

Original Paper

An Explanation of the Double Slit Experiment Based on the Circles Theory

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Abstract: The circles theory tries to explain the complex functioning of the harmonic oscillator. It is a non-quantum mechanics theory, but it shows a good similarity with the forms of equations of the relativistic quantum mechanics. The Circles Theory explains the association of the wave and the point that corresponds with the wave and particle of quantum mechanics. According to the circular motions of an individual system, a fluid model for a huge number of the circular system is expected to be formed. Then, a wave of fluid may appear. So, a real wave of fluid-type is seen due to the circular motion in addition to the wave associated with the point or the particle. In this article, the double slit experiment has been explained in accordance with the circles theory. According to the circles theory, the double slit experiment shows that this fluid-like wave is responsible for the interference pattern, whereas the associate wave is responsible for the uncertain location of the particle on the screen. On the other hand, the observation of the fluid may destroy the formulation of the wave of fluid. If this happens, then the interference disappears, but a pattern of shot bullets appears. The rolling circles model of the circles theory cannot be investigated experimentally. This explanation of the double slit experiment may prove the existence of this rolling circles system.

Keywords: particle and wave duality, circle theory, partial observation, complex wave, de Broglie wave, Pilot wave, double slit experiment

1. Introduction

From Newton's point of view, at the beginning of the nineteenth century, it was thought that light was composed of particles. In 1801, Thomas Young proposed a double slit experiment. The experiment showed that the light demonstrates a wave-like behaviour. This was first reported to the Royal Society of London by Young in 1803.

In 1909, Sir Geoffrey Taylor performed the first low-intensity double-slit experiment (Taylor, 1909); this experiment was carried out by reducing the level of incident light.

In 1927, Clinton Davisson and Lester Germer proved the concept of matter wave that was initially proposed by de Broglie. The experiment showed a diffraction pattern of an electron beam (Davisson and Germer, 1928).

All the double slit experiments before 1961 were performed using light. However, in 1961, Jönsson demonstrated diffraction from different number of slits using electrons instead of light (Jönsson, 1961, 1974).

In 1963, Richard Feynman gave this experiment (in his well-known book, “The Feynman Lectures on Physics”) more importance because of its role in the concept of particle wave duality in quantum mechanics. He called it the “central mystery” of quantum mechanics; in his own words, it is “impossible, *absolutely* impossible, to explain in any classical way In reality, it contains the *only* mystery ... the basic peculiarities of *all* quantum mechanics” (Feynman, 1963).

However, based on his explanation for the experiment in the third volume, Feynman proposed an individual electron or photon experiment.

In 1973, single-electron double-slit diffraction was first demonstrated by Giulio Pozzi and their associates in accordance with Feynman’s suggestion made in 1963 (Pozzi, *et. al*, 1973). In this experiment, single electrons were passed through a biprism. These single electrons resulted in the build-up of a diffraction pattern.

In 1989, a similar experiment was carried out by Akira Tonomura and their associates (Tonomura, *et. al*, 1989).

This experiment was performed with several different particles such as neutrons (Zeilinger, *et. al*, 1988), atoms (Carnal and Mlynek, 1991), and buckyballs (Arndt, *et. al*, 1999). Several others tried to design a precise methodology for the experiment described by Feynman, such as Herman (Batelaan, *et. al*, 2016).

1.1 Feynman’s experiment

Richard Feynman had proposed a thought experiment (Feynman, 1963), which suggested to perform the double slit experiment using a single electron as a technique to demonstrate the wave–particle duality. In his pedagogical style, Feynman had asked to imagine firing individual electrons through two slits and then marking the spot each electron strikes the screen at behind the slits. His setup and the results have been shown in Fig. 1.

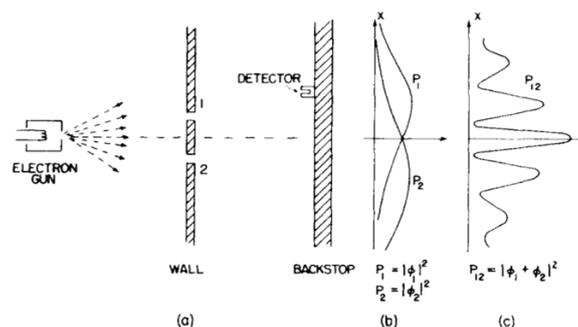


Fig.1 The experiment without observation (Feynman, 1963)

According to this experiment, the total probability of electrons reaching the backstop, as shown in Fig. 1, is as follows:

$$P_{12} \neq P_1 + P_2, \tag{1}$$

This result is same in the case of wave interference. As can be noticed, in this experiment, the electron is not recognised. Thus, to recognise the electron, Feynman proposed a modification in the previous setup, as shown in Fig 2.

