I see color differently

By

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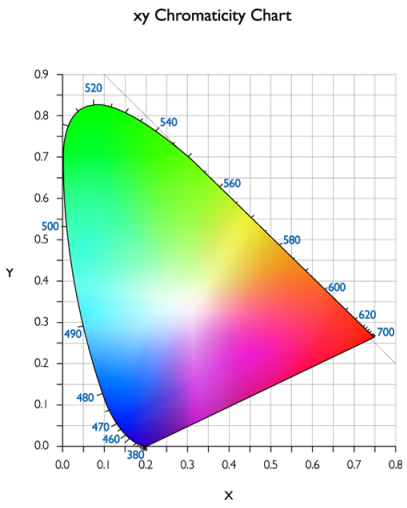
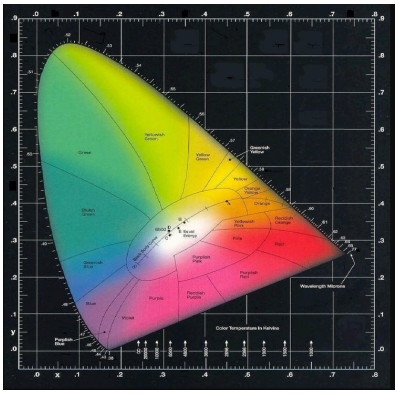
The story of how I learned about color and light

And it changed my view on the universe

I became fascinated with the notion of color and color models while I was interviewing at MIT's School of Visual Studies and staying with a friend. He was a smart, talented photographer, but was having a hard time understanding the C.I.E tristimulus XYX axis color model that was in a small ABC book on color. At the time, I didn't know anything about color models except the basics, mostly with subtractive colors, not additive color as in light.





http://hyperphysics.phy-astr.gsu.edu/hbase/vision/cie.html

When I looked at the C.I.E. XYZ graph model, I saw that it was actually a tetrahedron with the Z axis rising off the page, where all of the "white light" was located. So in an attempt to explain it, I cut out a triangle and folded the three points in to form a three-dimensional tetrahedron. The three corners were where the primary colors R, G, and B were located, and the raised top center was where the white was located. Simply put, as primary colored lights are added, the light moves up toward the white or toward the

complementary color for the mixed light. That is the way the actual C.I.E works, by placing mixed colors within the area defined by the three primaries and the white top. The math is just a matter of adding the luminance and moving to the point where the colors meet based on their percentage of the total.

I showed this to my friend, but I did not explain it well enough, so my friend was still confused. I realized it was a tricky model to explain and hard to visualize color in three dimensions. So I opened the tetrahedron up into a flat triangle and saw that the three endpoints were now on the midpoints. The endpoints on the flat triangle were now the three whitest areas of red, green, and blue. The center in this flat model would need to be black, which did not exist in the C.I.E model since black is the absence of light and therefore color.

But, in looking at this flat triangular model, I realized that it was a good way to explain subtractive color as in pigment. When those colors are mixed, they move toward black. So this model, in a way, could be used to describe both additive and subtractive color! When used at a tetrahedron, it followed the rules in the C.I.E model, and when used as a flat triangle, it uses the same rules as a primary color wheel. I wasn't introducing any cutting-edge new rules per se, just a new perspective.

At this point, it was late, my friend was tired, we had been enjoying ourselves the whole night with lots of spirits, and he said it was his bedtime. I, on the other hand, was fascinated with my findings. I started to see color differently and had no intention of sleeping while my brain was racing. By the morning, I was mesmerized by the simple complexity of light and color. My friend gave me his little ABC book on color that we had used as a reference, and wished me well! I think he was still a bit confused, but my insights were not very helpful.

So I spent the next few days with very little sleep, if any. I watched the sunrise and sunset and looked at the light during the day. I started to look at objects and realized that the colors I saw were the light that was reflected. No news to most, but it gave me

an energetic light insight. If I saw the red, then blue and green light (wavelengths) were absorbed. If I saw blue, then the green and red wavelengths of photon energy were absorbed. Then I saw green! I realized that if I saw green, then all the other wavelengths were absorbed. Green is the center of our visual spectrum, and I understood why most plants are green. They absorb as many of the other wavelengths and reflect just those in the middle of the spectrum, green. Green was the best color, so the plant could get the most energy from the light that the sun had to offer. So enlightening to me!

