



THE PHOTON-TRAIN

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--Ayush Gupta (01-06-2025)

One day I got a thought while I was eating lunch, “If photon could see the world, then which dimension of space would they live in?”, this question at first do feels absurd but if you think about it more then you will see why this is a head scratching question. Photons or we can simply say Electromagnetic waves travel at the speed of light, so from their perspectives or we can say if they had eyes, then they wouldn’t feel time because time don’t exist for them because they can see every possible location that they will(future tense from our perspective) jump and that have already(again past tense from our perspective) jumped(according to general relativity). So they would experience $3d+1d$ (1 dimension extra to see where they have jumped and where they would jump) = 4D, but if that’s a 4d world for it then it should be also a perfect 4d object, because even in 3d world a perfect 2d object doesn’t simply exist same goes to in a 2d world a truly 1d object can’t exist, so these all seems logical and are pointing to one thing that photon is 4d or an Electromagnetic waves are 4Dimensional.???

Why perspective of Photons is literally impossible

A normal train stops at a station where you can board it, and when it moves you can see from the perspective of the moving train. Now imagine a Photon-Train that doesn’t have breaks and runs on an infinite energy of oscillations of electric field and magnetic field orthogonally so that train can never stop and runs at a constant speed so it’s quite impossible to board that train and if no one boards it then no one can see from its perspective. A normal train have its rest frame (at its station), but that photon-train doesn’t, so from the views of mathematics the rest frame of that photon-train is like dividing by zero—its undefined and hence the perspective of photon is undefined.

But since imagination have no rules, we still can think about the perspective in a hypothetical world where photon had a rest frame. The perspective is in 4D space, where you can see many 3D worlds around you but you can’t move because there is no time and since there is no time then velocity is not possible, those many 3D worlds that you see at once will be the photon’s path travelled through space. Actually, just like imagining a 3D world for a 2D person is really difficult so in the same way for a 3D human, it’s quite hard to imagine 4D space because our mind isn’t built to handle that level of complexity.

So, what about that electromagnetic field being a 4-Dimensional field?

Actually, here things would get a little more complicated because the electromagnetic field is actually a 4-dimensional tensor existing in a 4-dimensional space-time.

A tensor is basically a mathematical object or some set of numbers that represents scalars, vectors, relations between vectors, relation between relations of vectors and the list goes on OR (a more defined definition) A tensor is a mathematical object that generalizes scalars, vectors, and matrices to represent

multi-dimensional relationships. A Scalar is a rank 0 tensor, a vector is a rank 1 tensor, a matrix is a rank 2 tensor, a cube is a rank 3 tensor and the list goes on about the rank.

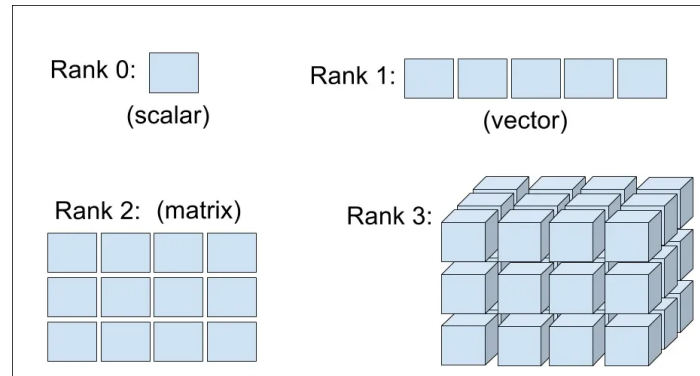


Image from - <https://medium.com/@schartz/the-shape-of-tensor->

So, the electromagnetic field is represented by a rank-2 tensor that is in the 4-dimension of spacetime so that we can account for how electric and magnetic fields change between observers moving at different speeds and this framework treats them as parts of a single object. This is the representation the 4D electromagnetic field tensor that incorporates both electric field and magnetic field into a single object

$$F_{\alpha\beta} = \begin{pmatrix} 0 & E_x/c & E_y/c & E_z/c \\ -E_x/c & 0 & -B_z & B_y \\ -E_y/c & B_z & 0 & -B_x \\ -E_z/c & -B_y & B_x & 0 \end{pmatrix}$$

The EM field is 4 Dimensional because 3 space + 1 time(as told earlier). It's obvious to think why we need this complex looking tensor but the reason it exists is because of the problem: **Electric field and Magnetic field Are Not Absolute**; this is something so mind bending that we will talk about this more in depth in a different paper.

So maybe, when we look at a beam of light, we're not seeing something moving rather we're seeing a frozen bridge in spacetime, stretched from emitter to absorber, a 4D object unfolding in our 3D view. In quantum field theory, the photon is not even a particle, but an excitation of the electromagnetic field.