

Re: The time it takes to emit one photon

Source: <http://sci.tech-archive.net/Archive/sci.physics.research/2005-08/msg00467.html>

- *From:* Igor Khavkine <igor.kh@xxxxxxxxxx>
 - *Date:* Sun, 21 Aug 2005 06:00:01 +0000 (UTC)
-

On 2005-08-20, Eugene Stefanovich <eugene_stefanovich@xxxxxxx> wrote:

> "Igor Khavkine" <igor.kh@xxxxxxxxxx> wrote in message
> news:slrndgasck.2p5.igor.kh@xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

>

>> Whatever your opinion of QFT, it is equivalent to a quantum theory of a
>> variable number of particles. You are free not to make use of this
>> mathematical equivalence, I myself and many others choose to use it.

>

> I agree completely: QFT is equivalent to a quantum theory of a variable
> number of particles.

So far so good.

> And the best way to see it explicitly is to use the
> "dressing transformation" which eliminates bare and virtual particles and
> reduces QFT
> to a theory of real particles interacting at a distance.

Non sequitor. The way to see it is $\psi(x,y,..) = \langle \psi | \phi(x)\phi(y)... | 0 \rangle$.

>> Particle mechanics is the
>> classical limit of a quantum theory with a fixed number of particles. I
>> explained this in the paragraphs below the diagram in my previous post.

>

> You are right. Traditional classical particle mechanics conserves the
> number of particles. But this is only because classical mechanics was
> formulated long before $E = mc^2$ was invented and the possibility of
> converting energy to mass was understood. Nobody forbids us to
> formulate a classical theory in which particles move along
> well-defined trajectories and creation/annihilation processes are
> allowed (trajectories may start and terminate at certain points).

True, no one forbids it. But it is also true that no one has done it yet.

>> When you allow the number of particles to vary (use Fock space),
>> strictly speaking you have a different quantum theory. This different
>> quantum theory also has a different classical limit, which happens to be
>> a field theory.

Re: The time it takes to emit one photon

- >
- > I see a logical gap in your statement. I think if I take a classical
- > limit of a quantum theory with variable (but finite) number of
- > particles, I should obtain a classical theory with variable (but
- > finite) number of particles. Nobody has constructed such a theory (as
- > far as I know), but this is not a reason to believe that such a theory
- > cannot exist.

What you see is not a logical gap, but something that you wish were true. However, once you put wishful thinking and what you think should be aside, you'll see that the limit of a quantum theory with finitely many particles (wave functions of as many arguments) has classical particle dynamics as the classical limit, while quantum field theory (Fock space with field operators) has classical field theory as the classical limit.

This has been known for 70+ years. And when I say "known", I don't mean in the sense of folklore. The calculations are there for anyone to see, check any book on QM or QFT.

- > I fully agree that electrons can and should be treated classically.
- > However, photons is a different matter. They have very peculiar properties:
- > 1) Photons can be easily emitted and absorbed.
- > 2) There is a huge number of them. Billions and billions of photons
- > are emitted by an ordinary lightbulb. So, any attempt to describe this
- > situation
- > in the language of particles (either quantum or classical) would be
- > suicidal.
- > 3) Photons have zero mass, so quantum
- > effects (such as diffraction and interference) for photons could be easily
- > seen
- > hundreds of years before invention of QM.

Again, so far so good.

- > So, in my view, Maxwell's theory is, actually, a hybrid in which
- > massive charges are treated classically while quantum behavior of
- > billions of photons is approximated by 2 vector functions $E(x,t)$ and
- > $B(x,t)$. Maxwell fields are just approximations (quite successful, I
- > admit) to multiphoton wavefunctions.

Yes, they are approximations in the classical limit, $\hbar \rightarrow 0$.

- > In addition to photons, Maxwell
- > lumped
- > interparticle forces (Coulomb and Biot–Savart) into his $E(x,t)$ and $B(x,t)$.

Non sequitur.

- > This created a lot of confusion.
- > Of course, Maxwell did not know that he was doing QM when

Re: The time it takes to emit one photon

Re: The time it takes to emit one photon

> he wrote his equations. But now, 150 years later we can understand that.

Hmm, confusion indeed. However, the confusion is on a different side of this computer screen than you think.

> In the approximation that leads from QED to Maxwell's field theory, the
> limit
> $\hbar \rightarrow 0$ does not play any significant role.

So the fact that \hbar does not appear in any classical formulas is a coincidence? How about the fact that \hbar 's value is so small in macroscopic (say cgs) units? Rhetorical questions aside, what we see around us every day is described by the $\hbar \rightarrow 0$ limit of the quantum theories that we believe to be fundamental. This simple observation gives the $\hbar \rightarrow 0$ a very significant role and it's name "the classical limit".

> Most important conditions are that
> 1) individual photon energies are small (like in the visible light),
> so that individual particles cannot be easily observed.
> 2) the number of photons is huge, so that they appear as a single
> continuous field.
> Condition 2) can be violated in radiation fields of very low intensity where
> even photons of visible light are emitted and registered one-by-one.
> This low-intensity radiation is not described by Maxwell's theory at all.
>
>>> The electric and magnetic
>>> fields in Maxwell's theory are just attempts to describe wave
>>> functions of (a very large number of) photons.

>> True. Large number of photons $\Rightarrow \hbar \rightarrow 0 \Rightarrow$ Maxwell field theory.
>
> I agree about "Large number of photons". I disagree about " $\hbar \rightarrow 0$ ". I think in this limit you should obtain Newton's corpuscular ray
> optics, i.e., photons moving along trajectories.

Again, belief is no substitute for calculation. See Sakurai's *_Advanced Quantum Mechanics_*. There he explicitly relates the strong field limit (many photons) to the classical limit ($\hbar \rightarrow 0$). Unfortunately, I don't have the book handy, so I can't give a more precise reference.

Igor

.

-
- *Follow-Ups:*
 - ◆ **Re: The time it takes to emit one photon**
 - ◇ *From:* Eugene Stefanovich

Re: The time it takes to emit one photon

- **References:**

- ◆ **Re: The time it takes to emit one photon**
 - ◇ From: nightlight
- ◆ **Re: The time it takes to emit one photon**
 - ◇ From: Eugene Stefanovich
- ◆ **Re: The time it takes to emit one photon**
 - ◇ From: nightlight
- ◆ **Re: The time it takes to emit one photon**
 - ◇ From: Igor Khavkine
- ◆ **Re: The time it takes to emit one photon**
 - ◇ From: Eugene Stefanovich
- ◆ **Re: The time it takes to emit one photon**
 - ◇ From: Igor Khavkine
- ◆ **Re: The time it takes to emit one photon**
 - ◇ From: Eugene Stefanovich

- Prev by Date: **Re: General Relativity**
- Next by Date: **Experiment**
- Previous by thread: **Re: The time it takes to emit one photon**
- Next by thread: **Re: The time it takes to emit one photon**
- Index(es):
 - ◆ **Date**
 - ◆ **Thread**