computers are bad

https://computer.rip - me@computer.rip - fax: +1 (505) 926-5492

2024-03-09 the purple streetscape

Across the United States, streets are taking on a strange hue at night. Purple.

Purple streetlights have been reported in Tampa, Vancouver, Wichita, Boston. They're certainly in evidence here in Albuquerque, where Coal through downtown has turned almost entirely to mood lighting. Explanations vary. When I first saw the phenomenon, I thought of fixtures that combined RGB elements and thought perhaps one of the color channels had failed.

Others on the internet offer more involved explanations. "A black light surveillance network," one conspiracist calls them, as he shows his mushroom-themed blacklight poster fluorescing on the side of a highway. I remain unclear on what exactly a shadowy cabal would gain from installing blacklights across North America, but I am nonetheless charmed by his fluorescent fingerpainting demonstration. The topic of "blacklight" is a somewhat complex one with LEDs.

Historically, "blacklight" had referred to long-wave UV lamps, also called UV-A. These lamps emitted light around 400nm, beyond violet light, thus the term ultraviolet. This light is close to, but not quite in, the visible spectrum, which is ideal for observing the effect of fluorescence. Fluorescence is a fascinating but also mundane physical phenomenon in which many materials will absorb light, becoming excited, and then re-emit it as they relax. The process is not completely efficient, so the re-emited light is longer in wavelength than the absorbed light.

Because of this loss of energy, a fluorescent material excited by a blacklight will emit light down in the visible spectrum. The effect seems a bit like magic: the fluorescence is far brighter, to the human eye, than the ultraviolet light that incited it. The trouble is that the common use of UV light to show fluorescence leads to a bit of a misconception that ultraviolet light is required. Not at all, fluorescent materials will emit just about any light at a slightly lower wavelength. The emitted light is relatively weak, though, and under broad spectrum lighting is unlikely to stand out against the ambient lighting. Fluorescence always occurs, it's just much more visible under a light source that humans can't see.

When we consider LEDs, though, there is an economic aspect to consider. The construction of LEDs that emit UV light turns out to be quite difficult. There are now options on the market, but only relatively recently, and they run a considerable price premium compared to visible wavelength LEDs. The vast majority of "LED blacklights" are not actually blacklights; they don't actually emit UV. They're just blue. Human eyes aren't so sensitive to blue, especially the narrow emission of blue LEDs, and so these blue "blacklights" work well enough for showing fluorescence, although not as well as a "real" blacklight (still typically gas discharge).

This was mostly a minor detail of theatrical lighting until COVID, when some combination of unknowing buyers and unscrupulous sellers lead to a wave of people using blue LEDs in an attempt to sanitize things. That doesn't work, long-wave UV already barely has enough energy to have much of a sanitizing effect and blue LEDs have none at all. For sanitizing purposes you need short wave UV, or UV-C, which has so much energy that it is almost ionizing radiation. The trouble, of course, is that this energy damages most biological things, including us. UV-C lights can quickly cause mild (but very unpleasant) eye damage called flashburn or "welder's eye," and more serious exposure can cause permanent damage to your eyes and skin. Funny, then, that all the people waving blue LEDs over their groceries on Instagram reels were at least saving themselves from an unpleasant learning experience.

You can probably see how this all ties back to streetlights. The purple streetlights are not "blacklights," but the clear fluorescence of our friend's psychedelic art tells us that they are emitting energy mostly at the short end of the visible spectrum, allowing the longer wave light emitted by the poster to appear inexplicably bright to our eyes. We are apparently looking at some sort of blue LED.

Those familiar with modern LED lighting probably easily see what's happening. LEDs are largely monochromatic lighting sources, they emit a single wavelength that results in very poor color rendering, which is both aesthetically unpleasing and produces poor perception for drivers. While some fixtures do indeed combine LEDs of multiple colors to produce white output, there's another technique that is less expensive, more energy efficient, and produces better quality light. Today's inexpensive, good quality LED lights have been enabled by phosphor coatings.

Here's the idea: LEDs of a single color illuminate a phosphorous material. Phosphorescence is actually a closely related phenomenon to fluorescence, but involves kicking an electron up to a different spin state. Fewer materials exhibit this effect than fluorescence, but chemists have devised synthetic phosphors that can sort of "rearrange" light energy within the spectrum.

Blue LEDs are the most energy efficient, so a typical white LED light uses blue LEDs coated in a phosphor that absorbs a portion of the blue light and re-emits it at longer wavelengths. The resulting spectrum, the combination of some of the blue light passing through and red and green light emitted by the phosphor, is a high-CRI white light ideal for street lighting.

