This is the first paper I have published on my site by another author. In it Howell claims to find support for my theory of refraction in petrography and the Michel-Levy charts. Since I have not studied either one in any depth, I cannot guarantee that he does so, but his paper seems solid enough at a glance to add to the pile. Although I haven't rerun his color mixing experiments and cannot confirm them, they seem promising. Since he doesn't misquote me, refute me, or go too far afield, this paper seems a good one to begin my experiment of publishing others. And since I am swamped with other projects right now, I will let my readers tell me if something is terribly wrong here (as they are so adept at doing). *Miles*

The Michel-Levy Chart
Proves that Light has
Four Primary Colors

by Michael Howell

http://www.itp.uni-hannover.de/~zawischa/ITP/figuren/thinfilm.PNG

In studying petrography, one learns early on some of the important ways that light behaves. Petrography, after all, is largely about analyzing the optical properties of rocks in thin section. One of the first items a student encounters is an interference diagram called the Michel-Levy chart. As Wikipedia says (in two articles):

> Michel-Lévy pioneered the use of birefringence to identify minerals in thin section with a petrographic microscope. He is widely known for the Michel-Lévy interference colour chart, which defines the interference colors from different orders of birefringence. (page "Auguste Michel-Lévy")
>
> An **interference colour chart**, first developed by Auguste Michel-Lévy, is an optical mineralogy tool to identify minerals in thin section using a petrographic microscope. With a known thickness of the thin section, minerals have specific and predictable colours in cross-polarized light, and this chart can help identify minerals. The colours are produced by the difference in speed in the fast and slow rays, also known as birefringence. (page "Interference colour chart")

The light starts out as white (black is simply the absence of light). The Michel-Levy chart is divided into segments known as "orders." The first appearance of white is known as "first-order white," or "White I." Approaching the end of the first segment, the light turns yellow and then red (looks brown above). Right on the border between Red I and Violet II is a dark magenta. After violet comes blue and then cyan. The cyan becomes pale green momentarily before turning yellow and then red/magenta.

Notice that Yellow I/II and Cyan II are quite broad bands. By contrast, Red I and Violet II are very narrow. This in itself is curious. How do we explain it? According to Miles Mathis' paper on refraction, visible light is composed of four primary colors: red, yellow, cyan, and violet. He adds, furthermore, that only red and violet are emitted wavelengths of photons; yellow and cyan are Doppler-like shifts of these photons by the ambient charge field. As we see in the chart, Yellow I seems to struggle to entirely distinguish itself from red/orange. The cyan struggles to distinguish itself from indigo. According to Mathis:

> If the field is less dense, then the charge field may not move red photons all the way to yellow. As in the Goethe illustration, the red photons may stay pretty red, if they are more toward the center of the gap. But the photons near the material will feel the denser field, and will be taken all the way to the maximum.

As per the photoelectric effect, the photons of the charge field have enough energy to shift red to yellow and violet to blue—but no more. Mathis argues that it is the charge field that explains prismatic effects such as birefringence—not the material that makes the prism itself. Yes, the material may determine the refractive index, but to do this the material must emit the charge field, and it is the charge field that interacts with the photons in the light. What we see with the width of yellow and cyan in the Michel-Levy chart is red and violet photons being refracted by a less dense charge field.

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Now let us study green in the Michel-Levy chart. According to standard colorimetry, the primary colors of light are red, blue, and green. We should observe, however, that much about how light behaves seems inconsistent with green being a primary component of light. Where red and blue pop up, such as in blackbody radiation spectra, green is strangely absent. Colorblindness seems to have much more to do with red, yellow, and cyan than with green, as Mathis also shows. Indeed, Wikipedia states the following:

> Color blindness very rarely means complete monochromatism. In almost all cases, color blind people retain blue–yellow discrimination, and most color-blind individuals are anomalous trichromats rather than complete dichromats.
>
> The vision of dichromats may also be compared to images produced by a color printer that has run out of the ink in one of its three color cartridges (for protanopes and deuteranopes, the red cartridge, and for tritanopes, the yellow cartridge).

Notice that last cartridge: yellow, not green. It isn't that certain colorblind people see red as green and green as red. Rather, they see everything as yellow. The idea that green is a primary color of light is refuted in the common descriptions of color blindness.

It is also refuted by the Michel-Levy chart, where, as you see, green does not come into play until *after* the initial splitting of light into Mathis' four primaries. Green II confirms this again, since it is but a pale green, a brief transition between Cyan II and Yellow II. (Remember that "II" refers to the segment of the chart—not the second appearance of the color.) Yes, Green III is a saturated green, but that is only thanks to a much better mixing of cyan and *yellow.* By the beginning of the fourth segment, red and violet have coalesced into Magenta IV. From here on out, everything is either green or magenta or some light or medium gray, confirming that, like magenta and gray, **green is a mixture, not a primary**.