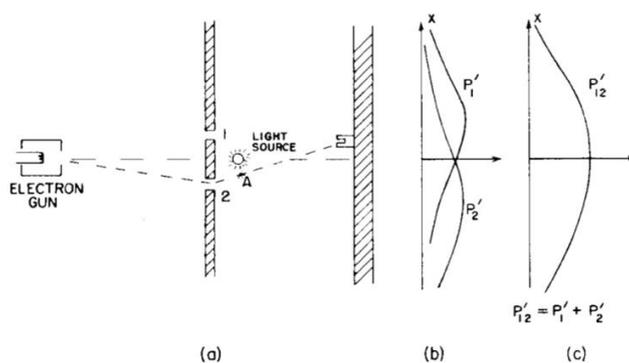


Fig.2 The experiment with electron observation (Feynman, 1963)

This experiment contains two setups: the first is same as that shown in Fig. 1, which is mainly for studying the wave property (interference); the second is that with an additional part, that is, a light source located between the two slits and an observation instrument (camera or eye) to detect the light reflected from the electrons. This light reflection is an indication for the incident electron. The total probability of electron incidence under the condition of particle recognition can be calculated as follows:

$$P'_{12} = P'_1 + P'_2, \tag{2}$$

This result is similar to the case of bullets shot towards the two slits. From these two experiments, the following can be calculated:

$$P'_{12} = P'_1 + P'_2 = P_1 + P_2 \quad (3)$$

However, Feynman used the term “lumps” to describe the group of particles in his thought experiment. In his words, “We have to say, Electrons always arrive in identical lumps”.

1.2 Particle and wave observation

In the double slit experiment, both particles and the wave feature are combined (may be observable). As an example, Bach *et al.* showed the particle distribution and the diffraction pattern in a single experiment (Bach, *et al.* 2013). In Fig. 3, both particles and the wave are acting and forming the pattern of diffraction. However, in 2007, Afshar showed experimentally the association of the particle and wave (Afshar, 2007).

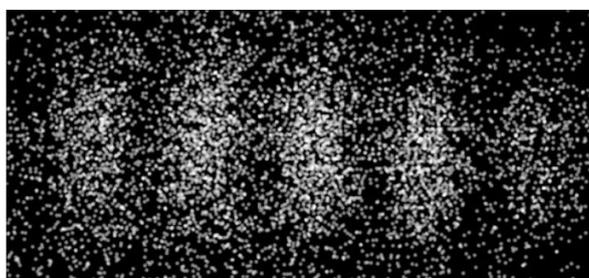


Fig. 3A The diffraction property related to the wave property and the blobs; the blobs are related to the locations of electrons (Bach, *et al.* 2013).

However, Fig. 3A may lead one to say that there are three elements, the particle and two types of waves. The white spots are related to the particles (electrons). Since the location of the electron obeys the uncertainty principal, the first wave indicates the probability. This wave is responsible for the probabilistic location of the electron within a fringe. This wave is a complex wave (wave function).

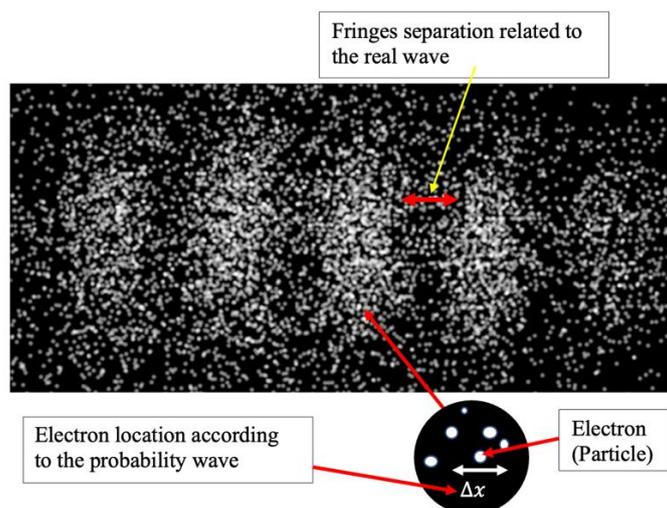


Fig. 3B The hint of two waves

The second wave responsible for the interference pattern and the appearance of the fringes distribution. This wave is a real wave and looks like a fluid wave or water wave. Fig. 3B depicts this concept of two waves.

1.3 The fluid model and the double slit experiment

In 1927, de Broglie (de Broglie, 1927) proposed the pilot wave model. This wave is real. Here, de Broglie used a concept brought from the macroscopic realm – the wave. The wave phenomenon works with continuous mediums. The continuous medium is related macroscopically to a statistical foundation. The wave function in this model is an ontological being.

Many physicists are influenced by de Broglie’s pilot wave, and the fluid model has been adopted several times for the double slit experiment. In 2006, Couder and Fort demonstrated that walking droplets (bouncing droplets) passing through one or two slits exhibit similar interference behaviour (Fort and Couder, 2006). Fig. 4 shows the wave as appeared experimentally.

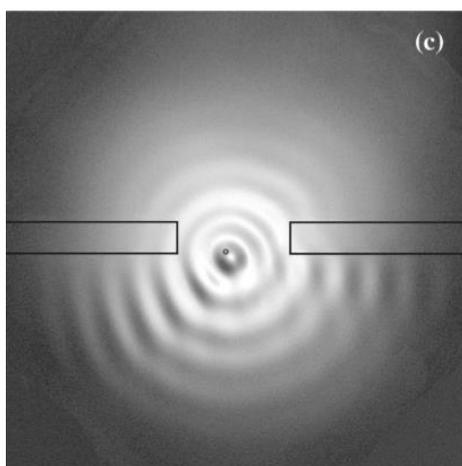


Fig. 4 A photograph of the experiment lit with diffuse light showing the wave pattern as the walker crosses the aperture (Fort and Couder, 2006)

In another attempt by Anderson and associates in 2006, no interference pattern such as that of Couder and Fort’s attempt was found (Anderson *et al.* 2015). Anderson concluded that “the particle-wave dynamics cannot reproduce quantum mechanics in general, and we show that the single-particle statistics for our model in a double-slit experiment with an additional splitter plate differs qualitatively from that of quantum mechanics” (Anderson *et al.* 2015). In 2017, Pucci and associates revisited the experiment reported by Couder and Fort using a refined experimental set-up. The experimental behaviour was captured by their developed theoretical model that allows for a robust treatment of walking droplets interacting with boundaries. The study underscores the importance of experimental precision in obtaining reproducible data (Pucci, *et al.* 2017).

