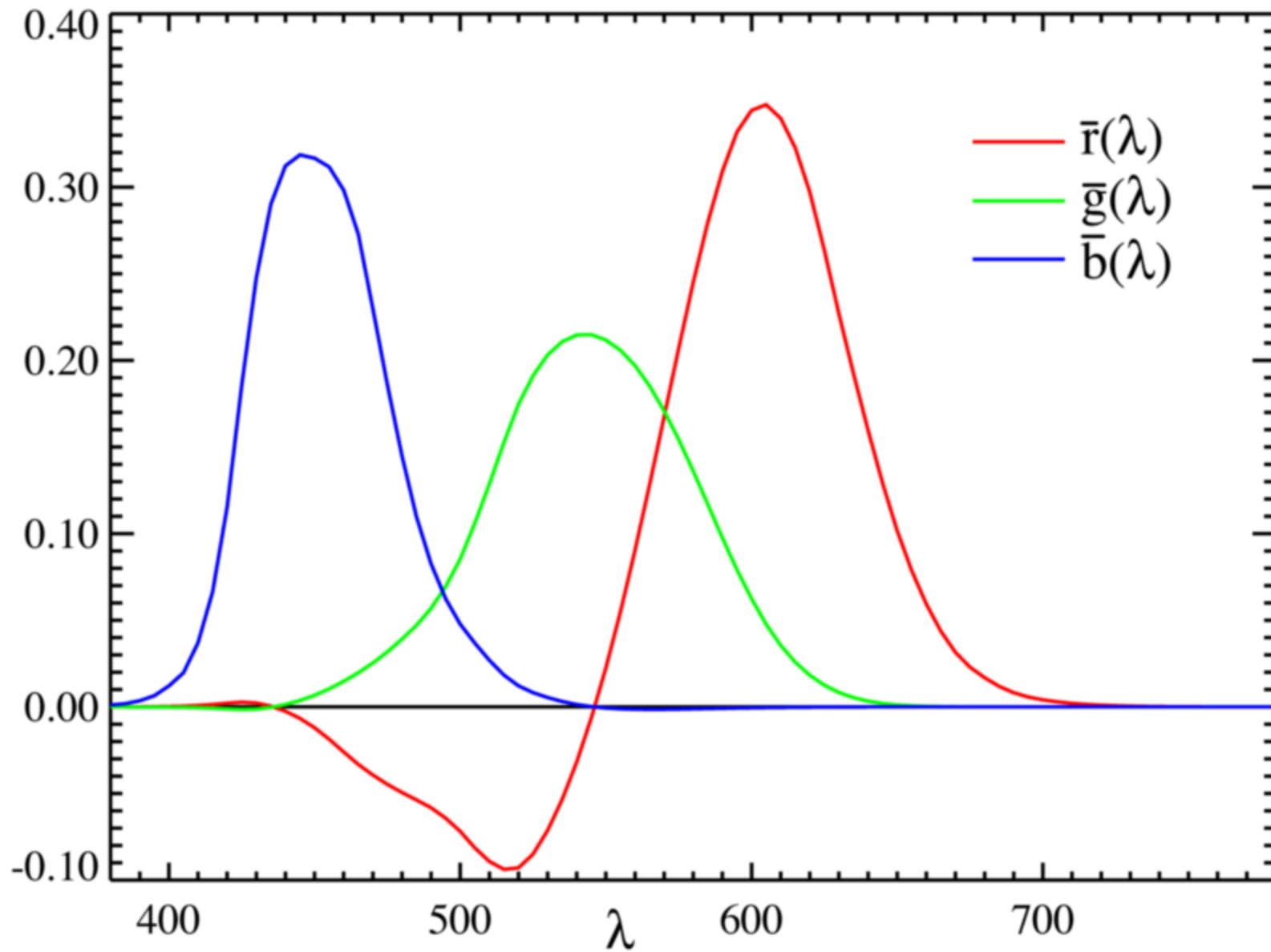
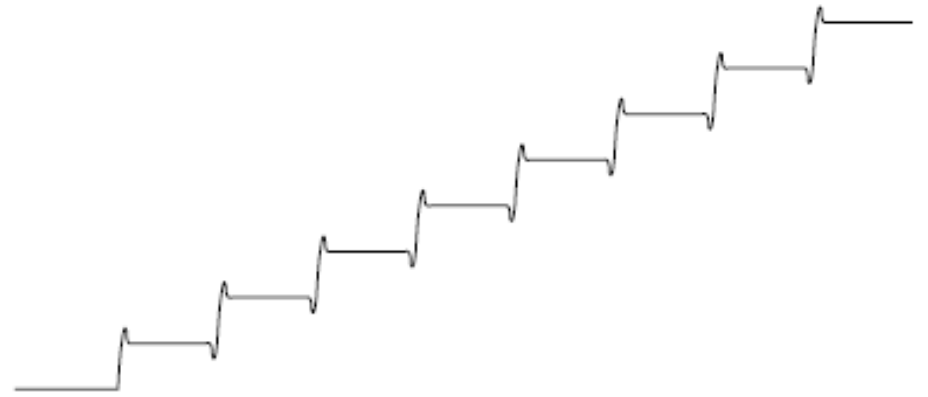


Svetelný stimul sa po spracovaní čapíkmi prenáša cez optický nerv do talamu napojeného na bočné kolienkovité telieska (LGN). V ňom sa v súlade s teóriou opozičných procesov prenáša do primárnej vizuálnej kôry (V1) Červeno-zelený signál pomocou parvocelulárneho kanálu a modro-žltý pomocou koniocelulárneho



