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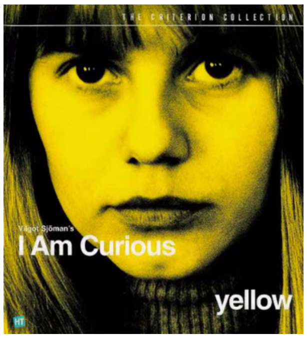
9 I Am Curious (yellow)



Sorry, I couldn't resist the title. It refers to a 1967 Swedish film by Vilgot Sjöman. There's a companion movie, *I Am Curious (blue).* The colours in the movie titles are those of the Swedish flag.

Sharp recently introduced several AQUOS Quattron™ television models, featuring "Quad Pixel Technology." Each display pixel has the usual three colour components (red, green, and blue) but adds a fourth component, yellow. I'm curious about how and why.

You may have thought that all colours could be formed from three additive primaries, but that was never completely true. When plotted on a CIE [*x, y*] chromaticity diagram, the path traced out by pure monochromatic source as it sweeps across the visible wavelengths from 400 nm to 700 nm takes on a "horseshoe" shape – the *spectral locus*. In additive colour formation with three primaries, it is possible to reach all of the colours whose coordinates lie within the triangle formed by the vertices. That's *most* of the colours, but no set of three primaries can reach *all* of the colours. Over the half-century from 1953 to about 2003, the television industry used a specific set of three RGB primaries (now standardized in BT.709) that covered most of the colours – let's call them the colours economically important in those times. In about 1993, computing industry reached *de facto* agreement to use the same set of primaries, which they called sRGB.

During the last 5 years or so, LED backlights have emerged that enable a wider range of colours – a wider *colour gamut* – than conventional backlights. One or more of the R, G, and B primaries is moved out closer to the spectral locus. The LED spectra are narrow, just 30 or 40 nm wide, a point to which we'll return in a moment.

Sharp's Quattron apparently uses a white LED backlight, instead of an RGB LED backlight. The white LED by itself offers no increase in gamut compared to a conventional fluorescent (CCFL) backlight; however, adding the fourth (yellow) component allows an increase in gamut in the yellow region of the spectrum (and a bit more in green).

Video content is mastered on studio-grade displays – typically CRTs – that exhibit near-perfect additive mixing. For faithful display, you also want near-perfect additive mixing! Any 4-primary display (or 5 or 6) needs signal processing to display colours reasonably close to those experienced by the content creators. Quad Pixel Technology involves signal processing that roughly mimics additive mixture of RGB, but substitutes a yellow stimulus for certain mixtures of red and green. The non-additive nature of the Quattron departs from the

Poynton's Vector Issue 8, *Wide gamut and wild gamut: xvYCC for HD*.

creative intent of the material, a subject that I took up in Issue 8. When such a new display is driven with “legacy” image data, the wrong colours are displayed.

CE vendors are generally more interested in colorful images than in accurate images, but as far as I'm concerned, the mismatch between content creation and content display is a problem. I want faithful display of what the director experienced. Faced with a Quattron, a home theatre calibrator has to dial-out the enhanced yellow gamut in order to maintain the director's creative intent. As mentioned in Issue 8, we await a coherent industry-wide approach to mastering and displaying wide-gamut content.

On a related topic, I recently got e-mail from a studio engineer colleague who had dusted off his ancient Minolta TV-2150 TV Color Analyzer II, a colorimeter, to calibrate some studio reference displays. He discovered that a fairly new LCD professional display measured off-the-scale according to his meter.

Colorimeter filters aren't a perfect match to the ideal CIE spectral functions (*colour matching functions,* CMFs): A particular instrument might have response slightly too high in some regions of the spectrum and slightly too low in other regions. When measuring spectrally broad and smooth stimuli, the errors tend to average out; colorimeters do reasonably well. But some modern displays have narrow or spiky spectral content. A spike of the display primary might sample the instrument's response over a narrow range where there happens to be a mismatch with the CIE standard. This was the issue faced by my colleague; erroneous readings resulted. The worst case occurs with laser primaries, which effectively point-sample the instrument curves with no spectral averaging at all. If the instrument curve isn't accurate at *every* wavelength, problems arise. The issue isn't academic: Lasers were used to illuminate a DLP in a recently withdrawn Mitsubishi rear-projection TV model; Kodak recently demonstrated a laser-illuminated digital cinema projector.

Some colorimeters can be calibrated (typically using a 3×3 matrix) to achieve higher accuracy on a particular type of display. The approach is useful when measuring a set of displays that have the same spectral characteristics, say a bunch of Sony BVM CRTs, but is of little use in applications such as home theatre calibration that are faced with a diversity of display types.

Returning to RGB LED backlights, they have narrow spectral bandwidths: They're “spiky.” They are potentially incorrectly measured by classic colorimeters. The lesson for the systems calibrator is to use either a really accurate colorimeter or a spectroradiometer. I fear that my colleague's old TV-2150 TV Color Analyzer II will have to be retired. It was fine for CRTs, but is bound to be inaccurate for newer displays. And CRTs are disappearing fast; see Issue 6.

Poynton's Vector Issue 6, *The demise of the CRT*.

A final comment on the Quattron: If its white LED backlights resemble others common in the industry, they are essentially blue LEDs augmented by phosphor that converts visible blue light to what you might call yellow. The blue from the LED adds to the yellow from the phosphor to yield white. But the white has a blue spike that is liable to cause measurement trouble on classic colorimeters.

I welcome your comments and suggestions! ■