Re: The time it takes to emit one photon

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- *From*: "Eugene Stefanovich" <eugene_stefanovich@xxxxxxx>
- *Date*: Sat, 20 Aug 2005 11:17:45 +0000 (UTC)

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

> 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. 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.

> 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).

> 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 clasical limit, which happens to be
> a field theory.

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 clasical 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.

> > For example, I would place Maxwell's theory somewhere between
> > QM and classical particle mechanics. In my view, Maxwell's theory
> > is a partial classical limit of QM in which heavy particles
> > (e.g., electrons) are treated classically, but the treatment of
> > photons remains quantum.
>
> There is no need to place anything half way between quantum and
> classical. Maxwell theory is purely classical. Photon number is not
> conserved. So, as per above, the classical limit of the photon sector is
> a field theory. Strictly speaking, electron number is not conserved
> either, but under low energy conditions the approximation that it is can
> be made. Moreover, electrons are massive and hence localizable.
> Therefore the clasical limit of the electron sector is a particle
> theory.

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 lighbulb. 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.

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 approximatons (quite successful,
I admit) to multiphoton wavefunctions. In addition to photons, Maxwell
lumped
interparticle forces (Coulomb and Biot−Savart) into his E(x,t) and B(x,t).
This created a lot of confusion.
Of course, Maxwell did not know that he was doing QM when
he wrote his equations. But now, 150 years later we can understand that.

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

I agree about "Large number of photons".
I disagree about "hbar −> 0". I think in this limit you should obtain
Newton's
corpuscular ray optics, i.e., photons moving along trajectories.

> > In the presence of
> > charged particles, these fields also incorporate instantaneous
> > interparticle potentials (e.g., the Coulomb potential).
>
> Only in special choices of gauge. Can of worms. I suggest not opening it
> until the Poincare noninvariance "proof" thread is exhausted.

That's a big can of fat worms. I totally agree not to open it now.

Eugene.

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- ***Follow−Ups***:
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- ***References***:
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    - *From:* nightlight
  - ***Re: The time it takes to emit one photon***
    - *From:* Eugene Stefanovich
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