Universidad Popular del Cesar

Tratamiento de Señales

Version 2024-I

Espacios de Color

[Capítulo 2]

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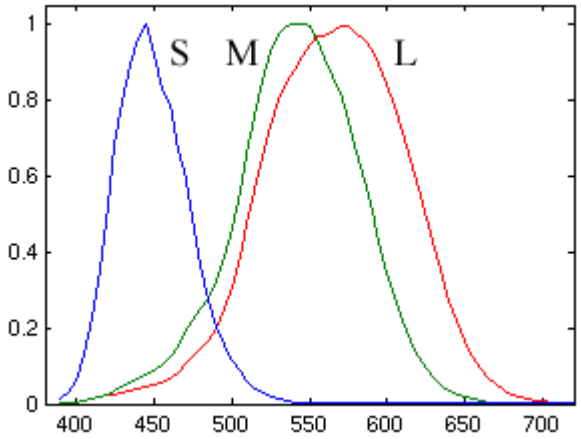
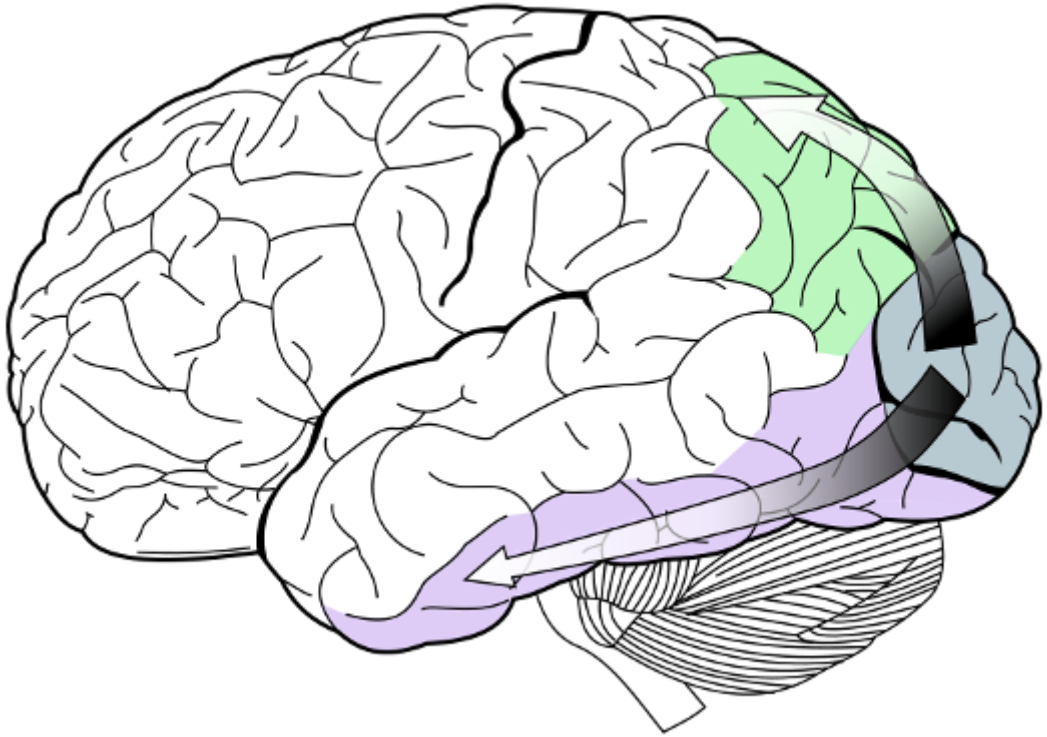
El objetivo de los espacios de color es ayudar al proceso de la descripción del color, ya sea entre personas o entre computadores.

[Percepción del Color]

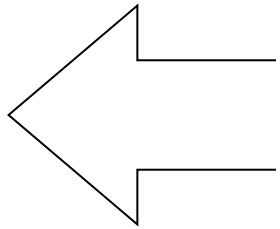




Cone type	Name	Range	Peak wavelength
S	β	400–500 nm	420–440 nm
M	γ	450–630 nm	534–545 nm
L	ρ	500–700 nm	564–580 nm

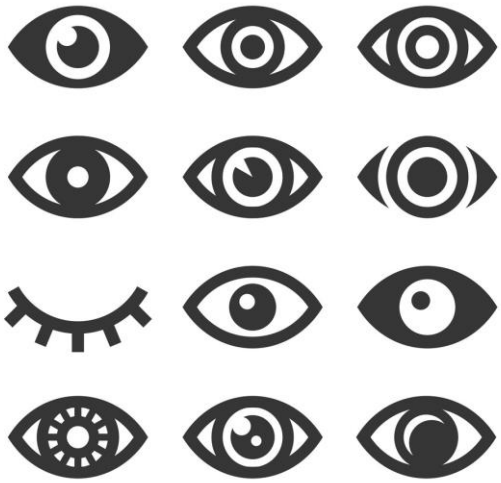
[Percepción del Color]

No olvidar que el color depende del espectro de la fuente

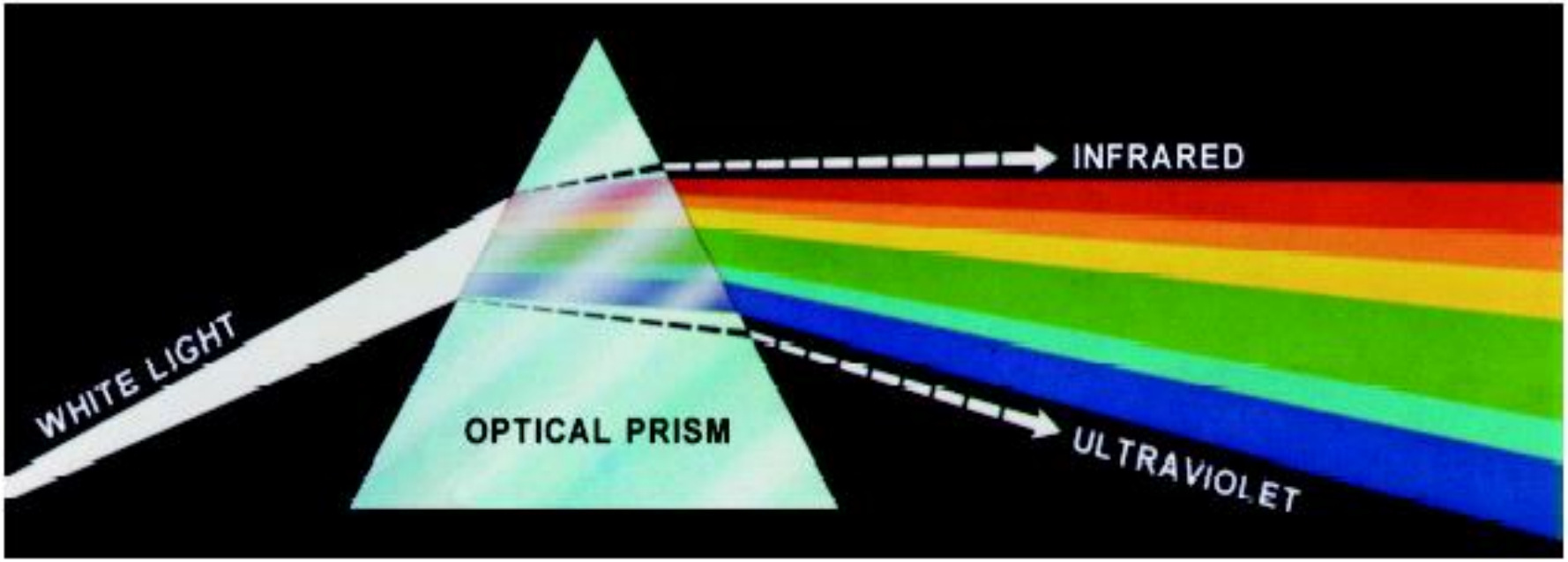


[Percepción del Color]

Y depende también de los ojos que miran

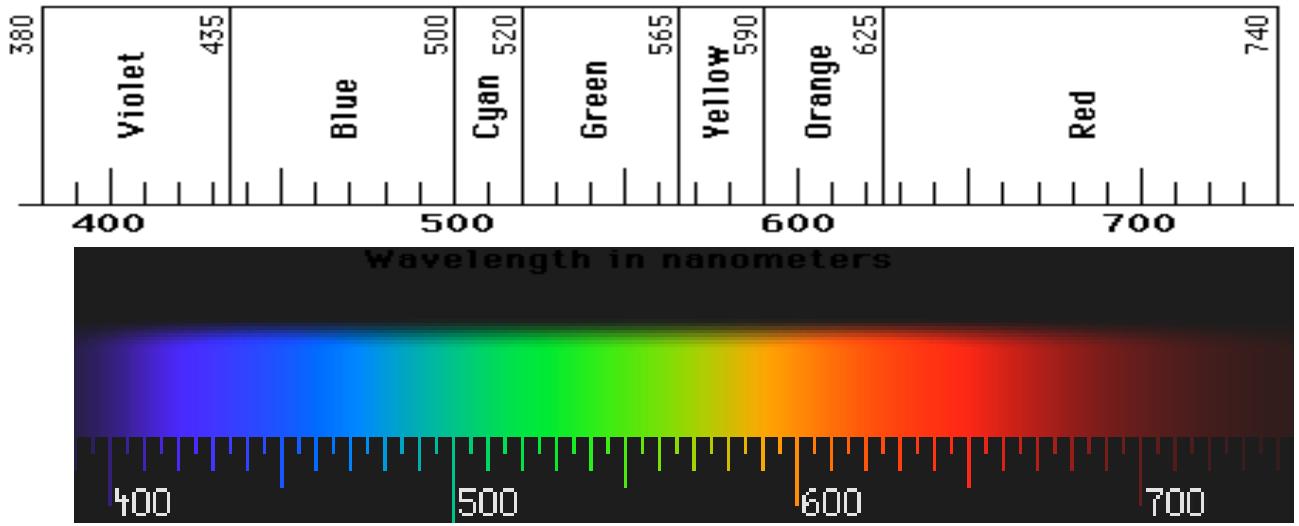


[Prisma Óptico]



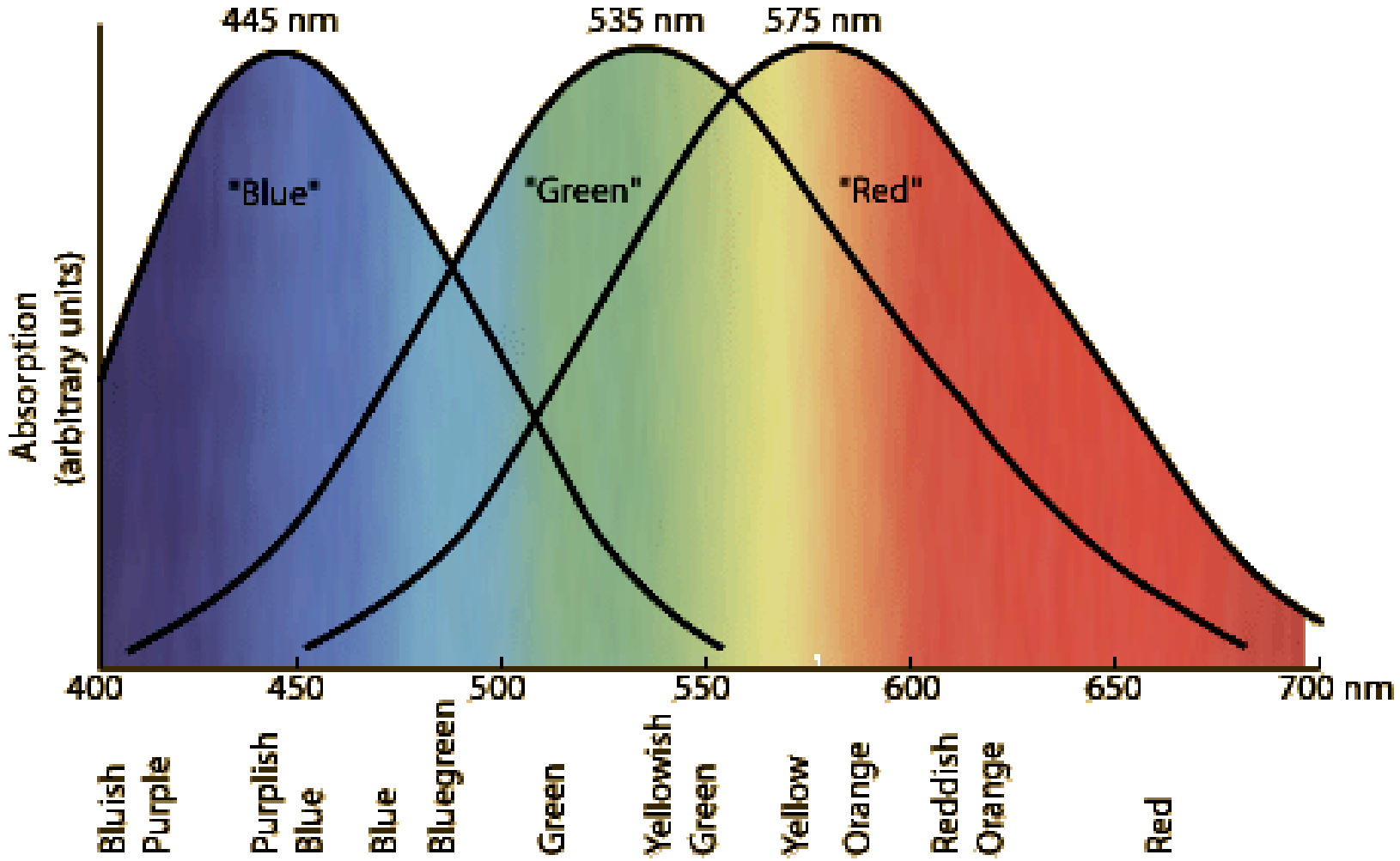
[Definición del Color]

El color es el resultado de la percepción de la luz en espectro visible, con longitudes de onda entre 400 nm y 700 nm, que inciden en la retina del ojo.



Longitud de onda [nm]

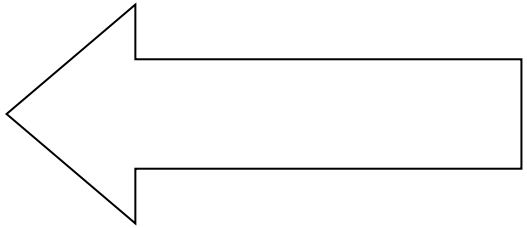
[Respuesta del ojo humano]



[Espacios de Color ‘Substractivos’]

[Modelo Substractivo]

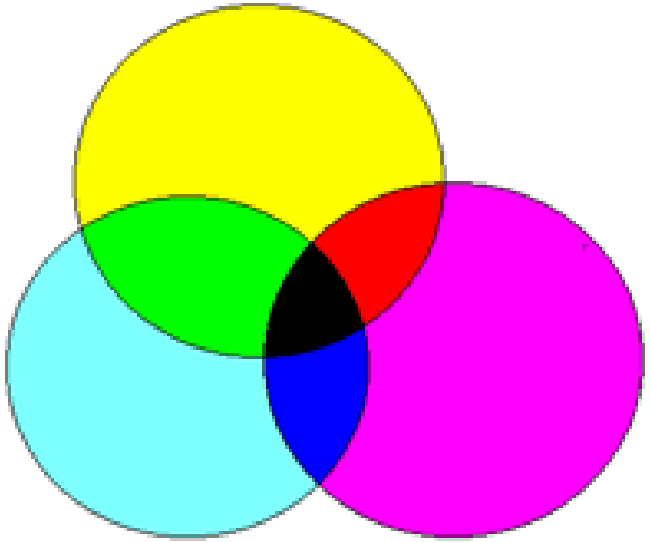
El color que muestra una superficie depende de las partes del espectro visible que no son absorbidas y por lo tanto permanecen visibles.



Luz Blanca
(todos los colores)

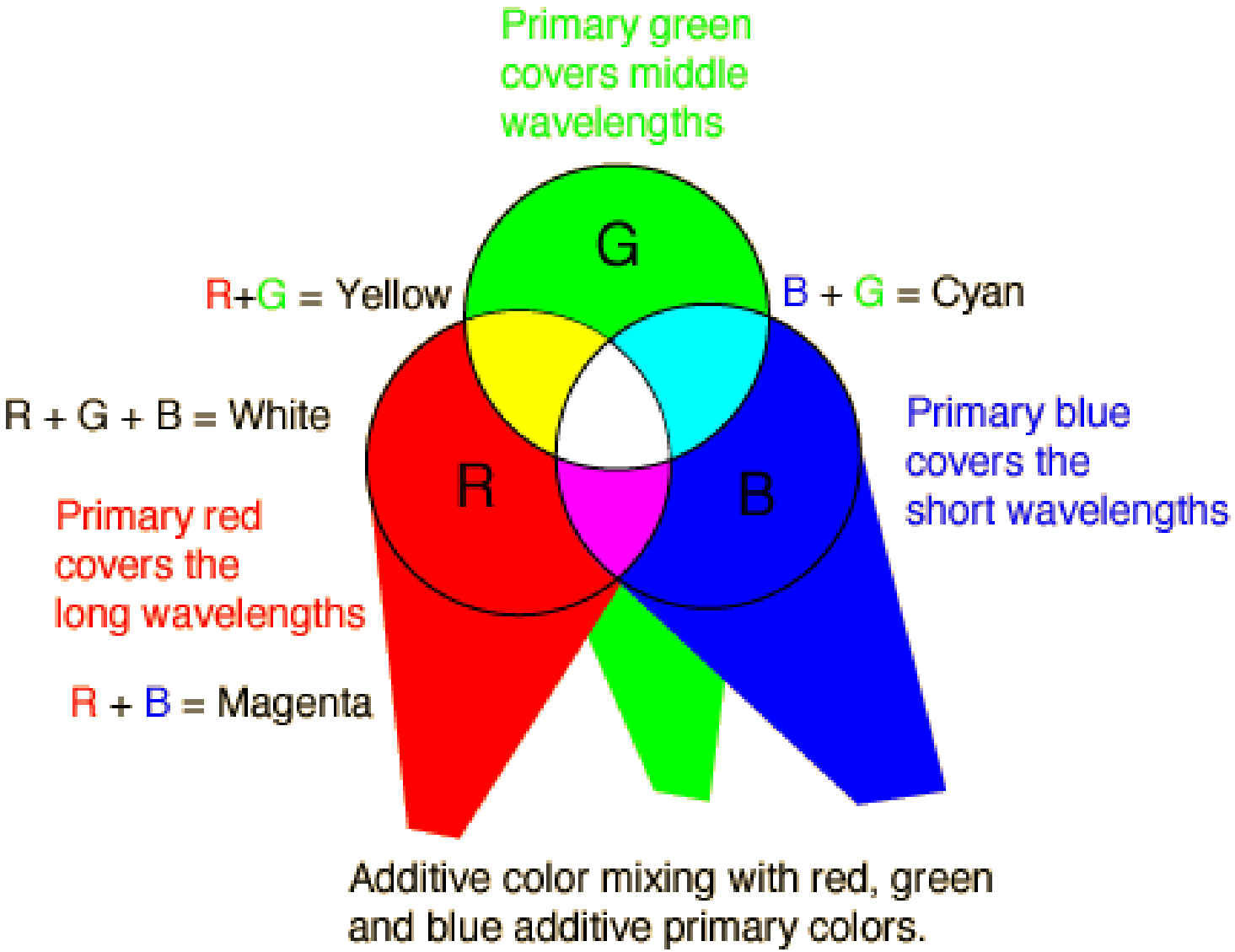
[Modelo Substractivo]