At this point, my way of seeing the C.I.E model was no longer about my simple color model; it was turning into something far more comprehensive and fascinating!!! I began to wonder about things far beyond the color model. One insightful thought experiment was if the light from the sun that plants use for their energy is in the middle of the spectrum at its current illumination temperature, what happens when the sun begins to burn out and becomes a red giant, and the middle of the visible spectrum is no longer green? Will plants evolve and change their color to maximize the energy they get? Thoughts like that were popping into my head, and I knew I had to write some notes.

I was confident that the foldable paper model would do a good job of explaining both the additive and subtractive color mixing since I was just adopting their existing rules, but I started to look at the implications of my observations. If what we see is the reflection of the light not absorbed, then how far out in the spectrum does light and wavelengths affect what I see? After all, there was no black in the C.I.E model, and the subtractive model never really gets to pure white, just highly luminous pastel hues.

And what was that white amorphous area in the C.I.E model? Then I remembered something that fascinated me from my youth. My sister collected rocks and crystals. She had a black light. When the black light was shone on the white quartz crystal rocks, they would glow a color, some reddish, some blueish, some greenish. When the light was turned off, the crystal just appeared white. It was in the amorphous area of

white that could only be seen with a wavelength outside our visual spectrum capacity. Ultraviolet light is outside of our standard visual spectrum and not really accounted for in any model.

The ink used in hand stamps at nightclubs and events is only visible under black light. So clearly that ultraviolet “black” light must be illuminating a color that is also outside of our natural visual spectrum! How far out in the non-visible spectrum did it go, I wondered?

I also found that an infrared light in a meat case helped the meat look redder and more appetizing. So light on both the longer and shorter wavelengths of the spectrum clearly affects what is reflected and therefore what we see.

Well, I knew I was in some very different area of thought than I was expecting and was not really prepared for what I was looking at or looking for!

I started to look at the properties of light and how it was seen from a physics perspective. Light was defined by a heated black body. The color temperature of the heated black body dictated the color of the light, so a 3200 kelvin heated black body will look redder than a 7000 kelvin black body. I was a cameraman, and I understood color temperature, filters, and white balancing to keep a consistent color look in a video production. But now I was wondering how hot or cold a black body would be, and what color would it produce? Again, outside of my comfort zone and the models currently in use. But I wanted my new model to address these concepts.

At this point, I realized that I needed to add to the current models and started to look for ways to define the parameters of the new model. This is where the trouble really began. First, the C.I.E model used the ~400 nanometers for the blue end of the visual spectrum, ~520 nanometers for the green middle, and ~700 nanometers for the red end of the visible spectrum. So if I wanted to calculate what happens to light mixing

outside of the end point, I needed to make something up, which was and is far outside my league!

My need to find an answer took me into the speed of light, indices of refraction, and lots of other heady, geeky areas! For brevity, the new model would need to account for the wave-packets of light, not just the wavelengths, since white light was a mix of wavelengths and they do not all travel at the same speed! That was a big problem! I was now messing with a hard and fast physics rule called the speed of light "c"!

That said, at the time of my brilliant insights (as in bright light terms only!) I was attending graduate school at Loyola and was also teaching holography to physics students in a lab at Tulane, which I helped to build. I was familiar with coherent light. We used a red laser with a wavelength of ~632.

When I returned to the Tulane Lab after my MIT trip, I was still very "excited" about my new fascination and told the Physics professors with whom I worked about my findings. One of them was that my new model hinted that light did not travel at the same speed. He immediately stopped me and told me in no uncertain terms of the sacrosanct law of "c". A violation of the consistent speed of light was not acceptable. He then said I should take his class on physics for artists, where they explained color matching and light. He showed me the material and the experiment about color matching they used. I asked him how he controlled the light in the room when doing the color experiments. He said What do you mean. I said that well, students by the window will see the colors as bluer, and the ones by the door will see it differently under incandescent light. He said, "Oh, that doesn't matter.

I realized right then that he did not understand that it did matter what light was used, and perhaps he was not the best person to talk with about my model. I also realized that if I were going to take on the scientific establishment, I would not have fun doing so or have the life I wanted to live. At that moment, I realized I would have to go it

alone. I would continue to explore my new color world, but not try to discuss it or present it. That was in 1979.