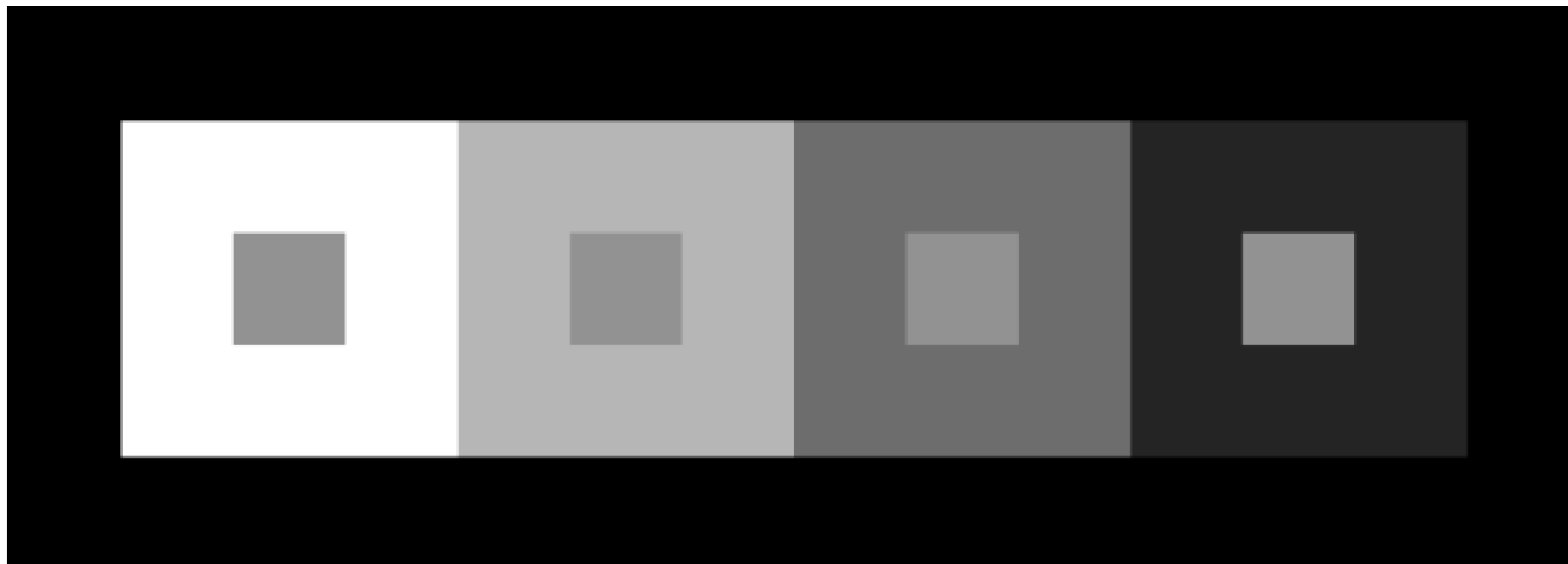
Psychológia vnímania

Machov pásmový efekt



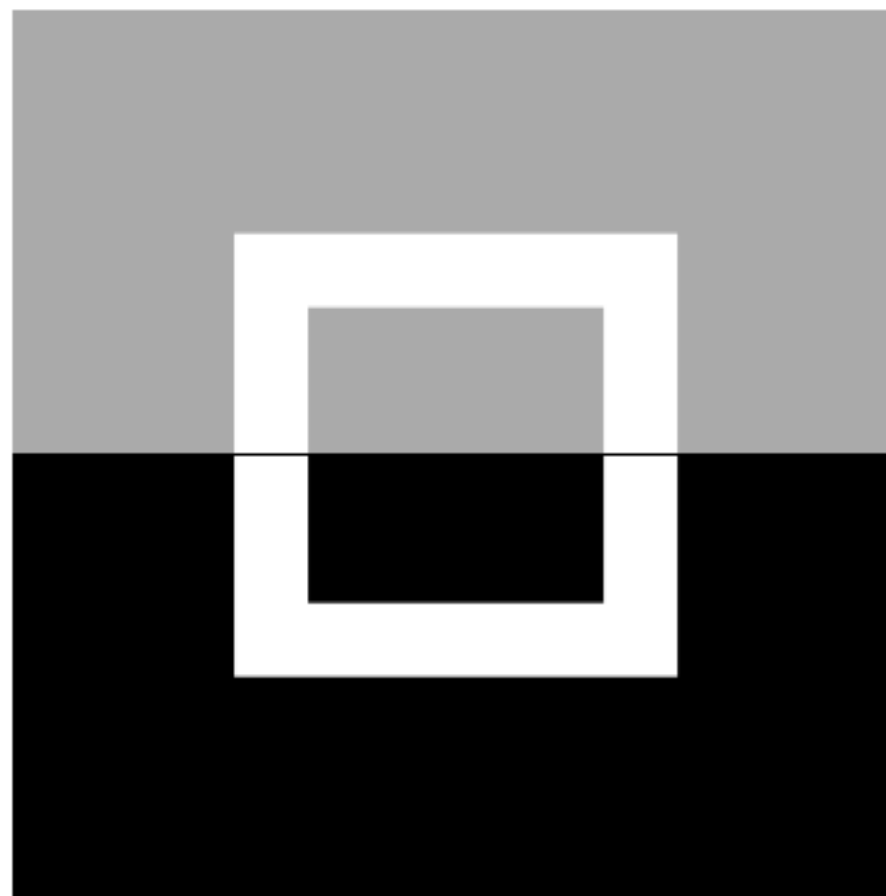
Psychológia vnímania

Efekt spojitého kontrastu



Psychológia vnímania

Benussiho kruh



Psychológia vnímania

"Gestalt" efekt



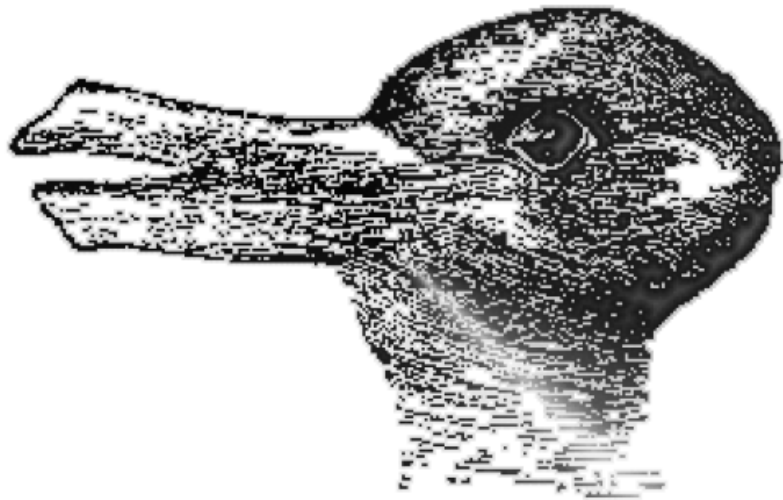
Psychológia vnímania

Schopnosť práce so zhlukmi



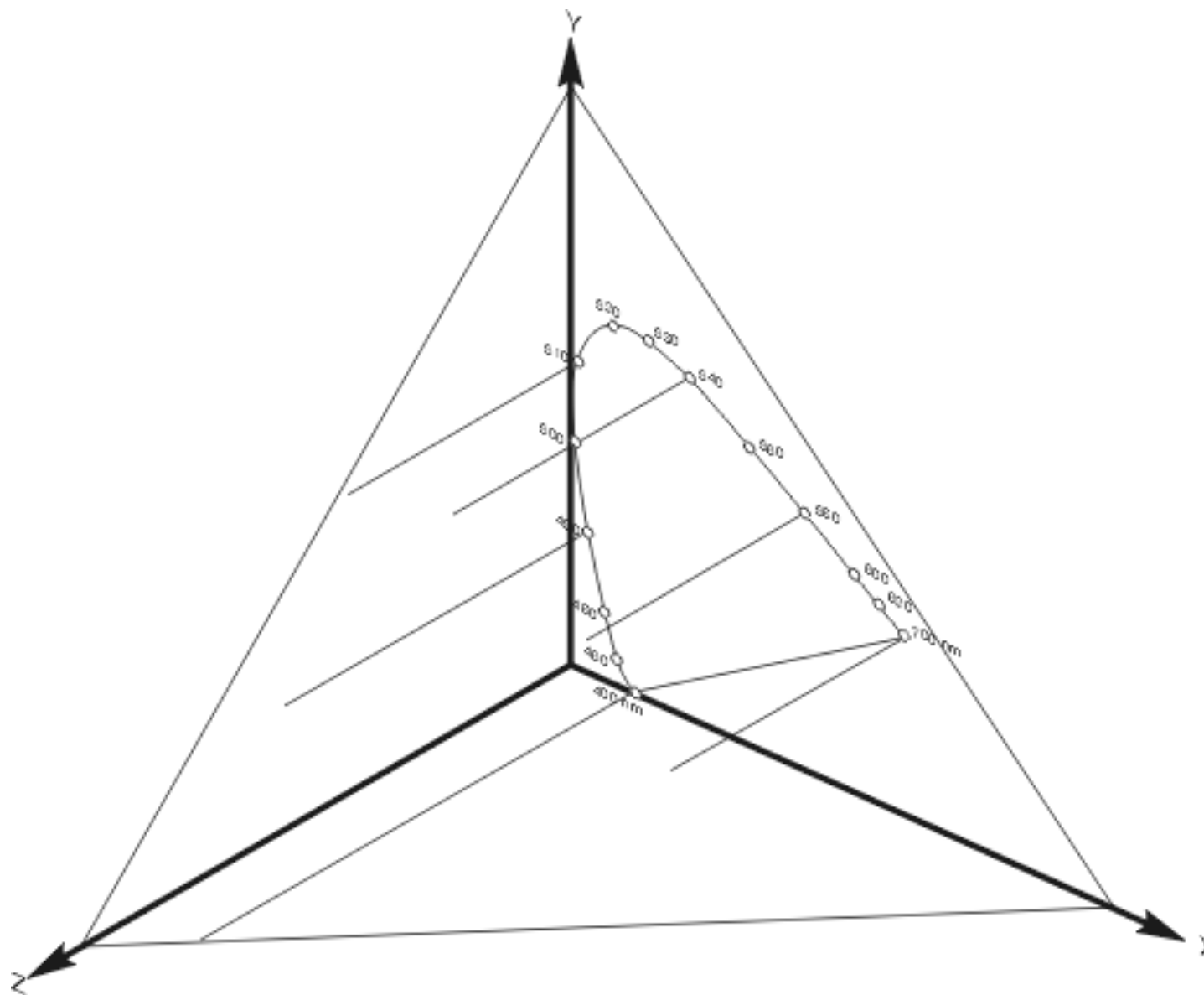
Psychológia vnímania

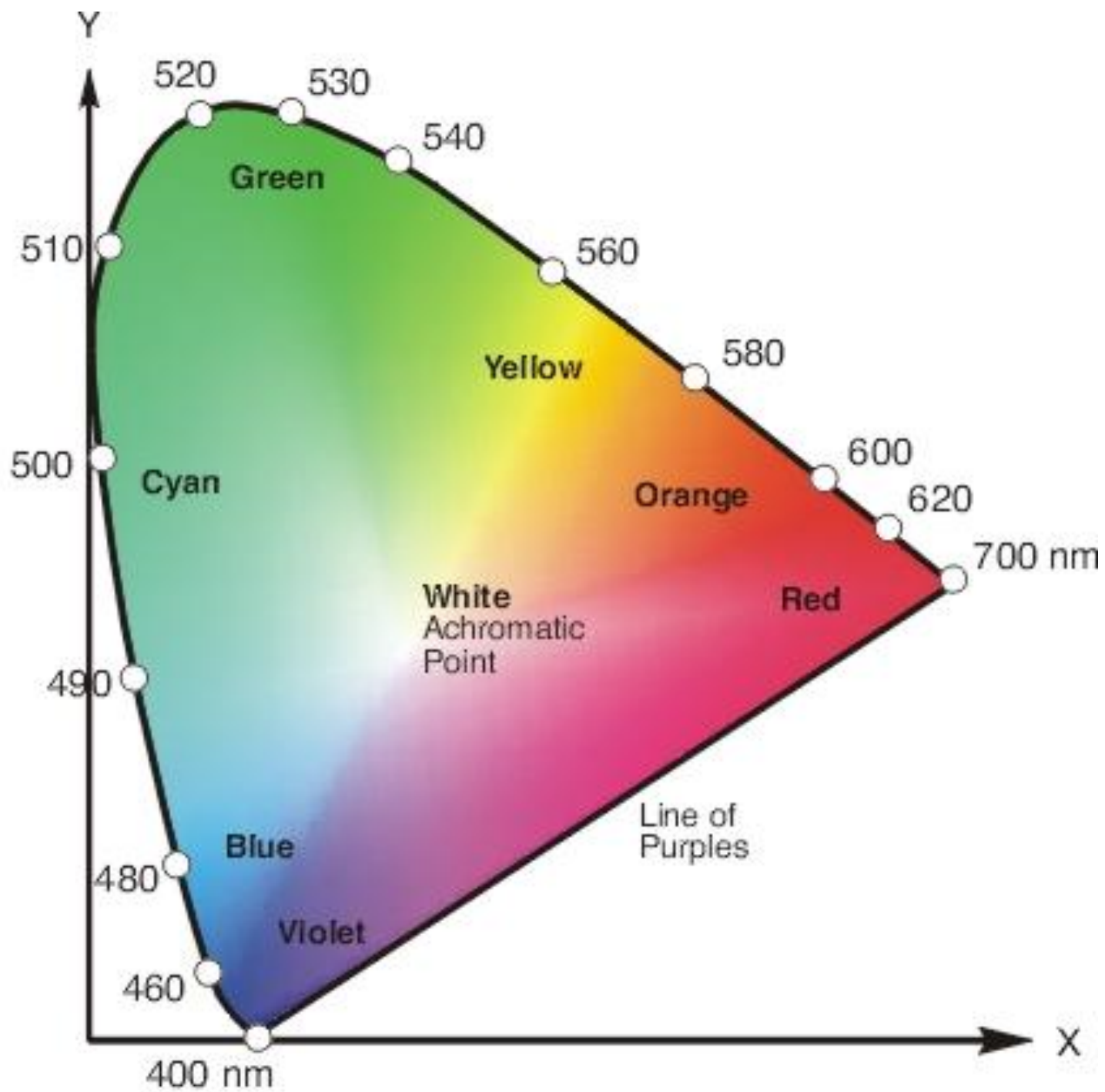
"Gestalt switch" - prepínanie medzi vzormi

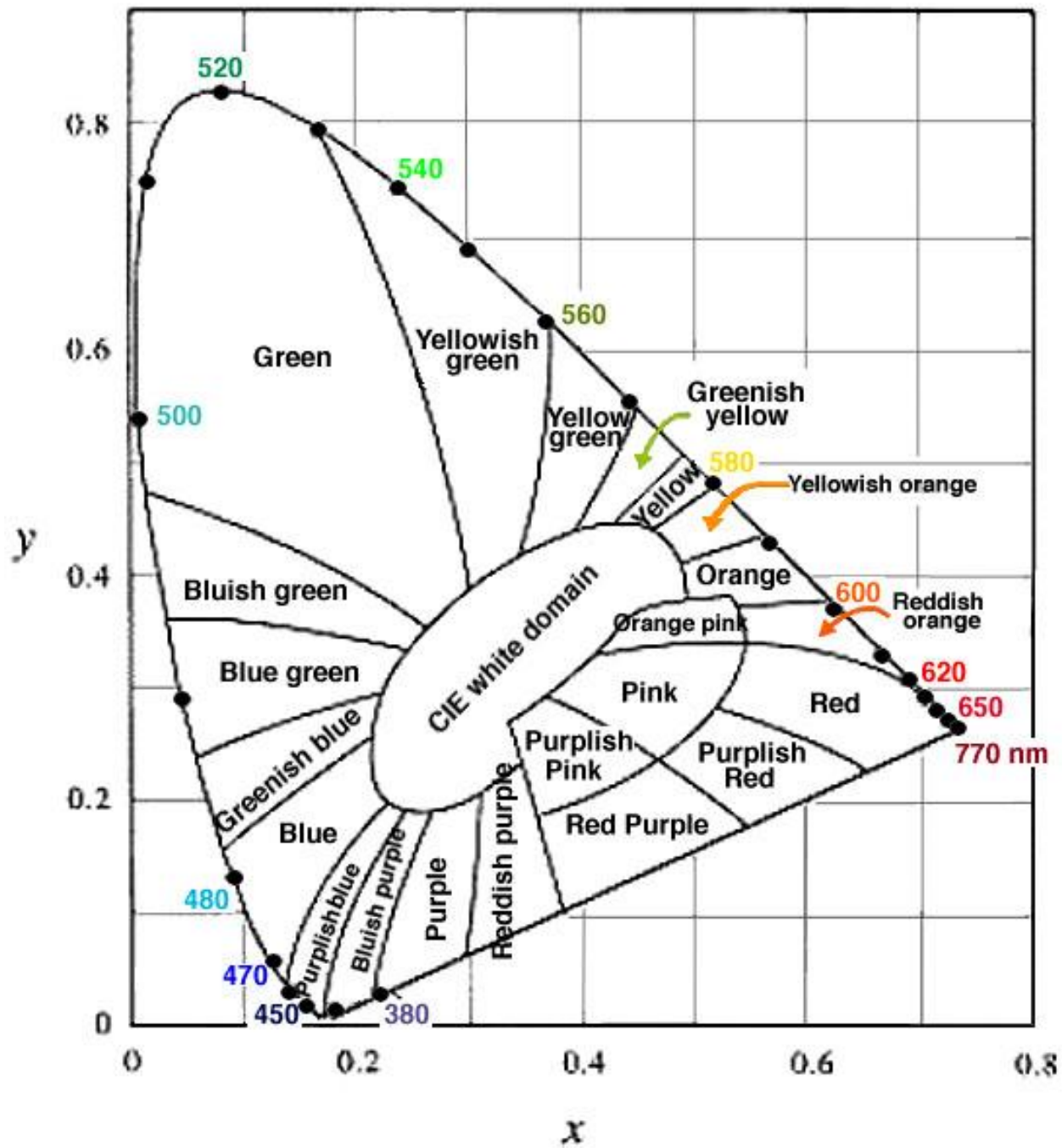


Farebné modely CIE

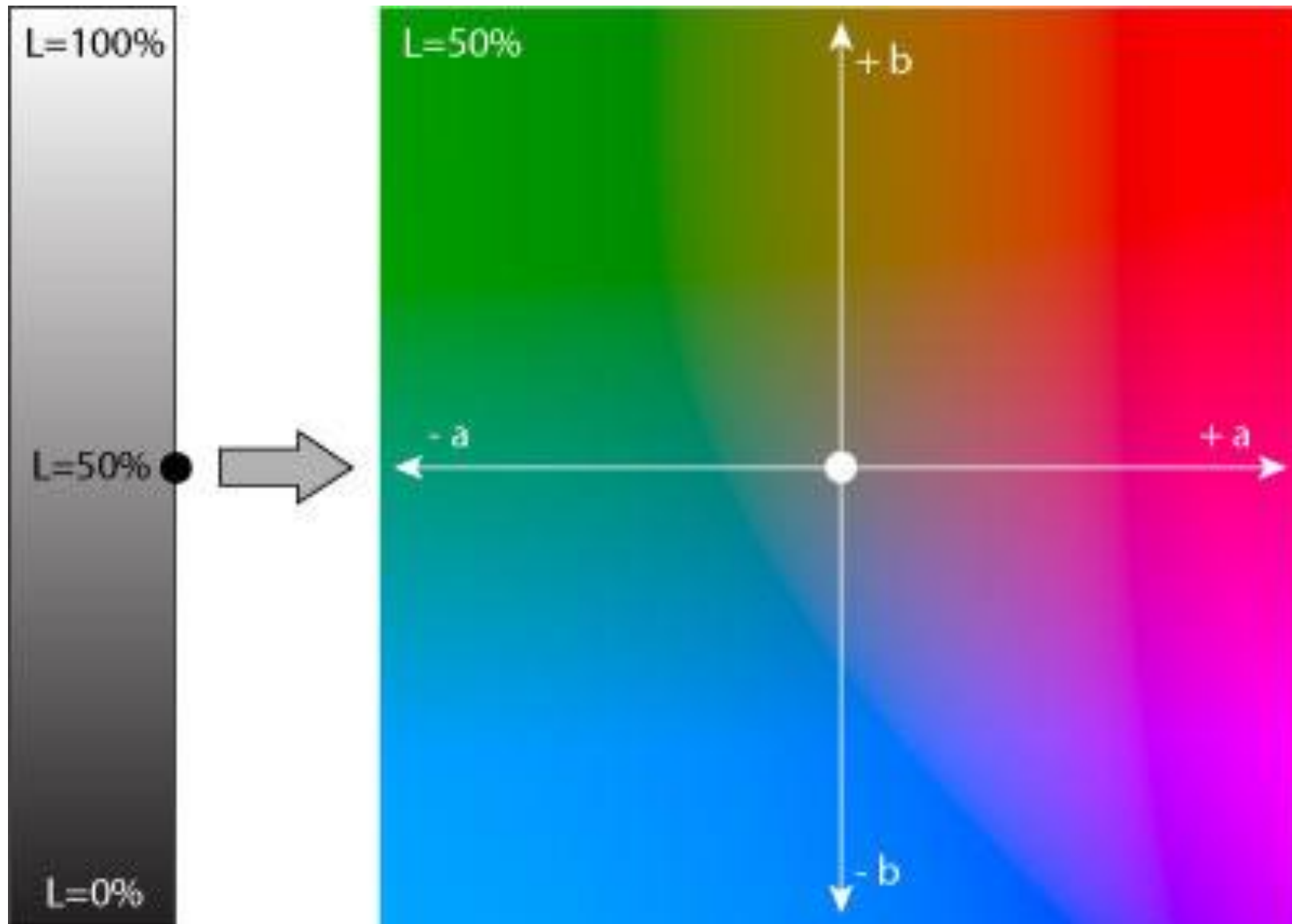
CIE (1931)



