Interferences and periodicity

XAVIER OUDET

Fondation Louis de Broglie, 23 rue Marsoulan, 75012 Paris, France
Laboratoire de Magnétisme et d'Optique de l'Université de Versailles
C.N.R.S., 45 Avenue des Etats-Unis, 78035 Versailles, France
E-mail: Xavier.Oudet@physique.uvsq.fr

The foundations of Science are most stable than granite; its walls, rooms and stairs rebuilt themselves when, here and there, some masonry-work, childly built, collapse, Groddeck [1].

ABSTRACT. The interferences observed with the light are supposed to reflect the periodic properties of the electrons of the atoms in the place of the phenomenon and of the momentum of the photons themselves. In this way, after absorption, a part of the photons have their energy dissipated as heat or are reemitted spontaneously; they are in a too small number to be observed. The other has a life time allowing them to wait to be in sufficient number to have a probability to be reemitted in a stimulated manner. These two parts are function of the optical way difference of the photons. In this way the difficulties of understanding the one by one photon experiments disappear.

1 Introduction

The interferences phenomena observed when two beam of light arrive on a screen show a periodic property. The understanding of the phenomena of interferences remains still an open question. During the 19th century with the wave theory of Fresnel of the light [2], proposing a simple interpretation of diffraction and interferences has seemed to prevail against the corpuscular conception of Newton published in 1704 [3]. But with Einstein the photon hypothesis starts up again the debate [3]. The discovery of the associated wave to the electron corpuscle by de Broglie in 1924 does not have allowed up to now to reunite a large consensus upon the respective role of these two aspects. Recently I have proposed to interpret the wave function as the generatrix function of the momentum and energy along a differential element of space and time [5]. According to this approach the wave, while being distinct from the electron, pilots it along its trajectory. The model of Dirac shows us the differential conditions to have this. Thus the electrons in the atoms have closed or almost closed trajectories.

Thanks to Taylor since 1909 we know that the interference fringes remain with a very small luminous intensity [6]. Since numerous experiments have confirm this result [7]-[12]. The most surprising aspect was the possibility to observe interferences with to independent lasers [8], result many times confirmed [9]-[12]. This puzzle have suggested to Dirac from 1930 the hypothesis or following stance: "Each photon then interferes only with itself. Interference between two different photons never occurs" often quoted in the discussions and introductions of works relating to interferences [13]. Up to now, this disconcerting stance does not seem to have been seriously contradicted. Nevertheless on the experimental point of view it is highly questionable. Indeed the photons are emitted by the atoms, as a result in the perpendicular directions to that of the propagation, it does not seem reasonable to attribute dimensions higher to those of the emitting atoms that is few angstroms no more. But the Young hole giving interferences can be distant of several millimetres.

The study of the interferences in particular with the Young holes experiment shows that the distance separating two fringes or interfringe is directly linked to the difference of walk between the two optical ways. The classical interpretation of the interferences supposes for example that two beams can arrive on the place of the phenomenon simultaneously on the same point where there it would have direct interaction between them. This approach is the inheritance of the wave theory of the light.

Nevertheless the alone evidence is that the interaction of the light with the screen shows a periodic property. The next step is to determine if this periodic property thus shown belongs only to the light, to the screen or to the both. The difficulties to explain the Young interferences lead to think that the periodic property, thus put in view, is the reflection of those of the atoms of the screen where they are observed. In this view one has to suppose that the photons are absorbed for a while into the matter of the place of the phenomenon. During the absorption each photon transmits to the atom a periodic component to its motion. The photons are then emitted again with a given probability linked to the difference of way. During this time the absorbing atoms and the others are responsible of the interferences. In this study we intend to show that the interferences are indeed the result of the periodic motion of the electrons of the atoms of the place of the phenomenon after absorption of the photons of a given energy.

2 Interferences and probability

In a perpendicular plane to the direction of propagation, we suppose that the dimensions of the photon could not be higher than those of the atom having emitted it. Consider then the atoms of the source included in a volume of few interatomic distances and having a section equal to that of the source in the perpendicular direction of propagation of the light. Suppose that they are all carriers of a same thermal energy able to be emitted as a photon. As a result it cannot arrive simultaneously upon the place of the phenomenon a number of photons higher than the order of magnitude of these atoms.