Los objetos restan porciones del espectro en determinadas longitudes de onda de la luz, conformando así el color



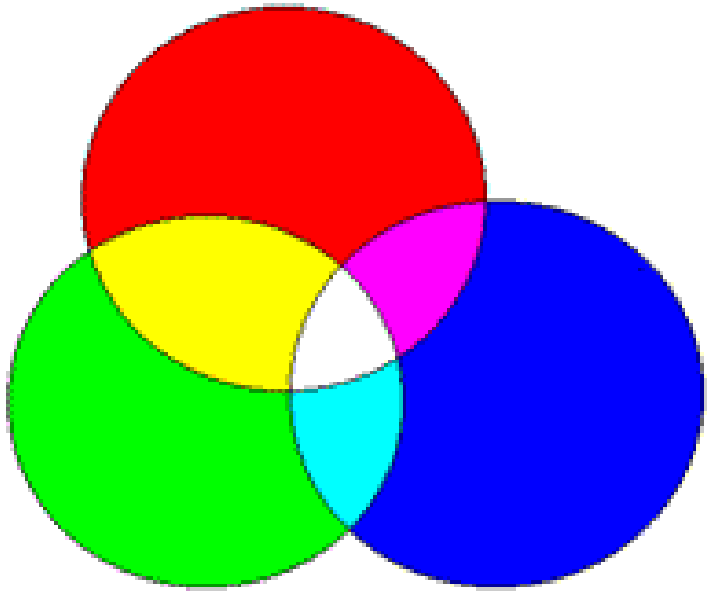
[Espacios de Color ‘Aditivos’]

[Modelo Aditivo]



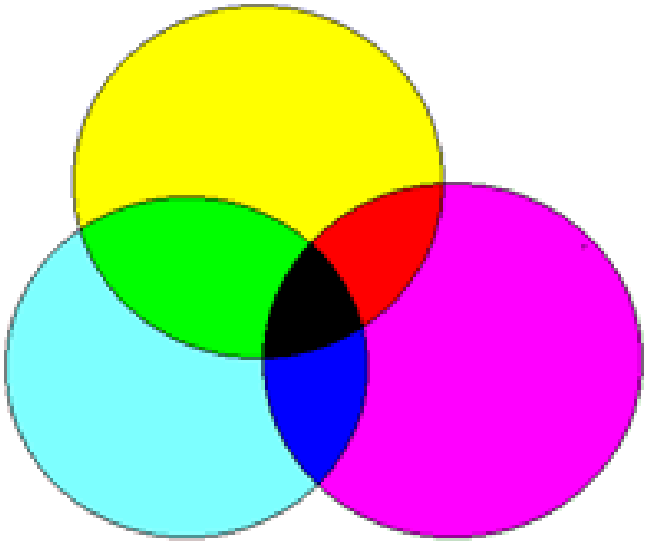
Additive color mixing with red, green and blue additive primary colors.

[Mezcla de Colores]



ADITIVO

Colores Primarios: RGB

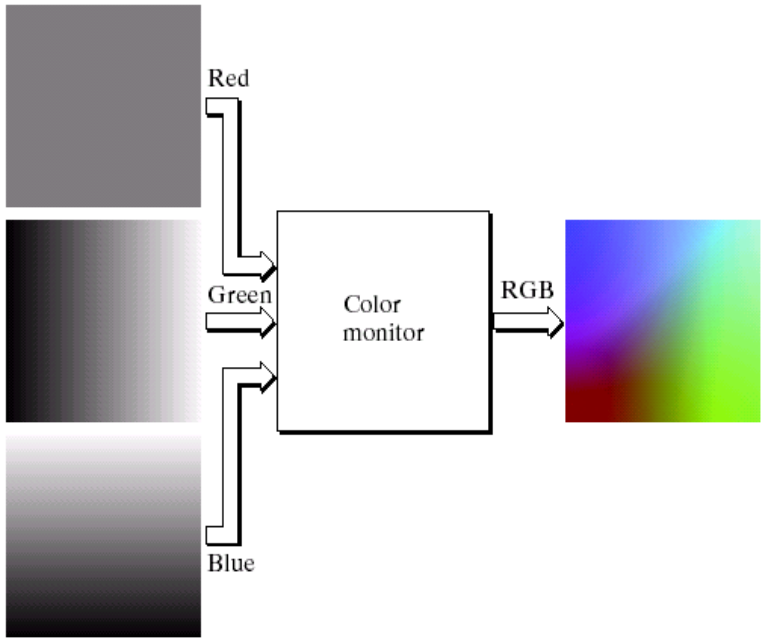


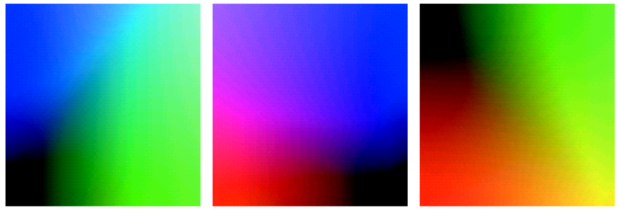
SUBSTRACTIVO

Colores Primarios :YMC, YMCK, RYB

[Espacio de Color RGB]

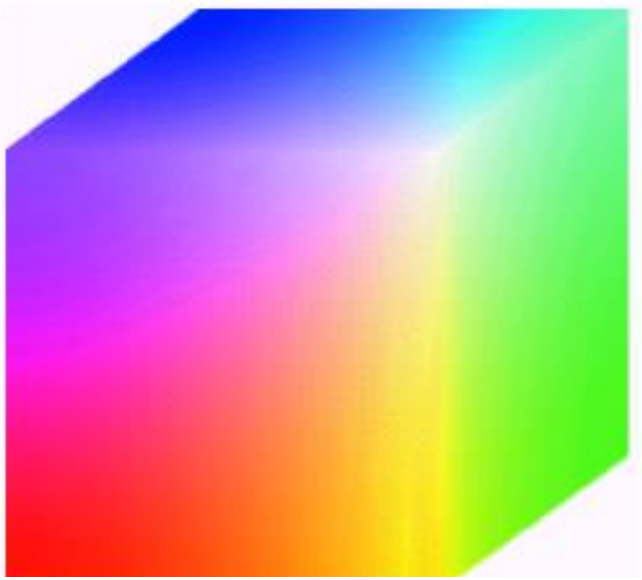
[Espacio de Color RGB]





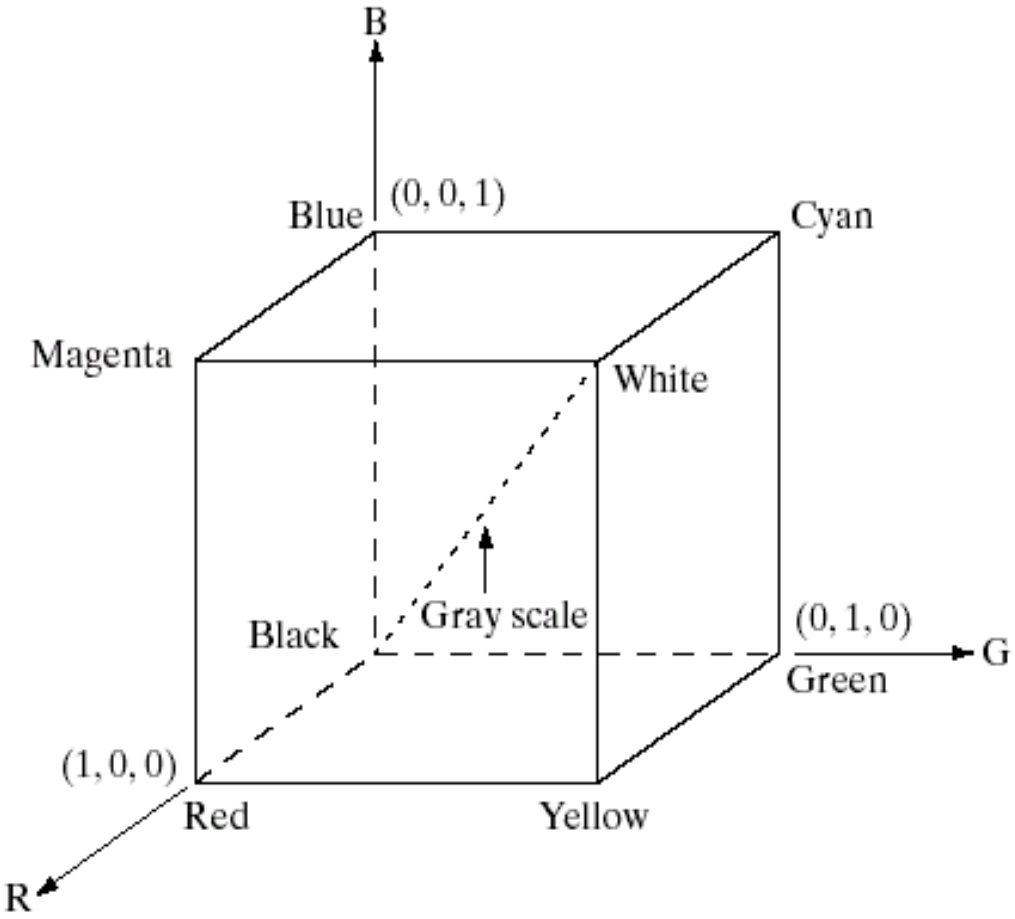
R. Gonzalez, R. Woods, S. Eddins (2009): Digital Image Processing Using MATLAB, 2nd edition. Gatesmark Publishing.

[Espacio de Color RGB]



$$\left(2^8\right)^3 = 16,777,216 \text{ Colors}$$

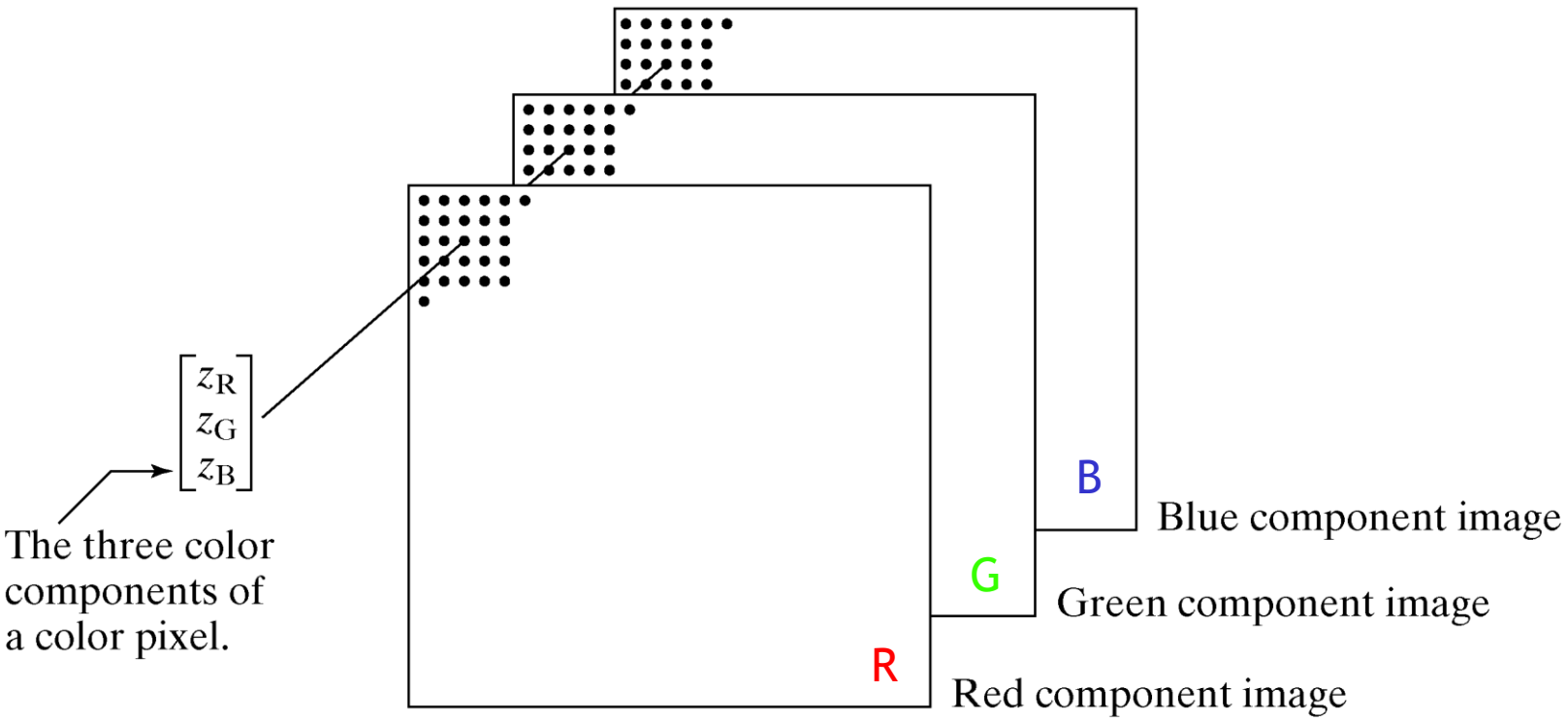
[Espacio de Color RGB]



R. Gonzalez, R. Woods, S. Eddins (2009): Digital Image Processing Using MATLAB, 2nd edition. Gatesmark Publishing.

[Espacio de Color RGB: Cómo se almacena una imagen a color 1/2]

Imagen digital a color



La imagen a color de N x M pixeles es almacenada como tres matrices de NxM pixeles, una para cada color (R,G,B). Así, el color del pixel (i,j) queda definido por el color dado por R(i,j), G(i,j) y B(i,j).

R. Gonzalez, R. Woods, S. Eddins (2009): Digital Image Processing Using MATLAB, 2nd edition. Gatesmark Publishing.

[Espacio de Color RGB: Cómo se almacena una imagen a color 2/2]

Imagen (X)

1	2	9	1	2	9	1	2	9	1	2	9	1	2	9	1	2	9	1	2	9	1	2	9
2	6	3	1	2	9	2	6	3	1	2	9	2	6	3	1	2	9	2	6	3	1	2	9
7	3	4	4	6	3	7	3	4	4	6	3	7	3	4	4	6	3	7	3	4	4	6	3
1	2	9	7	3	4	1	2	9	7	3	4	1	2	9	7	3	4	1	2	9	7	3	4
4	6	3	4	6	3	4	6	3	4	6	3	4	6	3	4	6	3	4	6	3	4	6	3
7	3	4	7	3	4	7	3	4	7	3	4	7	3	4	7	3	4	7	3	4	7	3	4
4	6	3	2	9	1	4	6	3	2	9	1	4	6	3	2	9	1	4	6	3	2	9	1
7	3	4	6	3	1	7	3	4	6	3	1	7	3	4	6	3	1	7	3	4	6	3	1
4	6	3	3	4	4	4	6	3	3	4	4	4	6	3	3	4	4	4	6	3	3	4	4
7	3	4	2	9	7	7	3	4	2	9	7	7	3	4	2	9	7	7	3	4	2	9	7
4	6	3	6	3	4	4	6	3	6	3	4	4	6	3	6	3	4	4	6	3	6	3	4
7	3	4	3	4	7	7	3	4	3	4	7	7	3	4	3	4	7	7	3	4	3	4	7
1	2	9	1	2	9	1	2	9	1	2	9	1	2	9	1	2	9	1	2	9	1	2	9
2	6	3	1	2	9	2	6	3	1	2	9	2	6	3	1	2	9	2	6	3	1	2	9
7	3	4	4	6	3	7	3	4	4	6	3	7	3	4	4	6	3	7	3	4	4	6	3
1	2	9	7	3	4	1	2	9	7	3	4	1	2	9	7	3	4	1	2	9	7	3	4
4	6	3	4	6	3	4	6	3	4	6	3	4	6	3	4	6	3	4	6	3	4	6	3
7	3	4	7	3	4	7	3	4	7	3	4	7	3	4	7	3	4	7	3	4	7	3	4
4	6	3	2	9	1	4	6	3	2	9	1	4	6	3	2	9	1	4	6	3	2	9	1
7	3	4	6	3	1	7	3	4	6	3	1	7	3	4	6	3	1	7	3	4	6	3	1
4	6	3	3	4	4	4	6	3	3	4	4	4	6	3	3	4	4	4	6	3	3	4	4
7	3	4	2	9	7	7	3	4	2	9	7	7	3	4	2	9	7	7	3	4	2	9	7
4	6	3	6	3	4	4	6	3	6	3	4	4	6	3	6	3	4	4	6	3	6	3	4
7	3	4	3	4	7	7	3	4	3	4	7	7	3	4	3	4	7	7	3	4	3	4	7

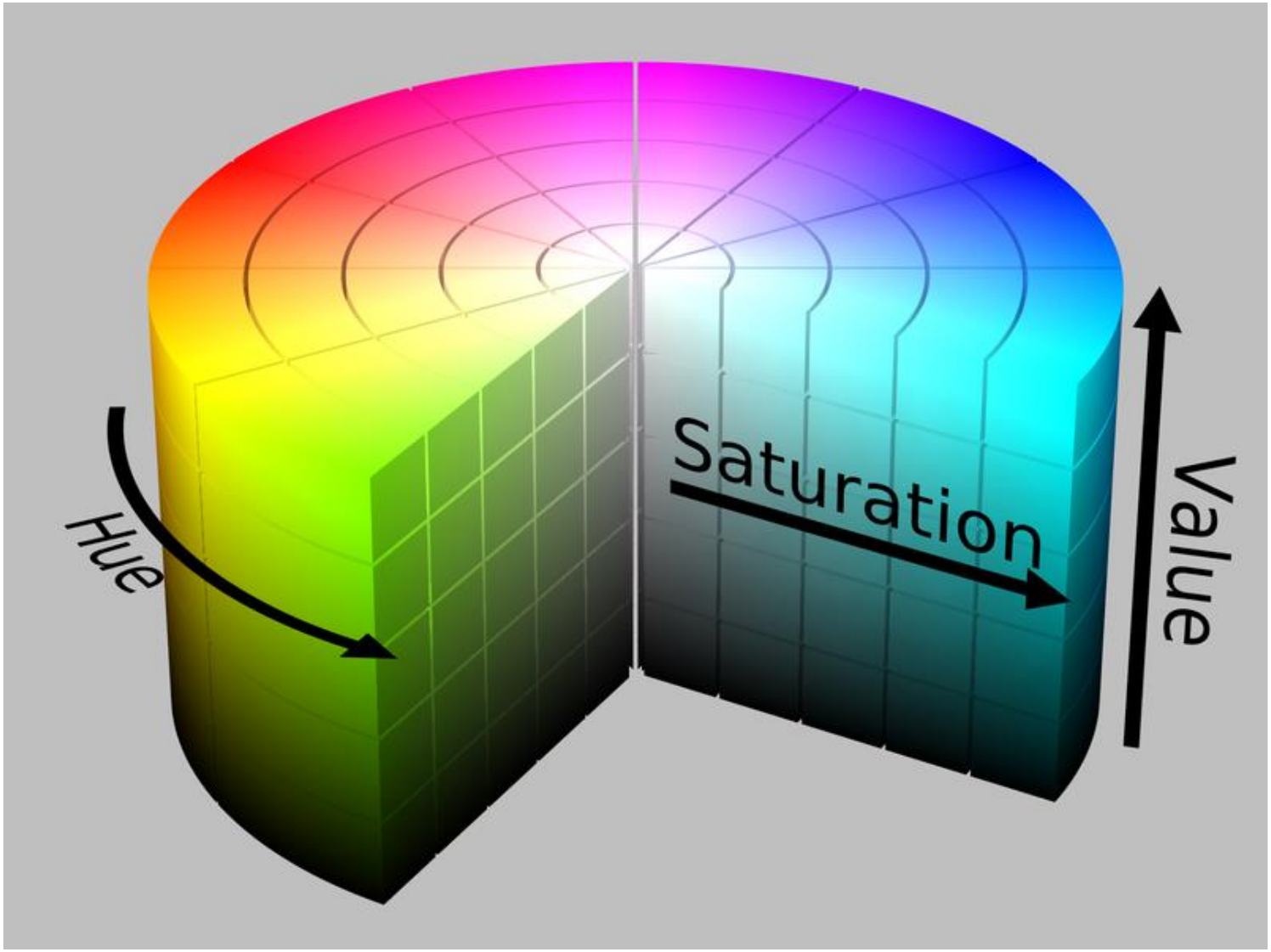
Paleta

	R	G	B
0	123	231	78
1	27	201	27
2	129	126	54
3	156	47	187
4	123	27	165
5	27	54	29
6	150	187	27
7	123	165	231
8	32	29	201
9	89	27	126

La imagen a color de N x M pixeles es almacenada como una matriz X de NxM pixeles que almacena índices de 0 a n-1, y una paleta de colores almacenada como una matriz de n x 3 elementos. Así, el color del pixel (i,j) de la imagen está definido en la fila k de la paleta, donde k = X(i,j).