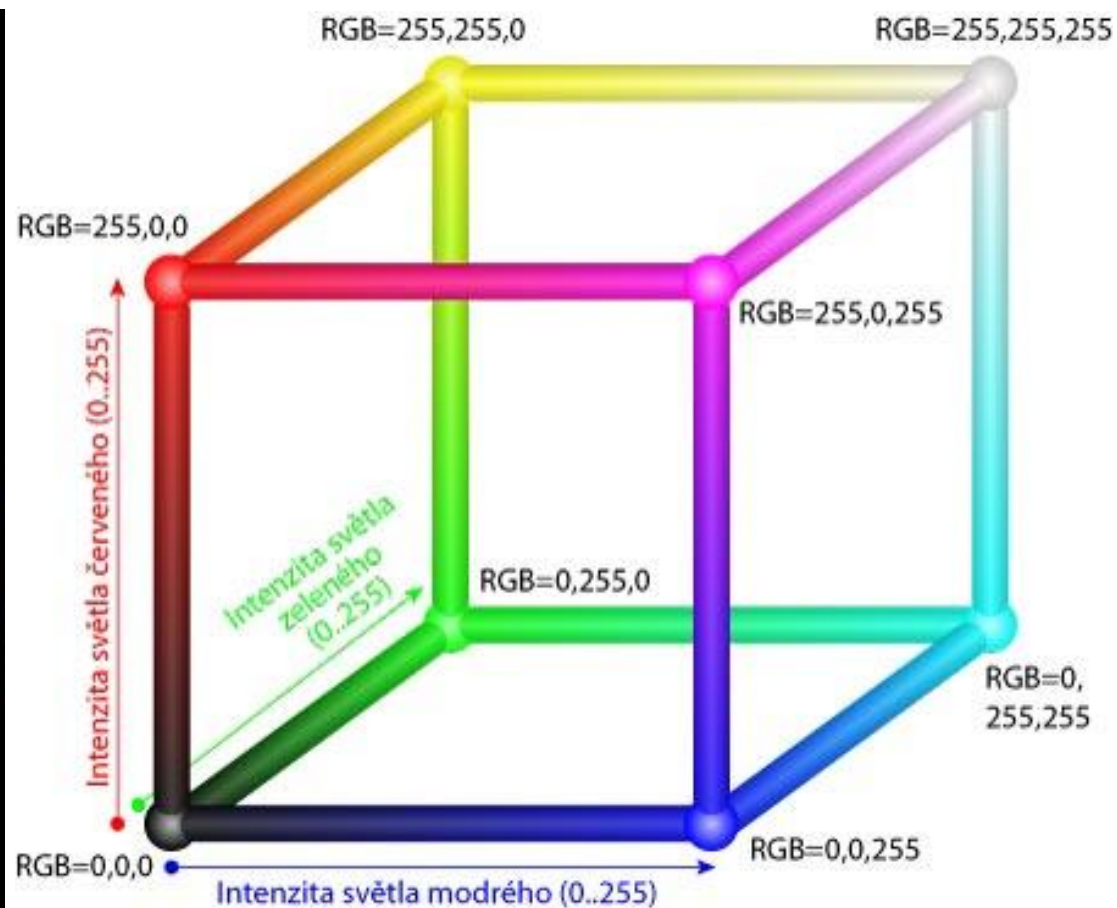
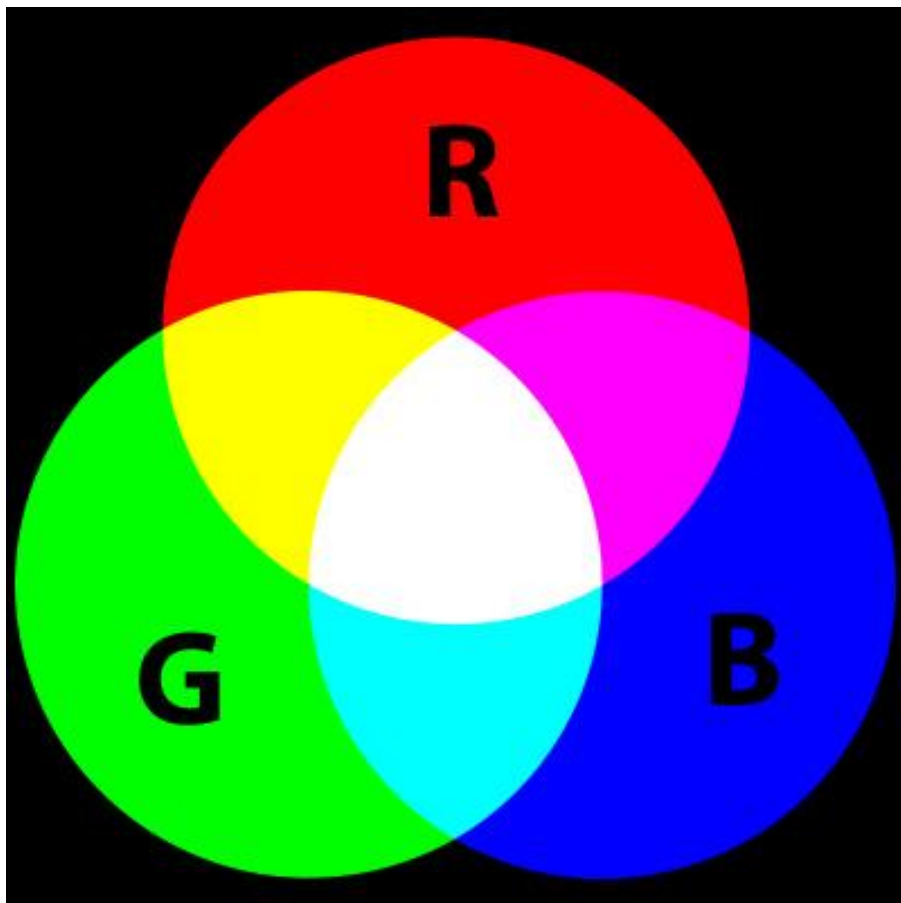




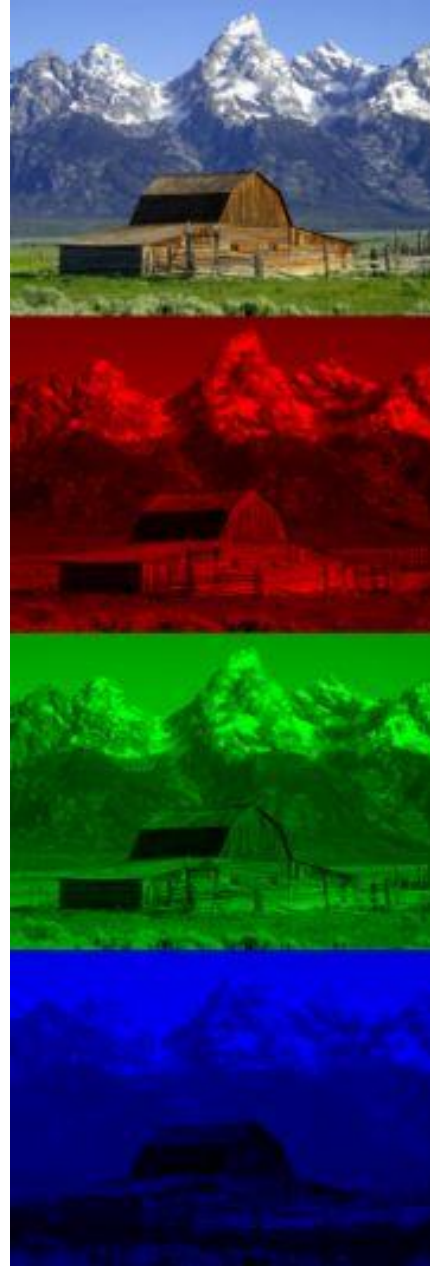
CIE L^*a^*b (1976)



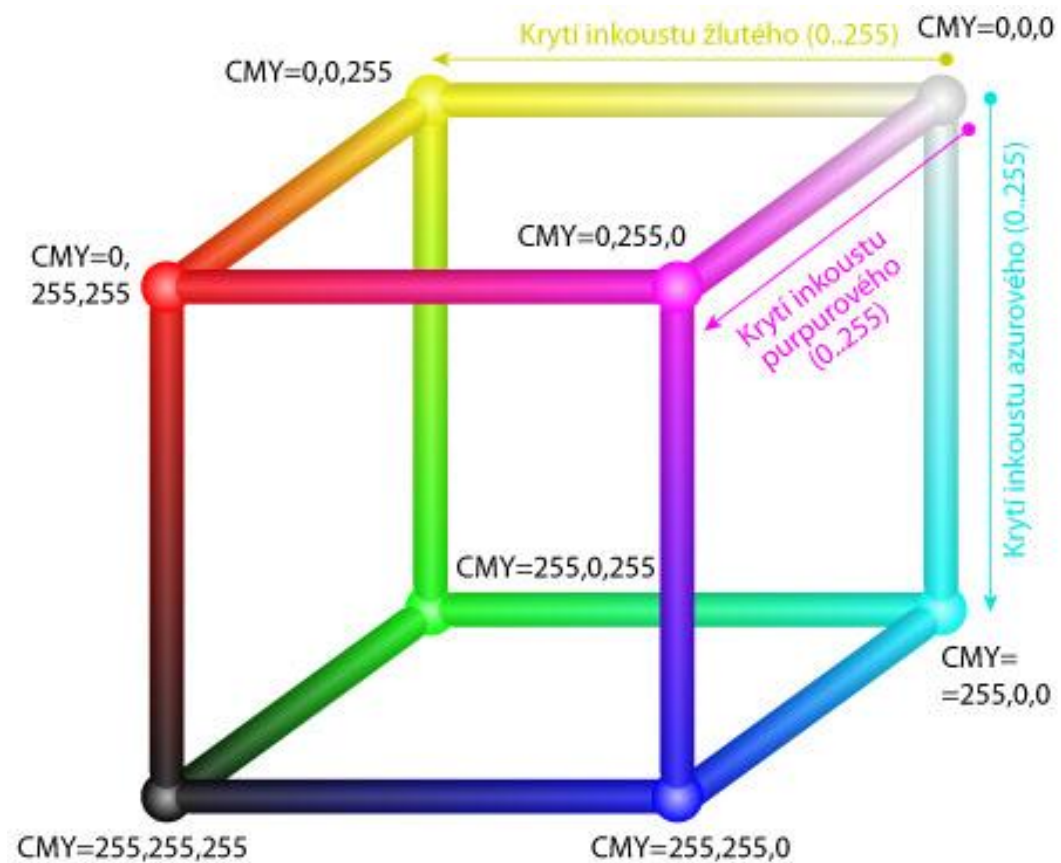
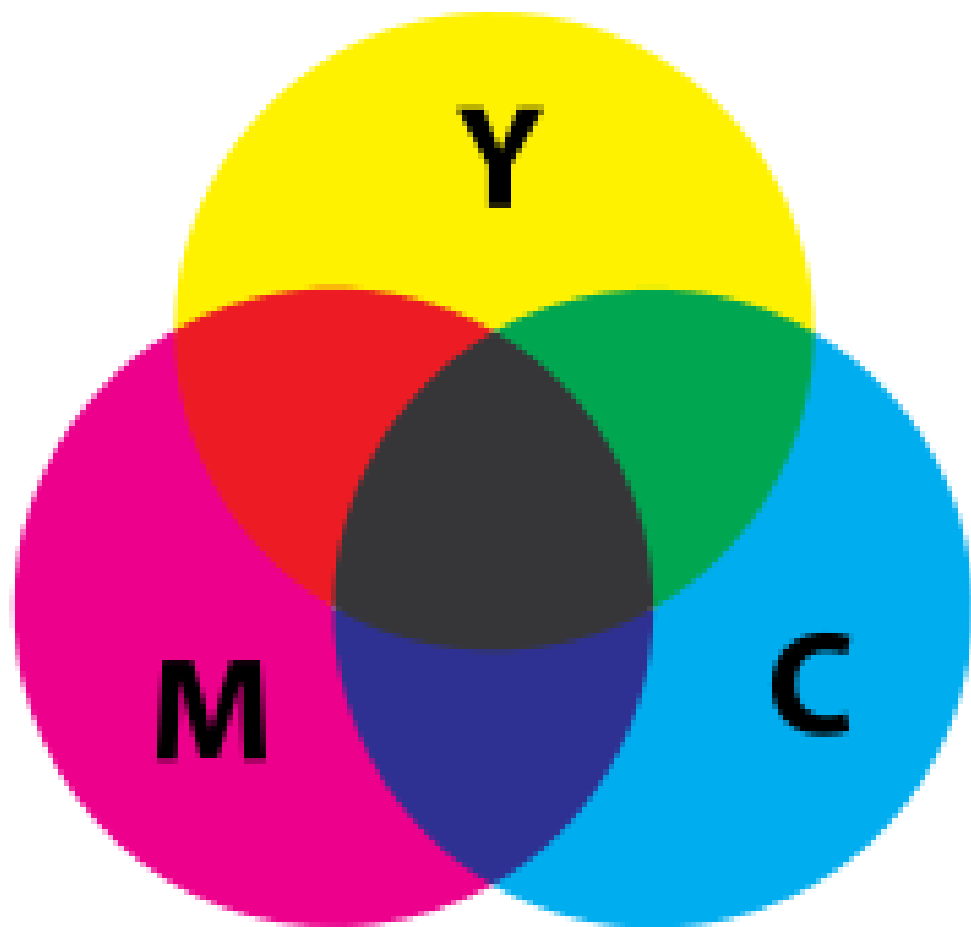
Aditívna sústava - RGB



