Collected Papers. Nijho, The Hague (1937)
[6] Einstein, Albert: "Zur Elektrodynamik bewegter Krper", 1905-06-30. http://www.zbp.univie.ac.at/dokumente/einstein3.pdf
[7] B. J. Hunt (1988), The Origins of the FitzGerald Contraction, British Journal for the History of Science 21, 6176.
[8] H. R. Brown (2001), The origin of length contraction: 1. The FitzGeraldLorentz deformation hypothesis, American Journal of Physics 69, 1044 1054. E-prints: gr-qc/0104032; PITT-PHIL-SCI00000218.
[9] FitzGerald, G. F.: The ether and the earth's atmosphere. Science. 13: 390 (1889)
[10] Su, Eric: Microwave Resonance and Doppler Effect. viXra: Relativity and Cosmology/1909.0175 (2019). http://vixra.org/abs/1909.0175
[11] Eric Su: List of Publications, http://vixra.org/author/eric_su