Re: Hydrogen in Relativistic QM

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- *From*: "Chris H. Fleming" <chris_h_fleming@xxxxxxxxx>

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Eugene Stefanovich wrote:
> Chris H. Fleming wrote:
> > In nonrelativistic classical mechanics and electrostatics the two body
> > bound state is an eliptical orbit.
> >
> > In relativistic classical mechanics and electrodynamics the electron
> > will radiate as it accelerates and spiral into the nucleus.
> >
> > In nonrelativistic quantum mechanics the two body bound state is fine.
> >
> > My question is this: how do I know that the electron will not spiral
> > into the nucleus in relativistic quantum mechanics?
> >
> > In the only QFT book I have that deals with bound states thoroughly,
> > the relativistic Dirac equation is used, but then a static field used.
> > Everything else is just a perturbation off of that. That would be like
> > doing relativistic classical mechanics but without the electrodynamics.
> > But there is no problem there to be expected.
>
> There is nothing wrong in using static field. You are trying to find
> the stationary lowest energy state of the hydrogen atom. This problem
> is time−independent.
>
> >
> > Is Hydrogen stable in relativistic quantum mechanics when you do not
> > approximate the field as static? I am extra confused because
> > positronium is not stable. The spiral occurs there. What is special
> > about Hydrogen that stops the spiral?
>
> There is a sort of "spiraling" when excited states of the hydrogen atom
> are considered in quantum mechanics. The atom jumps to a lower
> energy state and the excess
> energy is released as a quantum of radiation − the photon.
> However, at the ground state, nothing can happen, because this is the
> lowest energy state (by definition). This state remains stable forever.

How do I know there is a ground state in the fully relativistic and electrodynamic, quantum problem. I only know there is a bound state in the nonrelativistic problem, or the relativistic problem with an

electrostatic field. But neither of these cases had pathology in the classical regime. I was never in doubt of these cases.

> Conservation laws (e.g., the conservation of the baryonic and leptonic
> charges) prevents its decay into lighter particles. Note that these
> decay laws do not apply to the positronium (all charges are zero),
> so it is allowed to decay into photons, as it does.

That is more in line with what I was thinking.

So is it true that if you modeled hydrogen simply with the electron and proton as different mass, spin−1/2 particles interacting via photon exchange, and ignored all other forces, then hydrogen would not be stable. Is it true that forces other than electrodynamics keep hydrogen and all other elements electronically stable.

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- ***Follow−Ups***:
  - ♦ ***Re: Hydrogen in Relativistic QM***
    - ◊ *From:* Eugene Stefanovich

- ***References***:
  - ♦ ***Hydrogen in Relativistic QM***
    - ◊ *From:* Chris H. Fleming

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