RGB



Subtraktívna sústava - CMY

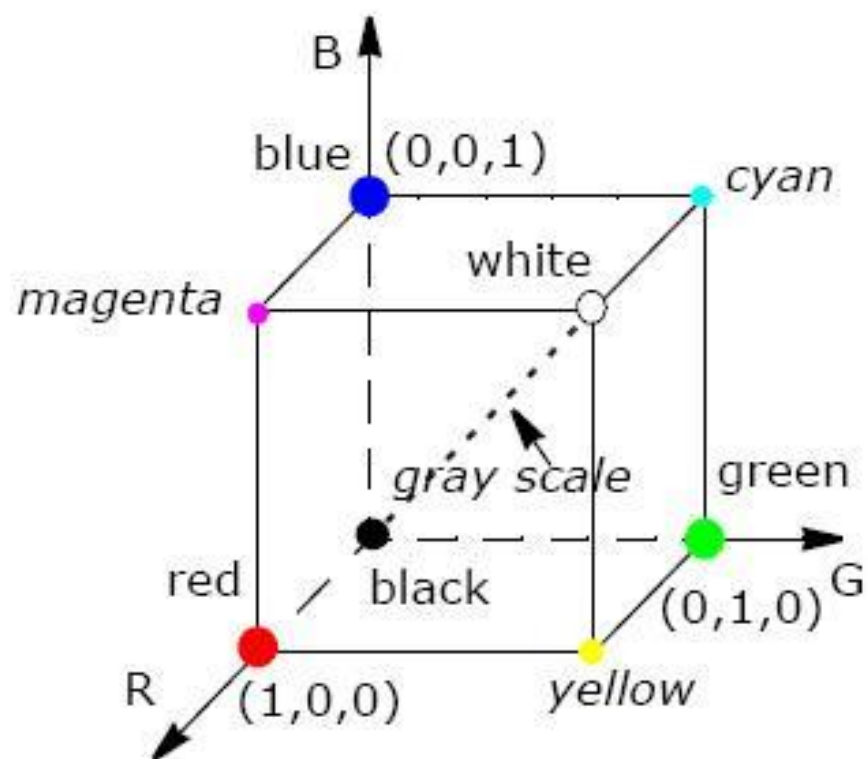


CMY

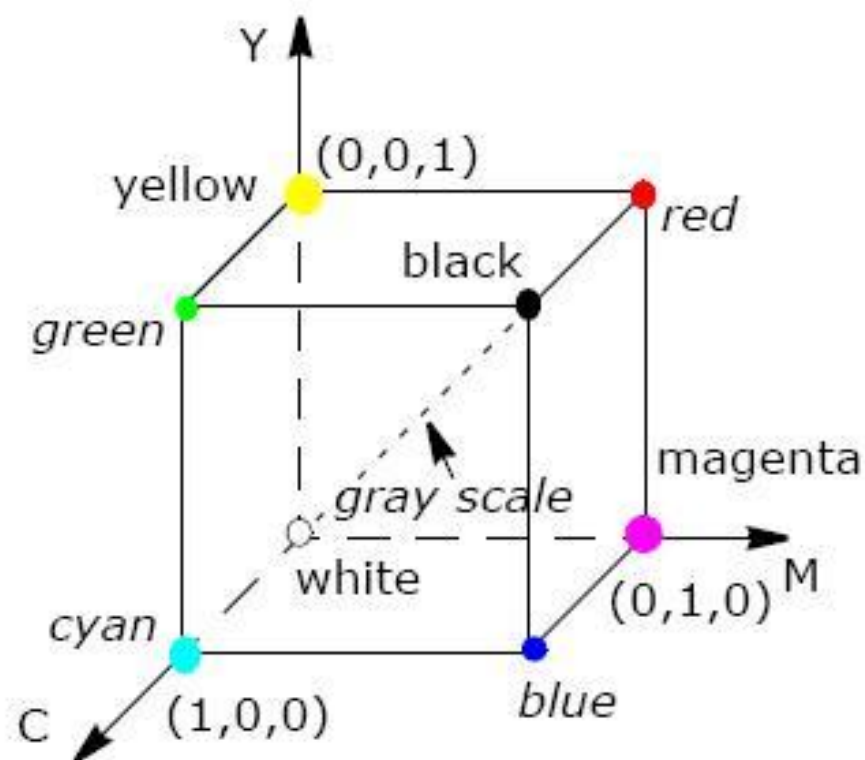
CMYK

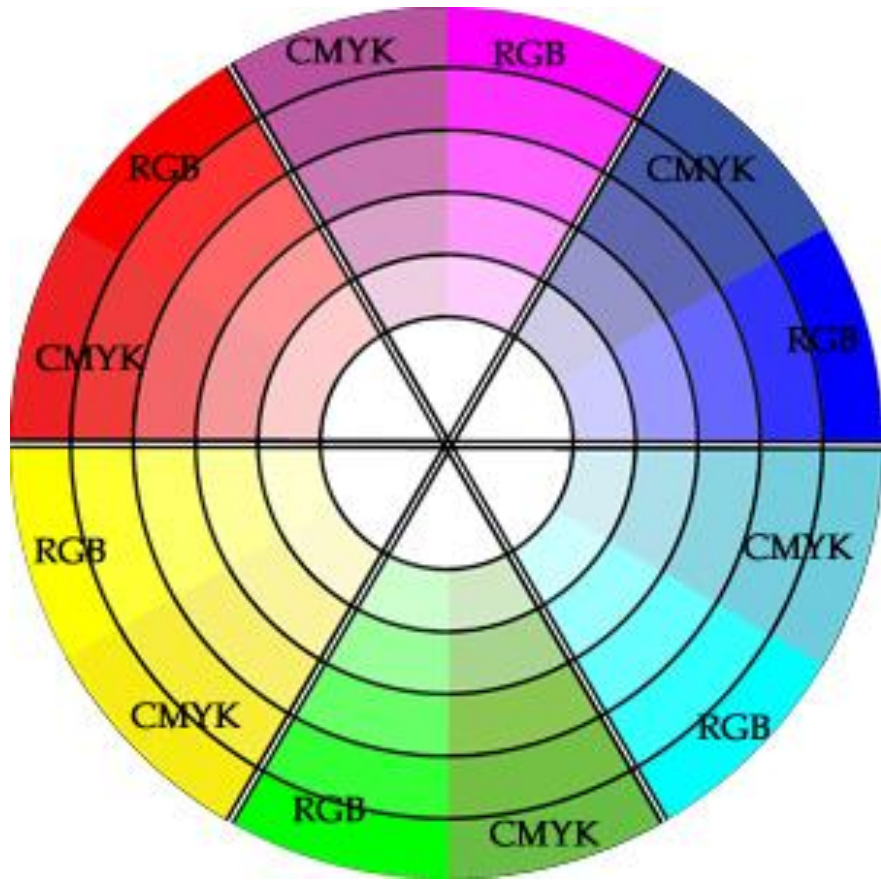


a) RGB

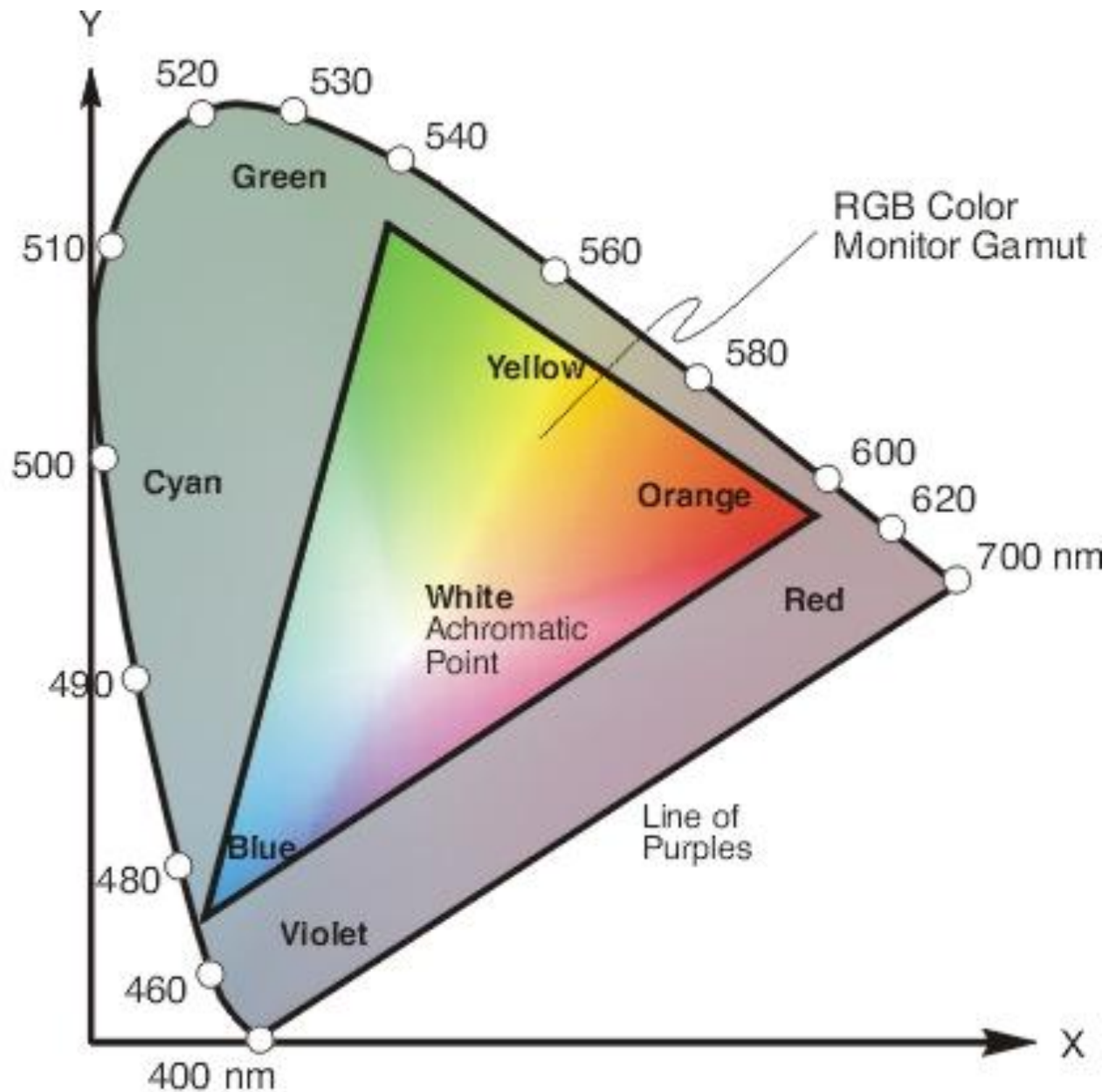


b) CMY



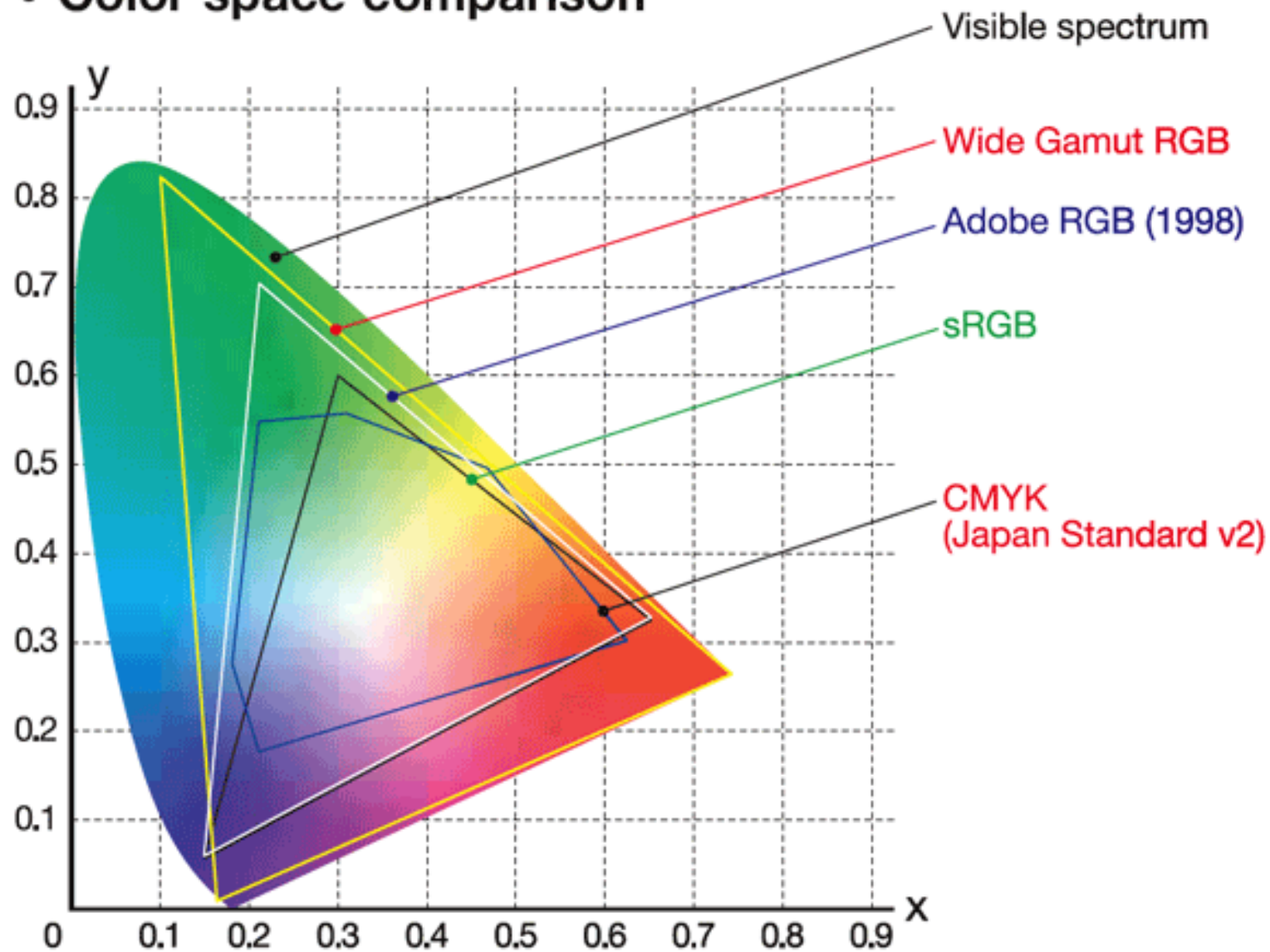


Gamut - vnímateľnosť, zobraziteľnosť

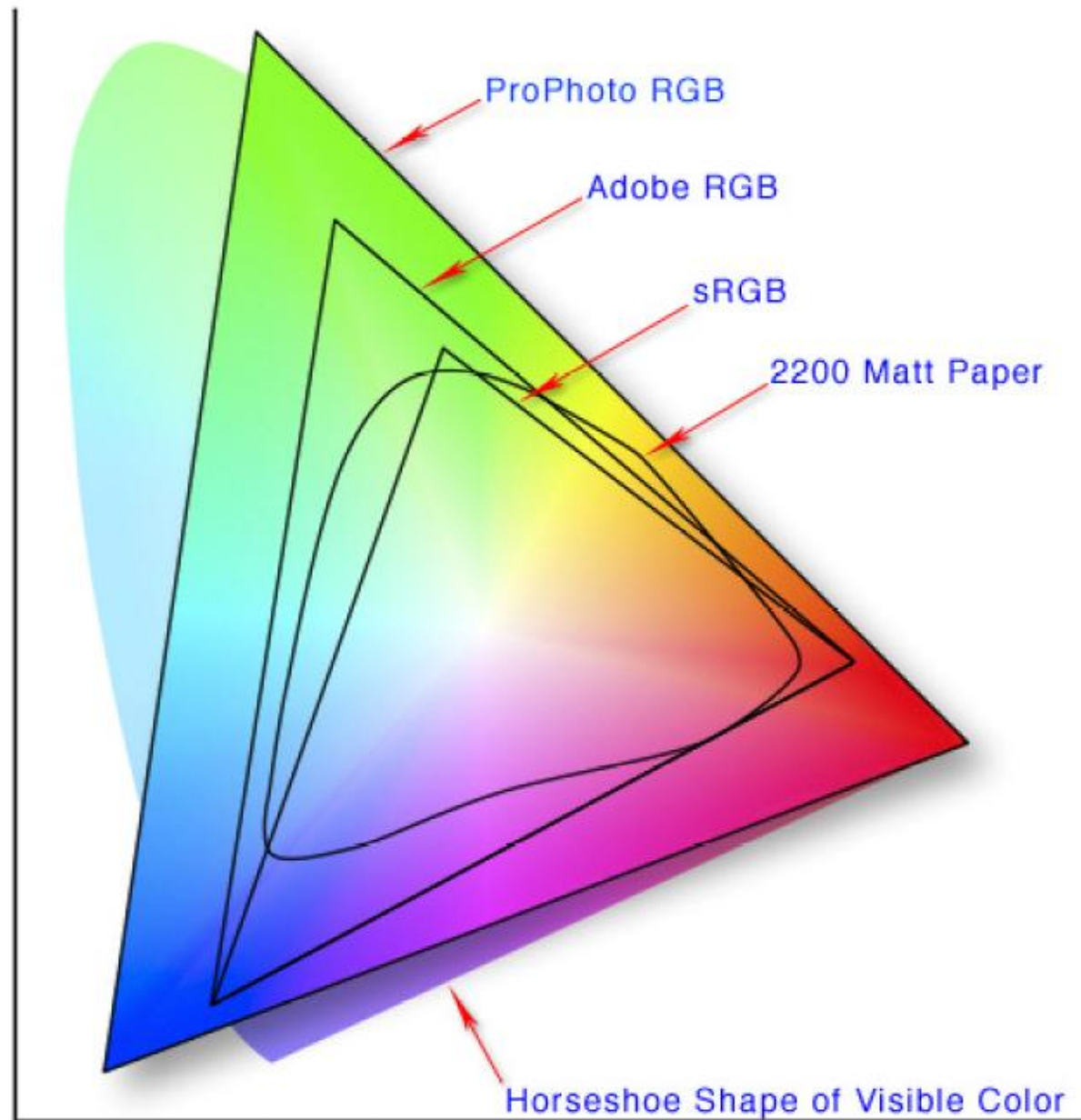


Gamut - vnímateľnosť, zobraziteľnosť

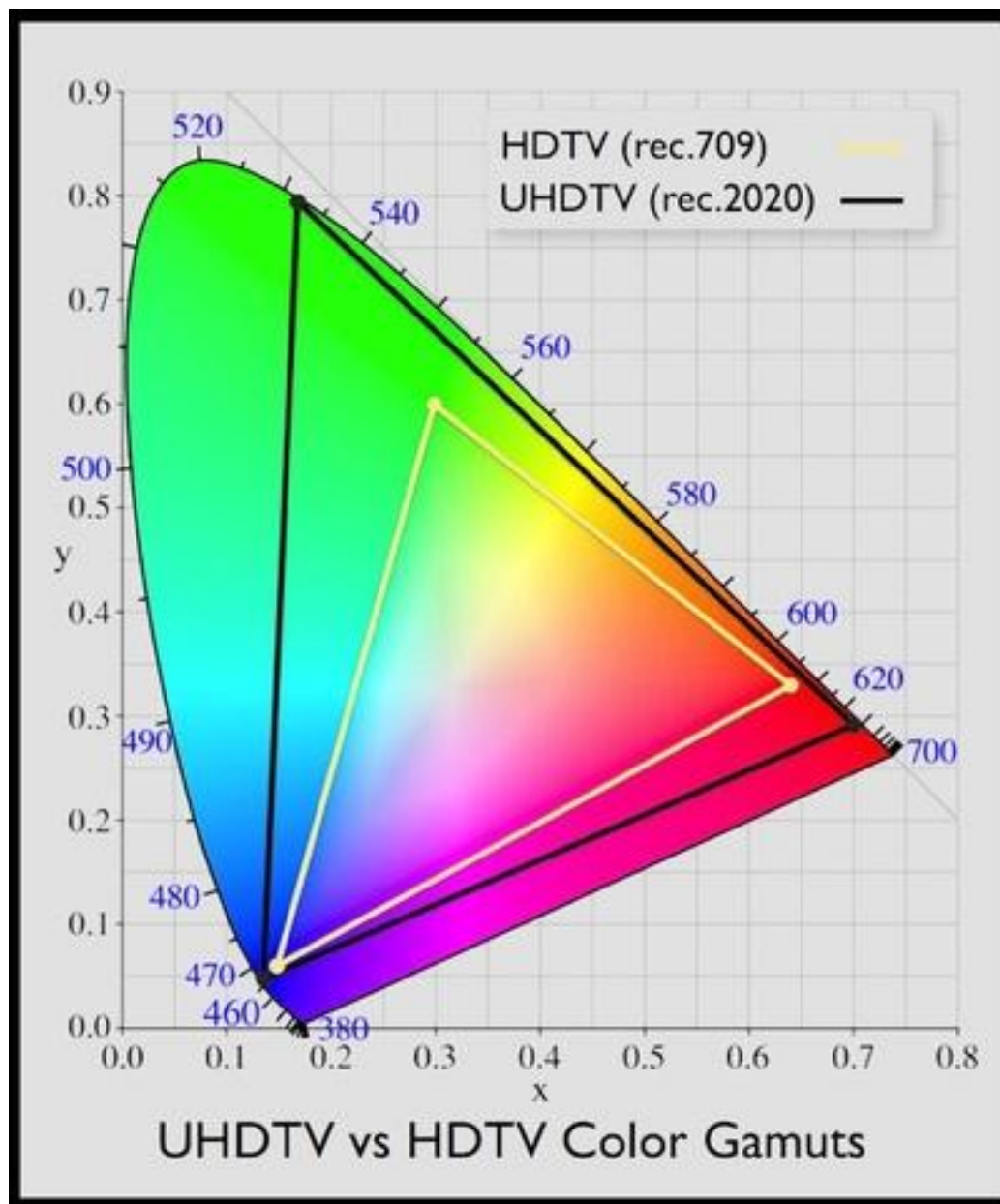
• Color space comparison



Gamut - vnímateľnosť, zobraziteľnosť



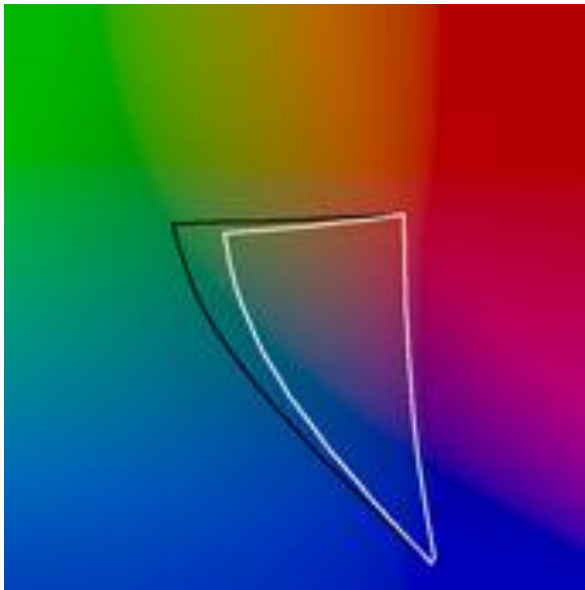
Gamut - vnímateľnosť, zobraziteľnosť



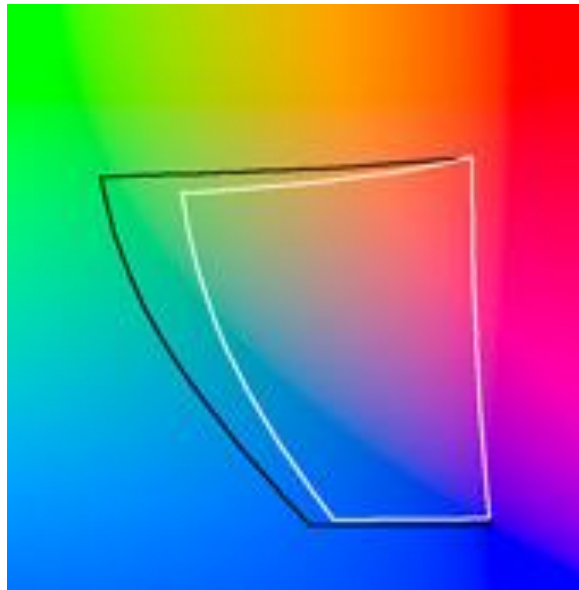
Gamut - vnímateľnosť, zobraziteľnosť

sRGB IEC61966-2.1

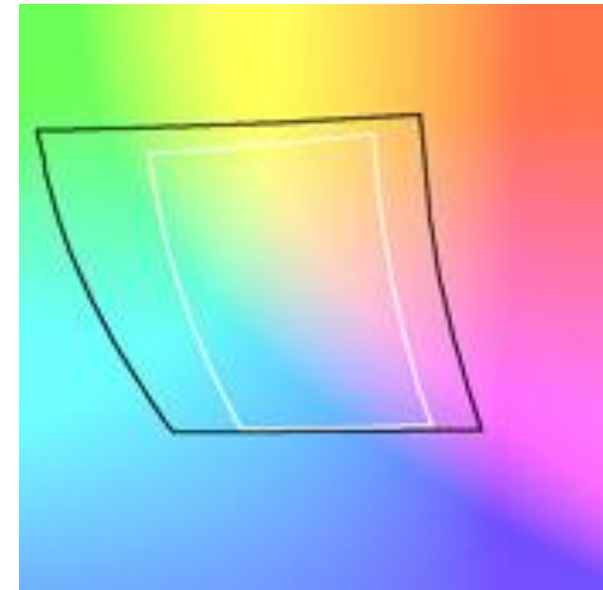
Adobe RGB 1998