Into the very high orders, everything becomes gray or white. This is known as "high-order white." At first, the prism effect splits the light into increasingly distinguished and saturated colors—peaking around third-order birefringence. From then on out, the diffusion becomes so great that the light coalesces once more into white/gray.

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After coursework in petrography, one commonly studies remote sensing. Here again, students learn some key behaviors about light. Colorimetry is a central component of reading spectral maps—especially false-color maps, where (typically) three bands are being interpreted in one layer.

In learning to distinguish different rocks in false-color infrared maps, I really had to hammer into my head how red, blue, and green interact to form different hues and saturation. It came to my attention one night that if I added cyan to yellow, then I should get under-saturated green. This is because cyan and yellow share a green component, according to standard colorimetry. The red and blue components (which they do *not* have in common) form magenta, which partially cancels out the green and leaves a whitish residue. On a scale from 0 to 100, green would be 100, and red and blue would be 50. Note that red plus blue equals magenta, the complementary color of green. (In additive color, two complementary colors equal white.)

This once again corroborates the theory of Mathis, and shows how standard colorimetry refutes itself. As he says, it is well documented that not all saturations can be reproduced with RGB—such as gamboge yellow. If you don't start with the proper primary colors, then you wind up with whitish residue.

Some academics think there is no such thing as primary colors of light, such as this teacher on handprint.com:

> The painter's three primary colors are the foundation of academic color theory (which is not really a theory), and some art school graduates develop a rigid attachment to primary colors and the formulaic **approach to color mixing** that goes with them. So it seems surprising to ask ... *do "primary" colors exist?* Even more surprising to learn that the answer is — *no!*

We have already seen that this cannot be the case even according to standard colorimetry. The very reason theories of primary colors have changed over time is so that no colors should remain *out of gamut*. The handprint article continues:

> Mayer embraced all visible colors in a single abstract measurement framework that (in principle) would apply equally to the natural colors of flowers or stars or the manufactured colors of pigments or dyes.
>
> However, Mayer stumbled over four practical problems:
>
> (1) Any set of three "primary" paints or lights cannot mix all possible colors, so his system is incomplete
>
> (2) Mixtures of lights or pigments, notated the same way in his system, can produce very different colors — $\mathbf{r}_0\mathbf{g}_6\mathbf{b}_6$ is approximately a "white" light mixture but a green paint mixture — so his system is not applicable to both colored lights and paints.

But these problems hardly belong to Mayer or to artists alone. They are “practical problems” for any color theory. Nor are they insoluble, as we will see. Handprint offers us modern colorimetry as the scientific solution, but it isn't much of a solution. As long as current colorimetry is careful to distinguish additive from subtractive color—and if it monitors the optical properties of the materials it is using—then each system can have its own distinct notation. Subtractive color is then about combining different absorbers of light; additive color is about reflecting different lights. That's fine as far as it goes, but we need a mechanics that explains both sets of notation. Just because scientists have not previously discovered that mechanics does not mean it does not exist.

Miles Mathis reminds us that ever since the Copenhagen interpretation, scientists have declared that certain things have no rational explanation. When these scientists found certain problems insoluble, they set out to keep anyone else from trying to solve them, and we see another instance of that here. But I have shown evidence from the Michel-Levy chart that the number of primaries is four, not three, and I will show more evidence below.

As we have already seen, the color triangle has turned out to be just as flawed an assumption as Ptolemy's circular orbits. To see this more clearly, we may continue to study Maxwell's color triangle, as in this quote from handprint:

Maxwell's method depends on the fact that a "white" light mixture can always be produced by the mixture of any spectral color with two of the three additive primaries. (Which two depends on the hue of the target color: **G** and **B** must be used with "yellow" to "red" wavelengths, **R** and **B** with "green" wavelengths, and **R** and **G** with "blue" wavelengths.)

But then here's the catch:

Maxwell used his color triangle to analyze the primary color composition of many common artists' pigments, only to discover that **some pigments were more saturated than any mixtures of his three primaries could match**. Thus, the artists' pigment natural gamboge (**NY24**) was a more intense yellow than any additive mixture of vermilion and emerald green on his color top.

