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Using particle exchange to model laws of repulsion and attraction

Pop books on QM (quantum mechanics) describe (and illustrate) particle exchange as a way to explain forces between particles and as a way to model laws of force between particles. QM uses photon exchange to model the inverse square law of repulsion between electrons. I have no problem with this.

I am fine with using particle exchange to model repulsion. I have a problem with using particle exchange to model attraction, but that is another issue taken up in another note.

A

The first issue for this note is how particle exchange is used to model repulsion and attraction. Since nearly all the pop books discuss only repulsion, and since that is what I understand best, I focus on that.

One episode of particle exchange is not enough to model continuous repulsion that varies with distance, or to model any other kind of variable relation. It would take many exchanges over the whole range of the force to model the relation. If we grant many exchanges over a wide distance, then it is not too hard to use exchange to model repulsion, and not too hard to use it to model a specific law such as the inverse square law. I don't go through the exercise here, but, if somebody wants, I will do it and post it on the website. It only takes a little algebra. It is something that Isaac Newton could have done in his sleep 400 years ago.

I don't know if textbooks on QM use multiple particle exchange, mostly because old QM textbooks that I used to look at gave me a headache. If anybody knows of any good simple textbooks that use multiple exchange, I would be glad to look.

B

One electron does not only repel another electron, it repels any other electron that is close enough. One electron does not only send out one virtual photon to interact with one other specific electron, it has to send out a cloud of virtual photons in all directions to interact with any number of electrons nearby and with any number of electrons that might happen to come nearby.

Think about a cloud of virtual particles all around an electron. Only one of those particles goes off to a target electron to produce repulsion. In the pop QM books that I have read, the release of the one virtual photon that will hit a target starts the repulsion between source and target when it leaves the source because of Newton's laws of conservation of momentum and equal-and-opposite reaction. The photon gains momentum one way (toward the target) while the emitting electron gains momentum in the opposite way (or, to say it another way, loses the momentum that the photon gained). This picture would be fine if there were only one emitting electron, one emitted photon, and the emitted photon was sure to strike the one target electron. If the photon is emitted as part of a cloud of photons going off in all directions, then the momentum of the emitting electron would not change at all even if the emitted photon hit a target. If the emitted photon that will hit the target electron is the only emitted photon, how do the emitting electron and the emitted photon know this in advance? The emitted photon does not know it will leave the emitting electron when it leaves the electron, so it leaves only as part of a cloud of emitted particles, and so it does not change the momentum of the emitting electron.

Either: (1) there is only one emitted photon, and it precisely hits the target electron, which is rather weird, OR, (2) there is a cloud of emitted photons, only one accidentally hits a target, and the momentum of the emitting electron does not change before the emitted photon hits the target.

C

An electron does not only repel another handy nearby electron by shooting out photons. In theory, a resident electron sets up a field. It sets up a field even if we think of the field in terms of a cloud of virtual photons. Once the field is set up, the field is already there. It just sits there waiting. We don't even have to know that a particular resident electron set up the field or that any resident electron set up the field. Imagine that an electron gets produced by something like beta decay; we assume that electron is at point 0; we use it as our frame of reference; for us, it is now stationary and resident. A minute later, imagine that another electron gets produced nearby but not extremely nearby. I think it does not take a long time for the first already-resident electron to repel the second new electron. I think the second electron feels the presence of the established field quickly.

I need instruction as to how quickly the second electron feels an influence from the first electron. Does the second electron have to wait during the time it would take for a photon to come from the first electron? Or, is the effect immediate, or nearly immediate, because of the already-established field? I am not trying to reinstate mysterious action at a distance here. I need clarification. Then I can go from there.

I assume any change that came from the already-resident electron could not travel faster than the speed of light, that is, faster than a photon. But change is not what I am after. The only change is introduction of the new electron that is a visitor to the already-resident field. Nothing has to move faster than the speed of light from the already-resident electron to the new visitor electron because the field already did the moving out a long time ago.

D

Think about a particle continuing outputting even virtual particles, such as an electron outputting virtual photons. On a short term basis, over a short distance, the Uncertainty Principle lets an outputting particle get away with this – thus the photons are "virtual" over short times and short distances. But electrons do not repel only for a short time over a short distance. In theory, they repel all the way across the universe. Sooner or later, near or far, conservation of energy has to have some effect. Especially as messenger particles take a longer time, and go a longer distance, it does not seem that Uncertainty can continue to cover production of more virtual photons. I don't know how to model this situation.

This question is related to question B.