25% Luminance



50% Luminance

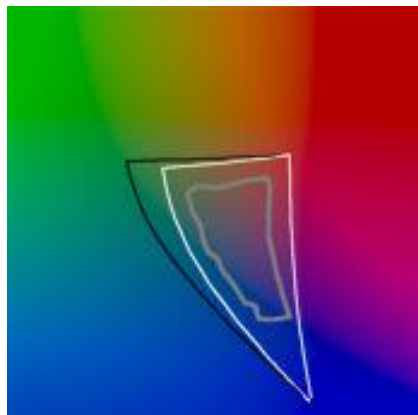


75% Luminance

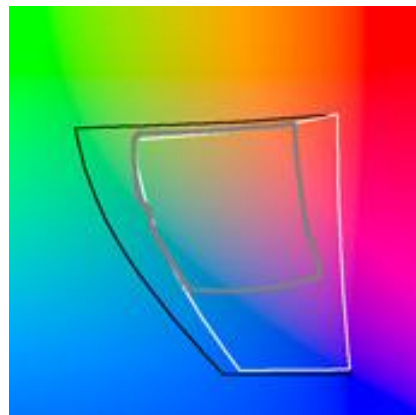
Gamut - vnímateľnosť, zobraziteľnosť

sRGB IEC61966-2.1

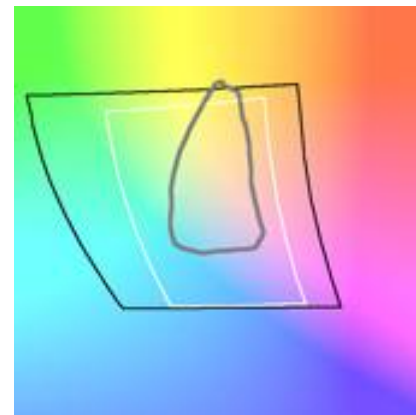
Adobe RGB 1998



25% Luminance



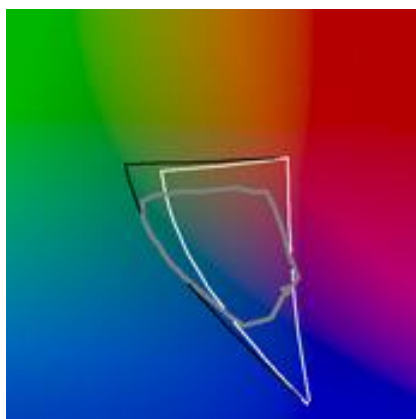
50% Luminance



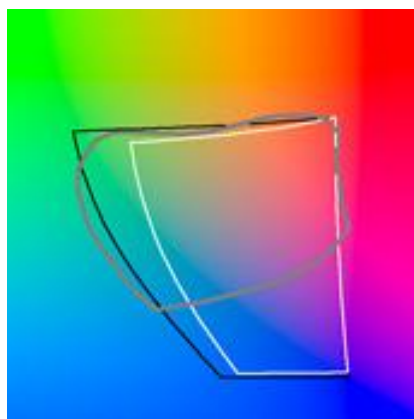
75% Luminance

sRGB IEC61966-2.1

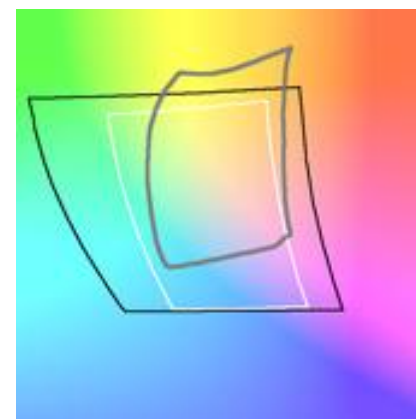
Adobe RGB 1998



25% Luminance



50% Luminance



75% Luminance

Gamut - vnímateľnosť, zobraziteľnosť

Adobe RGB



Apple RGB



sRGB



Wide Gamut RGB



Príklady farebných sústav a prepočtov medzi nimi

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = [M] \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