1.4 Puzzles of the double slit experiment

In this experiment, there are many puzzles. These puzzles made Feynman to describe this experiment as the “central mystery” of quantum mechanics. These puzzles are the following:

- In case when one electron is shot at a time, the interference pattern remains. This phenomenon may lead to say that the electron passes through both slits at the same time and produce the interference pattern. In this case, the electron looks like a wave rather than a particle.
- When an electron is monitored by a detector fixed near one of the slits to determine which slit the electron is passing through, the electrons behave like a particle and stop creating the interference pattern.
- The wave–particle duality: The particle property may disappear or appear as a wave, and the wave property may disappear or appear as a particle.

1.5 Aim of the work

In the present paper, we replicate the double slit experiment by using the model of rolling circles proposed by the circles theory to represent the particle and wave.

3. Circles theory

Circles theory is a theory based on an assumption of external world and observable world. The observable world is related to the observation of the external world. The circles theory tries to explain the complex functioning of harmonic oscillator. It is a non-quantum mechanics theory. Within this concept, the theory tries to show that the mathematical formulation of the observable microscopic nature description may be an abstract formulation related to physics of observation. The theory has no relation with quantum mechanics, but its results show an excellent similarity with the relativistic quantum mechanics.

The theory relates the concepts of the point and the associate wave – which may be interpreted as particle and wave used in quantum mechanics – to an observable system, which is originally related to the external world. The timeline of the circles theory is shown in Fig. 5.

The theory is based on two postulates. The first is related to a system, which is described to in external world, and the second is related to the observation problem.

The first postulate is a proposal of the external world system. It is a mathematical model of two rolling circles in a real plane, as shown in Fig. 6.

The second postulate is related to the observation of the system. The system may be perceived in different forms depending on the properties of the light used, which is the data carrier from the object to the lab observer (Sanduk, 2012, 2018a, 2018b). The problem of optical resolution may lead to missing data or a problem of partial observation.

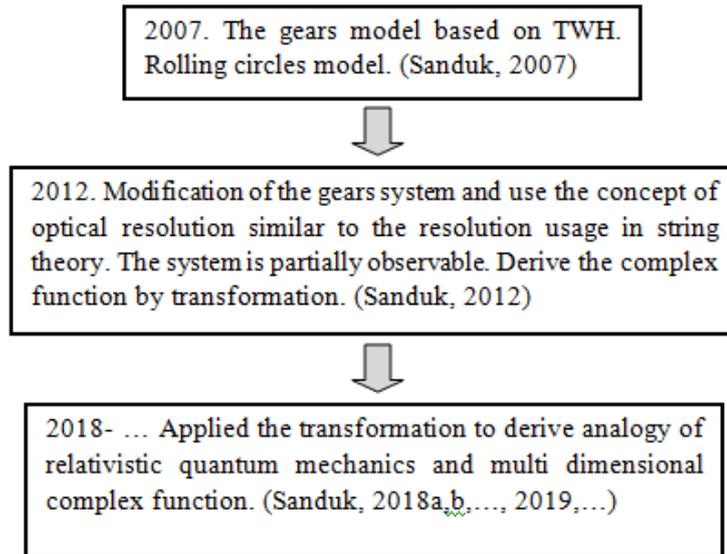


Fig.5. The timeline of the circles theory (Sanduk, 2020)

The observation plays a serious role in forming the mathematical representation of the external world by the lab observer. It is worth mentioning that the string theory has used the concept of resolution to explain the point particle. However, in circles theory, this problem causes significant changes. It leads to explaining the point particle and the associate wave. In addition to that, it leads to a complex form or physical complexification (Sanduk, 2019a).

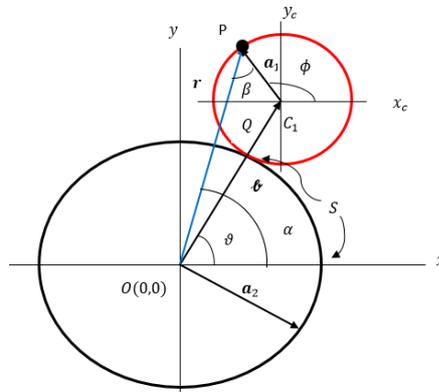


Fig. 6 The rolling circles systems (Sanduk, 2018a)

The theory studies the kinematics of a point (P), as shown in Fig. 6, the position vector, the velocity and the acceleration equations. The system has four parameters, as shown in Table 1.

Table 1. Parameters of the rolling circles system

	Radius	Angular frequency
Small circle	a_1	ω_1
Large circle	a_2	ω_2

Here, the position vector (\mathbf{r}) of the point P is mentioned only (Sanduk, 2018a, 2018b). However, the position vector of point P is:

$$\mathbf{r} = \left[\frac{a_2}{r} \hat{\mathbf{e}}_\vartheta + \frac{a_1}{r} (\hat{\mathbf{e}}_\vartheta + \hat{\mathbf{e}}_\phi) \right] (a_2 + b\sqrt{X}) \left\{ \cos(\mathbf{k}_2 \cdot \mathbf{s} - \omega_1 t + \omega_\beta t) \pm \sqrt{-\sin^2(\mathbf{k}_2 \cdot \mathbf{s} - \omega_1 t + \omega_\beta t) + X} \right\} \quad (4)$$

From this position vector, one can get the equation of velocity and the equation of acceleration (Sanduk, 2018b). All of these equations describe the motion of circles system as a virtual (unobservable) model in external world.

