Re: The time it takes to emit one photon

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- *From*: "Eugene Stefanovich" <eugene_stefanovich@xxxxxxx>
- *Date*: Sun, 28 Aug 2005 07:30:46 +0000 (UTC)

"Igor Khavkine" <igor.kh@xxxxxxxxx> wrote in message
news:slrndgti7m.pc8.igor.kh@xxxxxxxxxxxxxxxxxxxxxx

> > So far so good. The only thing is that quantum fields are not necessary
> > for describing the systems with a variable number of particles in the
> > Fock space. Such a description can be formulated entirely in the
> > language of "composite" wavefunctions, where each fixed−particle−number
> > function 1, psi(x), phi(x,y), chi(x,y,z) enters with its own
> > coefficient, and the sum of squares of all such coefficients is 1.
>
> Necessity is a subjective notion. Necessary to whom? To yourself, who
> does not use the field formulation? Or to the hunderds (thousands?) of
> physicists who do? Equivalence is what it is. You either either
> contradict it or you don't. If you do, I suggest you avail yourself of
> the references I cited numerous times and follow the proof yourself. If
> you don't, you've said nothing to change other people's opinions of QFT.

Thank you for acknowledging that my particle−based approach is equivalent
to the traditional field−based aproach. I may agree with you that both
approaches
lead to the same numerical results. However, I hope you'd agree that they
offer
two different perspectives. One approach says: "Fields are basic
ingredients.
Particles are excitations of fields". Another approach says: "Particles are
basic
ingredients. Fields are just formal mathematical constructs"

I hope you'd also agree that having more than one perspectives or equivalent
formulations of the theory is a very useful thing. Take for example quantum
mechanics.
Heisenberg's matrix mechanics, Schroedinger's wave mechanics, and Feynman's
path integrals are three different perspectives that enhance and enrich each
other.
Some property that may look obscure in one formulation may be completely
transparent in
another formulation.

Another example is the old debate about the center of the universe.

Now we know that the choice of the frame of reference − either connected
to the Sun or to the Earth − is completely arbitrary. We can write all
equations
in both these frames. However, it appears that equations governing the
movement
of planets take especially simple form in the heliocentric system. This was
crucial
for formulation of the law of gravitation by Newton.

> > This is not a purely philosophical debate. Particle picture is
> > essential to make the "dressing transformation" in QFT and to
> > eliminate "bare particles" and "ultraviolet infinities" for good.
>
> Yes it is. The ultraviolet infinities have been eliminated long before
> your philosophy or "dressing transformation" existed. Old news. We've
> been there.

Feynman−Schwinger−Tomonaga theory "swept infinities under the rug".
True, one can have a completely finite formulation in terms of
Glazek−Wilson "similarity renormalization". However, this approach
requires unphysical "bare particles". The only approach to QFT that
can be formulated from the beginning to the end without encountering
a single divergent integral or bare particles is RQD.

> > The number of particles (including photons) in the Universe is finite.
> > Field theories seem to disregard this important fact. They use infinite
> > number of degrees of freedom to describe even one electron
> > with its field.
>
> Your objection is void. Any normalizable state in Fock space has a
> finite expectation value for the number of particles. Just like,
> classically, any physical field configuration has finite energy.

I was talking about the number of degrees of freedom, which is infinite
for fields in any finite volume. Please understand me, I am not saying that
field
theories are wrong. I am saying that there exists an alternative
particle−based
approach that seems to be simpler and more intuitive.

> > Take the Young's double−slit experiment. Maxwell's wave theory describes
> > the light intensity on the screen by continuous functions E(x) and
> > B(x). This is all fine while the intensity of light is high: there are
> > many photons, and the light intensity appears continuous on the screen.
> > At low intensities, when we can distinguish individual
> > photons on the screen, the field description doesn't work anymore.
> > The light intensity produced by one photon is more like a
> > delta−function. One can reconsile these two contradicting
> > descriptions in the tradition
> > of quantum mechanics.
>

> This situation is handled no differently than single electron
> diffraction. The distribution pattern of detections is predicted by the
> amplitude of the single photon wave function. As I illustrated above,
> this wave function satisfies the wave equation for a relativistic vector
> particle. There aren't that many wave equations that have this property.
> In fact, there is only one, we call it "Maxwell's equations".

Let me rephrase what you said to see if I understood it correctly.
You are saying:
1. In the case of high intensities, the light diffraction is a classical phenomenon described by Maxwell's wave equation.
2. In the case of low intensity, the diffraction pattern has quantum origin, but individual photons are still described by the same Maxwell's equation, so the diffraction pattern does not change.

What I cannot understand is how the switch is ossured (physically, not formally) between quantum and classical mechanisms when we simply change the light intensity (the number of photons) without changing anything else.

> > One can say that E(x) and B(x) are "sort of"
> > photon wave functions, and when the photon reaches the screen these
> > wavefunctions collapse to produce a single observable dot.
> > This is my interpretation of Maxwell's theory: the fields E(x) and B(x)
> > there are some surrogates of multi−photon wavefunctions that remained
> > after we took the (incomplete) classical limit from QED to the theory in
> > which electrons are treated classically, while photons (due to their
> > zero mass) are treated in a "sort of" quantum way.
>
> What would be really nice is if you could give an even "sort of" precise
> and quantitative statement of this correspondence. Something like a
> formula relating these many−photon states to the electric and magnetic
> fields, perhaps?

First, I don't think that the task is to reproduce Maxwell's fields E(x) and B(x) and related equations. I think, these fields and equations are phenomenological constructs. They were designed to fit Faraday's empirical observations, and I am not sure that Maxwell's theory will folow in its entirety as a "classical" limit of the more general QED.

My goal is to have a simplified formulation of QED in which electrons are treated in the classical (hbar −> 0) limit, while (some simplified) quantum desription is used for photons. I started to do that in my book, but this task is not completed. In the case of low accelerations, when radiation can be neglected, I have a theory of charged particles interacting at a distance. Taking into account the emission and absorption of photons is more tricky. One needs to find a way to approximate multi−photon wavefunctions by functions with a few arguments. It has not been done yet.

Eugene.

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