A true perceptual HSL colour space

We will use the Lab colour space to obtain a quantitative colour description in terms of hue, saturation, and lightness. But one that truly corresponds to our knowledge on human vision and colour perception, in contrast to *ad hoc* spurious HSB/HSV/HSI/... so-called "natural" colour spaces, which contradict the very basics of human colour vision.

From RGB to XYZ

Let us assume we are working with RGB CCIR_{709} primaries. To get the Lab components of an RGB_{709} triplet, we have to pass through the Rosetta stone of colour systems, CIE XYZ,

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} 0.412453 & 0.357580 & 0.180423 \\ 0.212671 & 0.715160 & 0.072169 \\ 0.019334 & 0.119193 & 0.950227 \end{pmatrix} \begin{pmatrix} r \\ g \\ b \end{pmatrix}$$

where r, g, and $b \in [0,1]$ denote *normalized* R, G and B components. Does perhaps the central row of the RGB to XYZ conversion matrix look familiar to you?

From XYZ to Lab

Then we proceed from XYZ to Lab coordinates by

$$L = \begin{cases} 116 \cdot Y^{1/3} - 16, & \text{for } Y > 0.008856 \\ 903.3 \cdot Y, & \text{for } Y \leq 0.008856 \end{cases} \in [0, 100].$$

$$a = \frac{1000 \left(f(\frac{X}{X_{\mathrm{W}}}) - f(Y) \right) + 1}{255} \in [-1, 1]$$

$$b = \frac{400\left(f(Y) - f(\frac{Z}{Z_\mathrm{W}})\right) + 1}{255} \in [-1, 1]$$

where X_W and Z_W denote the X and Z components of white, and

$$f(\alpha) = \begin{cases} \alpha^{1/3}, & \text{for } \alpha > 0.008856 \\ 7.787 \cdot \alpha + \frac{16}{116}, & \text{for } \alpha \leq 0.008856 \end{cases}$$

L stands for lightness, a nonlinear transformation of luminance which is related to perceptual brightness, and a and b are chrominance (or "colour") components, known as the green-red axis (a) and the blue-yellow axis (b), with white (or gray, depending on L) in the center. Pay attention to the range of each component, specified above.

A Hue–Saturation–Lightness Lab space (HSLab)

Hue and saturation at a given lightness L are directly determined by the polar coordinates of the point (a, b) within the chrominance ab plane. Thus we define saturation S_{ab} as the distance from (a, b) to the origin $(0, 0)$, and hue H_{ab} as the angle of the vector $(0, 0) \rightarrow (a, b)$ with respect to an arbitrary reference, e.g. if we use $\hat{a}$ as the starting angle, we will have hue $H_{ab} = 0°$ for red and $H_{ab} = 180°$ for green.