[Espacio de Color HSV]

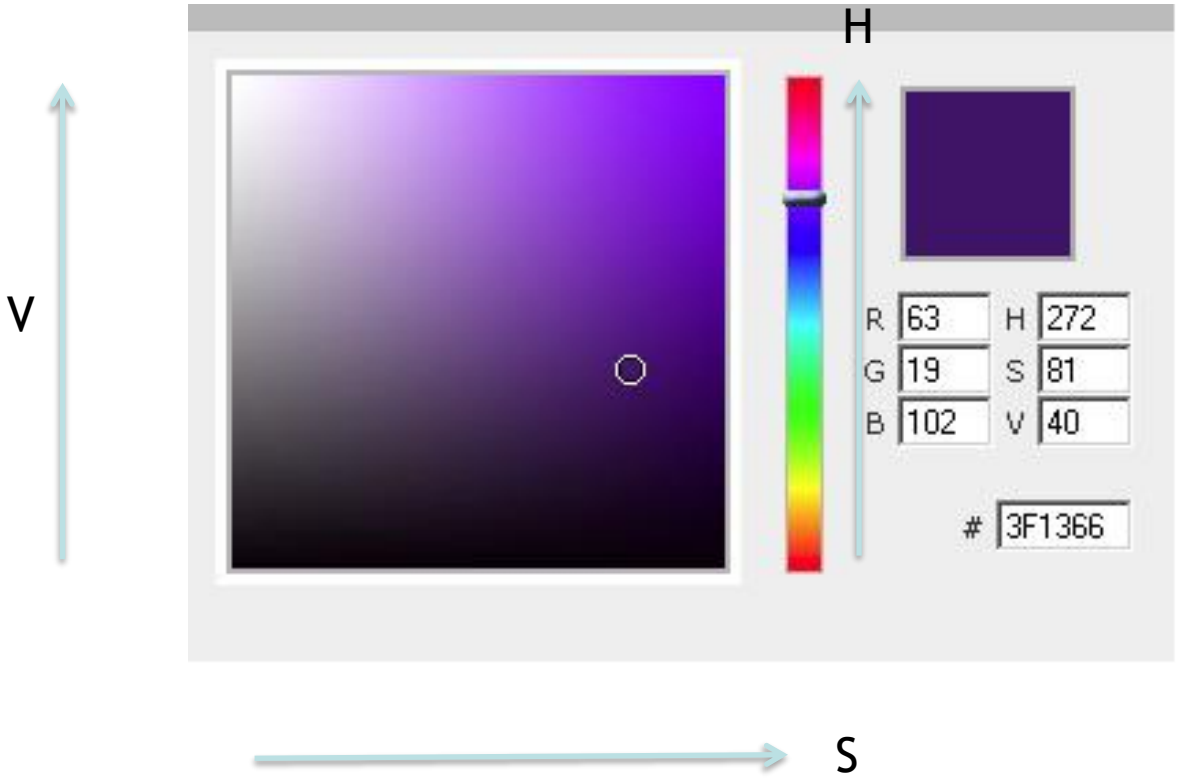
[Espacio de Color HSV]



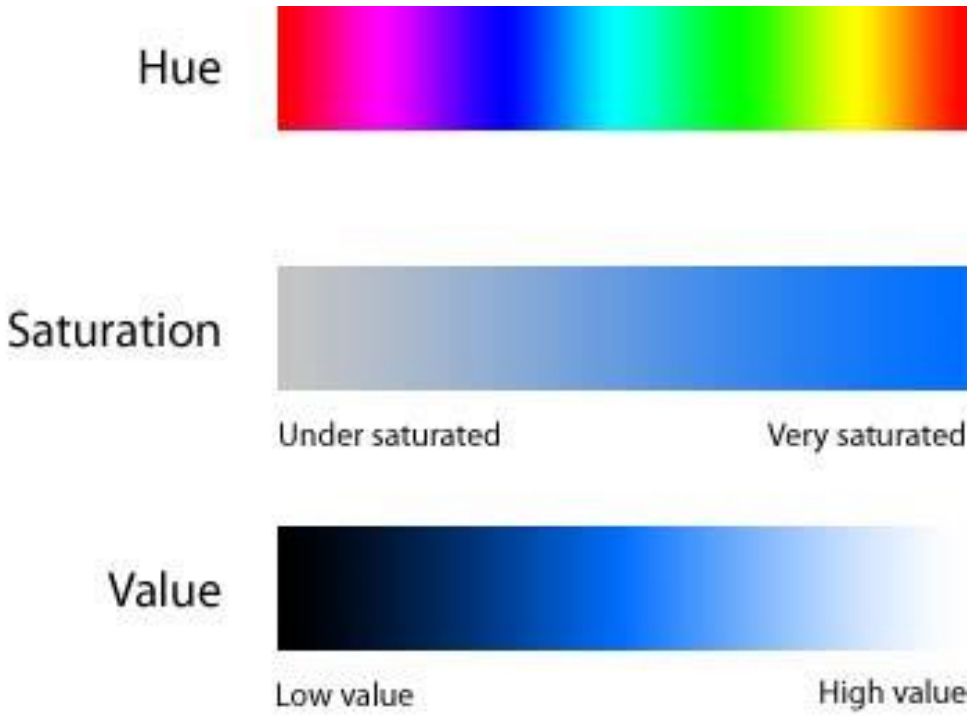
[Espacio de Color HSV]

Color Picker Tool:

http://www.dynamicdrive.com/dynamicindex11/yuicolorpicker/index.htm



[Espacio de Color HSV]



Conversión RGB a HSV

The *R*,*G*,*B* values are divided by 255 to change the range from 0..255 to 0..1:

$$R' = R/255$$

$$G' = G/255$$

$$B' = B/255$$

$$Cmax = \max(R', G', B')$$

$$Cmin = \min(R', G', B')$$

$$\Delta = Cmax - Cmin$$

Hue calculation:

$$H = \begin{cases} 0^\circ & \Delta = 0 \\ 60^\circ \times \left(\frac{G'-B'}{\Delta} mod 6\right) & , C_{max} = R' \\ 60^\circ \times \left(\frac{B'-R'}{\Delta} + 2\right) & , C_{max} = G' \\ 60^\circ \times \left(\frac{R'-G'}{\Delta} + 4\right) & , C_{max} = B' \end{cases}$$

Saturation calculation:

$$S = \begin{cases} 0 & , C_{max} = 0 \\ \frac{\Delta}{C_{max}} & , C_{max} \neq 0 \end{cases}$$

Value calculation:

$$V = Cmax$$

Conversión HSV a RGB

When $0 \le H < 360$, $0 \le S \le 1$ and $0 \le V \le 1$:

$$C = V \times S$$

$$X = C \times (1 - |(H / 60^\circ) \bmod 2 - 1|)$$

$$m = V - C$$

$$(R', G', B') = \begin{cases} (C, X, 0) & , 0^\circ \le H < 60^\circ \\ (X, C, 0) & , 60^\circ \le H < 120^\circ \\ (0, C, X) & , 120^\circ \le H < 180^\circ \\ (0, X, C) & , 180^\circ \le H < 240^\circ \\ (X, 0, C) & , 240^\circ \le H < 300^\circ \\ (C, 0, X) & , 300^\circ \le H < 360^\circ \end{cases}$$

$$(R,G,B) = ((R'+m)\times 255, (G'+m)\times 255, (B'+m)\times 255)$$

[Lightroom Demo]

[Cómo mejorar una imagen a color]

1. Tomar la imagen a color
2. Convertir RGB a HSV
3. Ecualizar sólo el canal V
4. Convertir el nuevo HSV a RGB
5. Fin

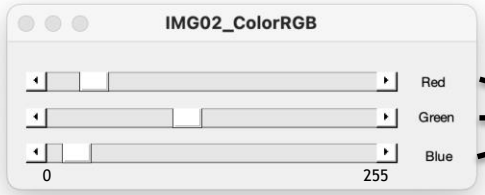
[Matlab Demo]

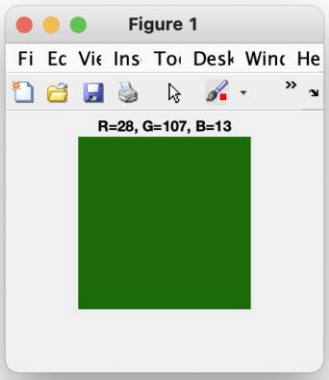
[Espacio de Color XYZ]

Experimento Wright – Guild (alrededor de 1920)

