

Doppler shift in de Broglie waves

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Abstract: In 1923 French scientist Louis de Broglie predicted the wave nature of particles. He extended the concept of wave - particle duality of radiation to matter & proposed the existence of matter waves. His equation was $\lambda = h/mv$. In 1927, the existence of matter waves was verified experimentally by Davisson & Germer where electrons were used to produce diffraction pattern that was identical to a light wave. An interference pattern has also been obtained when electrons were sent one by one through a double slit apparatus. In the present paper an attempt has been made to study Doppler effect in matter waves on the basis of wave structure of matter (WSM).

[I] Introduction

Doppler effect was introduced in classical physics to account for the frequency shift of sound waves when the source & observer are in relative motion. Electromagnetic waves including light waves also show Doppler effect. But Doppler effect in light is different from Doppler effect in sound in one fundamental way- For sound waves, the amplitude & the frequency of the wave is affected during Doppler shift but with light waves, only the frequency of the wave is altered, the amplitude remains unchanged. It has been shown that the classical Doppler shift equations can be applied if the corrected frequency is used according to relativity. [For a light source moving at a speed v , relativity states that the corrected frequency is $f = f_0(1 - v^2/c^2)^{1/2}$.]

[II] Wave structure of matter

According to WSM proposed by Dr. Milo Wolff, a particle is represented by spherical standing wave or a space resonance. According to this, a particle is nothing but two identical concentric spherical waves travelling in radially opposite directions to form a spherical standing wave. The wave which travels inwards is called IN- wave & the wave

travelling outward is called OUT-wave. The particle may be considered to be located at the wave center. The IN-waves arrive from all other matter in the universe & interfere with the OUT-waves leaving the wave center to form spherical standing waves. Thus each particle is a pair of IN- & OUT-waves, the inward wave converging to center & then become outward wave. Every particle depends for its IN-wave on all other particles in the universe & this explains that all matter in the universe is interconnected. Thus every particle in the universe owes its presence to every other particle in the universe. More precisely, the IN-waves are formed from Huygen's combination of OUT-waves of all the other matter in the universe. This occurs for every particle in the universe, so that every particle depends on all other particles for its existence.

Thus all the matter interactions are actually wave interactions. Even interactions of radiation with matter are also wave interactions. The spherical IN-&OUT-waves interact with all other wave center particles in the universe. When one spherical standing wave is moving relative to another, then the apparent frequency as seen by the other is different from the actual frequency. This can be called as

Doppler effect of matter waves. Thus when two spherical standing waves are in relative motion, Doppler shifts of IN- & OUT- waves are obtained.

[III] Doppler shift in matter waves.

WSM describes the particle as a standing wave comprised of spherical IN- wave & OUT- wave, that reflect at the combined standing wave nodes. The IN -wave becomes an OUT-wave at reflection & vice-versa. The OUT-wave of one particle may be the IN -wave for some another particle & vice-versa.

Let the two wave centers are moving towards each other. The spherical waves have a velocity 'c' & let the relative velocity be 'v'.

Now according to WSM, the rotation of the incoming wave is 720° at the center & transforms into outgoing wave.

The IN-waves are Doppler shifted classically & at the wave center transformed into OUT- waves. The apparent frequency of the IN-waves at the wave center is given by

$$f_{c1} = f_1 (1 + v/c) \quad \text{-----(1)}$$

where f_{c1} is the frequency of the IN-wave at the wave centre i.e. it is the apparent frequency seen by the wave center & f_1 is the frequency of the IN wave from the universe.

The OUT-waves leaving the wave-center are classically Doppler shifted before reaching the observer. The apparent frequency of the OUT-wave for the observer is

$$f_2 = f_{c2} (1 - v/c)^{-1}$$

$$f_{c2} = f_2 (1 - v/c) \quad \text{-----(2)}$$

where f_{c2} is the frequency of the OUT-wave at the wave center & f_2 is the frequency of the OUT wave seen by the observer.

Now at the wave center, OUT-wave is reflected as IN-wave. Therefore

$$f_{c1} = f_{c2} \quad \text{-----(3)}$$

According to WSM, antiparticle is just opposite phase standing wave of particle. Hence when electron & positron annihilate, two photons of same energy are formed. The two waves -IN & OUT superimpose to form standing wave called Space Resonance. The resonance pattern between two quantum waves is intermodulation product of the waves & this pattern is the photon we view. Thus when the IN-wave & its reflected OUT-wave interfere, intermodulation of the two waves may be considered & the resulting photon frequencies may be given by

$$f_{p1} = (f_{c1} f_1)^{1/2} \quad \text{-----(4)}$$

$$f_{p2} = (f_{c2} f_2)^{1/2} \quad \text{-----(5)}$$

where f_{p1} is the photon frequency by IN-wave intermodulation & f_{p2} is the photon frequency by OUT-wave intermodulation. Therefore

$$f_{p2} / f_{p1} = [(f_{c2} f_2) / (f_{c1} f_1)]^{1/2} \quad \text{-----(6)}$$

Eq.(1) implies

$$f_{c1} / f_1 = 1 + v/c$$

Therefore

$$f_{c2} / f_1 = 1 + v/c \quad \text{-----from eq. (3)}$$

Eq. (2) implies

$$f_{c2} / f_2 = 1 - v/c$$

Therefore

$$f_{c1} / f_2 = 1 - v/c \quad \text{-----from eq. (3)}$$

Therefore

$$f_{p2} / f_{p1} = [(f_{c2} / f_1) (f_2 / f_{c1})]^{1/2}$$

$$= [(1 + v/c) / (1 - v/c)]^{1/2}$$

Therefore

$$f_{p2} = f_{p1}[(1 + v/c) / (1 - v/c)]^{1/2} \quad \text{-----(7)}$$

Let $\beta = v/c$, then

$$f_{p2} = f_{p1}[(1 + \beta) / (1 - \beta)]^{1/2} \quad \text{-----(8)}$$

This is the relativistic Doppler shift for two photons formed by intermodulation of IN waves & OUT waves, which is the same as relativistic Doppler shift of light waves.

[IV] Conclusion

The wave structure of matter (WSM) is a link between the special theory of relativity & the Quantum mechanics. The relativistic increase of mass has also been explained on the basis of wave structure of matter by Declan Traill in his paper 'Relativistic mass increase explained.' The proof of WSM is that all natural laws can be obtained mathematically from the three basic principles describing the wave space medium. These three basic principles have been described by Dr. Milo Wolff in his thesis. Although matter waves are different from electromagnetic waves in one fundamental respect, i.e. the velocity of matter waves cannot be different from the velocity of the particle, but still the analogy between light waves & matter waves cannot be denied.

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