Re: Two−slit experiment

Source: http://sci.tech−archive.net/Archive/sci.physics/2006−09/msg00044.html

- *From*: "Ron Baker, Pluralitas!" <stoshu@xxxxxxxxxxxxxxxx>
- *Date*: Sat, 02 Sep 2006 03:51:22 GMT

"Timo A. Nieminen" <timo@xxxxxxxxxxxxxxxxx> wrote in message
news:Pine.WNT.4.64.0608302155230.276@xxxxxxxxxxxx

> On Fri, 25 Aug 2006, Ron Baker, Pluralitas! wrote:
>
> > "Timo A. Nieminen" <timo@xxxxxxxxxxxxxxxxx> wrote:
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> > > On Thu, 24 Aug 2006, Ron Baker, Pluralitas! wrote:
> > >
> > > > There is nothing intrinsic in the EM field
> > > > that makes
> > > > the energy of photons in the first Balmer line
> > > > be what it
> > > > is. It is determined by the mass and charge
> > > > of the electron
> > > > and proton of the hydrogen atom which
> > > > make a resonant
> > > > system.
> > >
> > > The ultimate test would be a bound system of a proton and a
> > > particle of
> > > charge −e and mass other than m_e. Isotopic effects and
> > > E=hf working for
> > > ions, neutral atoms, etc, are enough to convince me that E=hf
> > > isn't in
> > > the
> > > details of atoms, but you might like stronger proof.
> >
> > Maybe I'm missing something but it seems to me that
> > atoms with higher atomic number are analogous to your
> > hypothetical. e.g. helium with atomic number 2 gives
> > a whole different set of spectral lines.

> Yes, the energy levels are different, and the energy differences between
> them and thus the line spectra are different, but E=hf still works. I feel
> this shows that E=hf is not a result of the details of interaction between
> electron and nucleus, because the details are different in the two cases.

Yes I can see that. I see that as the "quantumization" I was talking
about.

And in a bound system (I'm thinking black body here)
E for any mode has discrete
quantized levels nhf. In an unbound system E and f are
continuously variable. What is interesting is that when
you put energy into the EM field, even in the unbound
case, it acts as a unit, a quantum. And it interacts
with massive charged particals as a quantum. I don't see
that necessarily implies that a quantum can only be completely
absorbed or created in an interaction with matter. The
arguments I have seen to contrary seem metaphysical.

> OK, the electron has the same mass and charge in all such cases, so the
> same relationship between energy and frequency is perhaps plausible −
> that's why I wrote you might like stronger proof. Exotic "atoms" composed
> of a nucleus and perhaps an anti−proton could be just the trick. I don't
> know if such have been experimentally studied, but it might be worth
> checking (electron−positron "atoms" have been, iirc, but that doesn't get
> away from the original mass/charge thing).

I accept that E = hf will always apply. The h doesn't come from
the mass or charge of the electron. The discrete allowed levels
of E come from the mass and charge of the entities involved.

> > > Yes, exactly. That's why you have one set of maths (the
> > > Maxwell
> > > equations)
> > > to describe fields and another (creation and annihilation
> > > operators) to
> > > describe photons. The rules for which rules to use when are
> > > not
> > > arbitrary − always Maxwell for the fields, a+/a− for photons.

> > :) I still find that dissatisfying. (But who the hell am I. ;)
> > It still seems like a bifurcated model to me.

> > I will agree that the rules are not arbitrary in the sense
> > that one could flip a coin in choosing which to use.
> > But I find the bifurcated model disquieting.

> You're certainly not the first to do so.

:) Yes, I know.

> But consider: is this _really_ any worse than having two different
> entities in classical physics: matter and fields? Fields and quantised
> excitations thereof may well be less bifurcated.

Rather my objection is that it seems that even when
some people talk about fields and quantized excitations
thereof they sometime still jump to refering to the 'photon'
and refering to it as if it were _point particle_.

> > > It's not that photons sometimes act as waves, requiring
> > > Maxwell, and
> > > sometimes as particles

> > But that is often just what is said.

> Yes. Especially in treatments that graft de Broglie matter waves onto
> classical particles. Perhaps a useful handwaving explanation, but it can
> cause trouble later down the track.

> > > Also, I don't believe there are things of spatial extent
> > > appearing and
> > > disappearing simultaneously or otherwise. There is a set of
> > > modes of the
> > > field, which don't change unless the geometry/boundary
> > > conditions
> > > change,
> > > and occupation numbers of each mode (how many photons in
> > > each mode). n
> > > changes but the modes don't. [Warning: I don't do QED; this
> > > might be
> > > wrong, misleading, or both!]

> Hmm. I'm inclined to honor your disclaimer but what you said
> seems schizophrenic. You subscribe to the quantum leap, to
> photons instantaneously appearing and disappearing but
> you say the field, which has spatial extent, doesn't change.
> How can the field not change? You say the mode changes.
> Instantaneously? The mode is separate from the field?
> Where is the mode?

The _classical_ EM field is the high−photon−number average behaviour. At this point, plane waves etc are really troublesome, since the value of the wavefunction for a single−photon plane wave mode is zero (well, the photon can be _anywhere_, so the probability of finding it at a particular location is zero). So consider modes in a resonator. If the expectation value of the number of photons in the mode is n, and n>>1, then the classical field is n*single_photon_wavefunction. If n changes, the single photon wavefunction doesn't change, but the classical field will. Note that both the wavefunction and the classical field are solutions of the Maxwell equations: n times one solution is still a solution.

The classical field is a combination of the quantum mode and the number of quanta in that mode. Unless the boundary conditions change, the modes stay the same, and quantumly, the number of quanta in the modes changes. Classically, E and H change, but to be in the classical limit, n is always very large, so classically, the change is smooth.

Iirc, Jackson has some interesting stuff about the angular momentum of classical multipole fields vs the small photon number angular momentum of the equivalent modes.

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