Colores Primarios

Pesos





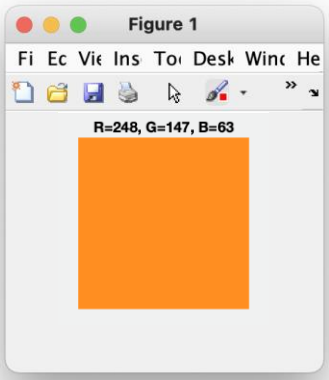
Resultado

Error

Referencia

Pesos

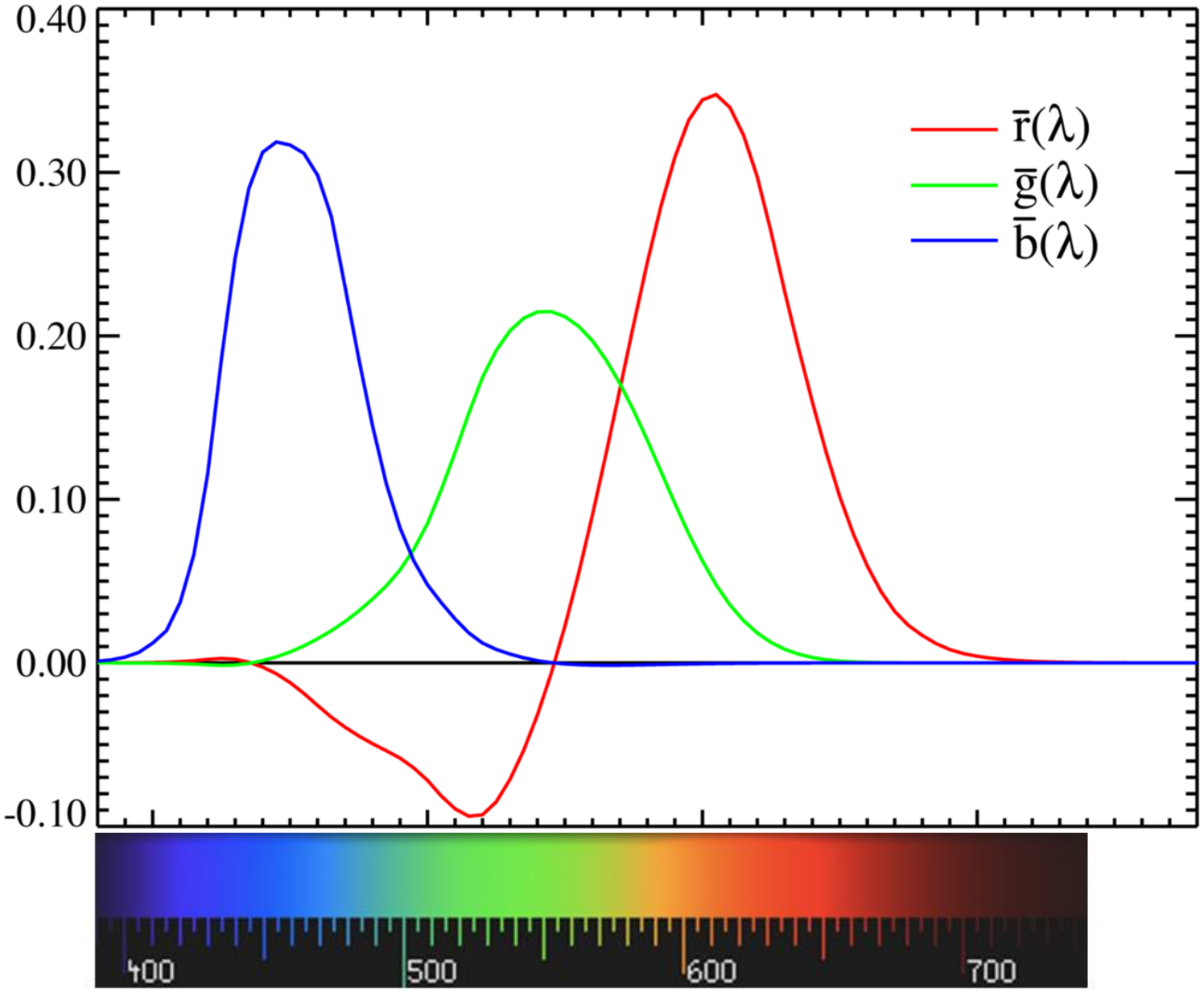
Colores Primarios

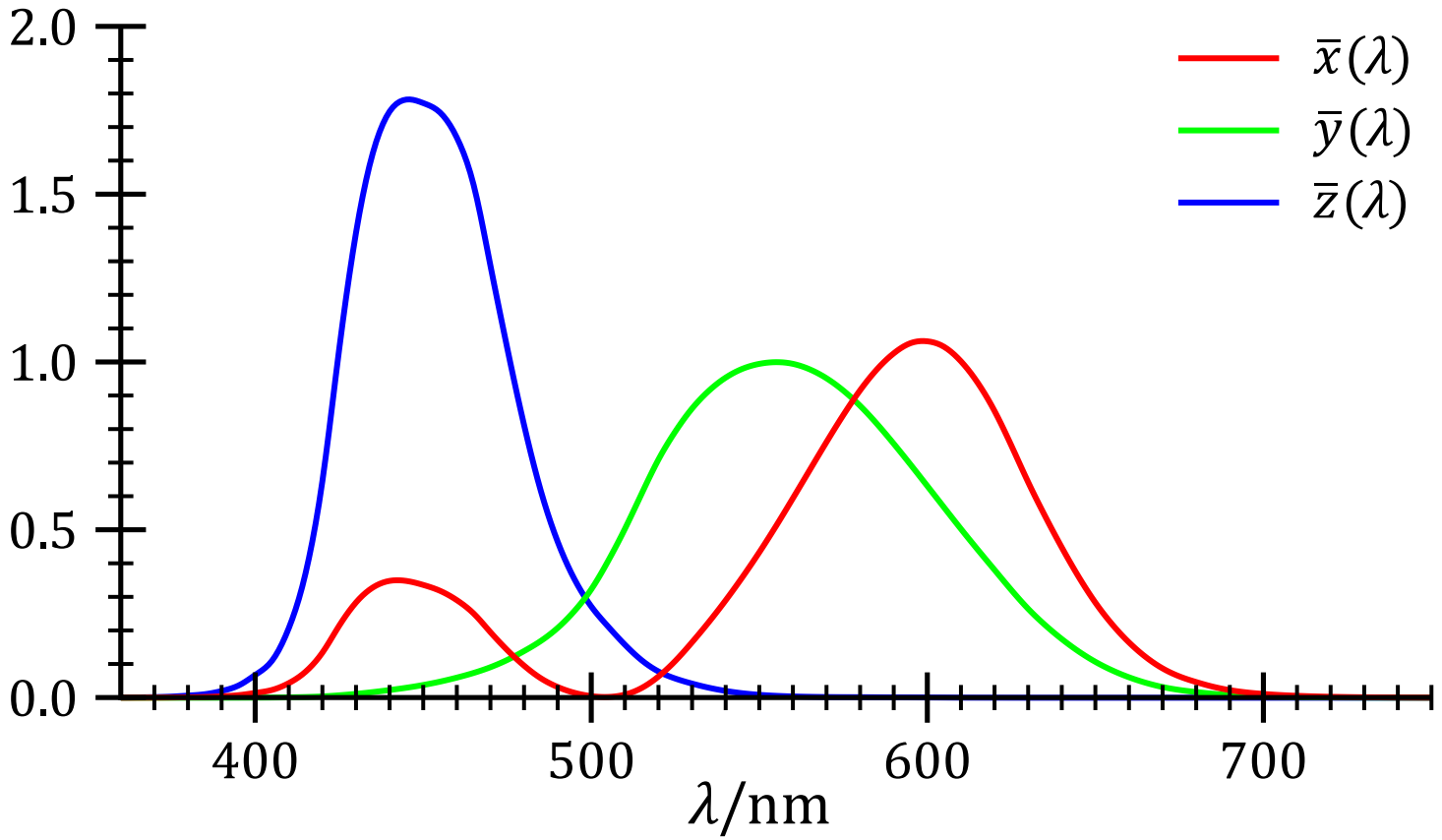


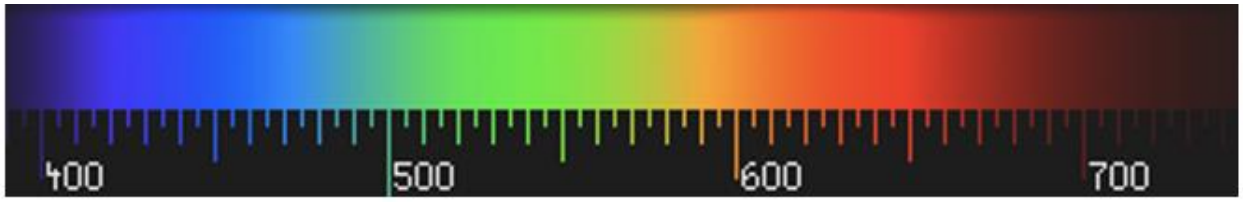
Resultado

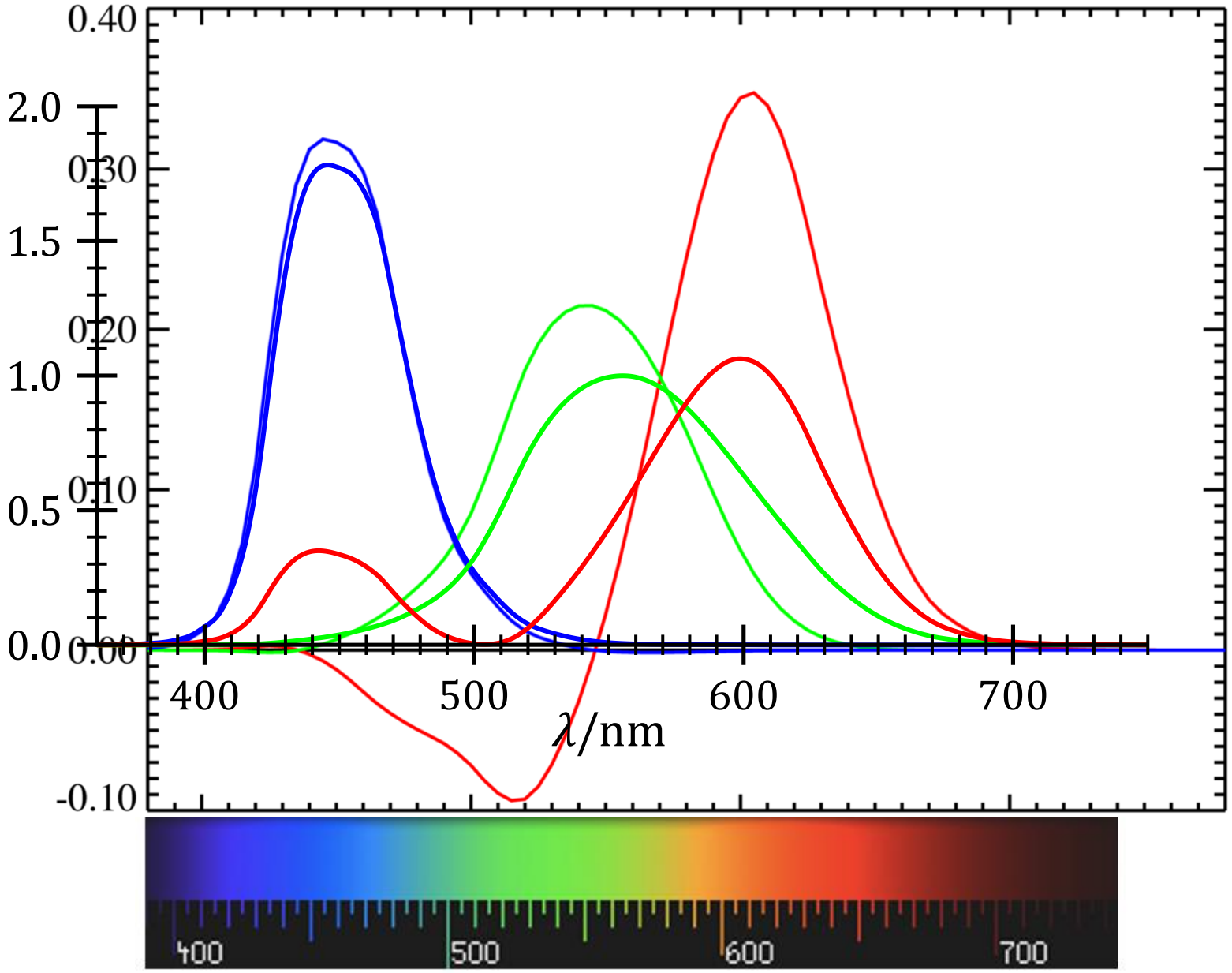
OK

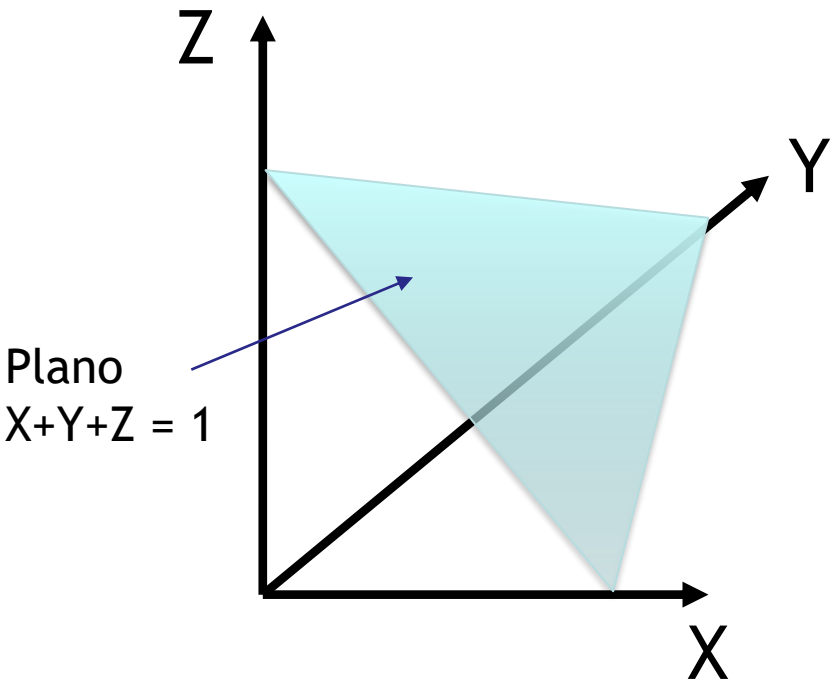
Referencia

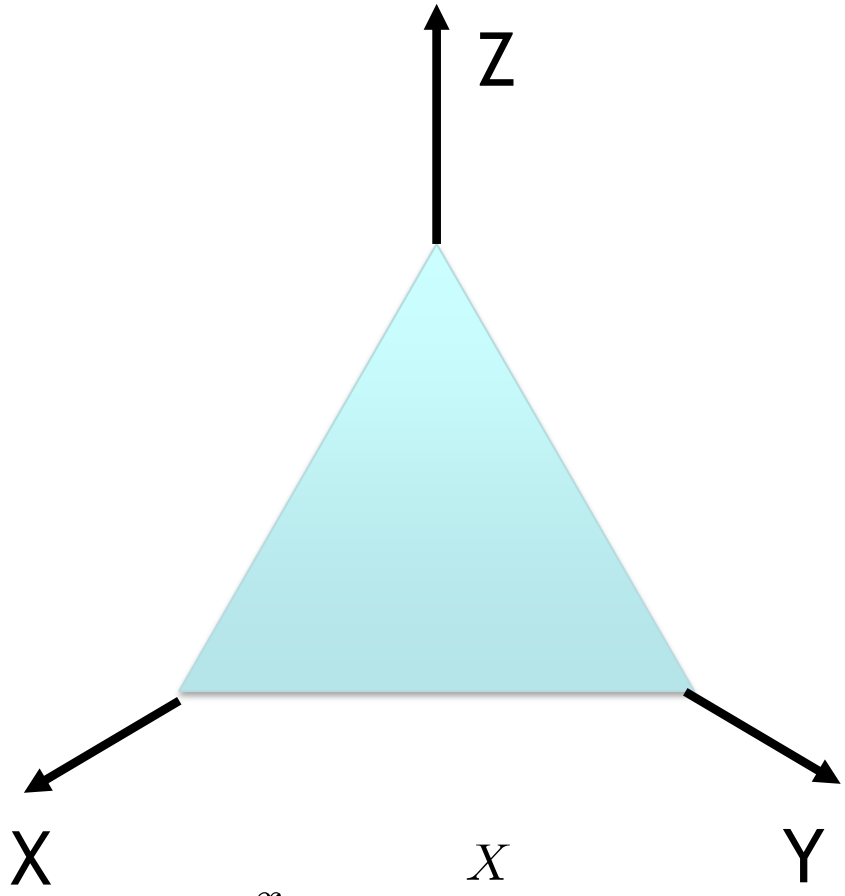

0.40
0.30
0.20
0.10
0.00
-0.10
r̄(λ)
ḡ(λ)
b̄(λ)
400
500
600
700


2.0
1.5
1.0
0.5
0.0
400
500
600
700
λ/nm
$\bar{x}(\lambda)$
$\bar{y}(\lambda)$
$\bar{z}(\lambda)$


400
500
600
700


0.40
2.0
0.30
1.5
0.20
1.0
0.10
0.5
0.0
0.00
-0.10
400
500
600
700
λ/nm
400
500
600
700

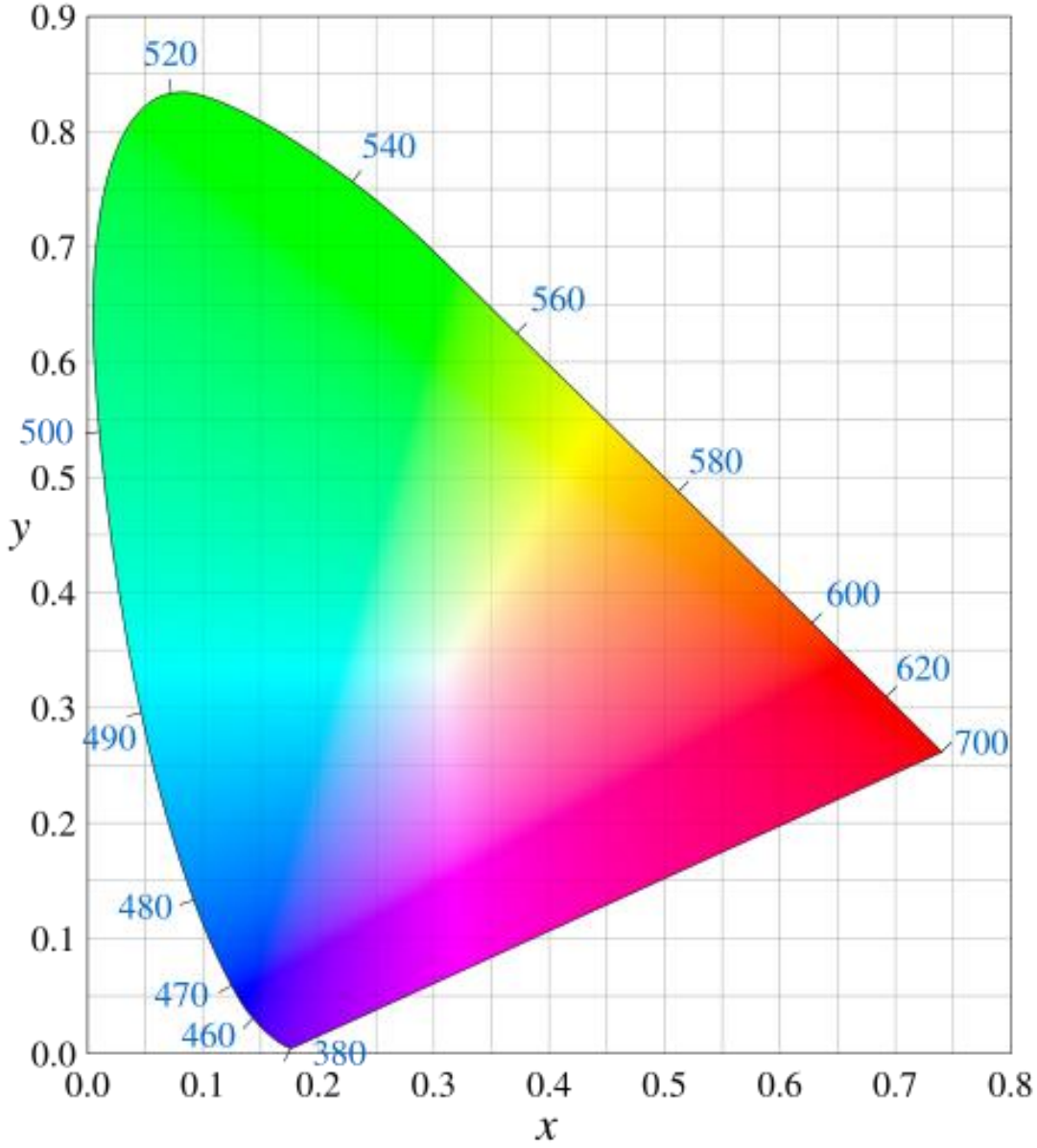




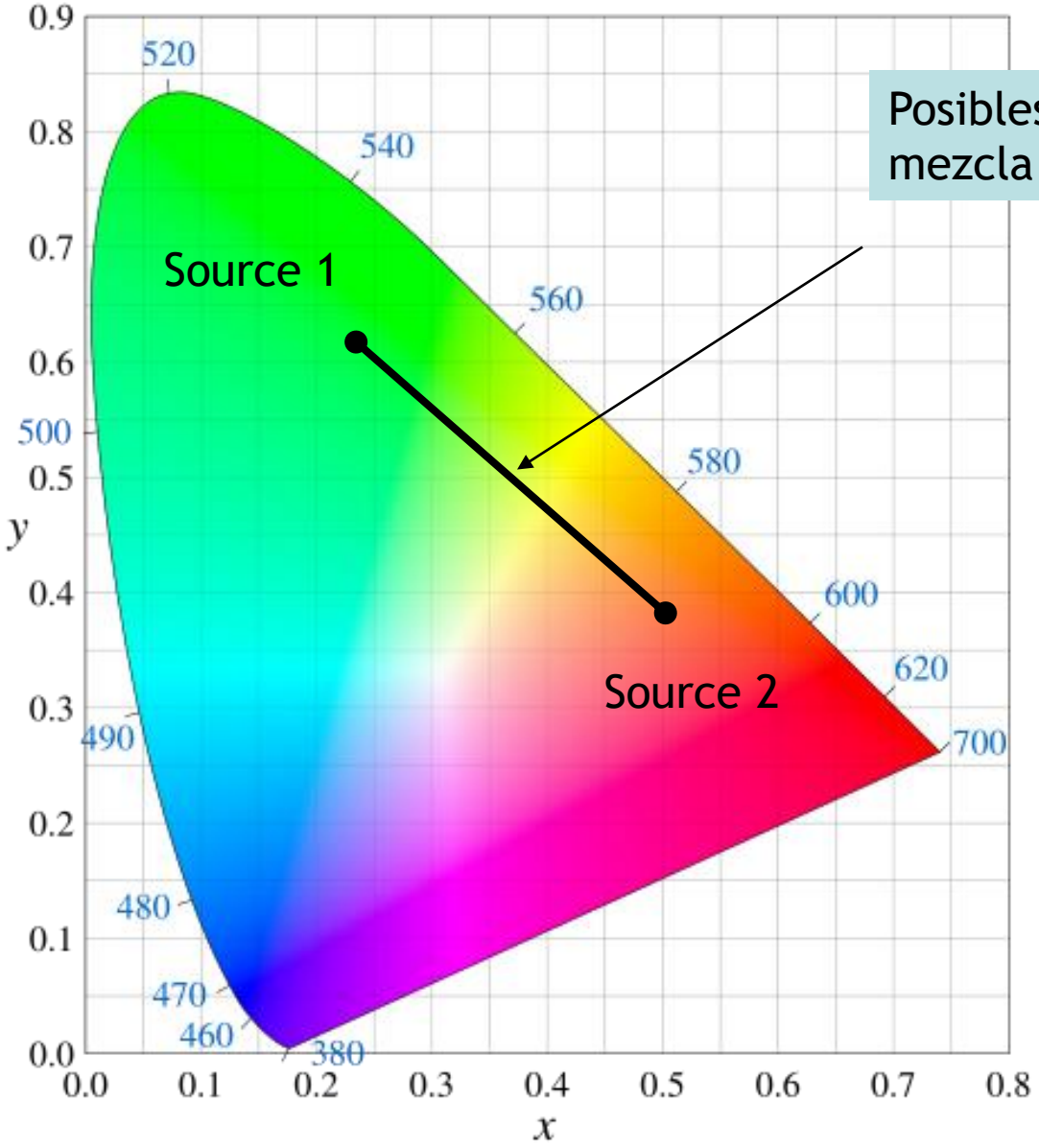
$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

[Diagrama CIE xy]