RGB Working Space	RGB to XYZ [M]			XYZ to RGB [M] ⁻¹		
Adobe RGB (1998)	0.5767309	0.1855540	0.1881852	2.0413690	-0.5649464	-0.3446944
	0.2973769	0.6273491	0.0752741	-0.9692660	1.8760108	0.0415560
	0.0270343	0.0706872	0.9911085	0.0134474	-0.1183897	1.0154096
AppleRGB	0.4497288	0.3162486	0.1844926	2.9515373	-1.2894116	-0.4738445
	0.2446525	0.6720283	0.0833192	-1.0851093	1.9908566	0.0372026
	0.0251848	0.1411824	0.9224628	0.0854934	-0.2694964	1.0912975
Best RGB	0.6326696	0.2045558	0.1269946	1.7552599	-0.4836786	-0.2530000
	0.2284569	0.7373523	0.0341908	-0.5441336	1.5068789	0.0215528
	0.0000000	0.0095142	0.8156958	0.0063467	-0.0175761	1.2256959
Beta RGB	0.6712537	0.1745834	0.1183829	1.6832270	-0.4282363	-0.2360185
	0.3032726	0.6637861	0.0329413	-0.7710229	1.7065571	0.0446900
	0.0000000	0.0407010	0.7845090	0.0400013	-0.0885376	1.2723640
Bruce RGB	0.4674162	0.2944512	0.1886026	2.7454669	-1.1358136	-0.4350269
	0.2410115	0.6835475	0.0754410	-0.9692660	1.8760108	0.0415560
	0.0219101	0.0736128	0.9933071	0.0112723	-0.1139754	1.0132541
CIE RGB	0.4887180	0.3106803	0.2006017	2.3706743	-0.9000405	-0.4706338
	0.1762044	0.8129847	0.0108109	-0.5138850	1.4253036	0.0885814
	0.0000000	0.0102048	0.9897952	0.0052982	-0.0146949	1.0093968
ColorMatch RGB	0.5093439	0.3209071	0.1339691	2.6422874	-1.2234270	-0.3930143
	0.2748840	0.6581315	0.0669845	-1.1119763	2.0590183	0.0159614
	0.0242545	0.1087821	0.6921735	0.0821699	-0.2807254	1.4559877
Don RGB 4	0.6457711	0.1933511	0.1250978	1.7603902	-0.4881198	-0.2536126
	0.2783496	0.6879702	0.0336802	-0.7126288	1.6527432	0.0416715
	0.0037113	0.0179861	0.8035125	0.0078207	-0.0347411	1.2447743

ECI RGB	0.6502043	0.1780774	0.1359384	1.7827618	-0.4969847	-0.2690101
	0.3202499	0.6020711	0.0776791	-0.9593623	1.9477962	-0.0275807
	0.0000000	0.0678390	0.7573710	0.0859317	-0.1744674	1.3228273
Ekta Space PS5	0.5938914	0.2729801	0.0973485	2.0043819	-0.7304844	-0.2450052
	0.2606286	0.7349465	0.0044249	-0.7110285	1.6202126	0.0792227
	0.0000000	0.0419969	0.7832131	0.0381263	-0.0868780	1.2725438
NTSC RGB	0.6068909	0.1735011	0.2003480	1.9099961	-0.5324542	-0.2882091
	0.2989164	0.5865990	0.1144845	-0.9846663	1.9991710	-0.0283082
	0.0000000	0.0660957	1.1162243	0.0583056	-0.1183781	0.8975535
PAL/SECAM RGB	0.4306190	0.3415419	0.1783091	3.0628971	-1.3931791	-0.4757517
	0.2220379	0.7066384	0.0713236	-0.9692660	1.8760108	0.0415560
	0.0201853	0.1295504	0.9390944	0.0678775	-0.2288548	1.0693490
ProPhoto RGB	0.7976749	0.1351917	0.0313534	1.3459433	-0.2556075	-0.0511118
	0.2880402	0.7118741	0.0000857	-0.5445989	1.5081673	0.0205351
	0.0000000	0.0000000	0.8252100	0.0000000	0.0000000	1.2118128
SMPTE-C RGB	0.3935891	0.3652497	0.1916313	3.5053960	-1.7394894	-0.5439640
	0.2124132	0.7010437	0.0865432	-1.0690722	1.9778245	0.0351722
	0.0187423	0.1119313	0.9581563	0.0563200	-0.1970226	1.0502026
sRGB	0.4124564	0.3575761	0.1804375	3.2404542	-1.5371385	-0.4985314
	0.2126729	0.7151522	0.0721750	-0.9692660	1.8760108	0.0415560
	0.0193339	0.1191920	0.9503041	0.0556434	-0.2040259	1.0572252
Wide Gamut RGB	0.7161046	0.1009296	0.1471858	1.4628067	-0.1840623	-0.2743606
	0.2581874	0.7249378	0.0168748	-0.5217933	1.4472381	0.0677227
	0.0000000	0.0517813	0.7734287	0.0349342	-0.0968930	1.2884099

Príklady farebných sústav a prepočtov medzi nimi

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 1]
Y [0 ... 1]
U [-0.436 ... +0.436]
V [-0.615 ... +0.615]

RGB to YUV color conversion for analog TV

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.140 \\ 1.000 & -0.395 & -0.581 \\ 1.000 & 2.032 & 0.000 \end{bmatrix} \cdot \begin{bmatrix} Y \\ U \\ V \end{bmatrix}$$

Ranges:
Y [0 ... 1]
U [-0.436 ... +0.436]
V [-0.615 ... +0.615]
R/G/B [0 ... 1]

YUV to RGB color conversion for analog TV

Príklady farebných sústav a prepočtov medzi nimi

$$\begin{bmatrix} Y \\ Pb \\ Pr \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 255]
Y [0 ... 255]
Pb/Pr [-127.5 ... +127.5]

RGB to YPbPr color conversion for SDTV

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.402 \\ 1.000 & -0.344 & -0.714 \\ 1.000 & 1.772 & 0.000 \end{bmatrix} \cdot \begin{bmatrix} Y \\ Pb \\ Pr \end{bmatrix}$$

Ranges:
Y [0 ... 255]
Pb/Pr [-127.5 ... +127.5]
R/G/B [0 ... 255]

YPbPr to RGB color conversion for SDTV

Príklady farebných sústav a prepočtov medzi nimi

$$\begin{bmatrix} Y \\ Pb \\ Pr \end{bmatrix} = \begin{bmatrix} 0.213 & 0.715 & 0.072 \\ -0.115 & -0.385 & 0.500 \\ 0.500 & -0.454 & -0.046 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 255]
Y [0 ... 255]
Pb/Pr [-127.5 ... +127.5]

RGB to YPbPr color conversion for HDTV

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.575 \\ 1.000 & -0.187 & -0.468 \\ 1.000 & 1.856 & 0.000 \end{bmatrix} \cdot \begin{bmatrix} Y \\ Pb \\ Pr \end{bmatrix}$$

Ranges:
Y [0 ... 255]
Pb/Pr [-127.5 ... +127.5]
R/G/B [0 ... 255]

YPbPr to RGB color conversion for HDTV

Príklady farebných sústav a prepočtov medzi nimi

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.257 & 0.504 & 0.098 \\ -0.148 & -0.291 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 255]
Y [16 ... 235]
Cb/Cr [16 ... 240]

RGB to YCbCr color conversion for SDTV

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.164 & 0.000 & 1.596 \\ 1.164 & -0.392 & -0.813 \\ 1.164 & 2.017 & 0.000 \end{bmatrix} \cdot \begin{bmatrix} (Y - 16) \\ (Cb - 128) \\ (Cr - 128) \end{bmatrix}$$

Ranges:
Y [16 ... 235]
Cb/Cr [16 ... 240]
R/G/B [0 ... 255]

YCbCr to RGB color conversion for SDTV

Príklady farebných sústav a prepočtov medzi nimi

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 255]
Y/Cb/Cr [0 ... 255]

RGB to full-range YCbCr color conversion

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.400 \\ 1.000 & -0.343 & -0.711 \\ 1.000 & 1.765 & 0.000 \end{bmatrix} \cdot \begin{bmatrix} Y \\ (Cb - 128) \\ (Cr - 128) \end{bmatrix}$$

Ranges:
Y/Cb/Cr [0 ... 255]
R/G/B [0 ... 255]

Full-range YCbCr to RGB color conversion

Príklady farebných sústav a prepočtov medzi nimi

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.183 & 0.614 & 0.062 \\ -0.101 & -0.339 & 0.439 \\ 0.439 & -0.399 & -0.040 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 255]
Y [16 ... 235]
Cb/Cr [16 ... 240]

RGB to YCbCr color conversion for HDTV

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.164 & 0.000 & 1.793 \\ 1.164 & -0.213 & -0.533 \\ 1.164 & 2.112 & 0.000 \end{bmatrix} \cdot \begin{bmatrix} (Y - 16) \\ (Cb - 128) \\ (Cr - 128) \end{bmatrix}$$

Ranges:
Y [16 ... 235]
Cb/Cr [16 ... 240]
R/G/B [0 ... 255]

YCbCr to RGB color conversion for HDTV

Príklady farebných sústav a prepočtov medzi nimi

NTSC

$R, G, B, Y \in [0, 1]$, $I \in [-0.5957, 0.5957]$, $Q \in [-0.5226, 0.5226]$

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.595716 & -0.274453 & -0.321263 \\ 0.211456 & -0.522591 & 0.311135 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad \begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & 0.9563 & 0.6210 \\ 1 & -0.2721 & -0.6474 \\ 1 & -1.1070 & 1.7046 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix}$$

YCC

From $R'G'B'$ with a 0–255 range, a luma and two chrominance signals (C1 and C2) are generated:

$$Y = 0.213R' + 0.419G' + 0.081B'$$

$$C1 = -0.131R' - 0.256G' + 0.387B' + 156$$

$$C2 = 0.373R' - 0.312G' - 0.061B' + 137$$

$$R' = 0.981Y + 1.315(C2 - 137)$$

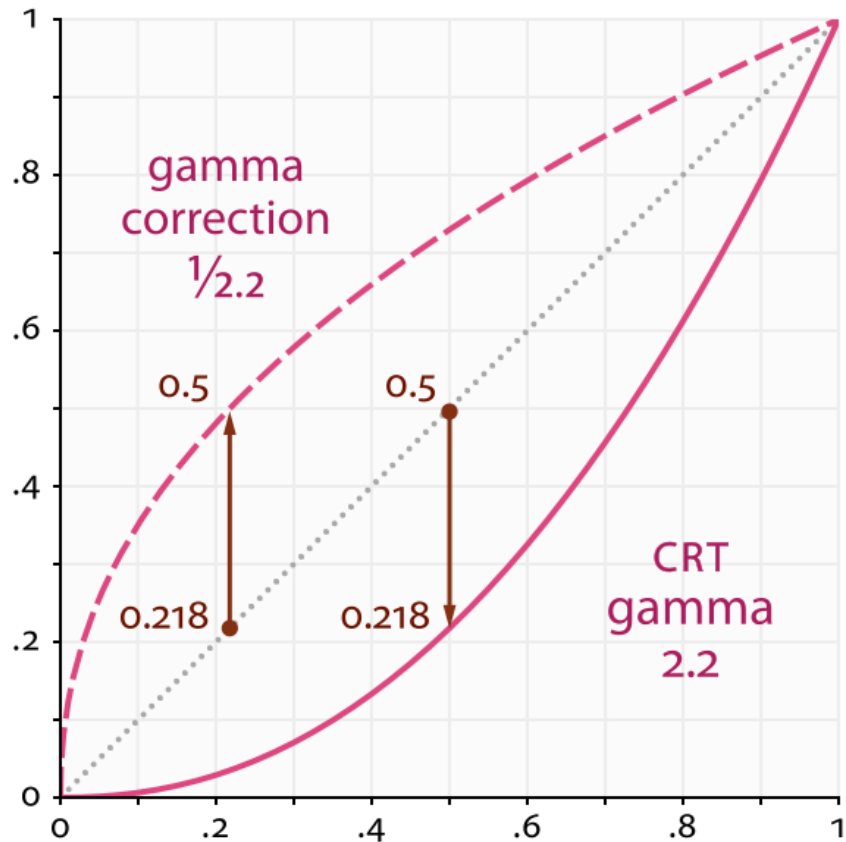
$$G' = 0.981Y - 0.311(C1 - 156) - 0.669(C2 - 137)$$

$$B' = 0.981Y + 1.601(C1 - 156)$$

Príklady farebných sústav a prepočtov medzi nimi

Poznámka: RGB pri zobrazovaní na CRT monitoroch má gama korekciu, preto pri konverzii do YUV musí byť urobená inverzná operácia.

$$V_{\text{out}} = AV_{\text{in}}^{\gamma}$$



Pôvodné NTSC 2,2 - PAL, SECAM 2,8, Macintosh 0,55 a 1,8

Súčasné NTSC, PAL, HDTV a PhotoYCC konverzia používajú:

$$E'_{709} = \begin{cases} 4.5L, & L \leq 0.018 \\ 1.099L^{0.45} - 0.099, & 0.018 < L \end{cases}$$

$$L = \begin{cases} \frac{E'_{709}}{4.5}, & E'_{709} \leq 0.081 \\ \left(\frac{E'_{709} + 0.099}{1.099} \right)^{\frac{1}{0.45}}, & 0.081 < E'_{709} \end{cases}$$



$\gamma=2$



$\gamma=1$ (original)