Rather than add a fourth, (yellow) primary to his system, Maxwell chose to *subtract* chroma from the gamboge. He did this by visually mixing it either with a gray of equal lightness or with a desaturating quantity of the complementary blue violet primary. This shifted the gamboge color toward gray and brought the color back within the triangle, where it could be matched by a mixture of the remaining two primary colors. The amount of desaturating color required to make this match was used to estimate how far the chroma of the gamboge exceeded the gamut of the three primary mixing triangle. This method was extended and carefully explained by the American physicist **Ogden Rood**, who showed that this "subtractive" method permitted accurate measurements of pigment chroma even if the color was more intense than the visual primaries used in the analysis.

In effect, Maxwell **defined "primary colors" as mathematical or imaginary concepts**, because the *true* primaries that could match the undiluted color of gamboge yellow would have to be much more saturated than the *actual* paint primaries used to match the dulled gamboge yellow on a color top

This was a crucial step in the development of color science, because primary colors no longer had to be *real* colors, that is, paints you can actually spin on a color top or lights you can actually extract from the spectrum. Even though this seems to make no physical or perceptual sense, it reflects the fact that the mind **never sees the cone outputs** and therefore our visual primaries are imaginary colors to begin with. Maxwell's system of imaginary, mathematically defined primaries is so useful that it has become the **standard method** for specifying the appearance and mixtures of all colors.

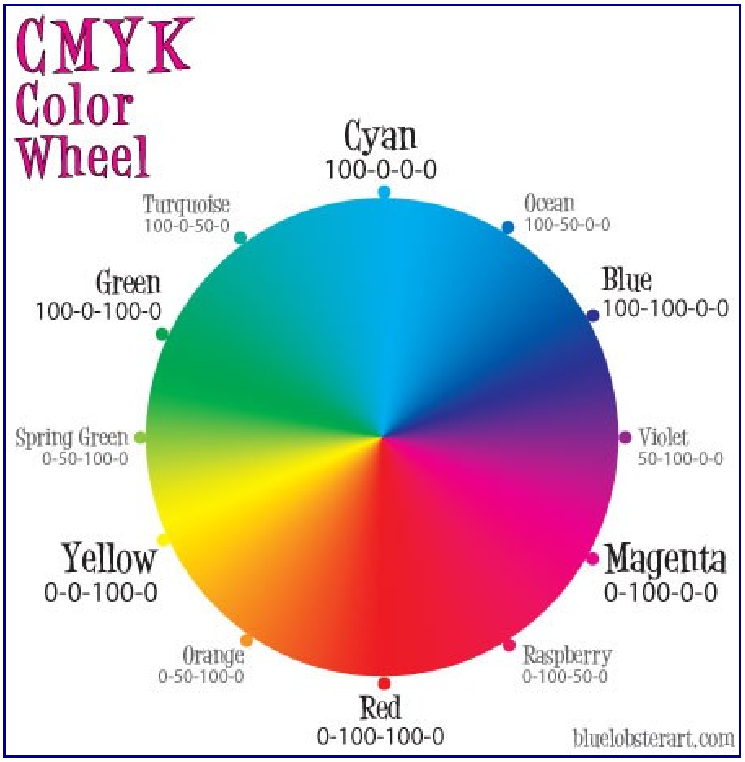
There we have it: the Copenhagen interpretation of colorimetry. The spirit of the Copenhagen interpretation is that man is the measure of all things. That is, meaning does not exist until we, as humans, apply it. It is Deconstruction as applied to the real world. Relativism did not follow Einstein's theory of relativity (which Mathis says is also grossly misunderstood). Rather, relativism *preceded* the standard interpretation of Einstein's theory.

The idea that man is the measure of all things corrupted astronomy for centuries. It took Johannes Kepler (and not Copernicus or Galileo) to liberate people from the idea that planets had to follow the shapes (namely circles) that matched their ideas of perfection. He did not fear the ellipse. To develop true science, the West had to abandon much philosophy of the Greeks in favor of certain Christian scholars like Kepler [see, for example, *The Sleepwalkers*, by Arthur Koestler].

Miles Mathis writes,

> Yellow is not the only color whose saturation cannot be matched by RGB. Two others, not surprisingly, are cyan and magenta. Using RGB, we find that even some greens cannot be matched. Why? No one knew before now, but I can tell you it is because you don't have yellow to add by itself.