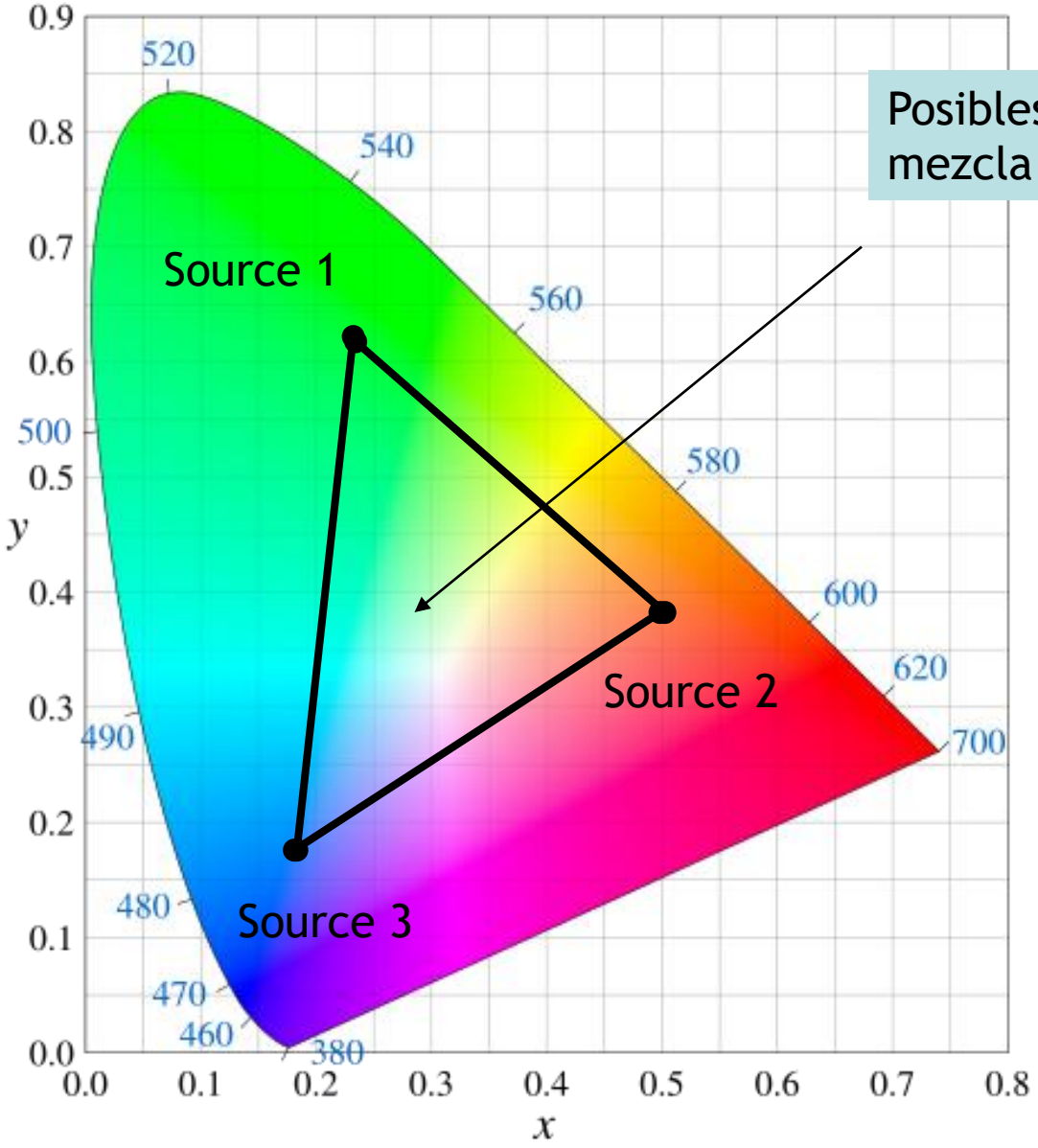


[Diagrama CIE xy]



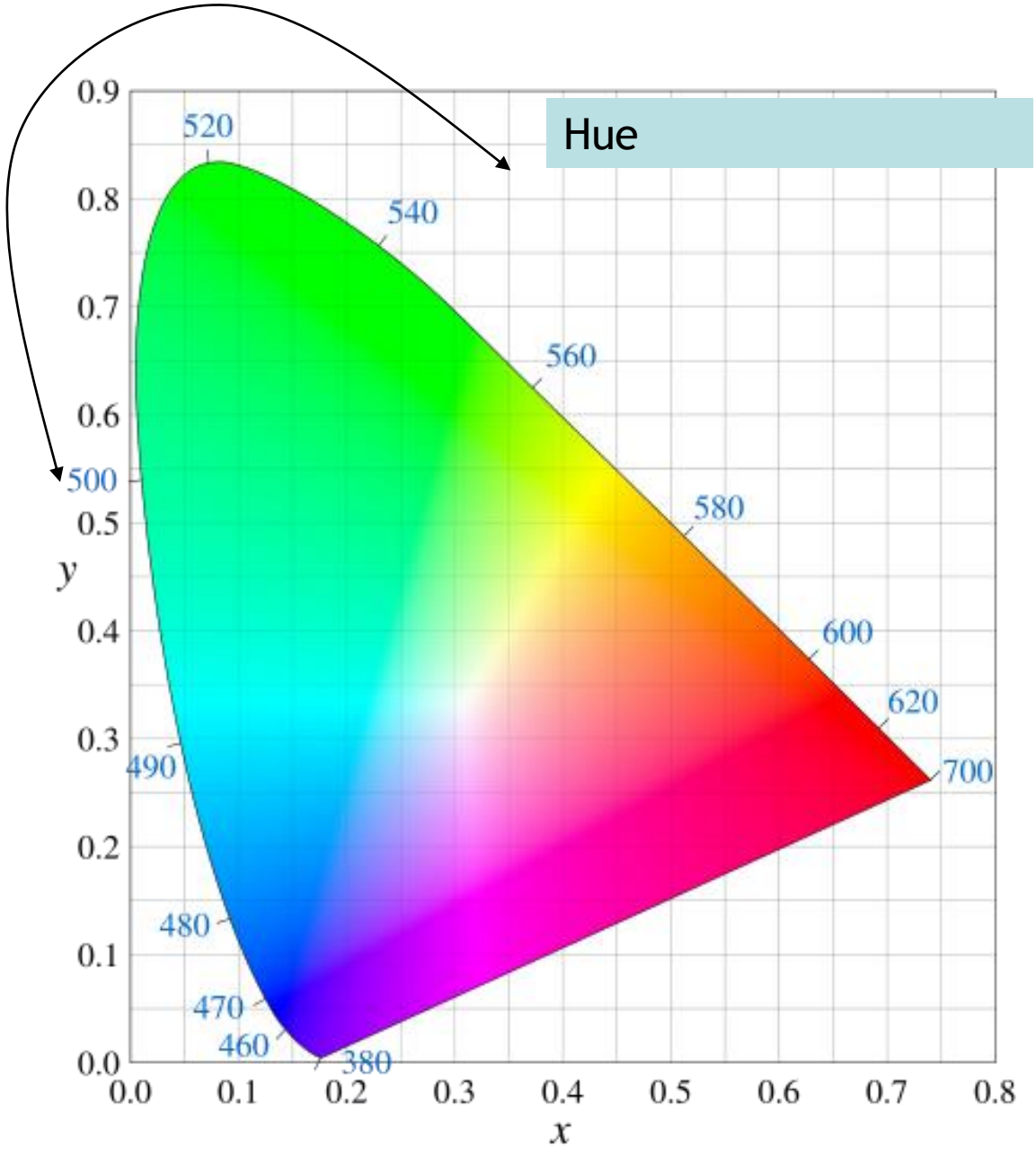
Posibles colores usando mezcla aditiva

[Diagrama CIE xy]

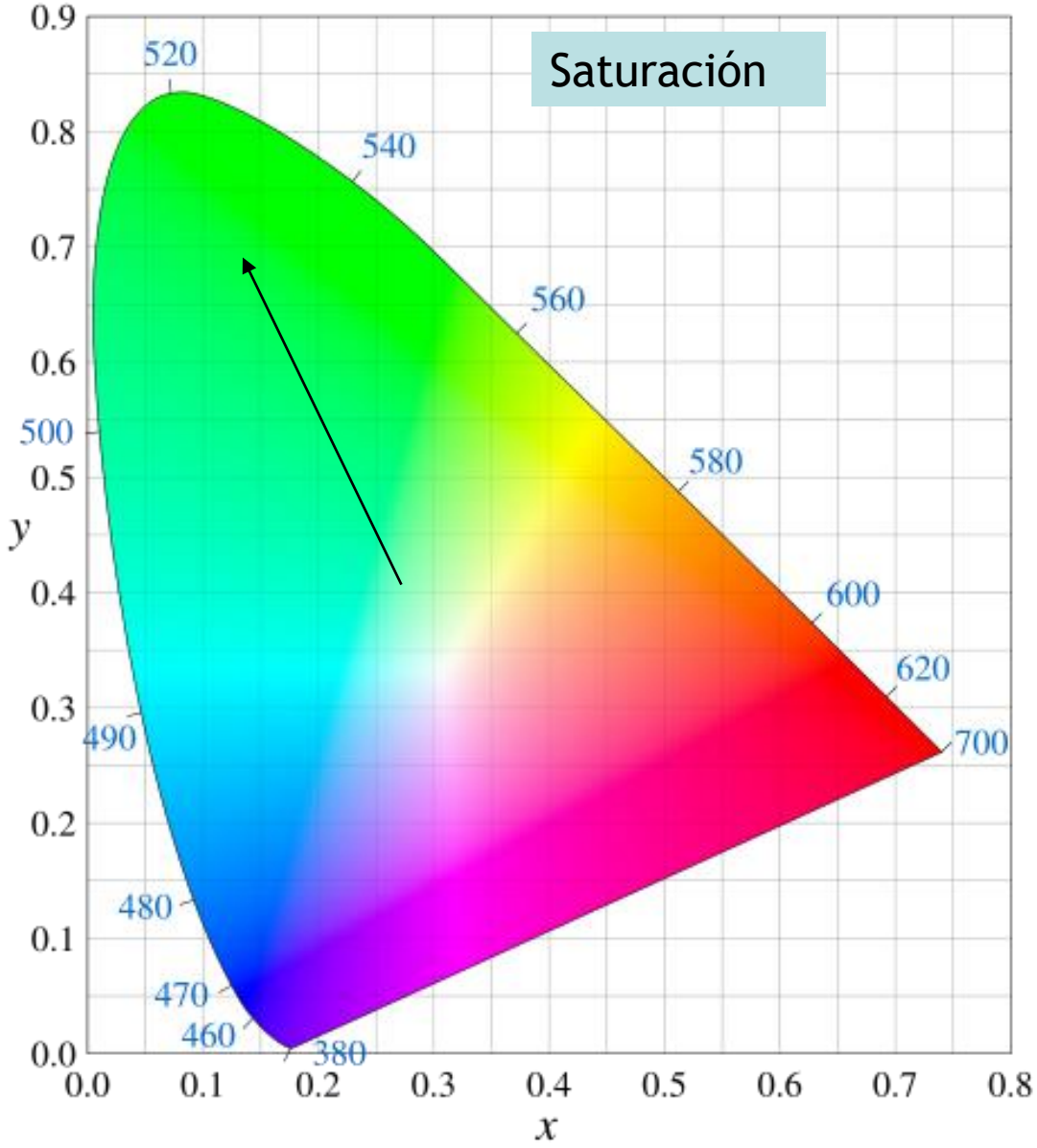


Posibles colores usando mezcla aditiva

[Diagrama CIE xy]

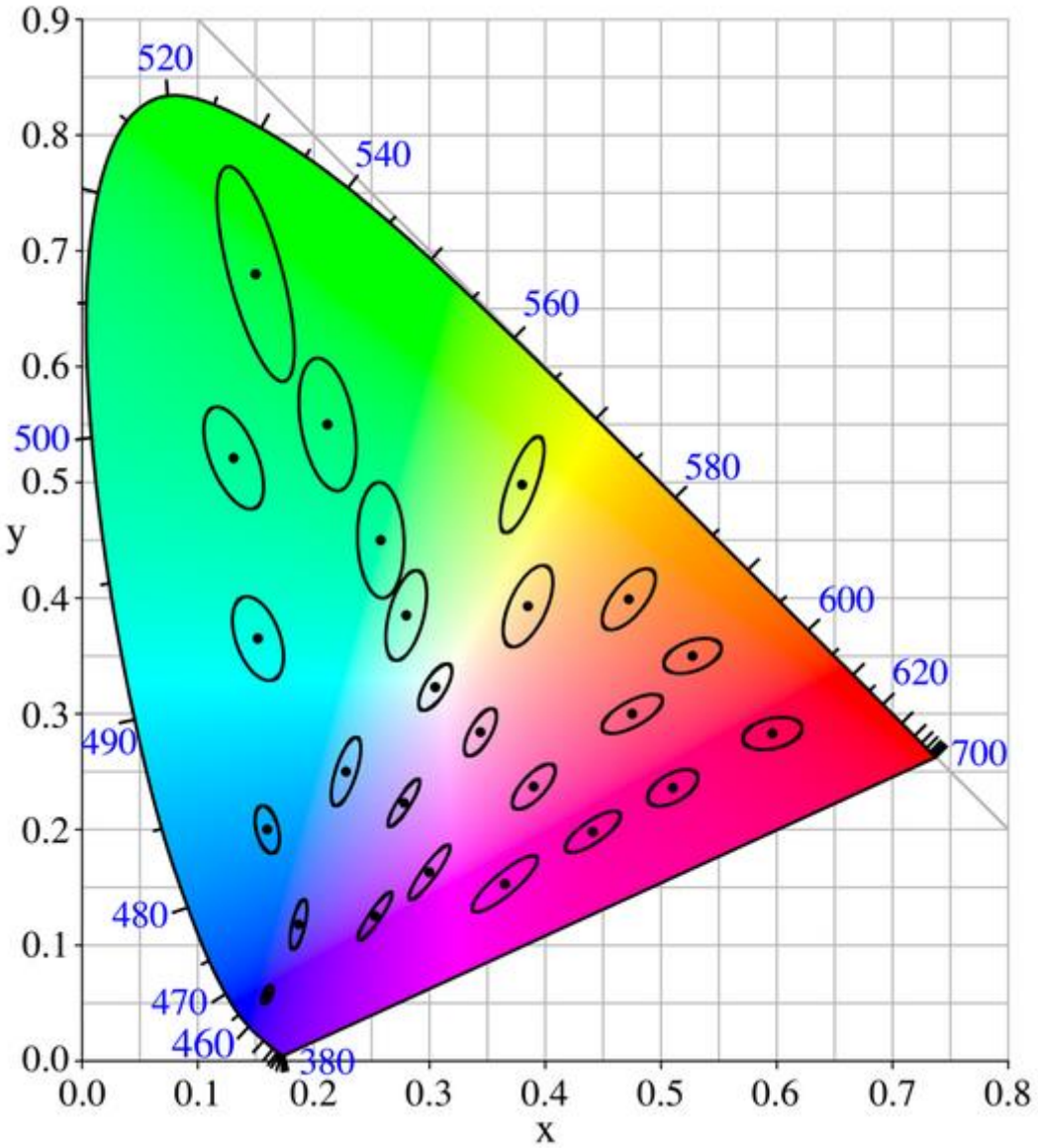


[Diagrama CIE xy]

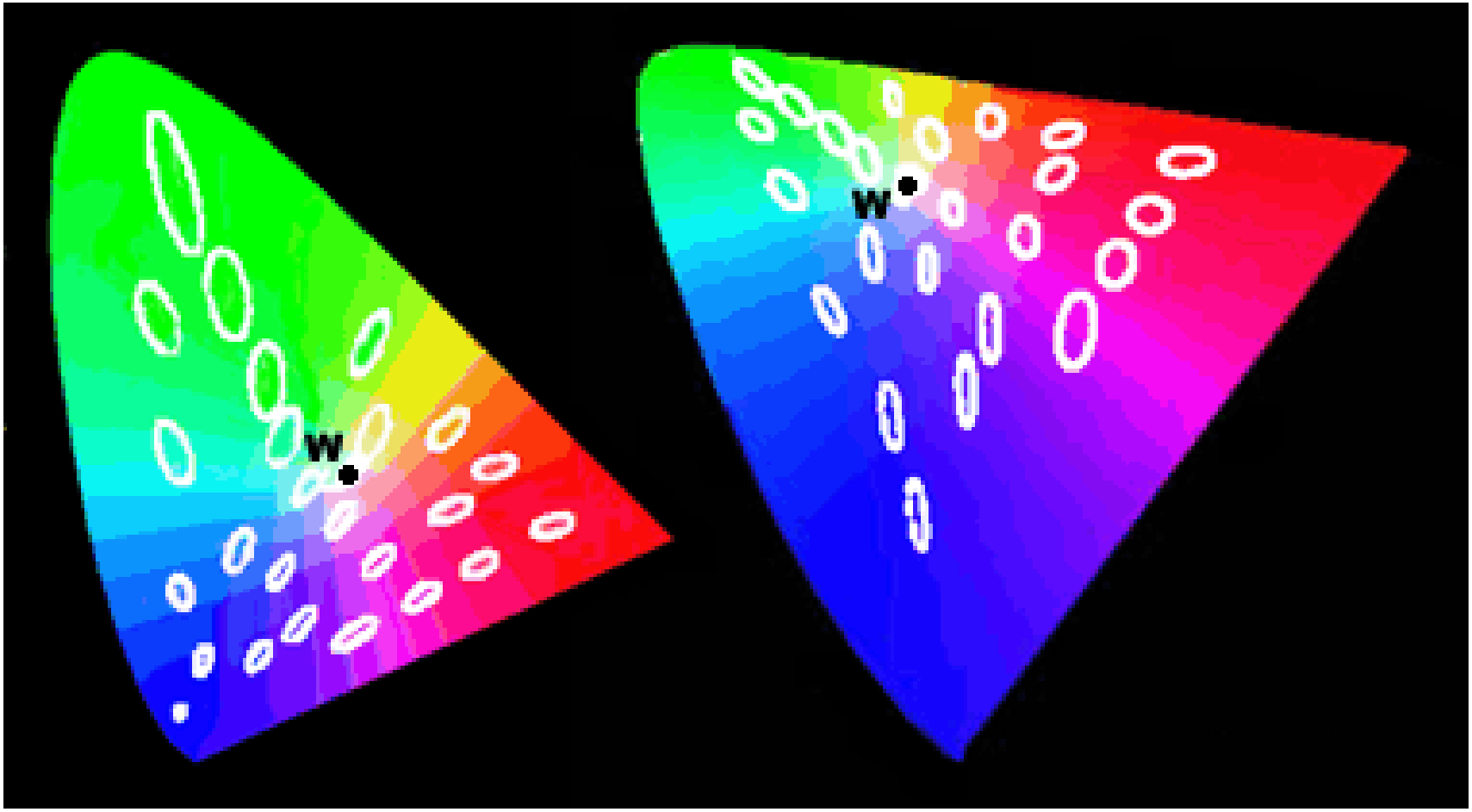


[Espacio de Percepción Uniforme]

[Colores Similares: Elipses de MacAdam]



