An Easy Intro to Feynman's QED, Part 3 Pre-Discussion: Do Photons Have 3D Shapes?

Terry Bollinger and Ron Schreiner
Presented at: Washington Quantum Computing Meetup (on OrionX YouTube)
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This is the start of the edited YouTube transcript. You can view the full video at https://youtu.be/k3-P-pdOBdI

A discussion before the presentation about whether one can "split" photons:

0:00 **Ron Schreiner** (RS): [Before we start,] I have a quick question for you.

0:01 **Terry Bollinger** (TB): Yes?

0:03 RS: Do you subscribe to the Phys.org mailing list for new papers that come by?

0:12 TB: I do subscribe to it. I haven't been watching it diligently lately. Was there an interesting paper?

0:17 RS: Yes, it's called cutting a photon in two.

Phys.org Quick Summary:
S. Jarman, G. Clark, and R. Egan, ***Cutting a photon in two creates an infinite swarm of particles***, Phys.org Physics News **2026**, 0602 [Jun. 2] (2026). https://phys.org/news/2026-06-photon-infinite-swarm-particles.html

Original Article:
I. C. O. Rukan, J. Gulla, and J. Skaar, ***Truncated photon***. Physical Review Letters **2026**, 0518 [May 18] (2026).
DOI (subscription needed): https://doi.org/10.1103/94pm-hp34; arXiv preprint (free): https://arxiv.org/abs/2510.21636

0:20 TB: Yes. [laughter] Oh, I had a somewhat bitter remark about that. I [would say] there's a *lot* of energy going into the process that they're talking about for cutting the photon in two. So, when they say that cutting [the photon] in two produces all these photons, I beg to object a little bit. That's kind of like saying, "If you take a guillotine blade made out of metal and run it through an electric field…" well, *of course* it's going to generate photons!

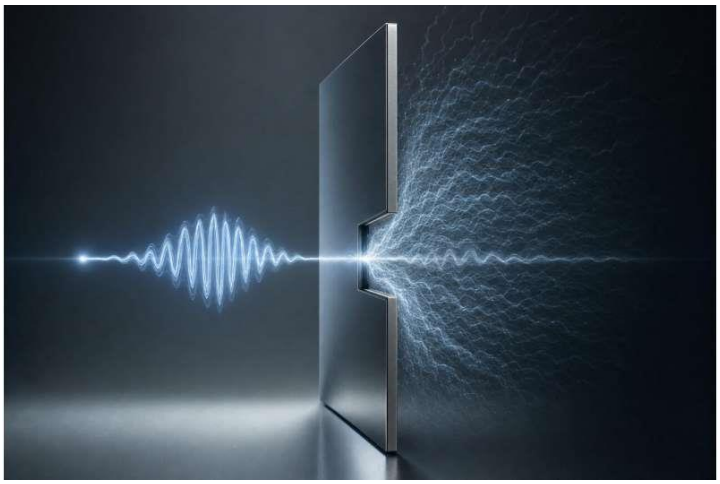
I haven't looked at the case of if you do a non-metallic [shutter], but certainly, if you [use] a metallic one [to implement] the idea of cutting the photon in half, it's going to generate an *enormous* [number] of [new] photons that don't *really* have anything to do with the [original] photon, except in the sense that the photon creates an electromagnetic field. The electromagnetic field [then] interacts with the mirror, and then you get photons.

> [TB: The authors note that "... the reflector in Appendix B is ...[is] an infinitely thin, dielectric slab of infinite permittivity." So, it's an impossibly thin **insulator** with infinitely high capacitance. It cannot pass direct currents, but it is fully capable of passing the alternating probability currents of photons.]

0:16 TB: So, it is an interesting paper, but I found it kind of [sensationalistic].

1:24 RS: The graphic that comes with [the short Phys.org news summary of the article] is very, *very* thought-provoking — or very sensationalistic. It basically makes the photon become a pile of powder for a whole bunch of different [photon] paths…

[TB: Here's that graphic from the Phys.org news summary of the article. This image is from the news article, *not* the actual paper. **Note the AI-generation warning** in the caption beneath the graphic.]