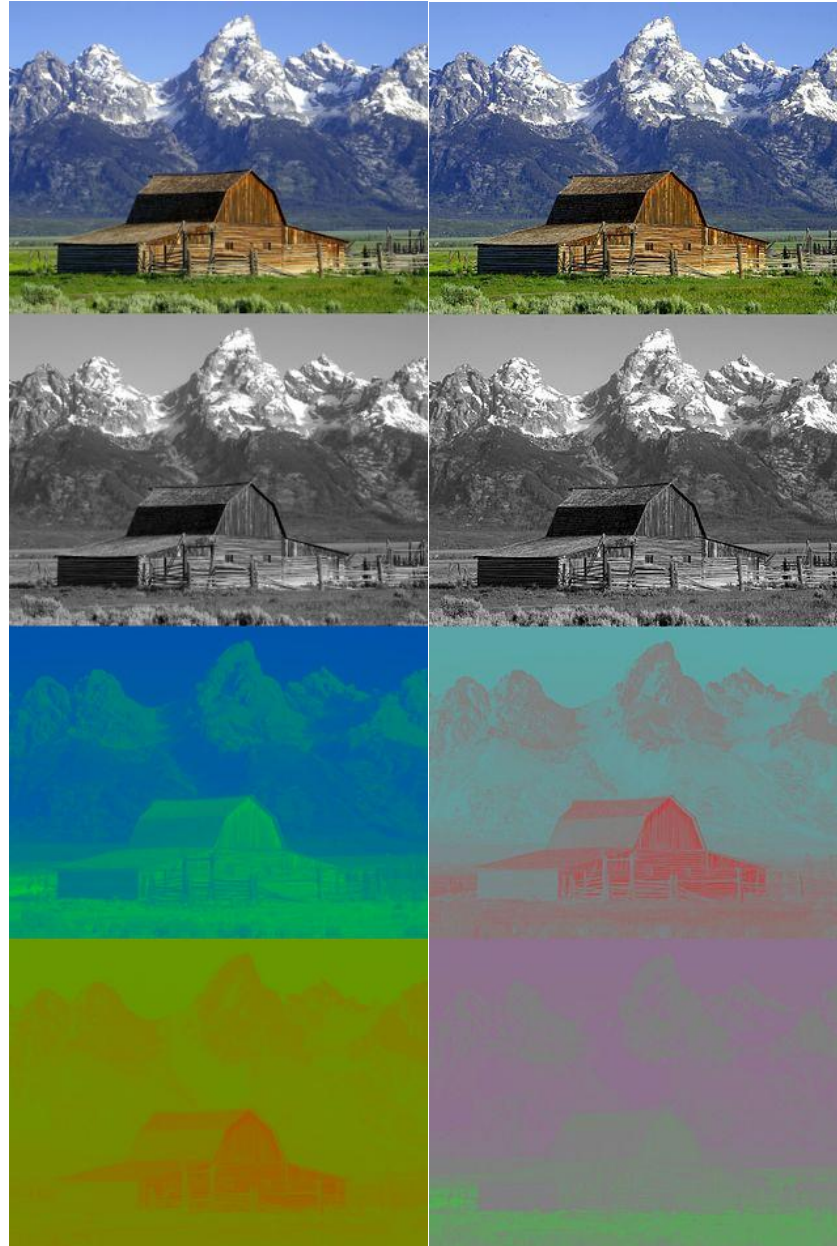
$\gamma=1/2$



$\gamma=1/3$

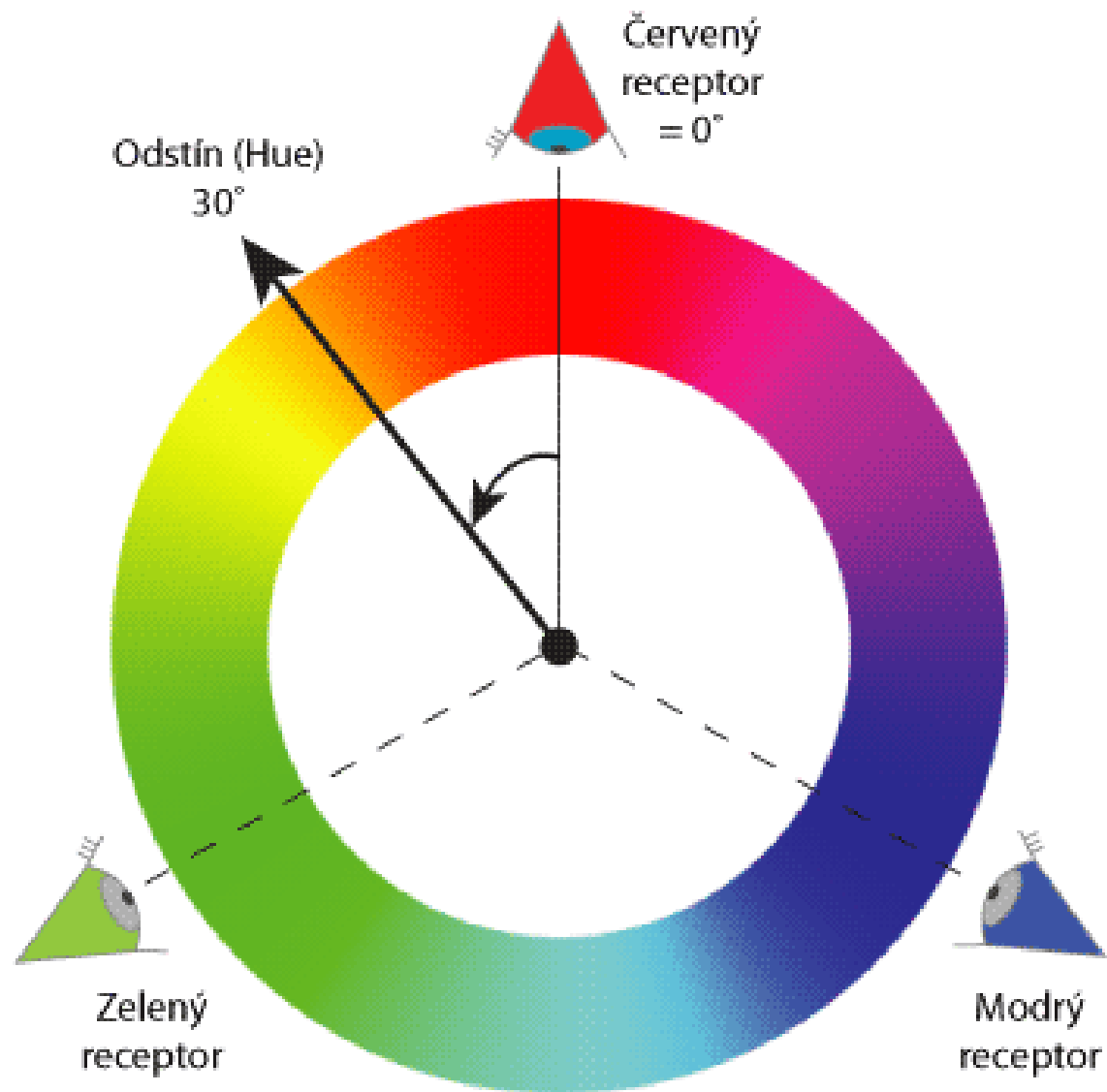
PAL/SECAM

NTSC

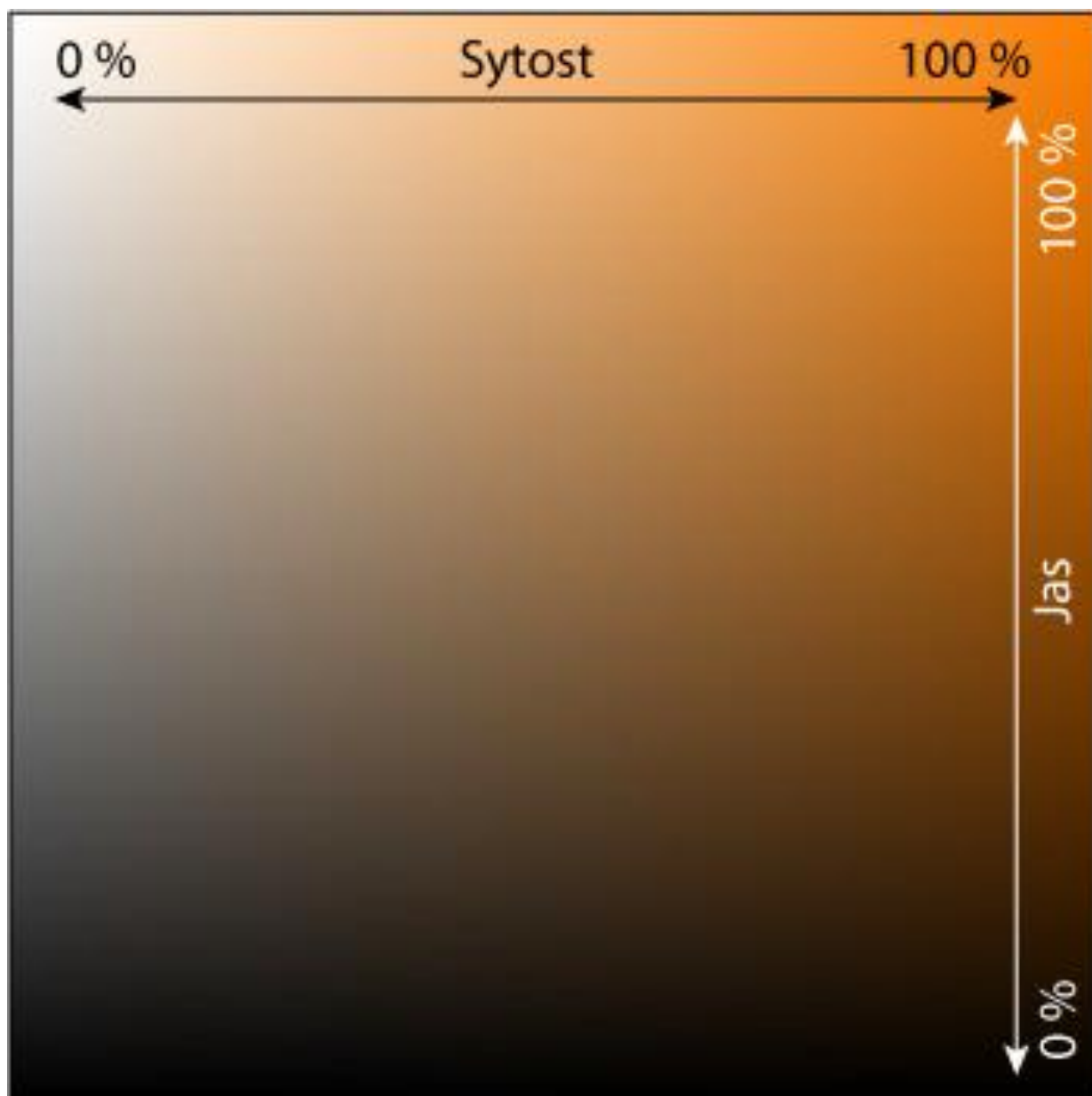


Farebné modely HSV, HSL

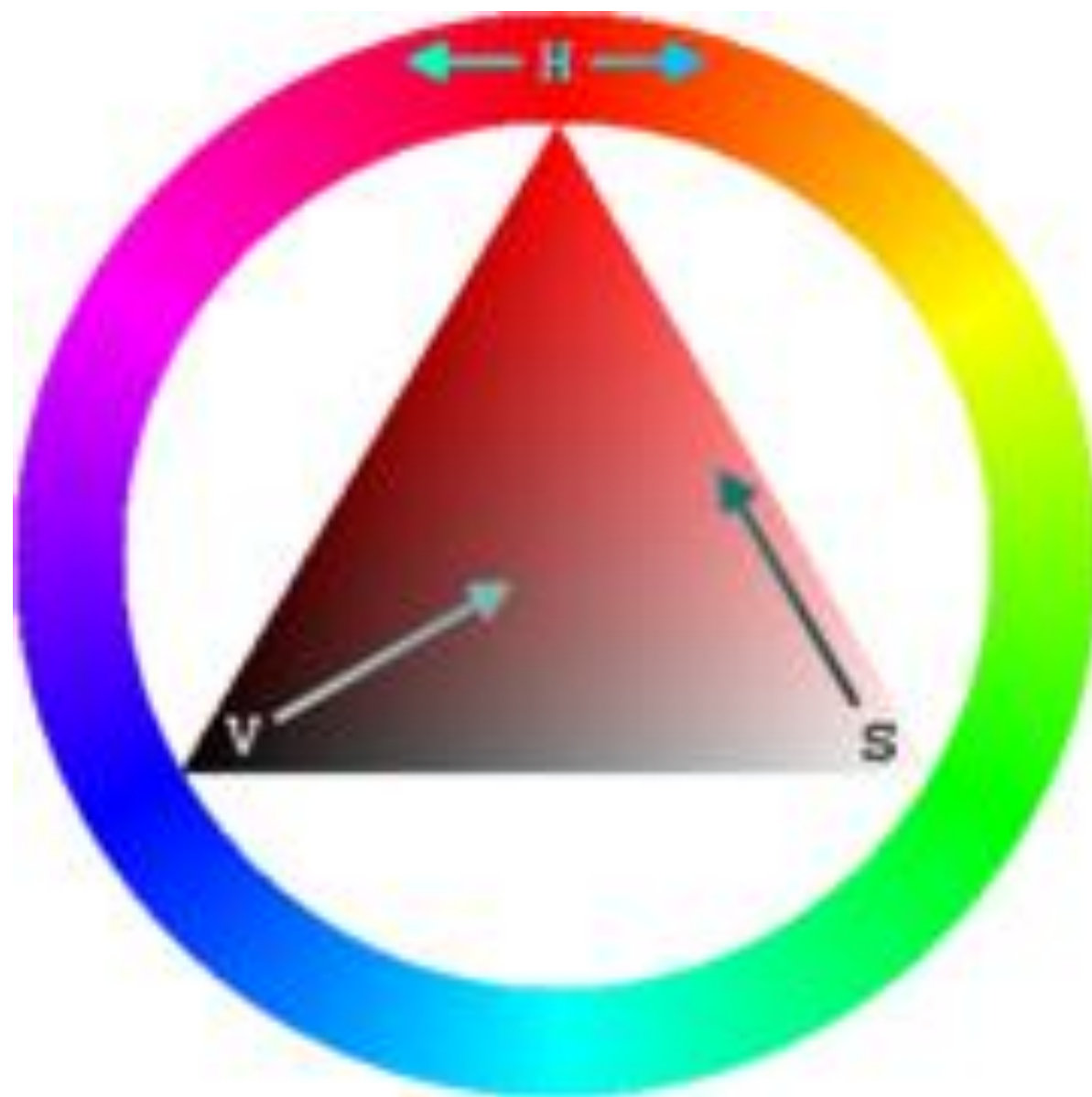
HSV - farebný tón, sýtosť, jas



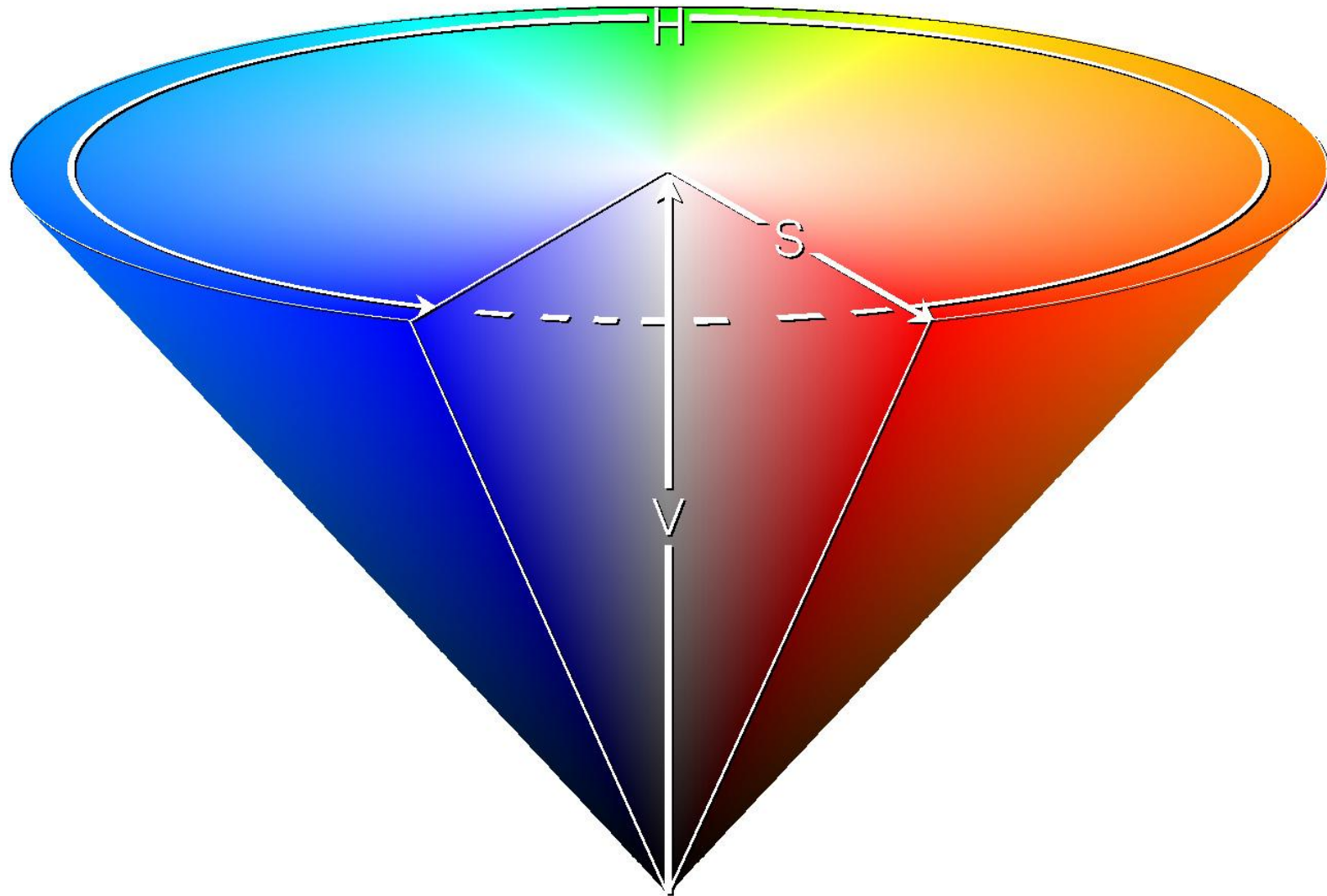