Let us consider the interferences obtained with monochromatic light after to have crossed the Young holes. In such a system to observe the interferences a primary source must to give birth to two secondary sources S_1 and S_2 (figure 1). These two sources generate each one a beam interfering on a screen put at a distance D. The two secondary sources are call coherent because they generate interferences. We know that the coherency disappears if the difference of walk between the two beams is higher than about ten metres. This property leads to suppose that in a coherent source, the photons during the emission are emitted by successive trains of a given time in which the photons are distant of integer multiples of the wave length λ of the photons.

If now we compare the ratio between the surfaces of the source and of the place of the phenomenon of the interferences, it is clear that very few photons arrive simultaneously. For a source of 0.1mm of side and a surface of observation of 100mm of side, without taking looses into account, the ratio is of one for a million. Thus it appears that to have interactions, one has to suppose that the photons are absorbed on the place of the phenomenon and emitted again by stimulated emission when they are in a sufficient number. It is still important to keep in mind that the distance of the order of magnitude of 10 metres above which the coherence disappears, corresponds to a time of the order of magnitude of 10^{-7} second for velocity of the light, as confirms by experiments with a laser source [14]. This time indeed is that below which correlations disappear in one by one photon experiments [9]. Thus it emerges that the interpretation of the interferences is based on the notion of storage of the coherent photons. There is still to explain how take place the bright and black fringes. For this purpose we will first consider the synchronous bond.

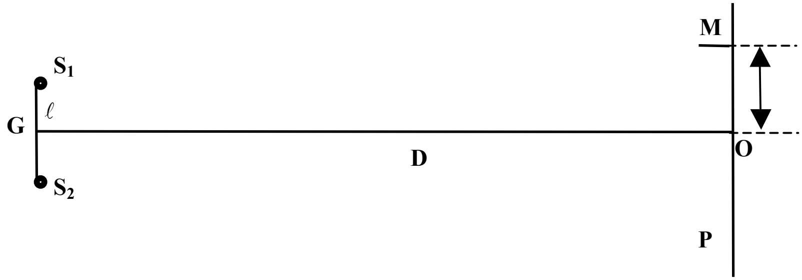


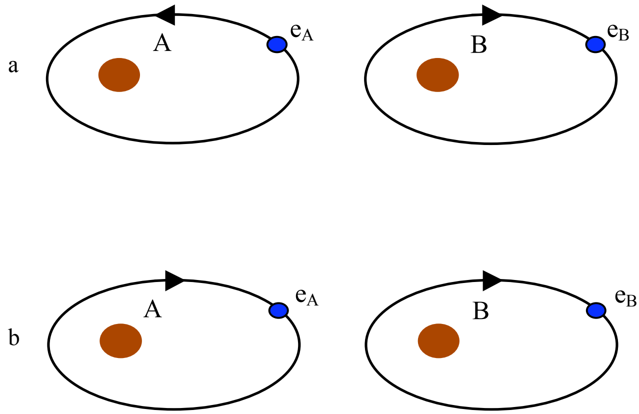
Figure 1. Schema of a device of interferences. An optical system gives of a source S two images S_1 and S_2 separated by a distance ℓ. The interferences fringes are observed in a perpendicular plane to the symmetry axis GO of the system.

3 The synchronous bond

There is in the solids a mechanism of order-disorder which is the clue to understand the interferences. For simplicity we first consider a crystallized solid. In its crystallographic site the atom takes an ordered position at low temperature corresponding to the synchronous motion of the outer electrons between the neighbouring atoms. We will say that the make with its neighbours synchronous bonds which are directional. When the temperature increases the atoms are suppose vibrate.

