

Man-made electromagnetic fields/radiation, continuous waves or photons?

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In two recent publications on the relation between electromagnetic fields (EMF) / electromagnetic radiation (EMR) and Health:

[https://www.researchgate.net/publication/327578880\\_Man-Made\\_Electromagnetic\\_Radiation\\_Is\\_Not\\_Quantized](https://www.researchgate.net/publication/327578880_Man-Made_Electromagnetic_Radiation_Is_Not_Quantized)

and chapter 1 in:

<https://ehtrust.org/new-textbook-electromagnetic-fields-of-wireless-communications-biological-and-health-effects/>

the author, Dr. Panagopoulos, writes, I quote:

*'man-made electromagnetic radiation does not consist of photons but of continuous "classical" polarized waves, in contrast to what has been postulated by quantum physicists in the past 100 years.'*

The author refers here to the EMR part of the EMF used for wireless communication. The EMR part is the far field, beyond about two wavelengths from emitting antennas, while the EMF refers to both the near and far field:

[https://en.wikipedia.org/wiki/Near\\_and\\_far\\_field](https://en.wikipedia.org/wiki/Near_and_far_field)

This note is about the EMR part.

From the normal version of physics, generally accepted in the last 100 years, we know that:

- continuous "classical" polarized waves don't exist,
- all (natural and man-made) electromagnetic radiation is quantized and
- this radiation consists of photons and nothing else.

The normal version of physics thus disagrees with the Panagopoulos version, and that is the reason I am writing this note, to inform those active in this field and to prevent further distribution of the Panagopoulos pseudoscience version. Further distribution might hurt our credibility in informing the general public of the negative health effects of the non-thermal EMF from wireless communication.

To inform the readers of the normal version I made a selection of quotes taken from relevant publications in this field.

- From: <https://en.wikipedia.org/wiki/Photon> :

A **photon** (from [Ancient Greek](#) [φῶς](#), [φωτός](#) (phôs, phōtós) 'light') is an [elementary particle](#) that is a [quantum](#) of the [electromagnetic field](#), including [electromagnetic radiation](#) such as [light](#) and [radio waves](#), and the [force carrier](#) for the [electromagnetic force](#).

I can add that photons are the only quanta (force carriers) known in electromagnetism.

- From: [https://en.wikipedia.org/wiki/Radio\\_wave](https://en.wikipedia.org/wiki/Radio_wave) :

*In an antenna transmitting radio waves, the electrons in the antenna emit the energy in discrete packets called radio photons, while in a receiving antenna the electrons absorb the energy as radio photons. An antenna is a [coherent](#) emitter of photons, like a [laser](#), so the radio photons are all [in phase](#).<sup>[6][5]</sup> However, from [Planck's relation](#) the energy of individual radio photons is extremely small,<sup>[5]</sup> from  $10^{-22}$  to  $10^{-30}$  [joules](#). So the antenna of even a very low power transmitter emits enormous numbers of photons per second. Therefore, except for certain [molecular electron transition](#) processes such as atoms in a [maser](#) emitting microwave photons, radio wave emission and absorption is usually regarded as a continuous [classical](#) process, governed by [Maxwell's equations](#).*

- From: [https://en.wikipedia.org/wiki/Electromagnetic\\_radiation](https://en.wikipedia.org/wiki/Electromagnetic_radiation) :

*In [quantum mechanics](#), an alternate way of viewing EMR is that it consists of [photons](#), uncharged [elementary particles](#) with zero [rest mass](#) which are the [quanta](#) of the [electromagnetic field](#), responsible for all electromagnetic interactions.<sup>[6]</sup>*

- From: [https://en.wikipedia.org/wiki/Electromagnetic\\_field](https://en.wikipedia.org/wiki/Electromagnetic_field) :

*The quantized field is still spatially continuous, but its energy states are discrete and integer multiples of quanta of energy called photons.*

And next the three Nobel prizes awarded in this field.