Credit: Image generated by the editorial team using AI for illustrative purposes.

[TB: The actual graphic from the article was far less spectacular, but also far more precise. Here it is:]

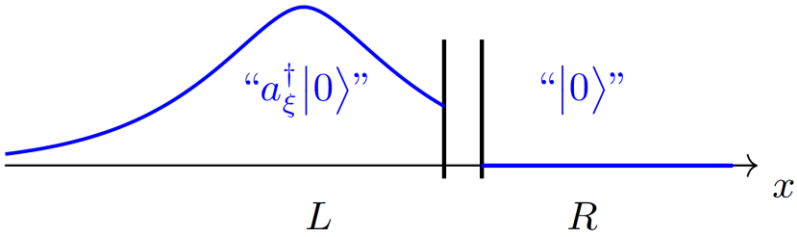


FIG. 2. Considering forward-propagating modes, the truncated photon state is locally equivalent to a single photon…

1:39 RS: … And the other thing is, I don't know if they claim to have invented an optical shutter that works at the femtosecond scale. …

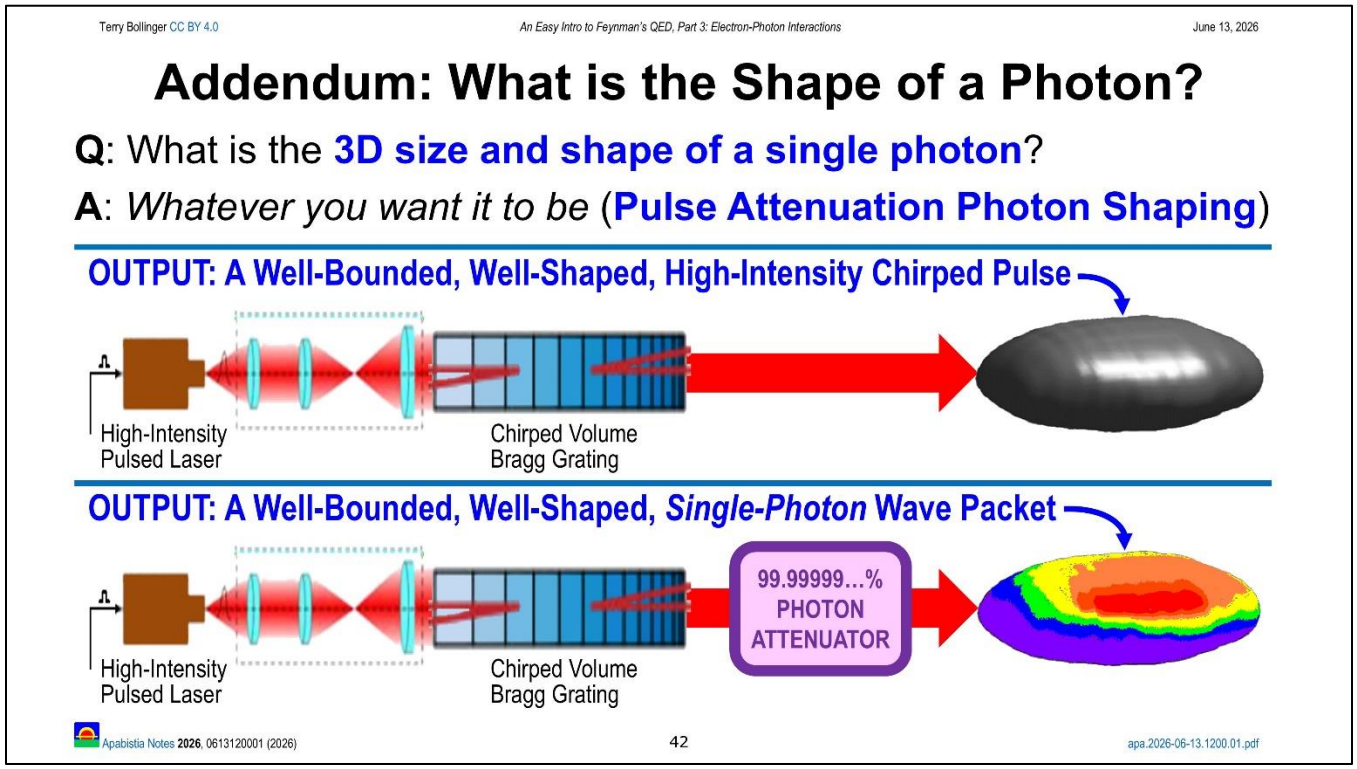
[TB: The original paper was pure math and assumed a physically impossible instantaneous shutter to simplify analysis. They then modified their analysis in Appendix B to obtain finite results. Since assuming an instantaneous shutter necessarily also assumes infinite energy insertion, this energy is the source of the photon proliferation, not the incident photon. From the Rukan paper:]