To characterize synchronization let us consider in a crystal a chain of atoms of the same chemical species and the same crystallographic site. Furthermore let us consider upon two neighbour atoms an electron in the same quantum state. To simplify the figure we suppose closed and periodic their movements but the following reasoning stays valid with a motion almost close. For each one of these electrons the period of the associated movement is thus the same one. Let be in this chain A and B two close atoms and on each one of them e_A and e_B the considered electrons (figure 2).

There are two cases of figure to consider, if according to a reference plane, the electrons turn around in the opposite directions (figure 2a) antiferromagnetic coupling or in the same direction (figure 2b) ferromagnetic coupling. Without disorder at zero degree Kelvin there is correlation between the motions of the electrons of bond in such a way to have the maximum cohesive energy. For example the electron e_A comes between A and B when e_B is as far as possible from e_A. The kernel of the atom B thus attracts the electron e_A but the presence of e_B prevents e_A to leave its atom. In a similar way for e_B with its other neighbour in the same chain and so on. Thus each binding electron is attracted more by the kernel of its own atom than by that of a neighbour. It is the same for all the directions where there are identical chains. There is synchronisation of the motion of the electrons in the same quantum state on an atom of the same chemical species located in the same crystallographic site. Notice that this notion of synchronisation is still working step by step by successive neighbouring, in non crystalline solids as glasses and amorphous solids in general. As a result all the reflections relative to the synchronisation to explain the interferences are still working in these solids.



Figue 2. The synchronous motion: a) antiferromagnetic coupling, b) ferromagnetic coupling.

Let us then consider the solid at sufficiently low temperature so that absorbed energy preserves synchronization between the greatest number of homologous electrons. The synchronization has a role in the transfer of the energy. Indeed, at the time of the interaction of a gas atom with the wall of the solid, a part of the energy of translation of the atom of gas is transferred on one or more electrons from one or more atoms of the solid. Let us consider an electron e_A which absorbed some energy. The binding energy E_ℓ to its atom varies. The synchronization with its neighbors is not respected any more. The electron e_A tends, after some number of revolutions, to pass between the atoms A and B at the same time as e_B. This tendency has for effect to modify the period of the electron e_B by transfer of energy. Gradually all the electrons homologous with a same site tend to preserve synchronization. This is shown with the study of the specific heat at low temperature [15]. So that the tendency to preserve synchronization takes place, it is necessary however that transferred average for a direction remains weak compared to E_ℓ energy. Such bonds take place with the whole of the outermost electrons in different directions of the space, the corresponding energies being a priori different. Consider then an atom, when the thermal energy is higher than the barrier of potential E_g, we suppose that the synchronous bonds are broken and that the atom topple into a disordered stat.

4 The absorption of the photons in a solid

To tackle the photon absorption in a solid, consider first the absorption of the thermal energy. The study of the Dulong and Petit law shows how the disordered atoms keep a mean thermal energy equal to $3kT$ [16]. The thermal energy is kept by the nucleus as well than the electrons turning around the nucleus of the atom. Indeed we have supposed that the motion of an electron is the result of an exchange of matter as grains between the potential and the electron [5]. On the other hand the same atom in a solid can received, to different times, some energy from opposite directions. Thus the solids can keep on disordered atoms a thermal energy double of that of the gas. The atoms in a disordered position are indeed like a gas, each one having a disordered motion but are however blocked on its site by the neighbours. The ordered atoms serve to this gas of transmitter of thermal energy. Thus the atom in disordered position receives a mean thermal energy of $3kT$. In the opposite when it returns to an ordered stat it must lose this thermal energy that is $3kT$ in mean value. It does it emitting a photon having in mean value this energy. The study of the black body allows verifying this analysis [16].

Then consider a solid at room temperature and absorption by its atoms of photons of the same energy in the visible. The carried energy is quite high; we suppose that the absorption of this energy breaks some of the synchronous bonds of the absorbent atom. As a result these atoms take a different orientation in comparison to their neighbours.