HSV



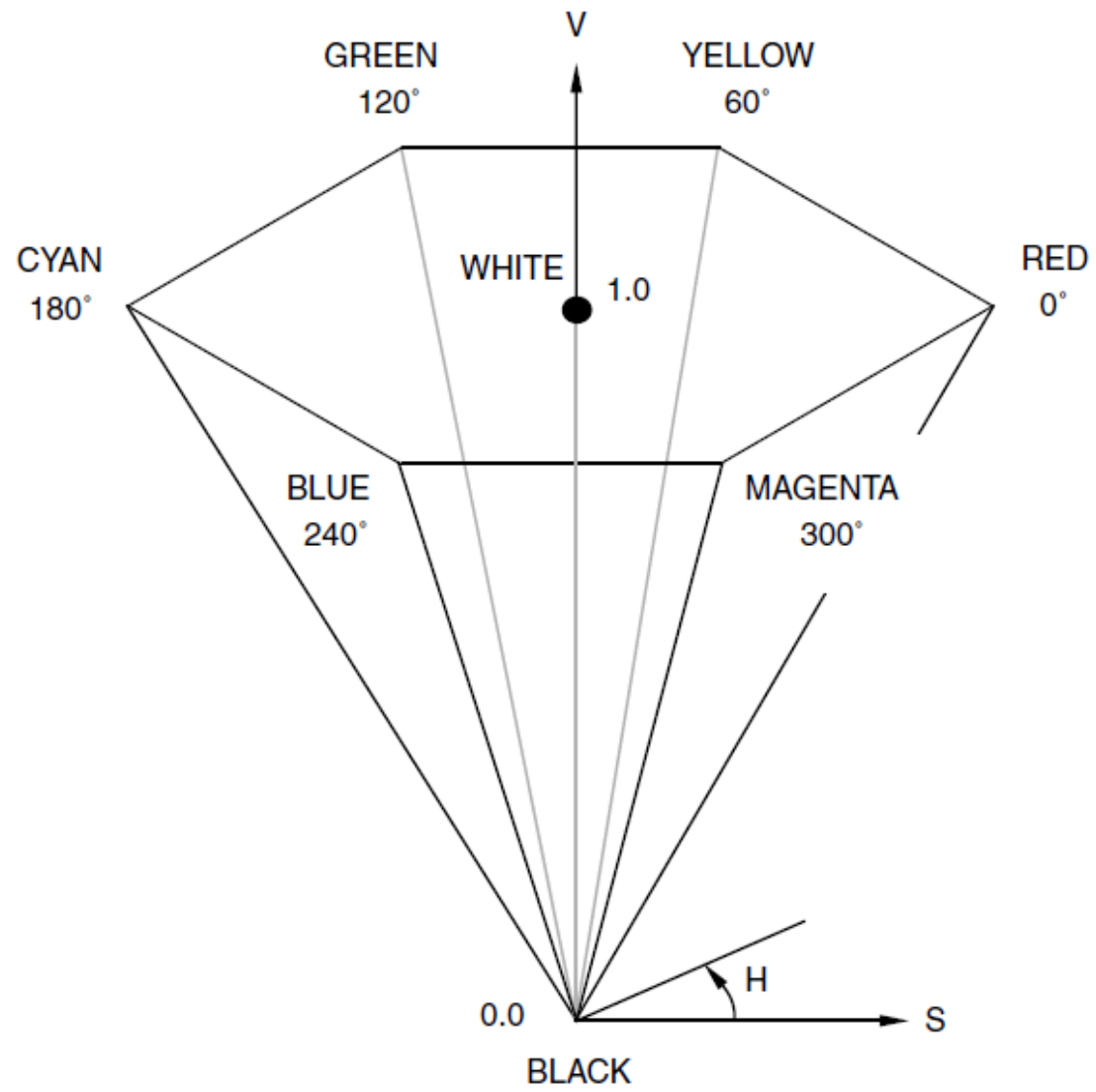
HSV



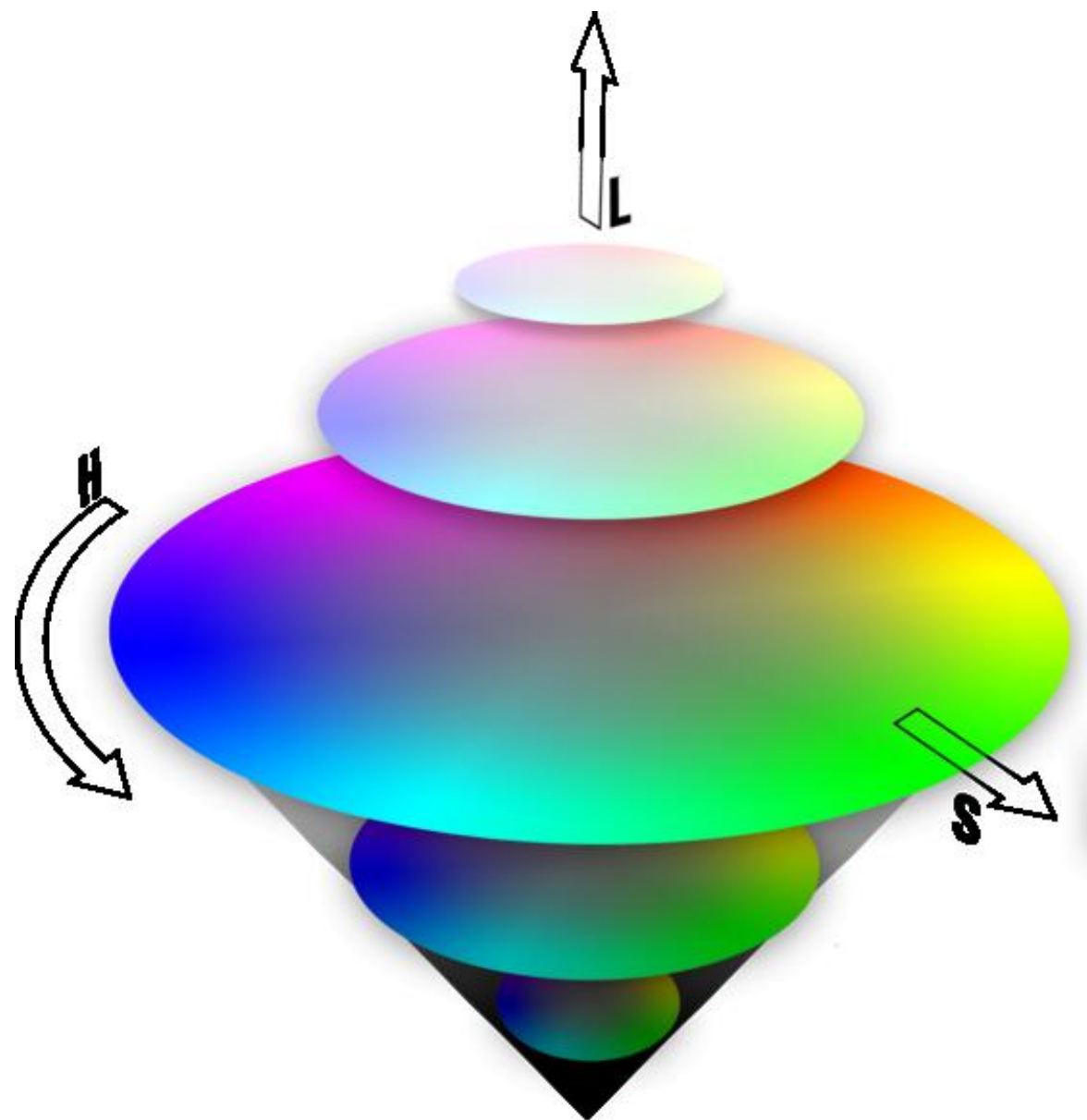
HSV



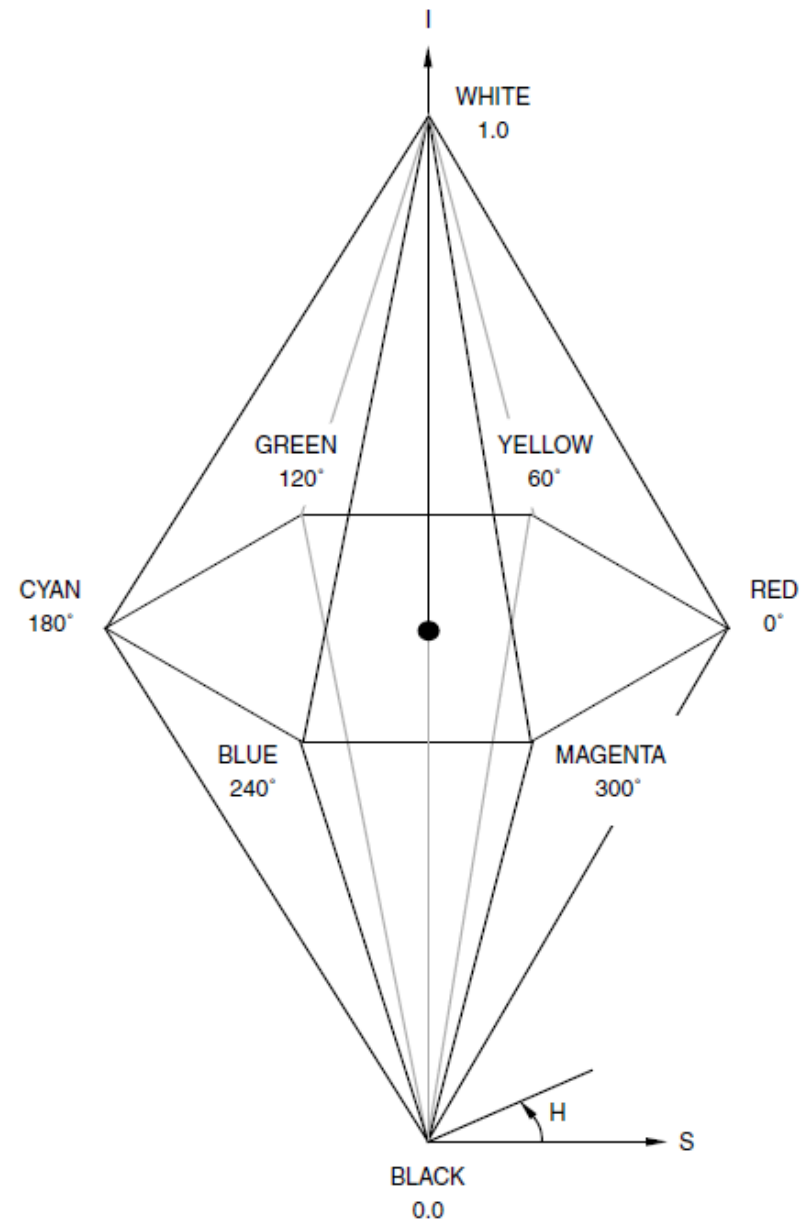
HSV



HSL - farebný tón, sýtosť, svetlosť



HSL



HSL



Original



Hue +50



Hue -50



Saturation +50



Saturation -50



Lightness +50



Lightness -50

HSV

HSL