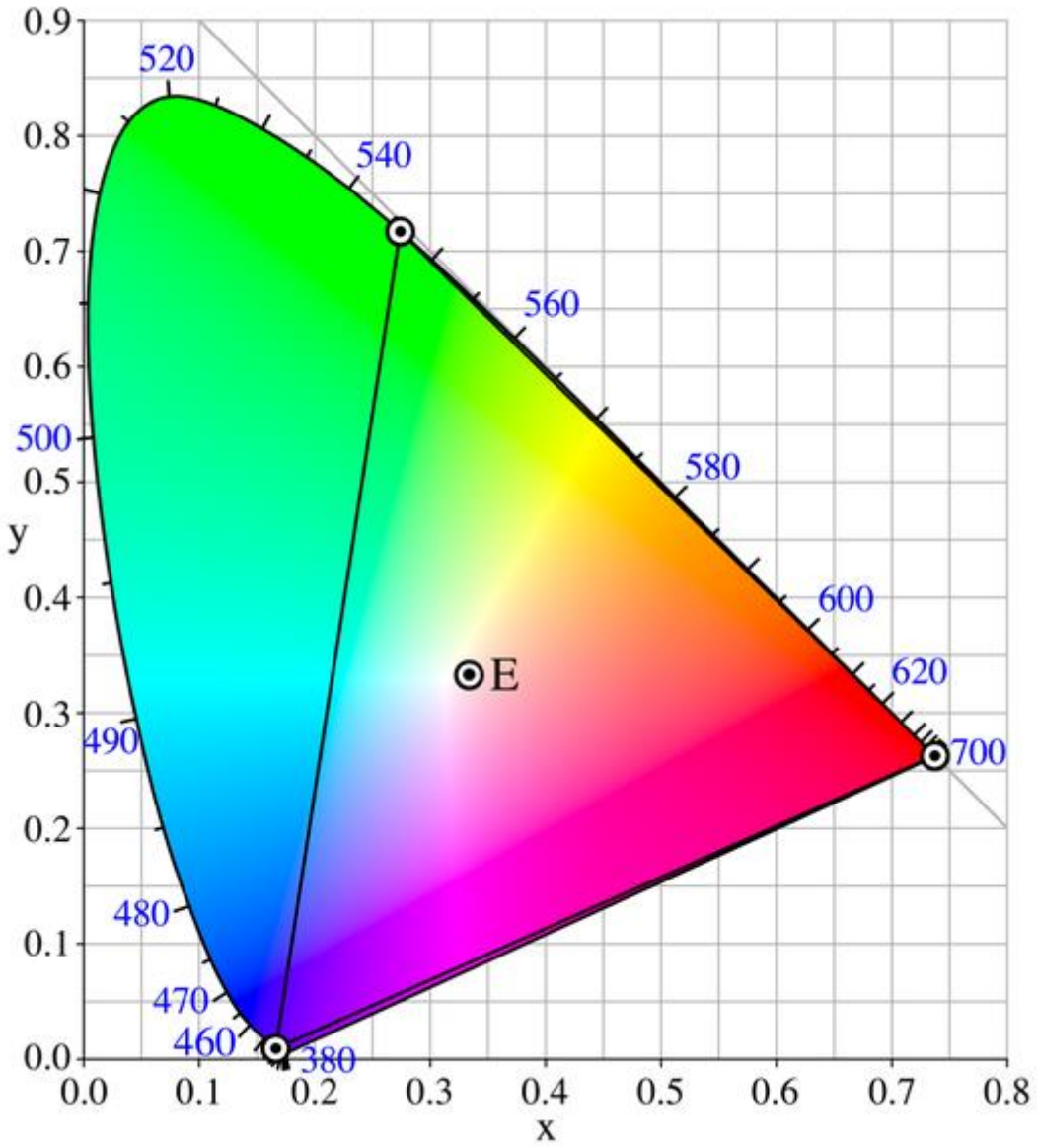
[Diagrama CIE xy vs. CIE u'v': Elipses de MacAdam]



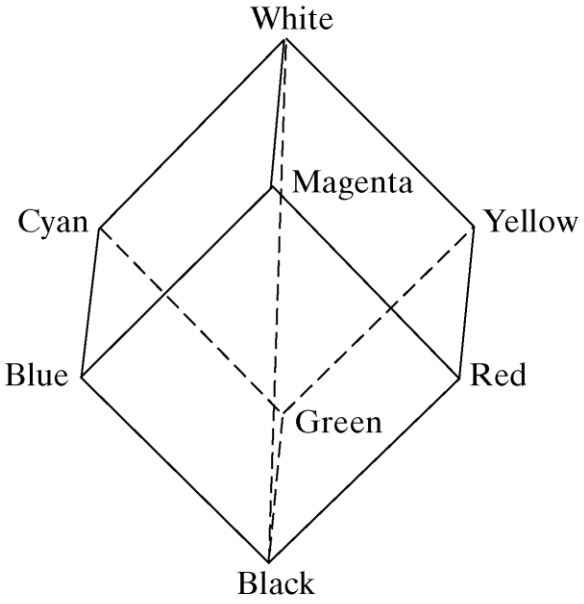
[Conversiones]

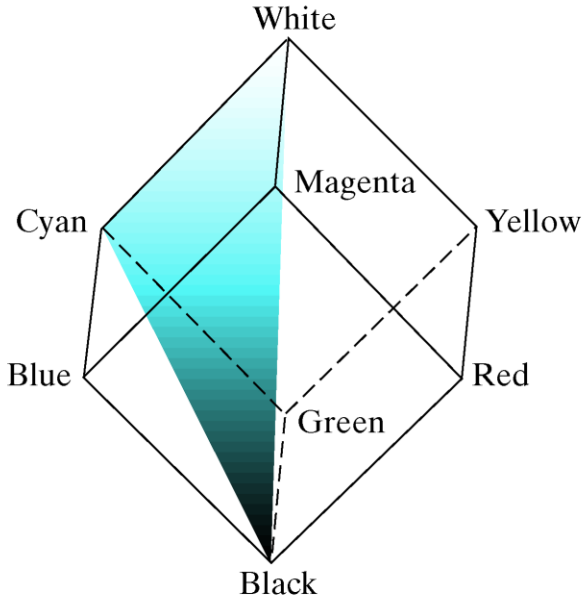
http://brucelindbloom.com/

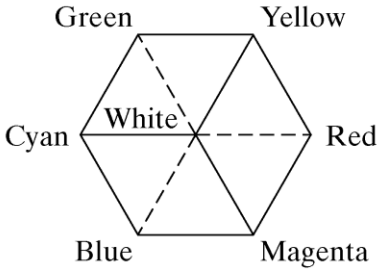
[Diagram CIE RGB]

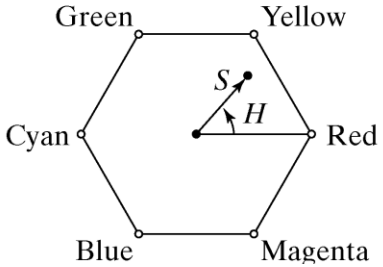


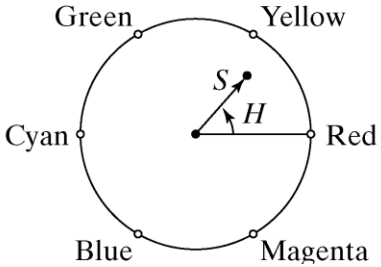
[Color Space HSI]

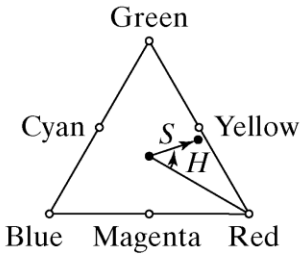




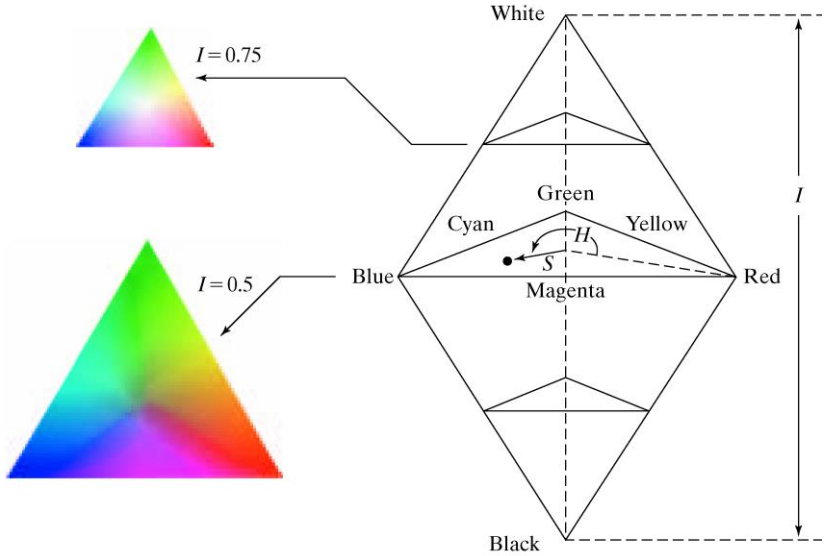


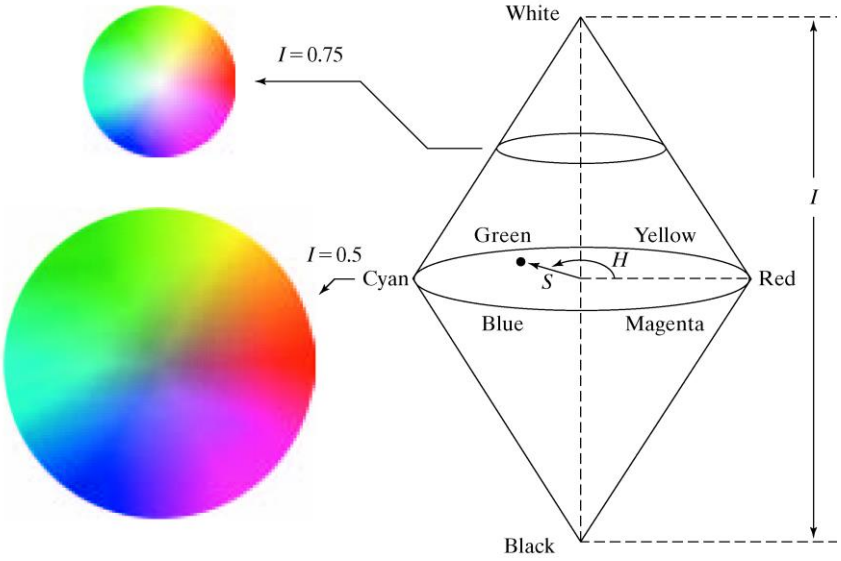




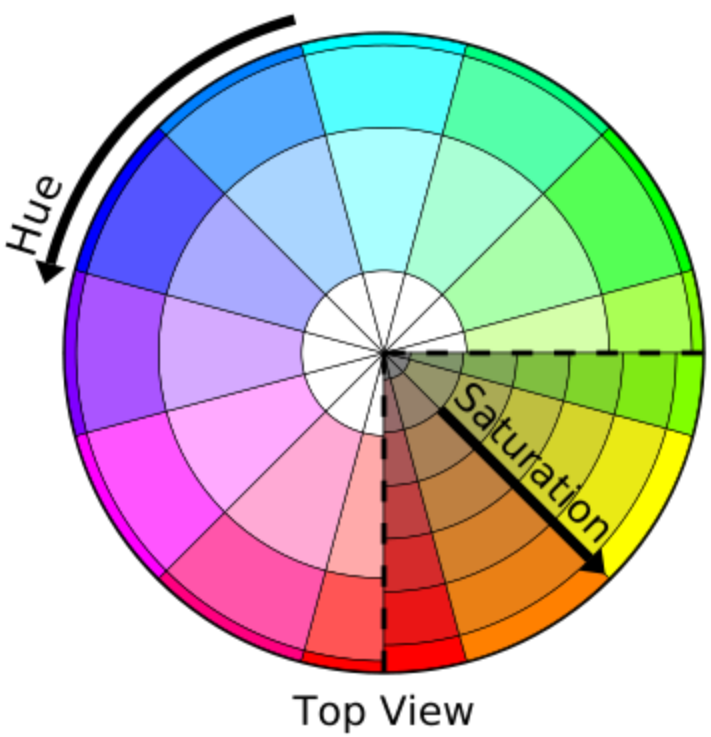


[Color Space HSI]

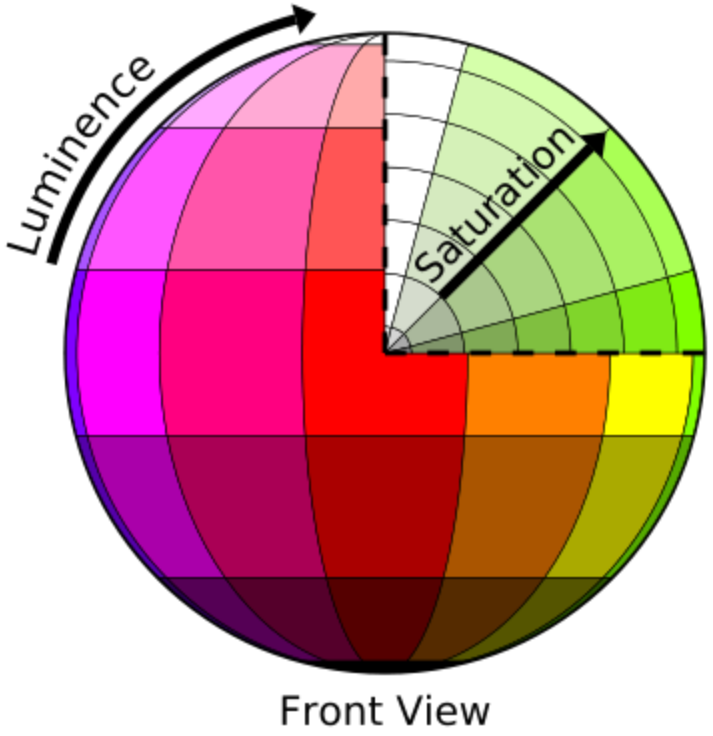




[Color Space HSL]

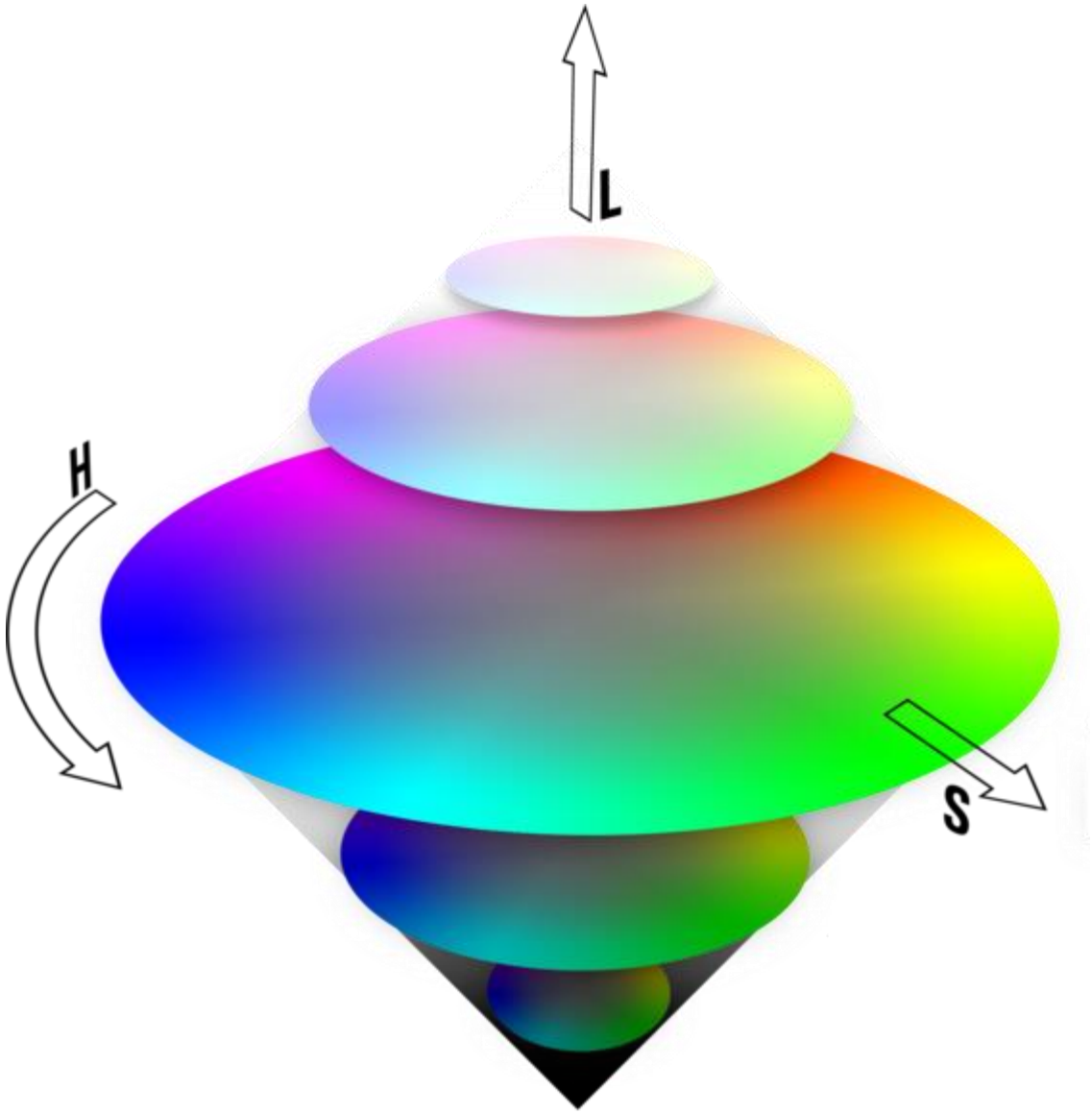


Top View

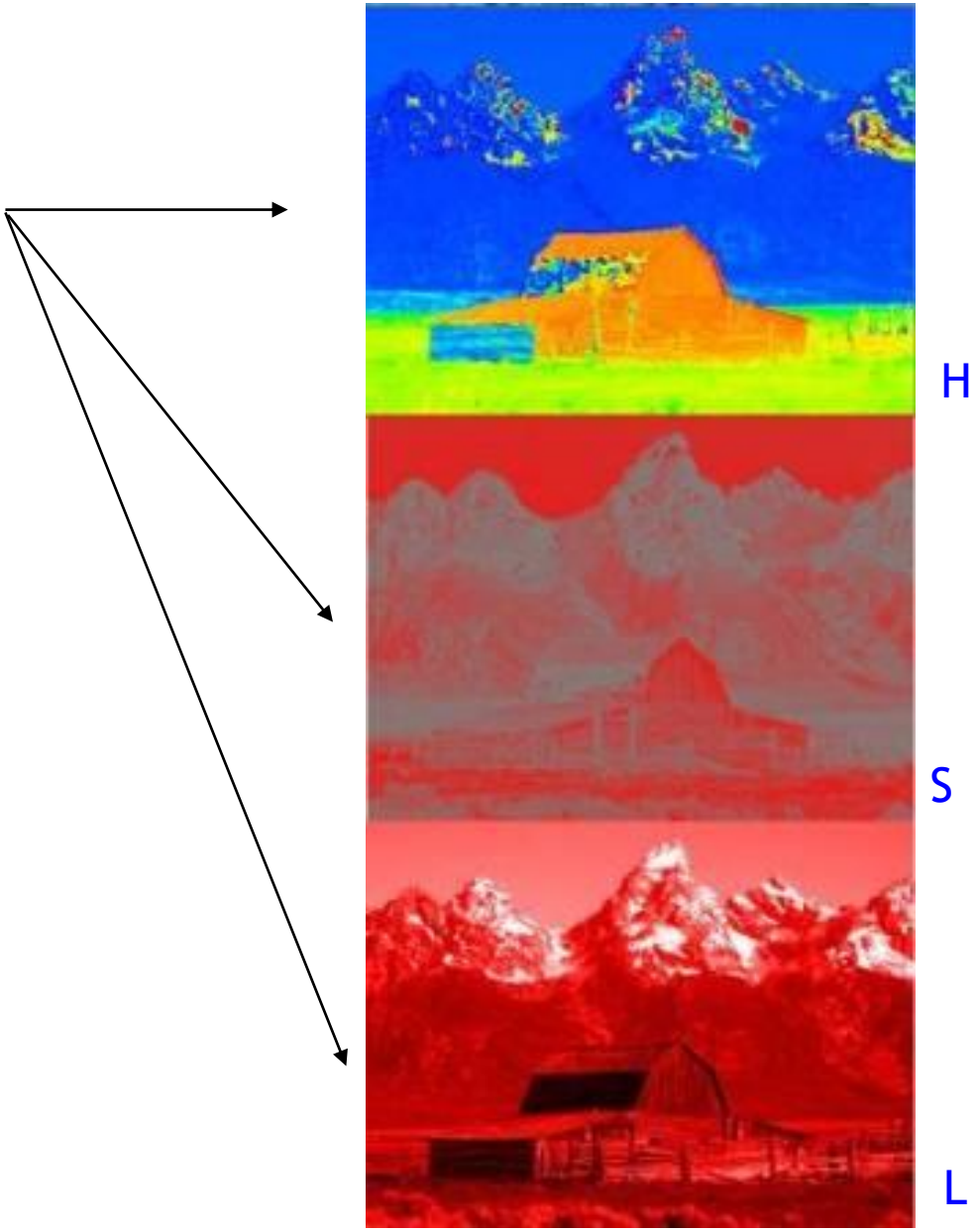


Front View

[Color Space HSL]



