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De-Broglie Corrected - Slow De-Broglie Waves

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This paper changes our perception of De-Broglie's waves; which should not be considered to propagate in front of the particle at the commonly-held superluminal "*phase velocities*" (c^2/υ), but rather, **follow in back** of the moving particle at the velocity $\upsilon/2$ i.e. half of the velocity of the non-relativistic particle. These **following** "Slow De-Broglie waves" (SDBW) seem to have their origin in the agitation or vibration of the ether medium after the passing of the moving (energetic) particle. Thus the rear of the moving particle is filled with the 'one-wavelength λ' spaced SDBWs. The vibrating ether under the rule or validity of "Zero Relative Phase Difference Principle" (ZRPDP) finally constitutes the rear beam, spatially coherent, and the wave-behavior of the moving particles becomes apparent.

The infinite speed of De-Broglie waves!

De-Broglie had confronted the difficult problem of physics of his epoch, "*the double wave-quantum character of light*" which was regarded by Einstein as the "*greatest problem of physics*" [1]. He reasoned very curiously, generalizing the wave behavior in physics: "If light, which is well recognized as a wave, exhibits a quantum or particle behavior, then the well-recognized particles, should also exhibit a wave character"!

That is why De-Broglie was the first who thought to use the relation $E = h\nu$ and for the particles, he wrote [2] it in the form:

$$h \cdot \nu = \frac{m_0 C^2}{\sqrt{1-\frac{\upsilon^2}{C^2}}} \qquad (1)$$

He thus determined, by relation (1), the frequency of the "material wave". He also considered the velocity υ of the particle as the *group velocity* of the "material wave" thus he wrote down the known relation from the mechanics of waves:

$$u_{group} \equiv \frac{d\nu}{d\left(\frac{1}{\lambda}\right)} = \frac{d\nu}{d\upsilon} \cdot \frac{d\upsilon}{d\left(\frac{1}{\lambda}\right)} = \upsilon \qquad (2)$$

From (1) he calculated by differentiation, the relation:

$$\frac{d\nu}{d\upsilon} = \frac{m_0}{h} \frac{\upsilon}{\left(1-\frac{\upsilon^2}{C^2}\right)^{\frac{3}{2}}} \qquad (3)$$

Thus from (2) and (3) he found the relation

$$d\left(\frac{1}{\lambda}\right) = \frac{m_0}{h} \frac{d\upsilon}{\left(1-\frac{\upsilon^2}{C^2}\right)^{\frac{3}{2}}} \qquad (4)$$

He integrated relation (4) between the limits: $\upsilon=0$ to $\upsilon=\upsilon$. Of course, he reasoned [2] that for $\upsilon=0$ it should be $\frac{1}{\lambda}=0$ i.e. $\lambda=\infty$. Thus De-Broglie [2] managed to present his own law for the wavelength of the "material waves":

$$\frac{1}{\lambda}=\frac{m_0\upsilon}{h\sqrt{1-\frac{\upsilon^2}{C^2}}}=\frac{p}{h} \qquad (5)$$

Relation (5) is a well-established law of Physics. But in the above, De-Broglie had committed a hidden, but very serious mistake: For $\upsilon=0$ he assumed essentially to have $\frac{1}{\lambda_0}=0$ i.e. $\lambda_0=\infty$; but this means that he introduced tacitly in Physics an infinite speed ($u=\infty$) of propagation for "material waves". Really for $\upsilon\to 0$, relation (1) gives a basic concrete frequency of magnitude: $\nu_0=\frac{m_0C^2}{h}$ to be generated by the stationary particle and as $\lambda_0=\infty$ we get $u_{(\upsilon\to 0)}=\nu_0\cdot\lambda_0=\infty$. The speed of De-Broglie waves is currently calculated [2, 3] as propagating at superluminal speeds:

$$u=\lambda\cdot\nu=C^2/\upsilon \qquad (6)$$

The above-mentioned infinite velocity $u_{(\upsilon\to 0)}=\infty$ is a consequence of (6).
De-Broglie was an "etherist" (real waves need a medium to vibrate). Does the "ether" (or anything whatever that is in free space) really expose such an extremely great range of speeds for De-Broglie waves, extended from $u\to C$ (when $\upsilon\to C$) to the infinite speeds $u\to\infty$ (when $\upsilon\to 0$)! Relation (6) was immediately recognized as flatly opposed to the relativistic conclusions about the speed of light C (as the upper speed in physics). That is why the theoreticians considered the De-Broglie waves as *"phase waves - not carrying at all any energy with them!! "* Of course here the theoreticians are entirely wrong, for the following reasons:

The product ($h\cdot\nu$) –containing this very *phase frequency* – still has energy dimensions; this means that the *phase wave* has energy by itself, 2) a phase wave carries an energy, otherwise the superposition of two phase-waves, -to *wave-group* formation, should transfer no energy and the formed group of waves should also be empty of energy!

What is the need for such superluminal speeds? Why should Nature "hurry" to interact, (of course after De-Broglie's calculations,) so rapidly or "instantly" ($u\to\infty$) when it simply has to be governed by such slowly-developed ($\upsilon\to 0$) phenomena in space? This "behavior" and the violation of relativity, (with energy propagating faster than C,) are very serious reasons and impose a correction of De-Broglie's calculations of "material waves".

De-Broglie waves at non-infinite speeds.

In trying to eliminate the infinite speed of De-Broglie waves, one can very well assume that the ether in space does propagate the De-Broglie waves at definite speeds $u=\lambda\cdot\nu$.

For $\upsilon\to 0$ we get from relation (1), the frequency $\nu_0=\frac{m_0C^2}{h}$ as supposedly generated by the stationary particle; i.e. we should have: "No cause i.e. no motion or turbulence in the ether, but generated waves" and additionally "the frequency ν_0 should correspond to some definite wavelength $\lambda_0 = \frac{u}{\nu_0} = \frac{uh}{m_0 C^2}$ (when $\upsilon \to 0$)". Thus we are leaded to a flat disagreement with the experimentally-verified De-Broglie (5) relation.

The only way to avoid this last difficulty is to remember the analog from Optics: "The speed of light is definite $C = \lambda \cdot \nu$ and for $\nu \to 0$ we have $\lambda \to \infty$". On the other hand, the Causality Principle dictates: "**The De-Broglie waves should be generated when there should be a cause for it, i.e. when the particle moves in "ether" and not when it is at rest.**" The above means that: when $\upsilon = 0$ it must be $\nu = 0$. Now we can reach De-Broglie waves in two well-separated ways:
We have to start with a relation (containing the kinetic energy of the particle) i.e.: $h \cdot \nu = T$

$$h \cdot \nu = \frac{m_0 C^2}{\sqrt{1 - \frac{\upsilon^2}{C^2}}} - m_0 C^2 \quad (7)$$

The frequency of the material waves is now defined by means of relation (7); and by following accurately De-Broglie's procedure in differentiating relation (7) to find (3) which if inserted into (2) again gives relation (4) ; after that it can be integrated between the limits υ=0 to $\upsilon = \upsilon$, of course for υ=0 we have $\nu = 0$ and thus $\lambda = \frac{u}{0} = \infty$ or $\frac{1}{\lambda}$=0 (where $u \neq \infty$). The result is again De-Broglie's (5) relation but free of the discussed difficulties.
B) In now trying to do a more complete the analogy of "material waves" with that of light, we will try to apply the relation of momentum of the photon: $p_{photon} = \frac{h \cdot \nu}{C}$ (known from electromagnetism and Compton effect etc) to the "material waves": Thus we can write down our second analogical equation for "material waves":

$$\frac{h \cdot \nu}{u} = \frac{h}{(u / \nu)} = \frac{h}{\lambda} = \frac{m_0 \upsilon}{\sqrt{1 - \frac{\upsilon^2}{C^2}}} \quad (8)$$