Incidentally, one of the properties of phosphorescence that differentiates it from fluorescence is that phosphors take a while to "relax" back to their lower energy state. A phosphor will continue to glow after the energy that excited it is gone. This effect has long been employed for "glow in the dark" materials that continue to glow softly for an extended period of time after the room goes dark. During the Cold War, the Civil Defense Administration recommended outlining stair treads and doors with such phosphorescent tape so that you could more safely navigate your home during a blackout. The same idea is still employed aboard aircraft and ships, and I suppose you could still do it to your house, it would be fun.

Phosphor-conversion white LEDs use phosphors that minimize this effect but they still exhibit it. Turn off a white LED light in a dark room and you will probably notice that it continues to glow dimly for a short time. You are observing the phosphor slowly relaxing.

So what of the purple streetlights? The phosphor has failed, at least partially, and the lights are emitting the natural spectrum of their LEDs rather than the "adjusted" spectrum produced by the phosphor. The exact reason for this failure doesn't seem to have been publicized, but judging by the apparently rapid onset most people think the phosphor is delaminating and falling off of the LEDs rather than slowly burning away or undergoing some sort of corrosion. They may have simply not used a very good glue.

So we have a technical explanation: white LED streetlights are not white LEDs but blue LEDs with phosphor conversion. If the phosphor somehow fails or comes off, their spectrum shifts towards deep blue. Some combination of remaining phosphor on the lights and environmental conditions (we are not used to seeing large areas under monochromatic blue light) causes this to come off as an eery purple.

There is also, though, a system question. How is it that so many streetlights across so many cities are demonstrating the same failure at around the same time?

The answer to that question is monopolization.

Virtually all LED street lighting installed in North America is manufactured by Acuity Brands. Based in Atlanta, Acuity is a hundred-year-old industrial conglomerate that originally focused on linens and janitorial supplies. In 1969, though, Acuity acquired Lithonia: one of the United States' largest manufacturers of area lighting. Acuity gained a lighting division, and it was on the war path. Through a huge number of acquisitions, everything from age-old area lighting giants like Holophane to VC-funded networked lighting companies have become part of Acuity.

In the mean time, GE's area lighting division petered out along with the rest of GE (they recently sold their entire lighting division to a consumer home automation company). Directories of street lighting manufacturers now list Acuity followed by a list of brands Acuity owns. Their dominant competitor for traditional street lighting are probably Cree and Cooper (part of Eaton), but both are well behind Acuity in municipal sales.

Starting around 2017, Acuity started to manufacture defective lights. The exact nature of the defect is unclear, but it seems to cause abrupt failure of the phosphor after around five years. And here we are, over five years later, with purple streets.

The situation is not quite as bad as it sounds. Acuity offered a long warranty on their street lighting, and the affected lights are still covered. Acuity is sending contractors to replace defective lights at their expensive, but they have to coordinate with street lighting operators to identify defective lights and schedule the work. It's a long process. Many cities have over a thousand lights to replace, but finding them is a problem on its own.

Most cities have invested in some sort of smart streetlighting solution. The most common approach is a module that plugs into the standard photocell receptacle on the light and both controls the light and reports energy use over a municipal LTE network. These modules can automatically identify many failure modes based on changes on power consumption. The problem is that the phosphor failure is completely nonelectrical, so the faulty lights can't be located by energy monitoring.

So, while I can't truly rule out the possibility of a blacklight surveillance network, I'd suggest you report purple lights to your city or electrical utility. They're likely already working with Acuity on a replacement campaign, but they may not know the exact scale of the problem yet.

While I'm at it, let's talk about another common failure mode of outdoor LED lighting: flashing. LED lights use a constant current power supply (often called a driver in this context) that regulates the voltage applied to the LEDs to achieve their rated current. Unfortunately, several failure modes can cause the driver to continuously cycle. Consider the common case of an LED module that has failed in such a way that it shorts at high temperature. The driver will turn on until the faulty module gets warm enough and the driver turns off again on current protection. The process repeats indefinitely. Some drivers have a "soft start" feature and some failure modes cause current to rise beyond limits over time, so it's not unusual for these faulty lights to fade in before shutting off.

It's actually a very similar situation to the cycling that gas discharge street lighting used to show, but as is the way of electronics, it happens faster. Aged sodium bulbs would often cause the ballast to hit its current limit over the span of perhaps five minutes, cycling the light on and off. Now it often happens twice in a second.

I once saw a parking lot where nearly every light had failed this way. I would guess that lightning had struck, creating a transient that damaged all of them at once. It felt like a silent rave, only a little color could have made it better. Unfortunately they were RAB, not Acuity, and the phosphor was holding on.