At the time, I didn't know whether my model would prove to be right or wrong, but I knew I didn't want to spend my life presenting and defending it. The science status quo, like most disciplines, does not like to be rocked. I, on the other hand, wonder why things are the way they are and look to see if they need changing. I also thought I would rather spend my life thinking my own thoughts and exploring my own models. If, after I am no longer here, my insights turn out to be wrong - so be it! Hopefully, those who matter to me will applaud my efforts and insights while alive. Those who would have torn my ideas and me to shreds if presented will have their chance, without my participation! If, on the other hand, I turn out to be right, well, they'll say nicer things about me, and that's all you get anyway!

So I have been going it alone ever since, and my original insights began to take me far, far away and opened so many fascinating, not fully understood areas of light, matter, and all that the universe is made of. Now science is even giving "color charge " to quarks and gluons. Not as in color, they use the color assignment of red, green, and blue as an analogy for the primaries to make white light. As I said, I am out of my league, but try to keep up. However, even at these tiniest of things, my model guides me.

As for the original model I did work on it more but as it turned out out in 1979 the same year I was exploring my color model Alvy Ray Smith of Pixar patented HWB color model that was very similar to what I was looking for and although it didn't go into the implication of non visible wavelength and their affect on color it was very complete and also patented. I didn't see any reason to pursue mine any longer except as a way to explore my view of color. Also, once computers entered the picture, color modeling and matching colors have become fairly easy and academic and of no real interest to me.

But I was now fascinated by what my model was telling me. If the white in the top center of the tetrahedron was achieved by mixing more extreme wavelengths, and the higher up in the white top of the tetrahedron you go, then non-visible wavelengths are required, like black light, ultraviolet, infrared, and beyond, then how far out in the electromagnetic spectrum would wavelengths affect the “whiteness/brightness. There is a point beyond a certain color temperature where we cannot discern white light, because it will blind us, and at hotter temperatures, melt us!

I reasoned that the brightest light would need to have the most extreme wavelengths. Like gamma rays and ultra-long radio-waves. And as for color temperature, was there a limit to how bright and hot a black body could be?

I also started to look at my original model and saw that the flat plane view with the whites at the tips and black as the center could itself expand down at the center, so the black in the middle would get blacker and blacker as it went deeper and deeper. Once again, to a point beyond what we can see. In this case, the absence of all light is described as a black hole. So the model could take on a diamond shape, much like several color models. The difference is those included non-visible wavelengths that go beyond the visible spectrum.

So my simple model may describe all light, (or may not since I am not dead yet and don’t feel like proving it - yet)

I knew I was now in uncharted territory, and no science book or website would be able to answer some of my questions. No reason to stop now, I thought so, I continued.

The electromagnetic spectrum in its entirety became my palette. But what did that mean? I started to ask some basic questions about light as wavelength and frequency, which I discussed earlier with the Tulane physics professor when I realized he didn’t take into account the index of refraction's effect on light and color, no matter.

The invariant constant “c”, which I questioned, states that wavelength times frequency equals “c”, the speed of light. I do not dispute that. What I disputed was that “c” was a constant!

After I learned more about the index of refraction, https://en.wikipedia.org/wiki/Refractive_index

which calculates the alteration of the speed of light in a medium. The waves throughout the entire spectrum are affected by the reaction index. And, I learned about the Chernov radiation effect https://www.sciencetimes.com/articles/50644/20240611/cherenkov-effect-speed-of-light-cherenkov-radiation.htm, which, under conditions like lightning and the blue glow in nuclear reactor that, seems to exceed the speed of light. I realized that yes indeed light can travel at a variable speed, and “c” is a fine answer when the actual velocity and impedance are taken into account. No problem there! The problems are elsewhere!

At this point in my exploration, there are several tangent questions that I began to contemplate and explore, like the big bang, black holes, the expansion of the universe, and … I can’t go into all of them since they each have branches, so I will just touch on a few interesting ones (to me)!

When gravitational waves were discovered at the LIGO facility, they detected the first gravitational waves in the gamma ray region of the spectrum, and then days later, they detected gravitational waves in the ultraviolet range, and then even later waves in the infrared regions. I wondered about the findings and thought, “If all those waves came from the same collision of the black holes and if all the waves are supposed to travel at the same speed, then they should all arrive at the same time. But that was not what happened. And since the waves arrived at different times from the same source, they must have travelled at different speeds. That was all I needed to hear! Clearly, there was something wrong or unclear about “c” as a constant. Again, I have no issue with “c” as an average, and the gravitational wave finding seemed to prove that.