By different orientation we mean that the atom is no longer in the set of bonds giving to the solid the minimum energy. During the stocking time the atoms having absorbed a photon are in a sufficient number to be able to interact. To understand the absorption one would keep in mind that it is the inverse process of the emission. These two phenomena are not instantaneous, they need time. Thus the grains making the photon leave the emitting atom progressively and this allows supposing that before the emission that they are distributed in the volume of the atom. Once the photon absorbed, its energy that is the corresponding amount of grains is shared as mass and kinetics energy mainly between the atomic kernel and the electrons which have adsorbed it. The additional amount of grains modifies the atomic density of grains in the direction of propagation of the photon in such a way that the variation of the momentum of the electrons orbiting in the vicinity reflects this variation. As a result there is an oscillatory component of the motion of the atom. These variations are the result of the getting into and out fluxes that we have considered with the study of the motion of the electron in a central potential [5]. For the electron by getting into flux we mean the grains which enter into the volume of the electron and by getting out flux those which get out. To the oscillatory component of the atom are associated a getting into and another one getting out for the atom and for each concerned electron.

On an M point of the screen where are observed the interferences the photons arrive at different time being of two types: either they differ of an n integer multiple of period T or they differ of (n +x)T if x is the fraction of the corresponding interfringe at the M considered point M. As a result in the same zone of the place of the phenomenon, the atoms having absorbed a photon are divided in two groups corresponding at this temporal difference. At the starting time of the absorption the atoms are ordered but the phase difference makes that they are divided into two types and that just after the absorption their orientations in comparison to the main part of the solid are of two types. Particularly their oscillatory motion exhibits a phase difference. On the other hand they are in a position different from that of the ordered state but in the new state there is a position with a minimum of energy. Once absorbed the photon the absorbing atoms will approach this new position. The understanding of the interferences is that of the mechanism allowing reaching this new equilibrium.

5 The mechanism

Consider the atoms having absorbed a photon in the vicinity of an M point where are observed the interferences. The thermal and structural disorder and their oscillatory motion put them into two possible situations. Indeed let us consider these interactions resulting of the oscillatory motions of the neighbour atoms. If these interactions are for the most part in phase, they allow these atoms to keep for a while the additional corresponding energy of the photon. These atoms approach a temporary position of equilibrium. One has to suppose that it is this situation which allows the storage, the absorption being quite stable the photon will be emitted in stimulated emission, more or less time after absorption. On the opposite if the interactions are for the most part out of phase these atoms are in a situation which does not allow keeping the additional energy of the photon. This energy will be dissipated as heat, inverse phenomenon of the black body emission; it can also be emitted spontaneously in a time of the order of magnitude of the period of the motion of the electrons. As a result the photons emitted in a stimulated emission are numerous per unit of time. The photon eventually emitted spontaneously are not visible they are in to small number per unit of time. The luminosity of the fringes is thus bound to the proportion of the atoms able to take a temporary equilibrium position.

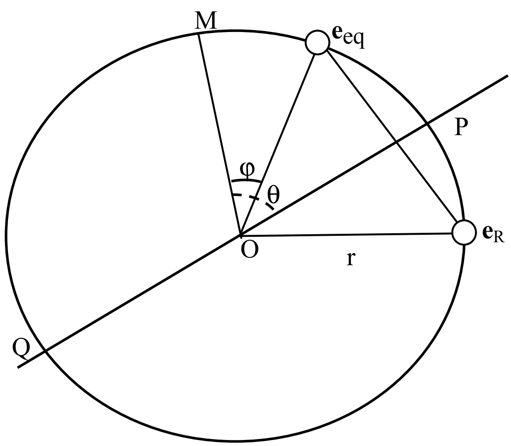


Figure 3. The calculation of the action during the motion of the absorbing atom towards its position of transitory equilibrium.

Let then e_R be on an absorbing atom the charge resulting from the electrons having broken their bonds. For the charge e_R all happen like if to an angular distance φ at a time t and to an equal radial distance there was a charge e_{eq} interacting with it (figure 3). This charge e_{eq} is the reflection of the two types of absorbing atoms just after the absorption. It is positive if the charges of the nucleus are dominant; the interactions are mainly in phase. In this case the motions of the absorbing atoms tend to be in phase in their position of temporary equilibrium, and the photons will be emitted in a stimulated emission. The charge e_{eq} is negative if the charges of the electrons are dominant; the interactions are mainly out of phase. In this case the absorbing atoms tend to gravitate in an opposite way to that their position of temporary equilibrium. The energy of the absorbed photon is then dissipated as heat or emitted in a spontaneous way. When the charges e_R and e_{eq} get closer or away their motion generates a mechanical action. One has to calculate the corresponding action, to determine probabilities corresponding to the two types of absorbing atoms.

