Suspended Reality and Quantum Field Theory

> *If you wish to continue your relations with my daughter, you will have to give up your present manner of 'courting'. You know full well that no engagement has been entered into, and that as yet everything is undecided.* Karl Marx to Paul Lafargue

Introduction

In a paper titled *Photon wave functions, wave-packet quantization of light, and coherence theory* by Brian J Smith1 and M G Raymer, they say:

> *There are still many puzzling aspects of the nature of light. A central point to understand is the distinction between a corpuscular viewpoint and a field viewpoint of light. In the old days, this was called wave-particle duality, but this phrase does little justice to the subtle issues involved. A key question is, can we view light as being comprised of particles called photons, or must one view light as a field?*

And later:

> *We note that there are three common interpretations of the photon. One is the notion of a fundamental particle. Another is that of an excitation of a quantum field. A third is simply what is registered by a photodetector*

In this article I wish to suggest an interpretation of quantum theory which can be applied not only to simple quantum states (such as a single photon passing through an interferometer) but to system involving huge numbers of photons (such as a TV broadcast signal).

To start my enquiry I asked the following question on a popular physics forum:

> *Just as General Relativity has superseded Newtonian gravitation, so QED is claimed to have superseded Maxwells laws of electromagnetism. What then is the standard quantum mechanical explanation of the fact that a bunch of electrons oscillating in a wire 100 miles away can make an electron in my TV aerial oscillate with the same frequency and appropriate phase?*

The answer I got was the following comment:

> *It is the same as the explanation with Maxwell's equations. QED reduces to Maxwell's equations at the scale of a TV aerial etc. Radio/TV carrier waves are so-called coherent (or Glauber) states of the quantized electromagnetic field. In a coherent state there are not a definite number of photons so I don't think that photons are even relevant here. You only get a definite number of photons if you measure them, and regular antennas don't do that.*

I infer from this that the 'coherent state' is a kind of wave function which closely resembles the electromagnetic wave as described by Maxwell's theory. It has also been described as *Maxwell's equations with some noise*. My question boils down to this: what is the physical reality behind such a coherent state? Following Smith and Raymer I might argue that there are three possible interpretations: one is that it is a cascade of physical particles (photons) in correlated motion; another is that it is a disturbance in what is called the photon field, much like ripples on a pond; and the third is that it is simply a mathematical device which allows us to predict what will happen to the electrons in the aerial which is placed in its path.

All three of these alternatives have enjoyed popularity over the history of the development of Quantum Field Theory (QFT) but the currently fashionable opinion is that physical reality is a collection of fields. Each fundamental particle is regarded as an excitation or disturbance in a field.

A photon is a disturbance in the photon field; and electron is a disturbance in the electron field etc. etc. The main problem with this approach is the huge body of evidence which supports the idea that the fundamental structure of matter is particulate. It is ironic, therefore, that the most successful application of QFT is the so-called Standard Model (SM) of particle physics which is firmly rooted in the reality of particles.

The arguments over whether a particle or a wave interpretation of QFT is to be preferred are highly technical[1] and, in my view, misguided. It seems to me to be pointless arguing about the interpretation of QFT when the question of the interpretation of standard Quantum Theory remains unresolved. At the heart of all these arguments is the assumption that physical reality must be capable of being described in detail at every instant of time. It is my belief that this assumption is false. In my view, reality can only be defined in the past and that, for any given observer, much of reality in the present is, or may be, *undecided*.

Let me explain in a bit more detail[2].

Suspended reality

Whenever a system is faced with a choice of possible outcomes, reality enters a period of suspension in which all the possible outcomes are tried out simultaneously. For example, when a single photon impinges on a half silvered mirror, reality splits into two possibilities. In one scenario the photon is reflected; in the other it is transmitted. The system is now governed by a thing called a probability wave equation. This is a mathematical object which has no physical reality but which none the less is going to determine what eventually becomes real. We now effectively have two potential realities evolving side by side – but which of them is going to become the actual reality is, as yet, undecided.

At some point, one or other of these two potential photons is going to interact with another particle – an electron in an atom, perhaps. This interaction can be either reversible or irreversible. For example, if the reflected photon hits an electron in an atom of aluminium of the surface of a mirror, the electrons on the aluminium react in a coordinated way to send the photon off in a new direction in accordance with the laws of reflection. This process is reversible because, knowing the direction of motion of the photon after the event is sufficient to reconstruct how it was moving before the even.

On the other hand, if the photon hits an atom in a piece of white paper, it will be scattered in a random direction. The process is not reversible because knowing the direction of motion of the photon after the event is not sufficient to reconstruct how its motion before the event.

Now I believe that irreversible events trigger what I call World Line Reduction. This is the point at which Nature has to make up her mind whether the event which triggers WLR is real or not. This decision is made in accordance with the amplitude of the probability wave function at that place. This is a genuinely random process. If the event is deemed real, then the whole history of the reflected photon becomes real also. Simultaneously, the world in which the photon was transmitted simply disappears.

There is nothing 'spooky' about this process. When you buy a lottery ticket for a pound, it is worth a pound and you could (if you were lucky) trade it for a beer. But as soon as the lottery numbers have been published your ticket either becomes worth a fortune or (more likely) nothing at all. There is no need for a signal to pass from the lottery machine to all those tickets that didn't win. Likewise, when an irreversible event happens to one of the potential realities in the system, the wave function simply changes (or collapses) to reflect the new (potential) reality.