Even before the LIGO finding and early on in my cosmic wonderings, I would talk to my daughters about some of my observations. I remember being at a July 4th celebration, and we saw the bright fireworks explode, then moments later heard the fireworks boom, and when we were close enough, we then felt the percussion. I said to them, “Isn’t it interesting that the same explosion gave us different effects?” I then wondered “if other waves, faster waves, could have arrived earlier than the visible light waves? I wondered if, in a nuclear explosion do the gamma rays fan out quicker than the other waves?

After the LIGO experiment, I had my answer. They did! But ironically, it is not a big deal to scientists. They still just say all light travels at the same speed. Again, it is not going to be my place to test or challenge them. I am content just pushing on in my lonely yet fascinating journey of the unknown, or the lesser known

Another tangent I decided to explore was the Big Bang. As long as I was at the edge of what science thinks it knows, why not take on the Big Bang? So I did.
The current thought is that nothing existed before the Big Bang. There was no time and no space. Then, at a moment in time, which did not exist at the time, everything expanded out from an infinitesimally small spot and went everywhere in an instant. In an instant, not at the speed of light “c”. Scientists gave the Big Bang's instantaneous rapid inflation a pass on having to obey the “c” speed ~ 300kps law.

While then resending the exception for faster than “c” light travel after the Big Bang. So now nothing can go faster than”c”. We’ll see!

I always wondered what was there before the Big Bang in both time and space. I just could not accept that there was nothing. But the prevailing science power brokers insist that there was no time or space before the Big Bang, and it didn’t matter, so why wonder about it! I then wondered if they say the Big Bang happened some 13.2 billion years ago, based on the cosmic background radiation and Doppler effect they detect,

then the universe is much smaller than what science has perceived. In fact, some studies say the universe is twice as old as first calculated! 26 billion and counting!

Now that I was getting more confident that my ideas and rumination were not completely far-fetched, just out of reach for most, I decided to get down to basics. You know, like the beginning of the universe and where it all goes and what it's made of.

For starters, I looked at light and photons, those massless morsels of energy that we are baffled by. Are they discrete morsels of mass or waves of energy? That is the duality debate that is still raging. Rather than take a side, I thought I would look at how they propagated via waves. The wavelength and the frequency are inversely proportional, so the combination will equal the same speed, “c”.

So I tried to look for the smallest wave. I found that the spectrum that we all use really does not extend to the tiniest or, for that matter, the largest wave. The spectrum and wavelength, and therefore the frequencies on the electromagnetic spectrum, get truncated. Most electromagnetic charts stop at a point and never extend to the tiniest and longest waves. I thought there really is a wavelength that is so small with a frequency that is so high it would appear as a dot. Oscillating infinitely fast and infinitely small. And conversely, the longest wave would have an infinitely long frequency as if it would never crest again, so it would appear to be flat. How small or large can a wave and frequency get?

Of course, as I am pondering this, looking for evidence, I am confronted again with a scientific law. This time, Planck constants. The smallest length, size, temperature, and time.

Apparently, if we allow things to get to an infinite amount, a lot of the math and the building blocks we use will crumble. Sad, but then I thought, what if those building blocks are flawed? Now I was in deep, deep, deep trouble. Since I had no real idea of

what I was doing or why, it was very easy for the confidence that I had started to build to begin to shake, and doubts rushed in.

So I stopped and looked. I looked at the universe from the perspective of that tiniest of perspectives as though I was living in a Planck world. While there, I wondered what could be inside for me to look at now. Well, if there is nothing smaller or hotter or shorter or wait a moment—— time could have a limit to. There is a Planck moment.

For the record, the Planck time is 5.39 times 10 to the minus 44th
Or the time it takes for light to travel one Planck length in a vacuum!

That is very small, but can nothing be smaller?

While we are at this primordial moment, let's take a moment to look at the calculation of it.

