

What is Light? A Coda

The simplest answer to this very simple question is that light is an oscillating electric field coupled

$$\begin{aligned}\mathbf{E}(\mathbf{r}, t) &= \mathbf{E}_0 \exp i(\mathbf{k} \cdot \mathbf{r} - \omega t) \\ \mathbf{B}(\mathbf{r}, t) &= \mathbf{B}_0 \exp i(\mathbf{k} \cdot \mathbf{r} - \omega t)\end{aligned}$$

to an oscillating magnetic field which propagates through space as a wave. The mathematical form

$$\begin{aligned}\nabla^2 \mathbf{E} - \mu_0 \epsilon_0 \frac{\partial^2 \mathbf{E}}{\partial t^2} &= 0 \\ \nabla^2 \mathbf{B} - \mu_0 \epsilon_0 \frac{\partial^2 \mathbf{B}}{\partial t^2} &= 0\end{aligned}$$

of this wave,

$$\begin{aligned}\nabla \cdot \mathbf{E} &= \frac{\rho}{\epsilon_0} \\ \nabla \cdot \mathbf{B} &= 0 \\ \nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} &= 0 \\ \nabla \times \mathbf{B} - \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} &= \mu_0 \mathbf{J}\end{aligned}$$

is determined by a pair of second order partial differential equations (wave equations), which in turn are derived from Maxwell's equations.

It is not my purpose to impress or intimidate. I have typeset and written out these equations because they are beautiful. The marks on the page are exquisite and the ideas that they encapsulate are breathtaking. This page explains (what a wonderful word that is) almost every element of common experience, the solidity of a table, the spring in your step, this thought in your head, the colour of your eyes...

This page is beautiful, I invite you to look at it again.

This gorgeous jumble is the simplest answer to any question about light. You can tell that this is a simple answer because,

1. It takes less than a page to write down.
2. It is not true.

I do not want to try to explain why these equations are not true. I do not want to wander through the quantum theory of light, though it is magnificent. I do not want to amble in relativistic fields of creation and annihilation operators, and vacuum fluctuations, spontaneous emission and Lamb shifts. Though I am drawn, I have been away too long. I feel the pull of the natural, the repulsion of the supernatural. I long for reality again. But I digress (and will again).

“True” is a difficult word. It excites passion, and removes it completely. It has started wars and ended them. It divides scientists from artists and rightly so. In the arts we are asked to “willingly suspend disbelief”, and we do, and it is wonderful. In science we are asked to willingly suspend belief, and we do, and it hurts.² “True” to an artist means something like straight, direct, meaningful. “True” to a scientist means “Not Yet False”. It means “We Have Not Hit This Accepted Belief Hard Enough”.

To say that the equations which I have (lovingly) reproduced above are not true is a scientific victory. The failure mode of scientific theories is discovery. Discovery. Explanation as discovery.

We scientists tell the world that we are building new technologies to make life better. I will whisper this, because it is a secret known only to every scientist who has ever lived, “Our lives are already full, technology is a distraction, we crave reality and cellphones cannot slake that thirst.”

The failure mode of scientific theories is discovery. Discovery is a drug, one taste will snare you forever. You will not sleep quietly again. And you cannot get another hit unless you kill the Truth.

1. from Sapientia Lucis (the wisdom of light)
2. “We” scientists” and “We artists” means the same thing pointing different ways. “We” are all Einstein’s “rascals”. (“All the fifty years of conscious brooding have brought

me no closer to answer the question, ‘What are light quanta?’ Of course today every rascal thinks he knows the answer, but he is deluding himself.” – Albert Einstein (1951) quoted in Raymond W. Lam, *Seasonal Affective Disorder and Beyond* (1998)