3.1 The observable system

In classical physics, the optical distinguishability may be related to the optical resolution (Rayleigh criterion). In the circles theory, a *monochromatic* light (λ, f) is used to observe the circles system (Fig. 6). The spatial resolution (d_λ) is the minimum linear distance between two distinguishable points, and the same for the angular frequency (ω_λ) depends on the wavelength of the light used.

The circles system is fully observed when

$$d_\lambda \ll a_1 \ll a_2 \quad (5)$$

and it will be partially observed when

$$a_1 \ll d_\lambda \ll a_2 \quad (6a)$$

and

$$\omega_1 \gg \omega_\lambda \gg \omega_2 \quad (6b)$$

Here, the observer cannot observe a_1 (or $a_1 = 0$) and ω_2 (or $\omega_2 = 0$). According to this problem of partial observation, the four parameters of the rolling circles system shown in Table 1 become, as shown in Table 2.

Table 2. System of observable parameters of the rolling circles system

	Radius	Angular frequency
Point	$a_{1m} = 0$	ω_{1m}
Complex wave	a_{2m}	$\omega_{2m} = 0$

The subscript m indicates the resolved (measured) values. In this case, there is missing data, because of which the position vector, the equation of velocity and the equation of acceleration are transformed under the effect of partial observation.

The results of these transformations are as follows:

- The complex position vector (Sanduk, 2018a):

$$\mathcal{Z}(\mathbf{s}, t) = \mathbf{a}_{2m} \exp \pm i(\mathbf{k}_{2m} \cdot \mathbf{s} - \omega_{1m} t) \tag{7}$$

- The complex velocity (Sanduk, 2018b):

$$i \frac{\partial \mathcal{Z}}{\partial t} = (-iv\mathbf{A} \cdot \nabla + B\omega_{1m})\mathcal{Z} \tag{8}$$

- The complex acceleration equation (Sanduk, 2018b):

$$i^2 \frac{\partial^2 \mathcal{Z}}{\partial t^2} = (-v^2 \nabla^2 + \omega_{1m}^2)\mathcal{Z} \tag{9}$$

The Equations 7, 8 and 9 are kinematical equations with imaginary i . The imaginary i arises due to the problem of partial observation.

3.2 Similarity with the relativistic quantum mechanics

As mentioned above, the circles theory is not a quantum mechanics theory and provided kinematical forms of motion, then certainly does not consider the Planck constant in representations. The theory shows complex kinetic equation forms. Table 3 shows how much the circles theory is similar to quantum mechanics. The comparison shows that the circles theory is closer to the relativistic quantum mechanics rather than the non-relativistic quantum mechanics (Sanduk, 2020). It is obvious that the agreement is quite good.

Table 3 Comparisons (Sanduk 2018a, 2018b)

Conventional definition	Kinematic forms of the relativistic quantum mechanics	Forms of the circles theory	Definition
Dirac wave function	$\psi_D = u_D \exp i(\mathbf{k} \cdot \mathbf{x} - \omega t)$	$\mathcal{Z} = \mathbf{a}_{2m} \exp \pm i(\mathbf{k}_{2m} \cdot \mathbf{s} - \omega_{1m} t)$	Z-complex vector
Dirac equation	$i \frac{\partial \psi}{\partial t} = (-i\mathbf{c}\boldsymbol{\alpha} \cdot \nabla + \beta\omega)\psi$	$i \frac{\partial \mathcal{Z}}{\partial t} = (-iv\mathbf{A} \cdot \nabla + B\omega_{1m})\mathcal{Z}$	Complex velocity equation
Coefficients	$\boldsymbol{\alpha}$ and β	\mathbf{A} and B	Coefficients
Property	$\alpha_i \alpha_j + \alpha_j \alpha_i = 0$	$\mathbf{A}_\theta \cdot \mathbf{A}_\varphi + \mathbf{A}_\varphi \cdot \mathbf{A}_\theta = 0$	Property
Property	$\alpha_i \alpha_i + \alpha_i \alpha_i = 2$	$\mathbf{A}_\theta \cdot \mathbf{A}_\theta + \mathbf{A}_\theta \cdot \mathbf{A}_\theta = 2$	Property
Property	$\alpha_i^2 = \beta^2 = 1$	$A^2 = B^2 = 1$	Property
Property	$\alpha_i \beta + \beta \alpha_i = 0$	$AB + BA = 0$	Property
Klein-Gordon equation	$\frac{\partial^2 \psi}{\partial t^2} = [c^2 \nabla^2 - \omega^2]\psi$	$\frac{\partial^2 \mathcal{Z}}{\partial t^2} = [v^2 \nabla^2 - \omega_{1m}^2]\mathcal{Z}$	Complex acceleration equation

3.3 Wave and particle system

The Circles theory attributes the particle and wave properties to a system of two circles. According to this, the particle and wave are both associated, but the observation techniques may show the feature of duality.

