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Doppler Effect on the wave associated with a particle

Alfredo Olmos Hernández
Academic Area of Mathematics, College of Bachelors of the State of Hidalgo, Hidalgo, MEXICO
Corresponding Author: alfredooh16@gmail.com

Reyna Romyna Olmos Hernández
Academic Area of Mathematics, College of Bachelors of the State of Hidalgo, Hidalgo, MEXICO
Corresponding Author: londonlun12@gmail.com

ABSTRACT:*It is known that a particle presents the duality corpuscle-wave. In such a way that a particle possesses an associated electromagnetic wave, the Doppler Effect appears in all the waves; in such a way that it also affects the wave associated with the particle.*
In this article we study the Doppler Effect on the wave associated with the particle.

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NOMENCLATURE

Symbol	Description	Unit
λ	Wavelength	*m*
h	Planck constant	*Js*
p	Linear momentum	*Kgm/s*
m	Mass	*Kg*
v	Velocity	*m/s*
γ	Lorentz factor	*Dimensionless*
c	Speed of light	*m/s*
fo	Frequency observed	*Hz*
fs	Frequency issued	*Hz*
po	Amount of movement measured by the observer	*Kgm/s*
ps	Amount of movement measured in the particle	*Kgm/s*
λo	Wavelengthmeasured by the observer	*m*
λs	Wavelengthmeasured in the particle	*m*

I. INTRODUCTION

Wave-particle duality is a quantum phenomenon, by which particles exhibit wave behavior.

This is an experimentally proven fact on multiple occasions. It was introduced by Louis-Víctor de Broglie, a French physicist of the early twentieth century. In 1924, in his doctoral thesis, inspired by experiments on electron diffraction, he proposed the existence of matter waves, meaning that all matter had a wave associated with it. This revolutionary idea, based on the analogy that the radiation had an associated particle, property already demonstrated then, did not arouse great interest, despite the correctness of its approaches, since it had no evidence of occurrence. However, Einstein recognized its importance and five years later, in 1929, De Broglie received the Nobel Prize in Physics for his work [1, 2, 5, 7 and 10]

The wavelength λ, of the wave associated with a particle is.

$$\lambda = \frac{h}{p} \quad (1)$$

Where h is the Planck constant and p the linear momentum of the particle

Where $p = mv\gamma$, with m the mass of the particle, v its velocity and γ the Lorentz factor.

The relativistic Doppler Effect is the observed change in the frequency of light from a source moving relative to the observer.

The change in frequency observed when the source moves away is given by the following expression [3, 4, 6, 8 and 9]

$$f_o = f_s\sqrt{\frac{1-v/c}{1+v/c}} \quad (2)$$

Where

fo is frequency observed.

fs is frequency issued.
v is relative speed, positive when the emitter and the observer move away from each other.
c is the speed of light

II. DOPPLER EFFECT PRESENT IN THE WAVE ASSOCIATED WITH A PARTICLE

To obtain the wavelength of a given electromagnetic wave, its frequency f is.

$\lambda = \frac{c}{f}$ (3)

Substituting (3) in (2)

$\frac{c}{\lambda_o} = \frac{c}{\lambda_s}\sqrt{\frac{1-v/c}{1+v/c}}$ (4)

$\lambda_o = \lambda_s\sqrt{\frac{1+v/c}{1-v/c}}$ (5)

Substituting (1) in (5)

$\frac{h}{p_o} = \frac{h}{p_s}\sqrt{\frac{1+v/c}{1-v/c}}$ (6)

$p_o = p_s\sqrt{\frac{1-v/c}{1+v/c}}$ (7)

Where
po is the amount of movement measured by the observer.
Ps is the amount of movement measured in the particle.

By the expression 7) we have that the amount of movement that is measured of a particle, depends on the observer.

There are 2 cases:

1. Case 1

The particle moves away from the observer.
In this case the relative speed is positive, then.

$p_o = p_s\sqrt{\frac{1-v/c}{1+v/c}}$ (8)

$p_o < p_s$ (9)

2. Case 2

The particle approaches the observer.
In this case, the relative velocity is negative, then.

$p_o = p_s\sqrt{\frac{1+v/c}{1-v/c}}$ (10)

$p_o > p_s$ (11)

III. CONCLUSION

In this article, we obtained the expression that allows us to observe the variation in the measurement of the momentum of a particle, depending on its relative movement with respect to the observer. In such a way that if the particle approaches, the observer measures a quantity of movement greater than the measure in the particle; and if the particle moves away from the observer, the amount of movement measured by the observer is less than if measured directly in the particle.
The expression is obtained from the study of the Doppler Effect to the wave associated with a particle.

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