- From: [https://en.wikipedia.org/wiki/Planck%27s\\_law](https://en.wikipedia.org/wiki/Planck%27s_law) :

*Quantum theoretical explanation of Planck's law views the radiation as a gas of massless, uncharged, bosonic particles, namely photons, in [thermodynamic equilibrium](#). Photons are viewed as the carriers of the electromagnetic interaction between electrically charged elementary particles.*

Planck got the 1918 Nobel price in physics for explaining (in 1900) the black body radiation problem (the [Ultraviolet catastrophe - Wikipedia](#) ) by introducing the above quantization into indivisible photons.

- From: [https://en.wikipedia.org/wiki/Photoelectric\\_effect](https://en.wikipedia.org/wiki/Photoelectric_effect) :

*Albert Einstein proposed that a beam of light is not a wave propagating through space, but a swarm of discrete energy packets, known as photons.*

Light is part of the electromagnetic spectrum, what holds for light in this respect holds also for all other parts of the electromagnetic spectrum, as is clear from the many quotes in the articles listed above.

Einstein got the 1921 Nobel price in physics for the at that time revolutionary idea that electromagnetic fields are not continuous but quantized and consist of photons (the name photon was introduced later).

- From: [https://en.wikipedia.org/wiki/Arthur\\_Compton](https://en.wikipedia.org/wiki/Arthur_Compton) :

**Arthur Holly Compton** (September 10, 1892 – March 15, 1962) was an American physicist who won the [Nobel Prize in Physics](#) in 1927 for his 1923 discovery of the [Compton effect](#), which demonstrated the [particle](#) nature of [electromagnetic radiation](#). It was a sensational discovery at the time: the wave nature of light had been well-demonstrated, but the idea that light had both [wave and particle](#) properties was not easily accepted.

About that now generally accepted wave-particle duality see the link above, an excellent review paper.

It should be clear that the unsupported idea of “classical” continuous waves is contradicted by an ‘overflow’ of scientific information, part of it quoted above. The generally accepted idea of photons as quanta of the electromagnetic field can to some extent be compared to water (H<sub>2</sub>O) molecules as quanta of water, although there are many differences of course.

About the idea of “classical” continuous waves, suppose they would be emitted somewhere and be continuous in emission for 1 second, then the continuous wave would have a length of 300.000 km (the propagation velocity of electromagnetic radiation in vacuum, and in good approximation also in our atmosphere, is 300.000 km/second). I don’t think anyone would seriously believe in the existence of such long waves.

Panagopoulos in his paper also writes (p.3), I quote:

*- considering photons simply as (divisible) wave-packets and not (indivisible) “particles” of light*

while photons are firmly embedded in the Standard model of Particle Physics:

[https://en.wikipedia.org/wiki/Particle\\_physics](https://en.wikipedia.org/wiki/Particle_physics)

as elementary particles. Elementary by definition implies indivisible in contrast the divisible of Panagopoulos.

In his paper (p.8) Panagopoulos denies the existence of photons at all frequencies by a number of arguments, the second one being:

- *There are no discrete lines in antennae spectra.*

He thus seems to think that there should be discrete lines in antennae spectra in the regular theory, implying that the frequency distribution would be quantized. This is not the case and has never been. In all papers of the regular theory it is made clear or taken for granted that only the energies are quantized, in integer multiples of the photon energy  $E = hf$ , where  $h$  is Planck's constant and  $f$  the photon frequency.

This should be enough I think to prevent readers to follow the pseudoscience track. I apologize for the difficult reading. Physics is not so easy to understand, I know. Fano, on whose invitation I worked in the USA in 1967, once told me '*physics is blood sweat and tears*'. He himself worked with Fermi and Heisenberg, two of the more prominent Nobel price recipients in physics. The first sentence in his biography <https://www.nature.com/articles/35065786> is:

*Ugo Fano was a master at understanding how radiation interacts with matter.* Very appropriate in the context of the present note. I would have liked to talk with him on this topic but he passed away in 2001.

For related work on this topic see:

<https://www.stopumts.nl/pdf/Man-made-and-Natural-EMF-EMR.pdf>

On the difference between Man-made and Natural Electromagnetic Fields/Radiation, in regard to Biological Activity.

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