For quantum mechanics, the phase of the wave function of a free particle shows a combination of the particle and wave. A table has been created for these two parts, as we did with the tables 1 and 2. This new table shows the two concepts of particle and wave with their related mathematical expressions with the aid of de Broglie and Einstein equations. Since we deal in quantum mechanics with a real particle (zero radius), it is possible to use the angular representation (radius and angular frequency) instead of the particle-wave representation. The particle has no dimensions; thus, ($r_p = 0$) is the radius of the particle. It is worth mentioning that the angular frequency that corresponds to the wave is zero owing to no observable energy for the wave ($\omega_w = 0$). So, there are two unobservable quantities – r_p , and ω_w . With the aid of angular representation, Table 4 depicts all possible parameters for particle and wave in angular forms.

Table 4: The parameters of the system of particle-wave using angular representation

	Radius	Angular frequency
Particle	$r_p = 0$	ω_p
Wave function (Complex)	r_w	$\omega_w = 0$

For the circles theory, it is worth mentioning that owing to the partial observation, the zero angular frequency ($\omega_{2m} = 0$) or the zero energy ($E_{2m} = 0$) is responsible for the motion of the point within the range of ($\lambda_s = 2\pi a_{2m}$) (associate wave), or according to the quantum mechanics, the range of uncertainty.

According to the quantum field theory, since vacuum virtual particles of the vacuum fluctuations are created spontaneously without a source of energy ($E_V = 0$), vacuum fluctuations and virtual particles *violate conservation of energy*; however, this is allowed because they annihilate each other within the time limit set by the uncertainty principle and so are not observable (Pagels, 2012 and Gordon, 2006) since the particle and the wave (de Broglie hypothesis) exist at the same time.

This concept of the associate wave, which is proposed by the circles theory corresponds the idea of vacuum fluctuations in quantum field theories.

However, since the particle and wave show different properties, each of them needs a different technique or instrument to be investigated. As per the quantum mechanics theory, the wave and particle are in duality. These different and separated properties of the wave and particle may make it difficult to investigate them due to their combination. These difficulties appear in the double slit experiment as well. The setup of the experiment may be used to demonstrate these properties, but there is no single instrument that can be used to investigate

both the particle and the wave. The slits are used to investigate the wave, whereas the detectors are used for particle investigation and so does the screen, where it acts as a detector to catch the projected electrons.

4. The fluid of rolling circles units

In quantum mechanics, the electron beam used in accordance with the de Broglie concept of wave should have a wave property as well. This wave property is related to the de Broglie wave. There are many attempts to consider the particles group as a fluid. After the publication of Schrödinger papers about the wave equation in 1926, Erwin Madelung reformulated the Schrödinger equation into a set of real, non-linear partial differential equations. These equations are important for hydrodynamics consideration, and they exhibit a strong link between quantum mechanics and Newtonian continuum mechanics (Madelung, 1926). In this, Madelung regards the wave function as an *ontological* being.

4.1 wave and fluid

In macroscopic physics, the wave may induce circular motion in the liquid. The transverse and longitudinal waves make the molecules of liquid move in a circular pattern. The transverse wave could assume a trochoid shape or sine curve, as shown in Fig. 7. The wave here induced the circular motion of the component of the liquid.

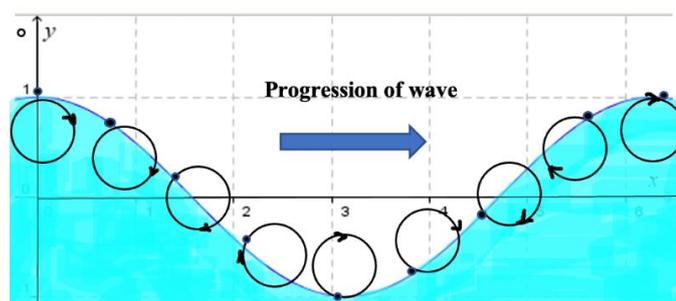


Fig. 7 The induced circular motion due to the travelling transverse wave in a liquid

In case there is no effect of gravity, the wavelength of the wave of the fluid is given as follows:

$$\lambda_F = 2\pi a, \quad (10)$$

where a is the radius of the circle.

4.2 The circles theory and fluid model

The circles theory explained the complex wave to be a result of partial observation. This wave is associated with the point (particle). So, this wave and the point form a single or individual model. What is the case of large number of these individual systems?

A huge number of this system may form a fluid-type medium with circular units, as shown in Fig. 8. Here, the circular motions may cause the wave motions in assume a fluid-like structure, as seen in the case of water. This picture is for the external world, but due to partial observation, the lab observer cannot distinguish these circles, as mentioned before. However, the lab observer notes a point with guiding wave motion. In such a case, it is expected that this fluid will exhibit wave forms. There are two types of wave: the guiding wave of the particle (associate wave) and the wave of the fluid. The wave of the fluid is real and carries the units (points in relation to the lab observer).

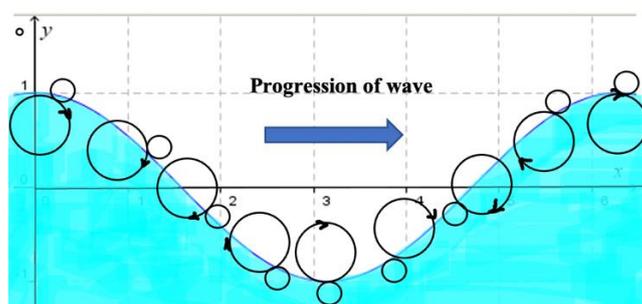


Fig. 8 The induced travelling transverse wave due to the circular motion in a huge group of rolling circles systems. This wave is of a group of systems.

The wavelength of the wave is calculated as follows:

$$\lambda_F = 2\pi a_2, \tag{11}$$

where a_2 is the radius of the large circle. This model shows that the wave is a companion of the group, and that it may be referred to as a part of the single system without group.