[Color Space HSL]

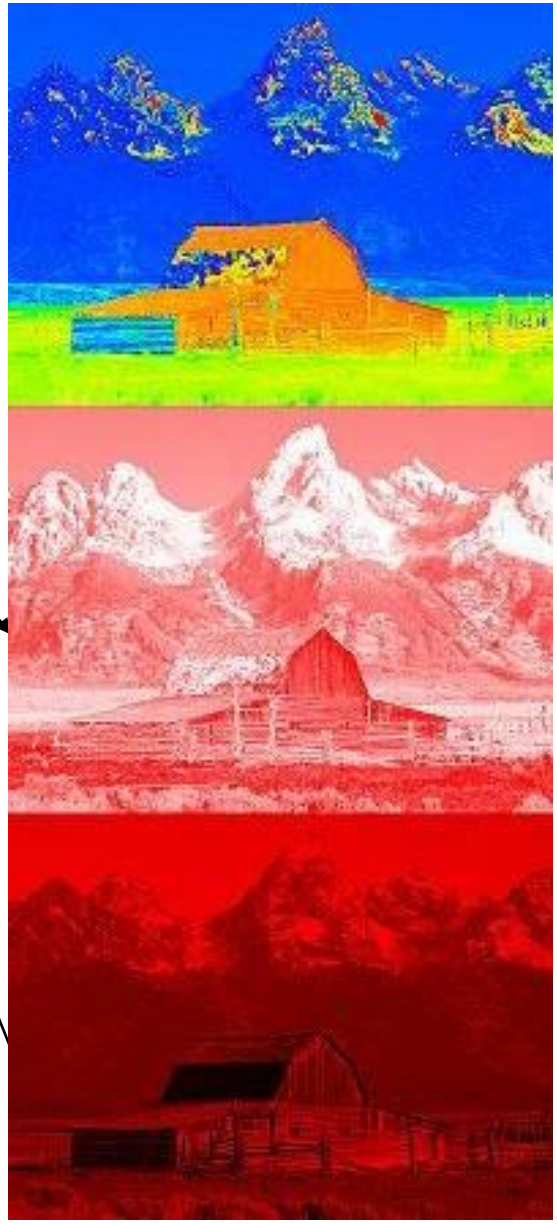


H

S

L

[Color Space HSV]



H

S

V

[Pseudocolor]

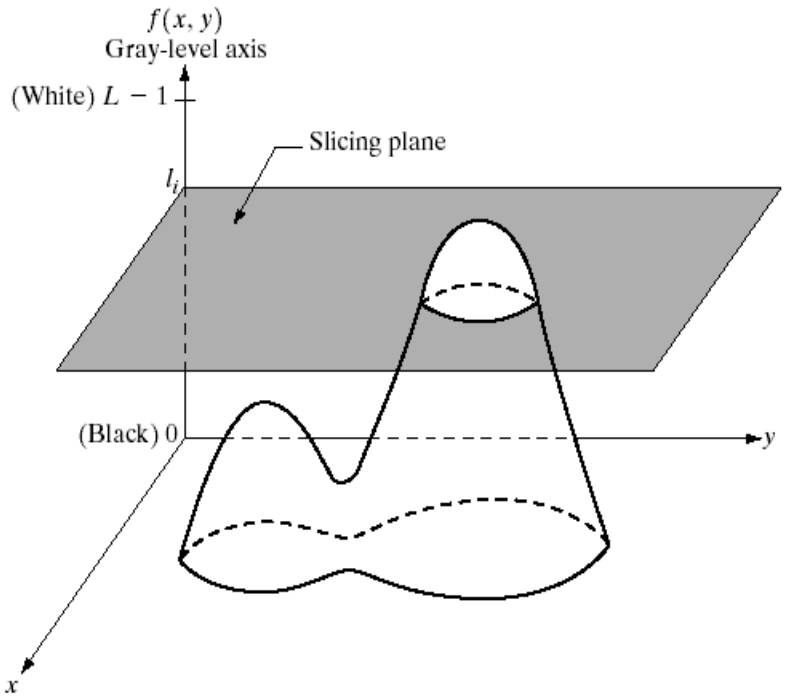


FIGURE 6.18 Geometric interpretation of the intensity-slicing technique.

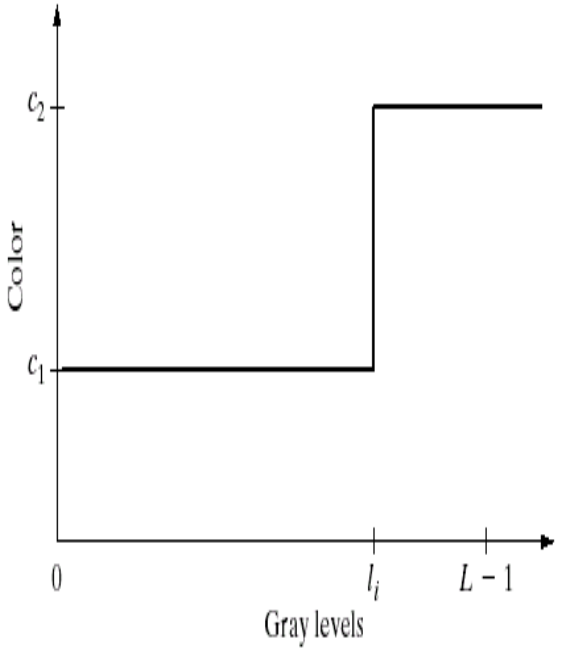
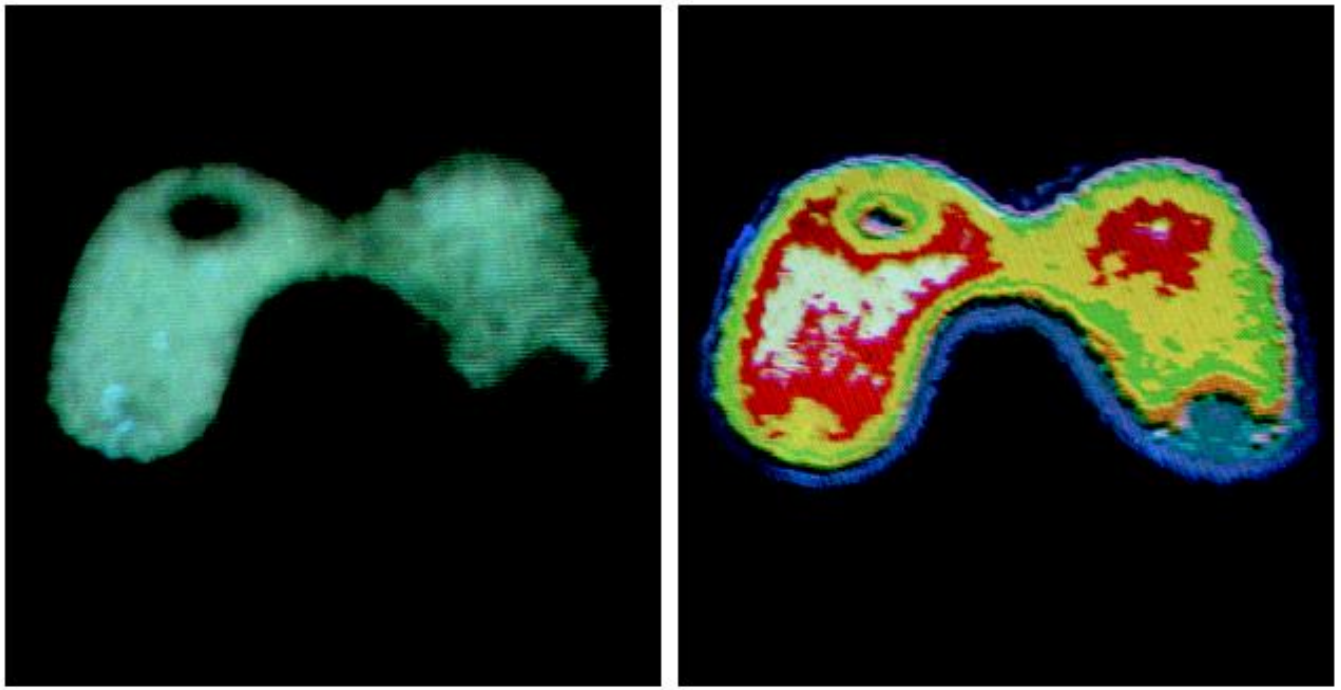


FIGURE 6.19 An alternative representation of the intensity-slicing technique.

[Pseudocolor]



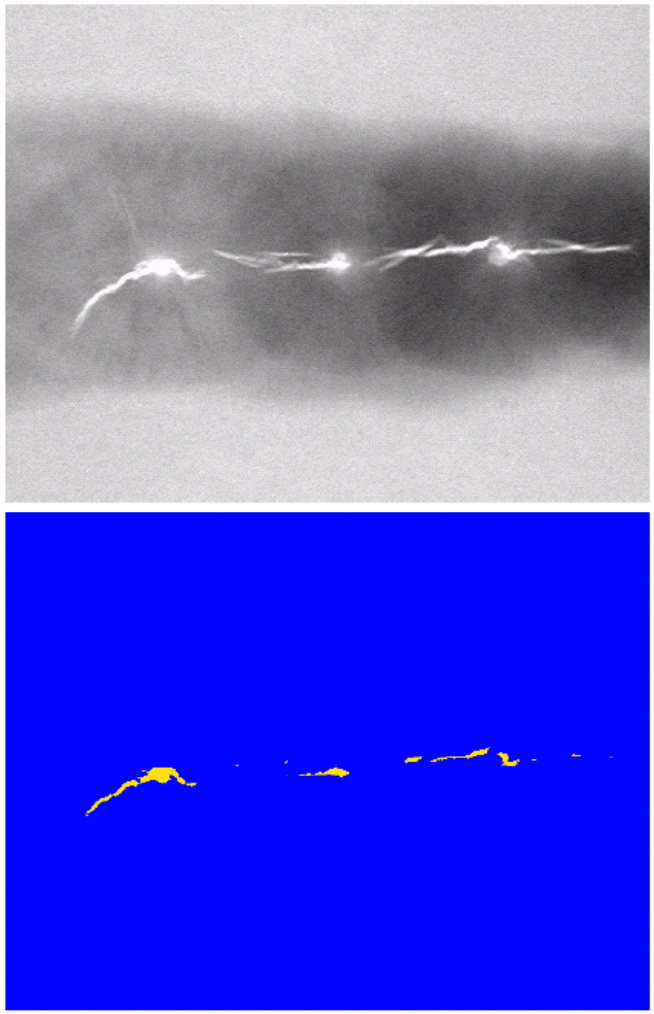
a b

FIGURE 6.20 (a) Monochrome image of the Picker Thyroid Phantom. (b) Result of density slicing into eight colors. (Courtesy of Dr. J. L. Blankenship, Instrumentation and Controls Division, Oak Ridge National Laboratory.)

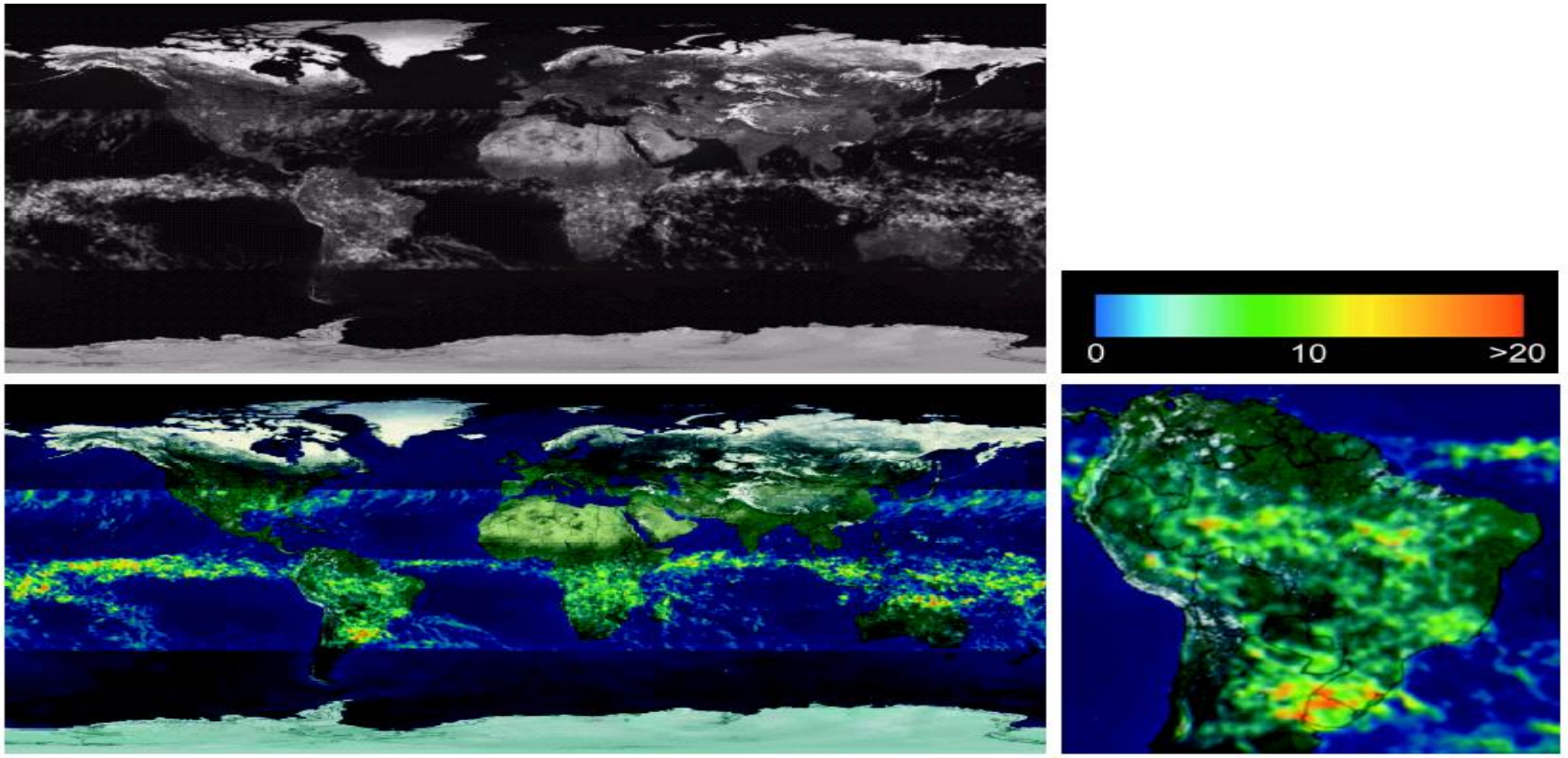
[Pseudocolor]

a
b

FIGURE 6.21
(a) Monochrome X-ray image of a weld. (b) Result of color coding. (Original image courtesy of X-TEK Systems, Ltd.)



[Pseudocolor]



a b
c d

FIGURE 6.22 (a) Gray-scale image in which intensity (in the lighter horizontal band shown) corresponds to average monthly rainfall. (b) Colors assigned to intensity values. (c) Color-coded image. (d) Zoom of the South America region. (Courtesy of NASA.)

