Figures for "Vectorial Color"
James A. Worthey, 2009
Captions are reproduced here for convenience. There may be discrepancies with the caption list in the ms.


Fig. 1. Four sets of color matching functions that are equivalent for matching. Set (a) are idealized experimental data for the $2^{\circ}$ observer, with narrow-band primaries at 603,538 , and 446 nm . Set (b) are cone sensitivities. Set (c) is the CIE $2^{\circ}$ observer functions, x-bar, y-bar, z-bar. Set (d) are Guth's 1980 opponent color functions, but normalized.


Fig. 2. Color matching functions, equivalent to the $2^{\circ}$ observer. The solid curves are similar to Wright's data, while the dashed curves are similar to Guild's.


Fig. 3. Chromaticity diagram, showing the cone sensitivity peaks, and the NTSC video phosphors.


Fig. 4. A familiar diagram for additive color mixing.


Fig 5. Red cone sensitivity minus green cone sensitivity. The functions of Fig. 1(b) are subtracted, without adjustment of amplitudes.


Fig. 6. Function $\omega_{1}$ is the usual y-bar, but normalized. $\omega_{2}$ then is red minus green, but with amplitudes set to make the functions orthonormal.


Fig. 7. Combining the functions of Fig. 6 into a parametric plot gives the black shape, $\omega_{2}$ vs $\omega_{1}$. Transforming by Eq. (7) with $\theta=81.8^{\circ}$ gives the rotated shape shown in gray.


Fig. 8. The dichromatic spectrum locus is the same as in Fig. 7. Arrows show vectorial addition of narrowband stimuli at 550 nm and 590 nm . Circles show where vector length reaches a local maximum.


Fig. 9. The orthonormal opponent CMFs, based on the $2^{\circ}$ observer.


Fig. 10. The locus of unit monochromats, LUM. The locus is the edge of the indicated surface, and is a parametric plot of the functions in Fig. 9. It is the same LUM as defined by Cohen, but his preferred method would leave the curve floating in space, without specific axes.


Fig. 11. The projection of the LUM into the $\omega_{2}-\omega_{3}$ (chromatic) plane.


Fig. 12. The heavy black curve is D65. The dash-dot curve is the fundamental metamer of D65, the total of the $\omega_{1}$ (green), $\omega_{2}$ (red) and $\omega_{3}$ (blue) components. Subtracting the fundamental metamer from D65 gives the metameric black (gray dashed).


Fig. 13. Two lights which have the same tristimulus vector. That is, they are metameric to the $2^{\circ}$ observer. The solid curve is a high-pressure mercury light, while dot-dash indicates a version of JMW daylight.


Fig. 14. The 2 lights of Fig. 13 are now seen as vector sums, with the LUM as a backdrop. The vector components of daylight make a smooth arc of thin arrows. The mercury light's path, with thicker arrows, takes a shortcut to the white point.


Fig. 15. The gray curves are CIE functions: gray dashed $=z$-bar; gray solid $=x$-bar. The black curves
are two of the orthonormal functions: dashed black $=$ dashed = z-bar; gray solid = x-bar. The black curves
are two of the orthonormal functions: dashed black $=$ $\omega_{3} ;$ solid black $=\omega_{2}$.


Fig. C1. Thin solid curves are the orthonormal basis, the same as Fig. 9. Grey dashes are an orthonormal set based on Stockman and Sharpe cones.