> *"[Page 1] ... **instantaneous removal of the shutter**, which we [use] for simplicity ... **produces an infinite number of photons**. ... [Page 5] ... The analysis of a gradual removal of the reflector in Appendix B is motivated by the divergent photon number found for the instantaneous removal of the reflector [which is implemented in our thought problem] ... [Page 8] as an infinitely thin, dielectric slab of infinite permittivity. ... Appendix B [examines the more realistic case of] **gradual removal**. ... [Page 11] [The emergence of a Dirac delta function as x goes to zero in function (B34)] ... [proves] useful [since it] combines with ... [field equations for the mirror] (B2a) [and] (B2b) [to give] a partial cancellation. [This behavior] **provides the required smoothening of the instantaneous mirror removal** in the main article, **giving a bounded photon number**."*

1:51 RS: But it also begs the question: Do photons have three-dimensional [forms — that is, shapes in three] dimensions?

1:59 TB: Yes. [TB: See Addendum Slide 42 below:]

2:00 RS: Wow!



2:01 TB: In fact, one of the things that I *absolutely* [want to address in future talks is this issue of particle shapes and volumes]. You know, I'm doing these Feynman presentations, and one of the things that I'll get into a little bit today, [and] that I have some difficulties with is, that if you stick really, *really* rigidly to the point interpretation, it starts getting very complicated. It's not *impossible*, but it gets *very complicated* to describe certain kinds of effects, because a single photon, radiated into space, has all the properties of a *gigantic coherent photon burst* in terms of how it interferes, how it reflects, how it interacts. And that is *completely* counterintuitive to classical mechanics because you say, "It hasn't got enough *energy* [to include the frequency relationships of, say, a chirped laser burst]. It can't *do* that." It doesn't matter if we don't *like* it — it's what it *does*. And the fact that a single photon can emulate an *enormous* burst of coherent light gives you a better model — and a coherent burst of light *absolutely* has volume. And you can't *make* a photon that doesn't have *some* kind of implicit volume.

So, when they describe it [in the paper], I found that I have to watch myself. I get a little annoyed with papers like that because they're saying something interesting — it was a *very* interesting experiment — but the claims were *framed in the wrong way*, because you have to address the interaction. You have to address the fact that you're sticking a physical object into the area in which the photon exists. And again, if you recognize that a photon behaves like a moving field — like an electromagnetic burst — then the idea of cutting in half doesn't become as radical sounding, because, yeah, *sure* — you can *intersect* with that field — with that probability field. If you do it the right way, *interesting things* pop up.

I didn't [like] — I had problems with — the way they explained that, because [I think] it sidetracked the [real] issue [of how energetic classical objects interact with low-energy probability fields]. I am pretty confident that, if Feynman were alive and seen that paper [laughter], he would have *shredded* it! I don't think he would have liked that paper *one bit*! Oh my goodness! He would have *immediately* reposed it as a QED problem, gone through the diagrams, and said, "Here's what you're *really* doing here!"

You know, it's so sad that he died relatively young. It would have been fascinating [to see how he would deal] with [papers like] that.