Our second analogical equation for De-Broglie waves is (8), which is this same relation as (5); by following the opposite of De-Broglie's procedure. From (8) we get by differentiation:

$$\frac{d\left(\frac{1}{\lambda}\right)}{d\upsilon} = \frac{m_0}{h} \frac{1}{\sqrt{1 - \frac{\upsilon^2}{C^2}}} + \frac{m_0}{h} \frac{\frac{\upsilon^2}{C^2}}{\left(1 - \frac{\upsilon^2}{C^2}\right)^{\frac{3}{2}}} \quad (9)$$

Inserting relation (9) into relation (2) we arrive finally at the relation:

$$d\nu = \frac{m_0 C^2}{h} \frac{\frac{\upsilon}{C} \cdot d\frac{\upsilon}{C}}{\sqrt{1 - \frac{\upsilon^2}{C^2}}} + \frac{m_0 C^2}{h} \frac{\frac{\upsilon^3}{C^3} \cdot d\frac{\upsilon}{C}}{\left(1 - \frac{\upsilon^2}{C^2}\right)^{\frac{3}{2}}} \quad (10)$$

The integration of the last, from $\nu = 0$ to $\nu = \nu$ and from $\upsilon = 0$ to $\upsilon = \upsilon$, gives

$$\nu = \frac{m_0 C^2}{h} \frac{1}{\sqrt{1 - \frac{\upsilon^2}{C^2}}} - \frac{m_0 C^2}{h} \qquad (11)$$

Relation (11) is identical to our new starting relation (7); the circle has been completed and the two procedures (A) and (B) lead us to the same conclusion or result.

We can write down our own phase velocity for De-Broglie waves:

$$u = \nu \cdot \lambda = \frac{C^2}{\upsilon}\left(1 - \sqrt{1 - \frac{\upsilon^2}{C^2}}\right) \qquad (12)$$

From (12) we see that for small velocities of the particles $\upsilon << C$ it is $u = \frac{\upsilon}{2}$ i.e. the De-Broglie waves propagate at just half of the velocity of the particle, while for the relativistic particles it is $u \rightarrow C$. What do these small velocities mean? Their meaning is simple: **De-Broglie's waves follow the particle from behind**; these reach to the generating particle but at half of the velocity of the particle. The path behind the particle is filled with waves traveling at velocity $u = \frac{\upsilon}{2}$ (for $\upsilon << C$) and equally spaced between them i.e. separated by the De-Broglie wavelength.

Ether, SDBWs and "Zero Phase Difference Principle"

These **following** from the rear, "Slow De-Broglie waves" (SDBW), seem to have their origin in the agitation or vibration of the ether medium after the passing of the moving particle. Thus the rear space of the moving particle is filled with λ -equidistant SDBWs. After our familiarization with geometrical Optics and water waves, it can safely be assumed that these SDBW open or expand linearly with their distance from the particle (like the expansion in the sea of 'agitation-waves' following a ship). Now we have to mention the meaning and strength of the De-Broglie waves: These De-Broglie waves are so strongly acting that, as De-Broglie proved, their integer number of wavelengths around the nucleus determines Bohr's stable electron orbits i.e. the proper quantization of the atom. Of course here we have admitted tacitly (in agreement with De-Broglie) the "Zero Relative Phase Difference Principle" (ZRPDP): ("The ether guides or tends to direct two closely-adjacent parallel wave-trains to such directions or paths in space where their relative phase difference should become zero, or an integral number of 2π "). This very dominant Principle is not applicable only around the atom, but is also applicable in the nearly parallel wave-trains of light, coming from lasers or in the two-slit, Young experiment, leading them in such directions where interference fringes are formed i.e. in the directions where their relative phase difference is zero or an integral number of 2π.

The co-existence any group of free moving particles (of some definite velocity $\vec{\upsilon}$) and of SDBWs, (even following in the rear of each particle), combined with the strong action of the "Zero Relative Phase Difference Principle" (ZRPDP) forces the particles and their waves to be micro-accommodated (or arranged) so that to form **spatially coherent beam** of SDBWs (where the particles acquire necessarily non-random positions between them). This coherent beam of particles and their waves is able to produce "*hkl - Bragg reflections*" in crystals (experiments [4, 5]), or to give ordinary Optical Interference due to the grating on the crystal surface – [6], or by the use of a suitable bi-prism to again give interference fringes [7].

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