To test this idea, I drew some distribution curves over red, yellow, cyan, and violet, along with a color wheel, in order to develop my own color diagram that covers all the possibilities of mixing Mathis' four color photons. I observed that there are two basic ways to make a color more whitish. One of these two ways desaturates the desired hue much less than the other. Since cyan is the complement of red, red can be made whitish simply by adding cyan (or, in terms of standard colorimetry, adding green+blue). This also has the effect of de-saturating the red, since cyan cancels out the red hue. Standard colorimetry thinks that making something more white is the same as de-saturating it, but I have found, from Mathis' work, that this is not quite correct. According to the color wheel, *any* pair of complementary colors will add a white channel to the pre-existing color. When cyan is added to red, the red channel doubles as a component of the white channel.



http://blulob.com/2009/03/13/the-cmyk-color-wheel/

To add white to red in the way that subtracts *the least* red, one must employ the pair of complementary colors whose line is perpendicular to the line between the target hue and its complement. In this case, one must make white with violet and yellow-green. Yellow-green, according to my interpretation of Mathis' theory, should be one part cyan and three parts yellow. Cyan cannot be cut entirely out of the picture, but its destructive interference can be minimized.

Violet, on the other hand, can be made whiter with *no* loss of saturation. Just add cyan and red. Green and magenta will require orange and blue-cyan for minimal loss of saturation. Green is half cyan and half yellow. Blue-cyan is three parts cyan and one part violet; orange is half red and half yellow. Two parts red plus one part violet equals red-magenta. Adding white to green cannot help but produce pale green, which must explain some of the weird behavior of green on the Michel-Levy chart. It must also tend to confirm Mathis' theory and refute RGB colorimetry, since if green were a primary it would not act this way.

Based on Mathis' theory of light, I also predict that transmission/reflection of all photons except yellow will produce whitish violet with maximum saturation of the violet component. This is in contrast with the standard expectation that the color would be blue. But then no one actually "sees" the four kinds of visible photons—only their collective effects. It seems to me that colorimetry has simply *assumed* that absorption of only yellow light will produce blue. But if white light begins with equal numbers of red, yellow, cyan, and violet photons, that cannot be the case. Red and cyan would cancel out their hues to form white, leaving only violet for the hue channel.

Standard colorimetry admits, by its own diagrams, that white can be formed either by using all the colors of the rainbow or by using certain halves. Physicists have overlooked that "white light" in the usual sense is not one white light but *two*. The first white light is red+cyan. I will call this "Primary White," or "White 1." The second white is yellow+blue or violet+yellow-green. I will call these lights, respectively, "White 2a" and "White 2b." White that holds all the colors of the rainbow is what I will call "rainbow white."

If red+cyan is eliminated from rainbow white, what remains is yellow+violet. Yellow and violet are *almost* complementary colors—but not quite. This is why White 2 requires a bit of cyan. My calculations are that violet and yellow would produce a pale red with a hint of magenta. (Yellow and magenta produce red.)

If the white light contains only red and cyan photons, then a surface that absorbs only yellow photons will reflect all the light. But if the white light contains only yellow and blue (cyan+violet), then the color will be blue, as standard colorimetry predicts. Overlooking the full degree of freedom in the behavior of visible light must have set back remote sensing and petrography in ways I can hardly begin to imagine.

I wonder if hyperspectral data could be replaced with bands that match Mathis' theory of photon spins. I notice that absorption bands seem to be rather regular in where they crop up, and I believe I have noticed that satellites are often optimized to focus on the most useful absorption bands. When Mathis' theory of photons is extended to explain everything from gamma rays to radio waves, I believe we will see a revolution in the way remote sensing is done.

Where remote sensing has not suffered too much, it is only thanks to old-fashioned heuristics: thanks to the engineers, not the theorists. What I mean is that another critical distinction often lost by the scientific community is the difference between engineering and science proper. Science proper is concerned with unified explanations for various observations. Engineering, which is often heuristics, is concerned mainly with building products that meet the goals of the designer. I would say that since about 1920, the West has not been scientifically based nearly as much as technologically based. It is living mainly off the momentum of past scientists.

Today's "scientists" are largely engineers clothed as theoreticians. Richard Feynman is perhaps the best example: he embodied and propelled the popular trend of confusing science *per se* with engineering. Heuristics is the branch of science that needs the *least* development. It is the oldest, most primitive form of science, which even a caveman exhibited when he constructed an arrowhead. The branch of science that needs the *most* development is the branch that is the most neglected. A lot that passes itself off as theory is simply exalted heuristic devices—no better than Ptolemy's astronomy.

If the arrival of the next Newton or Einstein seems rather late, it is because the "pure" science they pursued has become generally abandoned. Nor do scientists have the sense of wonder they once did. Maybe it's because physicists have never been so out of touch with the great trio: a real and physical world, a world governed by rationality, and a world where man is a creation of reality and not the creator of reality.