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1 See, for example: Gasparinetti, L. and A. Collavini, 2025, “Ontologies for quantum field theory”, *Philosophy Compass*, 20(11): e70061.

2 For an even more detailed discussions see: https://www.jolinton.co.uk/Articles/Suspended%20Reality/Text.pdf

In summary, whenever a system encounters a choice, multiple potential realities spring into being whose probabilities are determined by a probability wave function. Eventually, when World Line Reduction occurs, one of these potential realities becomes actual together with its whole history.

Relativistic Suspended Reality

When it comes to applying these ideas to QFT there is one word which signals trouble. That word is 'simultaneously'.

Standard Quantum Theory is incompatible with Special Relativity and there is no problem with saying that the wave function collapses everywhere at the same time. But QFT is Lorentz invariant and any interpretation of QFT must also be compatible with Special Relativity. The question, then, is whether my idea of World Line Reduction is or is not compatible with Special Relativity.

Let us pursue the analogy with the lottery ticket a bit further. I have suggested that, at the instant the balls fall into place, all the lottery tickets which have been issued for that draw except one instantly become worthless. This raises an intriguing legal conundrum. Suppose I have purchased my ticket on Earth and then have travelled to a nearby star several light years away. At the instant the draw on Earth takes place, my ticket becomes worthless – but, of course I do not know that because it will take several years for the information about the results of the draw to reach me. Suppose now that, a week after the draw, I sell the ticket to the commander of a passing space ship travelling at near the speed of light *away* from Earth. According to him, the draw has not yet taken place and the ticket will still be valid. The question is – when both he and I return to Earth and discover the results of the draw, will he be able to sue me for selling him a worthless ricket under false pretences? Even more intriguing, suppose my ticket turns out to be the winning ticket, who is legally entitled to the prize money?

Fascinating though these questions might be, it turns out that they do not actually have a bearing on the question of whether a lottery draw is or is not compatible with Special Relativity because the only relevant question is whether or not we can use the apparent instantaneous change in the value of my lottery ticket to send an instantaneous message from Earth to me. Obviously not. It is no good agreeing in advance to throw a party on the date of the draw if I win or commit suicide if I loose because I have no way of telling when I look at my ticket a week after the draw whether it is worth a fortune or nothing. In exactly the same way, it turns out to be impossible to use the apparent instantaneous collapse of the wave function to send a superluminal message anywhere so Suspended Reality is already compatible with Special Relativity.

To make this absolutely clear, consider the following scenario. A photon is directed at a half silvered mirror. If it is reflected it is detected by a photomultiplier tube $\mathbf{D_R}$ placed a certain distance from the mirror. We shall call this potential event $\mathbf{E_R}$ If the photon is transmitted it will hit a different photomultiplier $\mathbf{D_T}$ placed a slightly greater distance from the mirror. This event will be called event $\mathbf{E_T}$. In the frame of reference in which the mirror is stationary, $\mathbf{E_R}$ occurs before $\mathbf{E_T}$. World Line Reduction is triggered by the former and either detector $\mathbf{D_R}$ records a photon or it is the transmitted photon which is declared real and it is detector $\mathbf{D_T}$ which fires.

Now consider the situation from the perspective of a space traveller travelling so fast that, in his frame, $\mathbf{E_T}$ occurs before $\mathbf{E_R}$. According to him, WLR is triggered by $\mathbf{E_T}$ and the reflected potential photon has yet to reach $\mathbf{D_R}$. As before, Nature has to make a decision. If She decides that the transmitted photon is real, $\mathbf{D_T}$ will fire and the reflected potential photon will disappear. On the other hand, She might decide that the transmitted photon is not real after all and it will be the reflected potential photon which goes on to be detected by $\mathbf{D_R}$.

At the end of the day, both observers experience the same reality even though they may have different interpretations as to how the result came about. Naturally Nature never makes the mistake

of declaring different realities to different observers!

Suspended Reality and QFT

I hope I have established without doubt that the idea of Suspended Reality is perfectly compatible with Special Relativity. All that remains is to see how it can be applied to Quantum Field Theory and the case of the TV transmission.

When the electrons in the transmitting aerial are accelerated up and down, they emit potential photons in all directions. The rules of QFT dictate exactly what kind of probability wave this situation produces and it turns out that this wave has exactly the same shape and form as the traditional Maxwellian electromagnetic wave. In the case of a single photon impinging on a half silvered mirror it is possible to think of reality splitting into two potential worlds rather in the manner of the Many Worlds interpretation of standard QT. In this case, however, it is basically unhelpful to think in terms of splitting worlds, not just because there would have to be an infinite number of them, but because all these potential worlds – and the 'probability wave' which governs them have no physical reality at all. Only when the potential photons in these potential worlds reach the electrons in my TV aerial and WLR occurs is the decision made as to their reality and the electrons in the aerial are moved accordingly.

What then of the three 'interpretations' of QFT that I mentioned earlier. Is QFT a theory about fields? Or is it a theory about particles? Or is it just a mathematical construction which tells us nothing about reality?

My answer is clear. QFT is a mathematical procedure which uses the idea of a field to predict the outcomes of physical situations but these fields have no physical reality. The only things which really exist are particles and these only have existence *in the* past when World Line Reduction has occurred. At a subatomic level, the present is in a constant state of suspension. In the words of Karl Marx, at this moment in time *everything is undecided*.

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