[Pseudocolor]

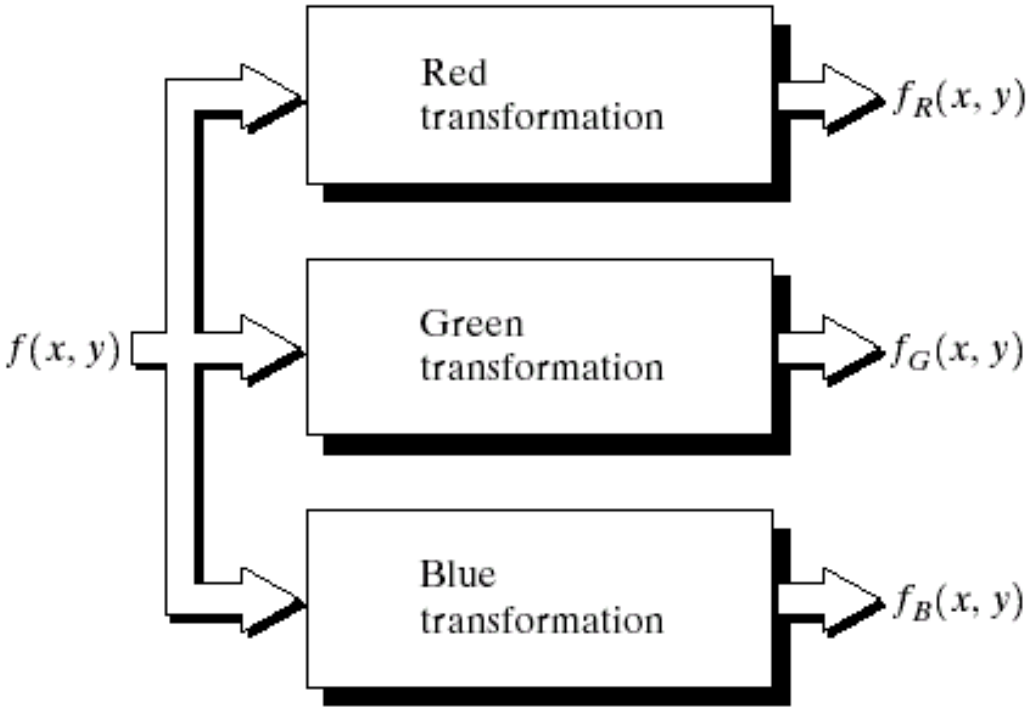
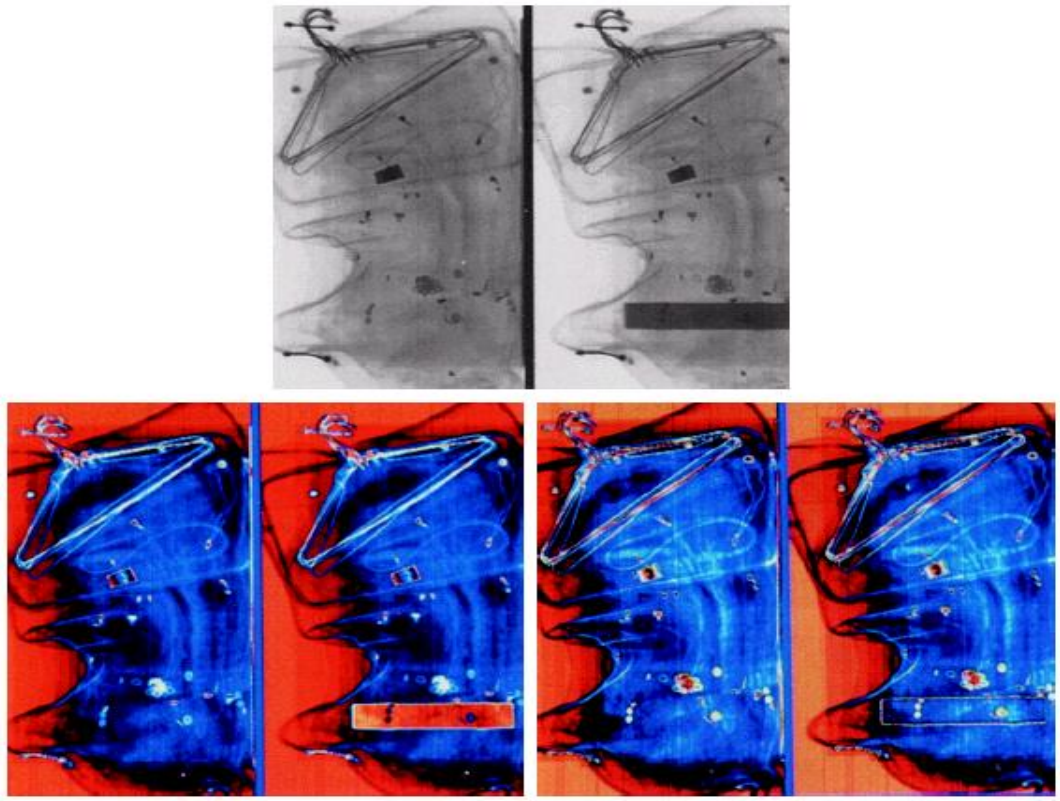


FIGURE 6.23 Functional block diagram for pseudocolor image processing. f_R, f_G, and f_B are fed into the corresponding red, green, and blue inputs of an RGB color monitor.

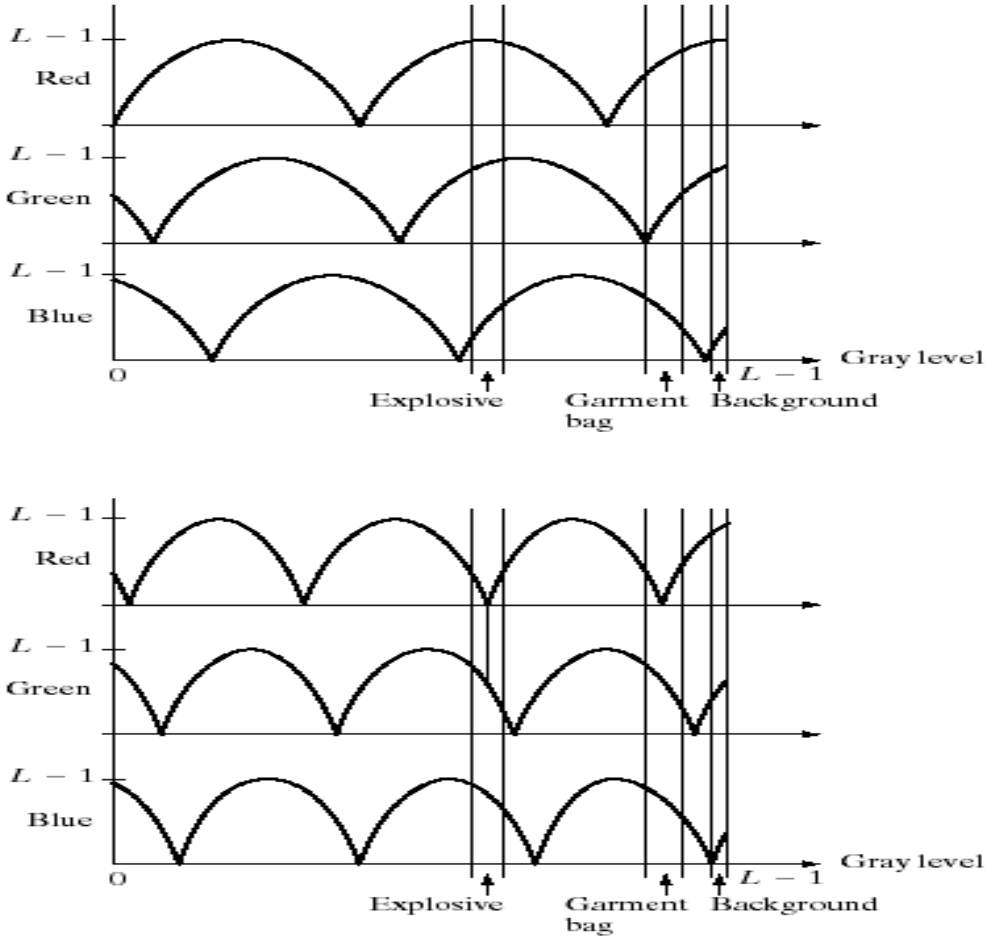
[Pseudocolor]



a
b c

FIGURE 6.24 Pseudocolor enhancement by using the gray-level to color transformations in Fig. 6.25. (Original image courtesy of Dr. Mike Hurwitz, Westinghouse.)

[Pseudocolor]



a
b

FIGURE 6.25 Transformation functions used to obtain the images in Fig. 6.24.

[Pseudocolor]

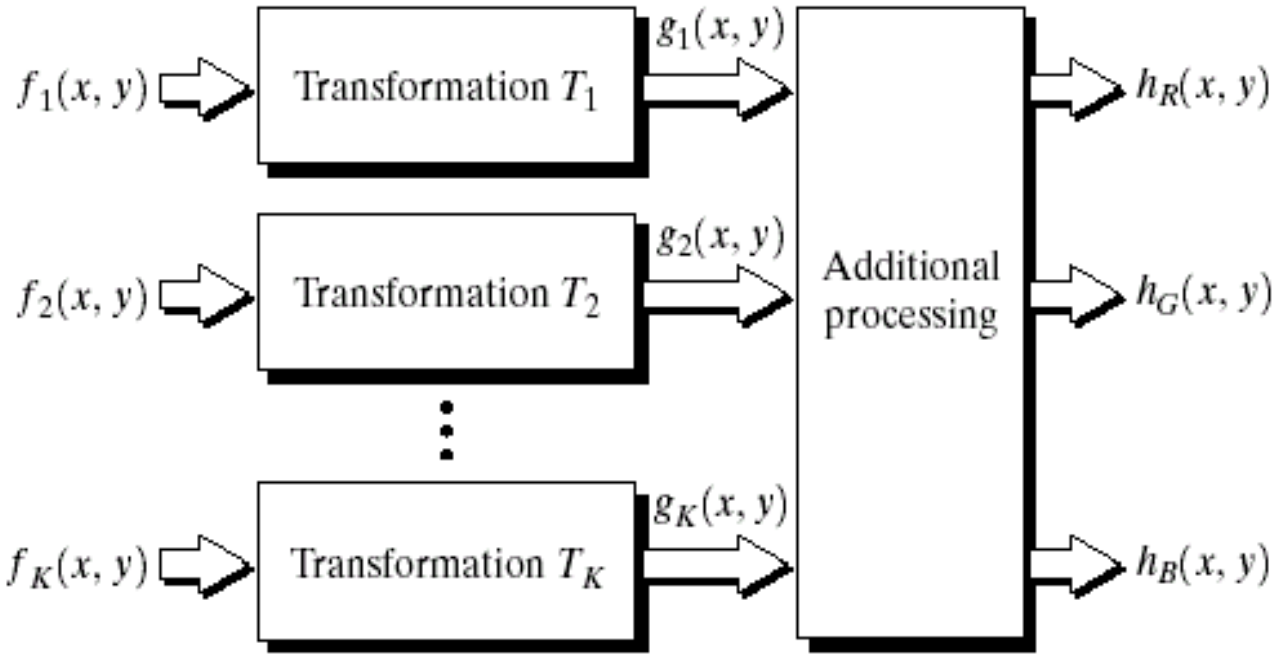
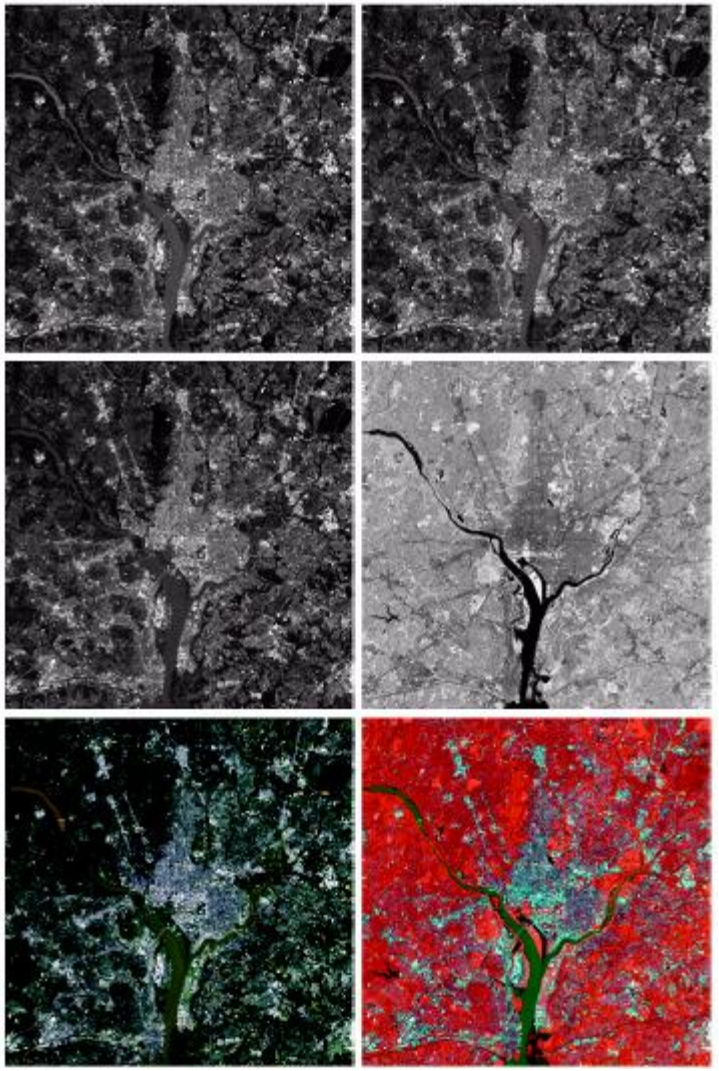


FIGURE 6.26 A pseudocolor coding approach used when several monochrome images are available.

[Pseudocolor]

TABLE 1.1
Thematic bands in NASA's LANDSAT satellite.

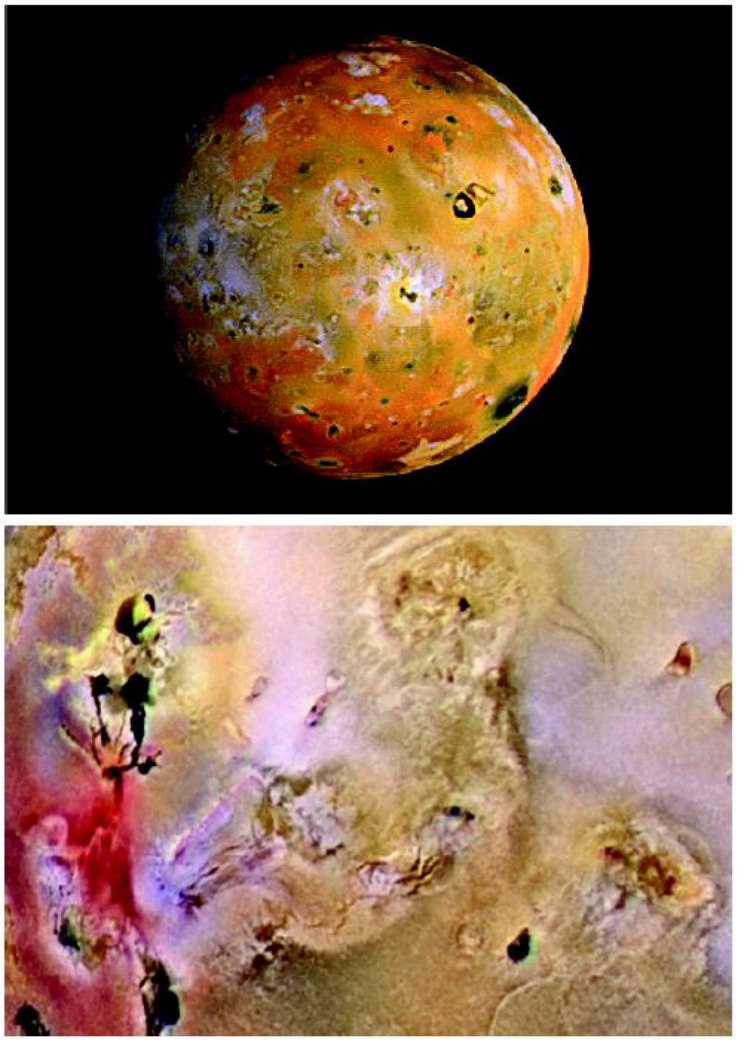
Band No.	Name	Wavelength (μm)	Characteristics and Uses
1	Visible blue	0.45–0.52	Maximum water penetration
2	Visible green	0.52–0.60	Good for measuring plant vigor
3	Visible red	0.63–0.69	Vegetation discrimination
4	Near infrared	0.76–0.90	Biomass and shoreline mapping
5	Middle infrared	1.55–1.75	Moisture content of soil and vegetation
6	Thermal infrared	10.4–12.5	Soil moisture; thermal mapping
7	Middle infrared	2.08–2.35	Mineral mapping



a b
c d
e f

FIGURE 6.27 (a)–(d) Images in bands 1–4 in Fig. 1.10 (see Table 1.1). (e) Color composite image obtained by treating (a), (b), and (c) as the red, green, blue components of an RGB image. (f) Image obtained in the same manner, but using in the red channel the near-infrared image in (d). (Original multispectral images courtesy of NASA.)

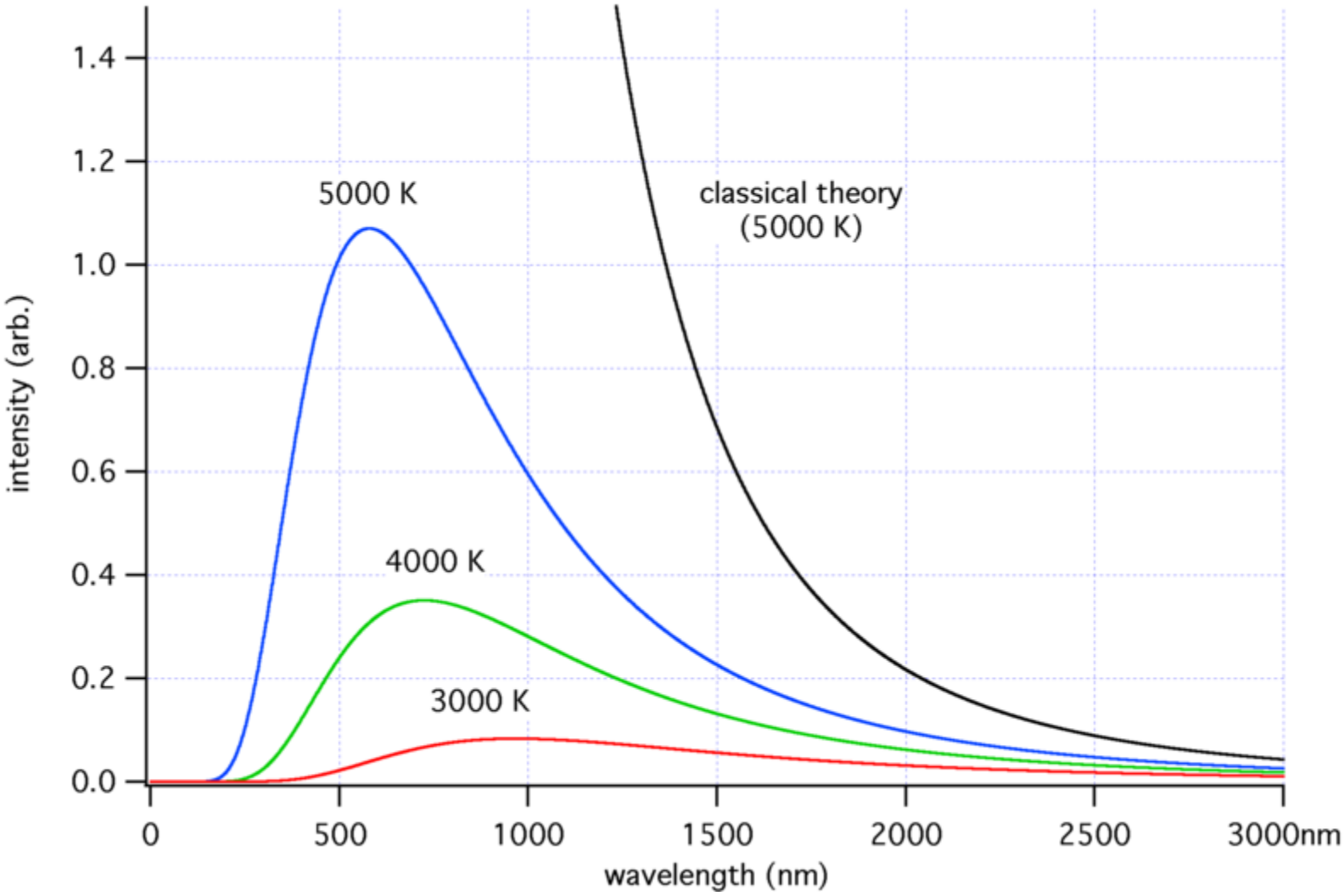
[Pseudocolor]



a
b

FIGURE 6.28
(a) Pseudocolor rendition of Jupiter Moon Io. (b) A close-up. (Courtesy of NASA.)

[Temperature of Color]



[Temperature of Color]