Available online at www.sciencedirect.com
SCIENCE DIRECT®
Chaos, Solitons and Fractals 27 (2006) 843–849
CHAOS SOLITONS & FRACTALS
www.elsevier.com/locate/chaos

# The idealized quantum two-slit gedanken experiment revisited—Criticism and reinterpretation

Mohamed Saladin El Naschie *

*Department of Physics, Alexandria University, Alexandria, Egypt*
*Department of Astrophysics, Cairo University, Cairo, Egypt*
*Department of Physics, Mansura University, Egypt*

**Abstract**

An idealized two-slit experiment is envisaged in which the hypothetical experimental set-up is constructed in such a way as to resemble a toy model giving information about the structure of quantum space–time itself. Thus starting from a very simple equation which may be interpreted as a physical realization of Gödel's undecidability theorem, we proceed to show that space–time is very likely to be akin to a fuzzy Kähler-like manifold on the quantum level. This remarkable manifold transforms gradually into a classical space–time as we decrease the resolution in a way reversibly analogous to the processes of recovering classical space–time from the Riemannian space of general relativity.

The paper's main philosophy is to emphasize that the quintessence of the two-slit experiment as well as Feynman's path integral could be given a different interpretation by altering our classical concept of space–time geometry and topology. In turn this would be in keeping with the development in theoretical physics since special and subsequently general relativity. In the final analysis it would seem that we have two different yet, from a positivistic philosophy viewpoint, completely equivalent alternatives to view quantum physics. Either we insist on what we see in our daily experiences, namely, a smooth four-dimensional space–time, and then accept, whether we like it or not, things such as probability waves and complex probabilities. Alternatively, we could see behind the façade of classical space–time a far more elaborate and highly complex fuzzy space–time with infinite hierarchical dimensions such as the so-called Fuzzy K3 or *E*–Infinity space–time and as a reward for this imaginative picture we can return to real probabilities without a phase and an almost classical picture with the concept of a particle's path restored. We say almost classical because non-linear dynamics and deterministic chaos have long shown the central role of randomness in classical mechanics and this is reinforced once more in our model which is directly related not to Newtonian motion, but rather to a diffusion-like random walk similar to that used with great skill by Einstein and later on by Nagasawa and particularly the English-Canadian physicist Garnet Ord.


## 1. Introduction

A deduction of the possible form of geometry and topology of space–time which is compatible with the quintessence of the quantum two-slit experiment was undertaken recently in a series of papers [1–5]. Subsequent vivid discussion as

* Address: P.O. Box 272, Cobham, Surrey KT11 2FQ, United Kingdom.

0960-0779/$ - see front matter © 2005 Published by Elsevier Ltd.
doi:10.1016/j.chaos.2005.06.002

well as private correspondences with leading world authorities on the subject has convinced the author that there is still room not only for stylistic improvement to avoid unclarity but also for better explanation to enhance the smoothness and ease of understanding. To start with, the name of the very vehicle employed to make the problem tangible, namely the quantum two-slit experiment may have caused the experimental experts on the subject, of all people, some difficulties. This name should be therefore modified to ''the idealized or mathematical two-slit experiment''. Indeed our model has very little to say about an actual two-slit experiment. For instance, in an actual experiment most of the quantum particles fired from the source does not go through either slits. In fact beside $P_1$ and $P_2$ as defined in our previous papers [1–5,11–13], we have a probability $P_3$ given in the classical theory of quantum mechanics by [10]

$$P_3 = P_1 + P_2 + 2\sqrt{P_1 P_2}\cos\varphi$$

From a purely formalistic viewpoint taking $\varphi = \pi/2$ one finds:

$$P_3 = P_1 + P_2$$

which in the case of our idealistic ''toy model'' of two-slit experiment leads to the normality condition [11,13,14]

$$P_3 = P_1 + P = \phi + \phi^2 = 1$$

The important point, in fact the only vital point in the two-slit experiment is the fact that a ''point particle'' could be said to have traveled two different paths simultaneously without splitting into two and that this wave-like behavior disappears if the faintest attempt is made to obtain a ''which way'' information apart of the experimental fact that at the end what arrives at the detection scene is always a particle regardless of whether this particle traveled as particle or as a wave. In this sense our two-slit experiment is a toy model or a gedanken experiment. It is an idealized hypothetical experiment designed with the only objective of understanding the nature of quantum space–time, pretty much like what Feynman and Hibbs have done in their classical book to derive the path integral formulation via the many-slit experiment [10,15,16]. Thus nowhere in our analysis do we use wave mechanics of any form.

In what follows we will attempt to remove further possible shortcomings of our previous analysis and may start by motivating the vital negative sign on the left hand-side of the indistinguishability condition used in the aforementioned publications [1–5,11–13].

## 2. The Einstein–Nagasawa–Ord random walk interpretation

In our derivation of the Fuzzy K3 from the idealized two-slit gedanken experiment, we have pretended to live at a hypothetical time where quantum mechanics was not invented yet although our experimental capabilities have reached such a sophistication which empowers us to fire a single quantum particle at a time and wait until it arrives at the detection screen before the second particle is fired.

That way we have been avoiding the use of any quantum mechanical concepts including that of phase. Our initial program consists of using classical probabilities. However, the attentive reader, and there have been many of them, must have noticed that on the left hand-side of our vital indistinguishability condition

$$P_1 + (-P_2) = P_1 P_2$$

we have been de facto subtracting probabilities rather than adding them as required by the classical theory of probability. It is true we have got rid of the phase, which is a relief, but we have negative norm. It is true that the final result is a positive norm, but even with negative intermediate steps, this could not be called classical probability theory. The author has proposed several arguments to explain this vital negative sign. However in the end analysis we cannot return to complete classicity. Quantum mechanics can be reduced only to a ''realistic'' model such as diffusion in space and time or equivalently a fractal random-walk in four dimensions. One of the better explanations of the negative sign which has the additional bonus of being in harmony with some of the basic concepts of loop quantum mechanics is the following which is largely due to Garnet Ord [7] and which uses the antiparticle concept indirectly.

In classical physics particles executing random walks in space yield probability densities that satisfy the diffusion equation. This is assuming that all trajectories move uniformly forward in time. However, in $E$–Infinity theory time is ''spacialized'' and we make no distinction between space and time. Consequently, we can assume a Brownian motion in time. Thus depending on how this new possibility correlates with Brownian motion in space, the superposition of the two gives the same PDEs of Schrödinger and Dirac as in quantum mechanics.

In such a situation the ''subtraction'' inherent in Q-M is the result of space–time loops. In two dimensions this is easily visualized by an $x$–$t$ plot where we find two loops. Loop A is anti-clockwise and loop B is clockwise. The two loops will either reinforce or annihilate each other as in Knot theory. The annihilation process in a system with Brown-