The observer notes a wave associated with the point (Sanduk, 2018a).

$$\lambda_S = 2\pi a_2 \tag{12}$$

Then one can say that

$$\lambda_F = \lambda_S \tag{13}$$

In this case, the λ_S is considered in single system consideration whereas for a group or fluid model is considered as well as.

Here, we have mentioned that the lab observer cannot recognise the single circles system but a beam of points with a wave of wavelength. It is possible that this fluid wave will not be dense and may disappear if the number of circles system is small. Nevertheless, this wave is real since the circles are real.

For the circles theory, the individual rolling circles model with the partial observation of the lab observer shows similarity with relativistic quantum mechanics. A group of these models may show a fluid model with waves. For the lab observer, this fluid is observable:

$$d_s < \lambda_F. \tag{14}$$

Here, d_s is related to the instrument of the wave investigation, such as the width of the slits in diffraction or interference experiments. This condition looks like that of the optical resolution. So, for the lab observer, there are three elements in his/her observations, the point (real particle), the complex wave or associate wave (wave function) and the wave of the fluid or the real wave.

4.2.1 The Rotating point

The ratio of the rolling circles is (Sanduk, 2018a):

$$\frac{a_2}{a_1} = \frac{\omega_1}{\omega_2} = \mu > 1. \tag{15}$$

In 2018, it has been assumed that if the electron has a rolling circles system, then the fine structure constant α may be related to the coupling constant (μ):

$$\frac{1}{\alpha^2} = \mu = 18778.87441 \tag{16}$$

And then

$$\frac{a_1}{a_2} = \frac{r_e}{r_B} = 5.325136191 \times 10^{-5} = (0.00729735075)^2 = \alpha^2 \tag{17}$$

Accordingly, the radius of large circle is:

$$a_2 = a_1 1.8779 \times 10^4 \tag{18}$$

So, the small circle is quite small compared to the large one. It looks as a point moves in circular motion.

A clear pedagogical simulation for the water wave and particle has been accomplished by Russell (Russell, 2016). This case of circles theory looks like that of Russell's simulation (Fig. 9).

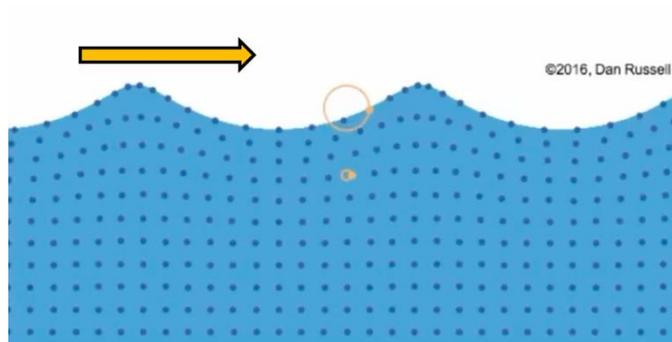


Fig.9 Russel's wave simulation (Russell, 2016).

4.2. Observation of the unit systems

During observation, light is used. The light is considered to have a similar structure. The pattern of fluid wave (λ_F) can be destroyed by a projection of another different fluid (light), where both may have similar structure, as shown in Fig.10. In this case, a collision is expected and reflections may occur. The individual systems may act individually, and the points (particles) might act with the associate wave.

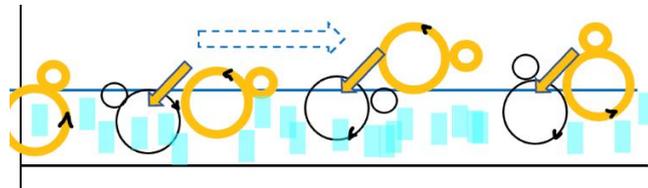


Fig.10 The destruction of the wave of fluid by fluid approaching from the opposite direction

5. Explanation of the double slit experiment

The lab observer depends on the theory to setup the investigation experiment. The theory shows that there are two features: wave and particle.

The set up will deal with both the sides of the system (circles) at the same time. Then, it will show their effect according to the purpose of the experiment. Each feature has its suitable instrument for detection.

According to the circles theory model, the wave enters the two slits and turns into two waves.

5.1 The wave of fluid

The wave of fluid model (λ_F) is related to the circular motions of the huge group of systems. This type of wave can be investigated by using the slit technique (double or single slit).The results show either diffraction or interference.

Fig. 11A shows a system for double slit experiment with the wave of the fluid model and the interference pattern.

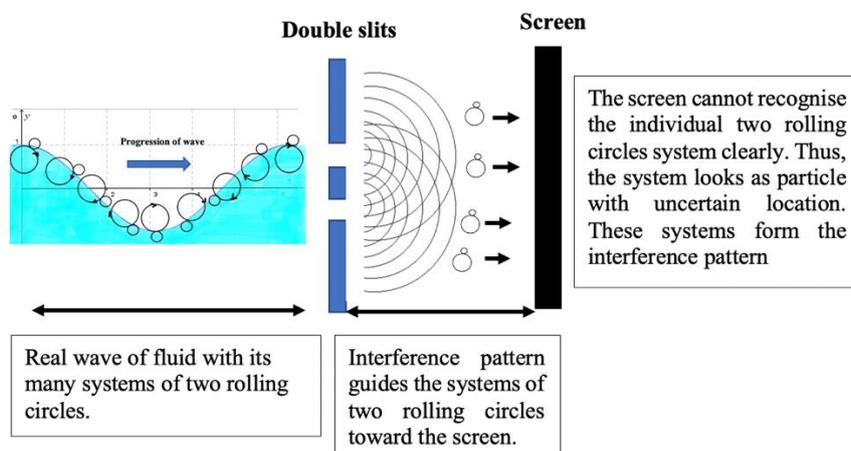


Fig. 11A The double slit experiment in accordance with the circles theory for a huge number of systems; interference due to group of systems