Let i be the interfringe and x the the fraction of the fringe corresponding to the considered M point. In M the angle of phase difference between the two types of e_R charges is $\theta = \pi x/i$ for the initial phase difference and φ that to an intermediate time counted positive when the charges e_R and e_{eq} become closer. During the time dt the angle φ varies of $d\varphi$. If r is the distance between the charges e_R or e_{eq} and the centre O of the potential, the corresponding variation of the distance between the charges e_R and the charge e_{eq} is $r\sin\varphi d\varphi$. On the other hand if $\vec{p}$ is the angular momentum of the photon, its projection on the direction e_R—e_{eq} is $\vec{p}\cos\varphi$.

Let $A_{\mathbf{sti}}$ be the action corresponding to the charge e_R corresponding to the atoms generating the stimulated emission. When the temporary equilibrium is obtains, the received action is $A_r = \int \vec{p}dl$. We suppose that the transitory motions to the temporary equilibrium position are symmetrically disposed in comparison to a plane. This plane divides the segment e_R—e_{eq} in its middle. The intersection of this plan with that of the figure 3 is the straight line PQ. As a result the action to calculate is developed on half a period. The motion of the electrons is governed by the action of the intrinsic rotation which is always equal to h upon one period [5]. Thus the action to consider just depend on the difference of angular coordinates, it comes:

$$A_{\mathbf{sti}} = ½h \int_0^{\theta} \cos\varphi \sin\varphi \, d\varphi = ½h \cos^2\theta \qquad (1)$$

Let $A_{\mathbf{spo}}$ the corresponding action to the atoms for which the photon energy is dissipated as heat or spontaneously emitted. For these atoms the charge e_R and e_{eq} go apart, the angle φ is negative and the integration is to do between π - θ and π equal in this case to the integration between 0 and π - θ. It comes:

$$A_{\mathbf{spo}} = ½h \int_0^{\pi - \theta} \cos\varphi \sin\varphi \; d\varphi = ½h \sin^2\theta \qquad (2)$$

The sum of these two actions being equal to ½*h*, the luminous intensity in a point of the screen is proportional to $\cos^2\theta$. We find again the law of variation of the luminous intensity along the interfringe.

6 Conclusion

At the door of the twentieth century Einstein suggested the photon hypothesis to explain the photoelectric effect. He supposed between the energy en the frequency the following relation $E = h\nu$ which can be write $h = ET$. It is this relation which involves that the generated action by the motion of the electron in comparison to the proton during one period has to be equal to *h*. It is this property, resulting of the rotation of the electron, which allows to calculate the action during a period and to understand the variations of the luminosity intensity along the interfringe.

Around eighty years ago, Louis de Broglie proposed for the electron the existence of a wave length λ given by the relation $h = p\lambda$ where *p* is the momentum. These two relations reflect through the mechanical action of the relation between the time and the space. The express for the motion of the electron in comparison to the proton, that the action during one period is $h = p\lambda = ET$. It is this link between the space and the time which allows the atom and its electrons to absorb the photon keeping the same action and energy. This energy conservation imposes at the mass to be variable. This hypothesis suggested by the emission and absorption of the photons also comes of the notion of relativity that we owe to Einstein. Indeed the cause of the motion in the proton or the electron must be the same, involving a variable mass as we have previously discussed [5].

Thus if the interferences exhibit a periodic property, it is the consequence of the rotation of the electrons in the atoms and of the bond $h = p\lambda = ET$ between the time, the space and the energy. In the end one has to recognize that the mysteries of nature are not easy to comprehend, and if indeed the wave length is driving the electron it must prompt us to the greatest prudence.

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