The time it takes for light to travel, ok, stop!!! At the moment, the calculation for travel is using "c" as the speed. There have been examples of things traveling faster than the current speed of light, and certainly light traveling slower with the index of refraction. And then that travel needs to take place within a vacuum - OK STOP! We used to think that space was a vacuum and offered no impedance. Recently, it's been found that there is no such thing as a real vacuum. When there is an attempt to create, they find that things pop in and out of existence with this vacuum, so it is not empty and may have some impedance. And since there is no perfect vacuum, and we know there is an index of refraction for wavelengths of light, then this calculation could be off. In fact, I have been researching that says the universe and the Big Bang may be twice as old as previously calculated. I will go so far as to say we won't know because if there is a variation in the speed of waves in a medium and there is no such thing as a true vacuum, then any calculation will be an approximation at best.

Further, I do not believe there was a single big bang that expanded out of nothing in an instant to encompass everything. I think the Big Bang is an ongoing event. With any new Big Bang wiping out information about what was there before. In fact, some researchers have found that the number of black holes within the observable universe at present is about 40 times 10 to the power 18. And at the center of each is a world we know very little about, and if they collide and explode like the ones detected in the LIGO experiment, anything nearby would be altered and obliterated, and it may appear to be a big bang-like event for those unfortunate to have been in the way.

I have many more thoughts and insights. They keep me busy and scared. Scared at how much there is to know and scared that maybe I don't know any of it! Since I have been on this journey since 1979, I have traversed lots of fields of knowledge. None of which was I an expert or even a player. I have been merely an observer. I see what I see and make what I can of it. I sometimes feel very free. My thoughts make me realize how fragile we are and how impermanent we are. But at the same time, I know that I will always be part of the universe and nothing can change that!
On a personal note, I remember when my children were born. The first was an awesome experience. She was born with her eyes wide open and seemingly ready for fun and action! The nurses called her bright eyes. My second came out, and I was less than pleased. She had an expression that said, "I know there is a place for me here, so get out of my way. Turn off those bright lights and put me back in, or make me warm and cozy. I love them both dearly, but each taught me that life is to be lived. We can't get out until it is over, and we can enjoy it while we are here.

A final note on the color model that started all of this. My model says that the rules of color matching follow those of the other models, but that color is only as accurate as the application requires. Each color has four sides like the tetrahedron model, so any color can always be subdivided and become more and more specific, in the same way as waves and frequencies of light can be subdivided and become more and more specific. There is no end to the spectrum; it just gets smaller and smaller until it reaches zero, and then the frequencies get larger and larger until they reach the middle,

and then they get smaller again and eventually reach zero on the return trip, like a circle. Take a look at the electromagnetic spectrum, and you will see what I mean. The plants understand that, and the midpoint of the spectrum, green for the moment, will always be where they get their energy.

To this day, I can walk out and see and sense the quality of light. At sunsets, during a sun-shower, at dusk. I will forever see light differently! I knew it was important because I knew I would never make a dime from my insights, and only a few would appreciate it! I feel that is where the real innovation and insights come from. I hope I am right!

In that same way, the universe can start from what appears to be another, but upon fourth analysis, it turns out to be everything.

If you look at the universe and imagine it is made of atoms, protons, electrons, proton, lepton, neutron quarks, bosons, and ever smaller, you might imagine that there is no smallest thing. When you get to that smallest point, it turns out it is everything just starting all over again, or a better way to put it, just continuing to be.

I prefer to imagine that the universe has been writhing and morphing forever and will continue to do so. The fact that we do not have a definitive answer as to how it all began and will end, if ever, is fascinating to me. I believe that as we learn more, we will change what we think we know. That will be a never-ending process. So anything I say now will likely be changed in the future, and there is nothing wrong with that. I have a much harder time when science tries to insist it knows how things are, only to find out it is wrong. Science and religion have that in common. It is a cult of believers who fight hard to keep their dogma in play!

Free thinkers, like myself, are rare. Mainly because we are taught throughout our lives to submit or are beaten down into intellectual and moral submission. I am very sad that this is the case. I would love to find I am wrong, and I hope the future will bring

about more and more open-minded people who question the status quo and revel in the unknown and the fear of it!

I love to imagine the universe billions of years from now. I don't need to include humanity in those visions since I am certain that our fragile plant and our unique existence will be either long gone or well adapted. No need to think about my species. As the universe expands out, it also expands in, so I imagine the place where the total expanse and the total core meet. As hard as it may be to imagine that expanse and core already exist. Once we get to the smallest of spots, that place where the big bang is said to have happened, we find everything. So the Big Bang didn't inflate it, just occupied the space it always was!

I'll continue to explore the ideas I've mentioned, and I expect I will continue until I can no longer think and wonder. I hope!