As shown in Fig.11, the wave enters through the two slits and produces the interference pattern due to the wave of fluid (λ_F). The slits cannot recognise the circles systems (the components of the fluid). The screen acts a lab observer and deals with the points as they are distributed by the wave property of the fluid in addition to the accosicate wave effect of the wavelentgh λ_S . These points make a pattern with time as they reach the screen depending on the interference pattern as shown in Fig. 11B. The associate wave does not appear as a wave, but it controls the location of the point or the particle, as in case of the uncertainty relation (Sanduk, 2018a)

$$\Delta x = \frac{\hbar}{\Delta p} \sim \lambda \equiv \lambda_S \quad (19)$$

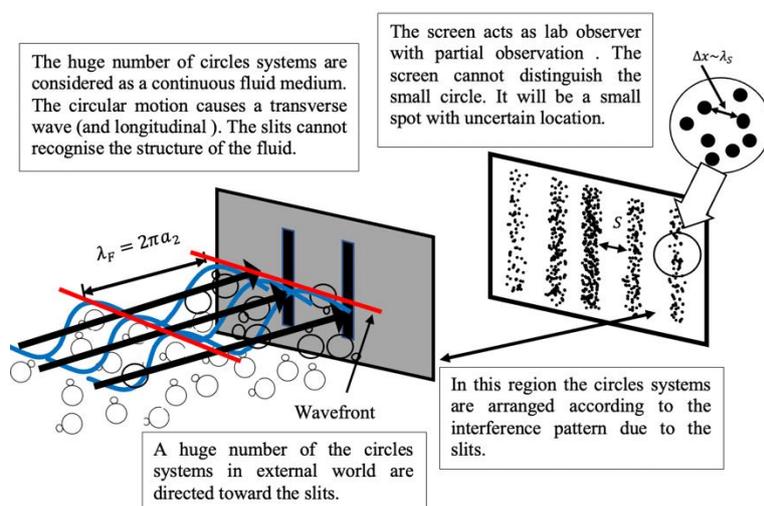


Fig. 11B The double slit experiment with interference fringes due to group of systems. On the screen, the effects of the two waves (λ_F and λ_S) appear.

The separation distance of the fringes (as shown in Fig. 11B) depends on the wavelength of the fluid:

$$S = z \theta_f = z \frac{\lambda_F}{d} \quad (20)$$

where S is the distance between the two slits, λ_F is the wavelength of the fluid wave, d is the distance between the slits and the screen, and θ_f is the angular spacing of the fringes. The intensity of the fringes (I) depends on the wavelength of the fluid (λ_F). The intensity of the diffracted light can be calculated as follows (Jenkins and White, 1967):

$$I(\theta) \propto \cos^2 \left[\frac{\pi d \sin \theta}{\lambda_{F,S}} \right] \left\{ \left(\sin \left[\frac{\pi b \sin \theta}{\lambda_{F,S}} \right] \right) \frac{\lambda_{F,S}}{\pi b \sin \theta} \right\}^2 \quad (21)$$

where $\lambda_{F,S}$ is the wavelength of the wave of the fluid or the associate wave of the system. Thus, one can say that the intensity may be related to origins of both the waves that entered the slits: the fluid wave and the particle associate wave.

Rueckner and Peidle showed how the interference pattern develops depending on the time of exposure (Rueckner and Peidle, 2013). Fig. 12 shows the accumulation of photons with time. The wave property becomes clearer with an increase in the numbers of particles. These results are for photons. Similar results are shown for electrons in Bach and Pope's experiment (Bach, *et al.* 2013).

In low density fluid, the real wave still existed. Individual systems may reach the screen individually but still under the control of the interference pattern. The formation of interference fringes on the screen takes time. This is clear in the first figure of Fig. 12.

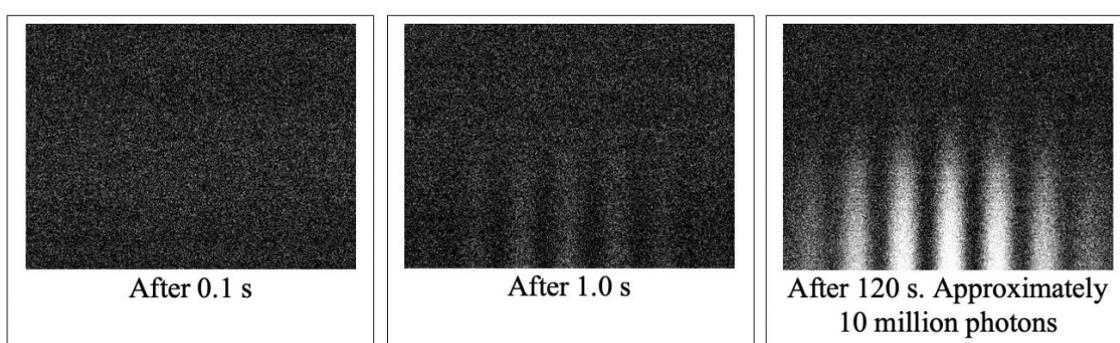


Fig. 12 The development of interference pattern with time (Rueckner and Peidle, 2013).

5.2 Fluid without wave

Light can be used to detect the individual systems of the circles system inside the fluid. In this case, light has similar structure and can destroy the pattern of fluid wave due to collisions. So, there will not be wave and the slits do not deal with wave of the fluid (see Fig. 13A).

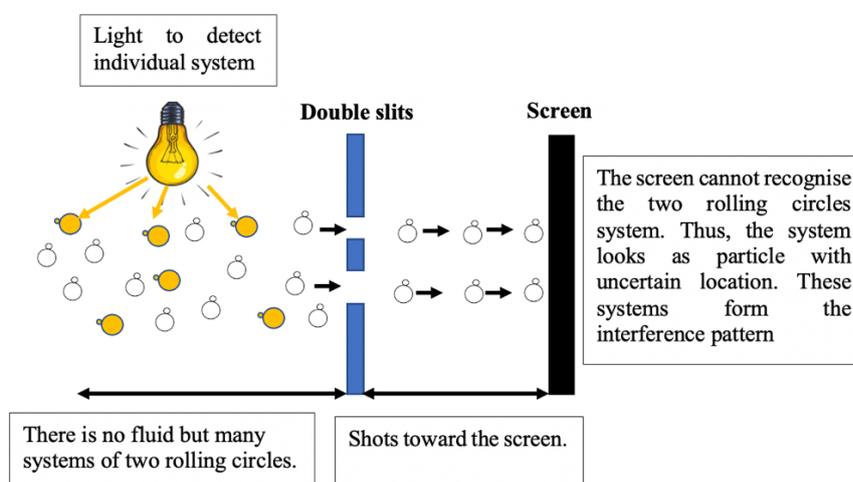


Fig. 13A The double slit experiment based on the circles theory for individual systems; there is no interference pattern due to the usage of detection light.

There is no acting wave to be organised in the interference or diffraction patterns. The wave in this case is only that which is associated with a single point (λ_s), as observed by the lab observer. Fig. 13B shows the individual systems due to the detection light and the form of the slits on the screen without interference pattern.

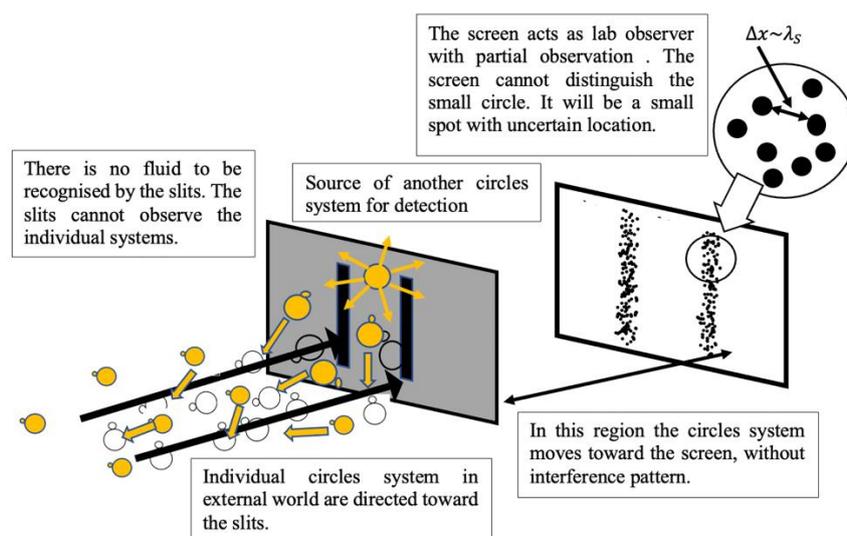


Fig. 13B The double slit experiment based on the circles theory for individual systems. The screen detected the system of rolling circles as a particle with uncertain location.

However, the double slit experiment shows two features: associate wave and particle; but it emphasises on the feature that the setup of the experiment is designed for it (particle).

6. Conclusions

According to the circles theory, the particle and wave are attributed to the partial observation of the two rolling circles system. This wave is associated with the particle. The observer of the particle may be a camera, detector, screen, etc. All of these observers detect the particle with a random or uncertain location. These observers cannot detect the wave property owing to the unreal existence of the wave (abstract) due to the partial observation. However, its effect appears as an uncertain location of the point that is associated with it.

Batelaan, *et.al*, suggested an explanation for the electron double slit experiment in terms of particle trajectories affected by a vacuum field (Batelaan, *et.al*, 2016). It is shown above for the circle theory explanation that the associate wave and owing to the partial observation has zero frequency. This associate wave play a serious role in the electron distribution in the fringe. We know that the vacuum field has zero energy or zero frequency.

For a large group of the rolling circles system, a phenomenon of wave on a fluid appears. This wave has no energy due to the partial observation. In quantum mechanics, this type of wave is attributed to the vacuum field of zero energy which violates the energy conservation.

According to the circles theory, there are two type of waves: the fluid wave, which is a real wave; and the associate wave, which is a complex wave (abstract). The first is related to the group of circles, whereas the second is related to an individual system.

The structure of the rolling circles model of the circles theory cannot be investigated experimentally. This explanation of the double slit experiment may prove the existence of this rolling circles system. The real rolling circles are the origin of the real wave of the fluid, which can be detected by conducting the double slit experiment and is responsible for the interference pattern. This wave carries groups of particles. This combination of the real wave and particles is explained by the circles theory. Everything is real in this experiment, except the circles system as seen by the lab observe and this lab observer here is the screen.

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