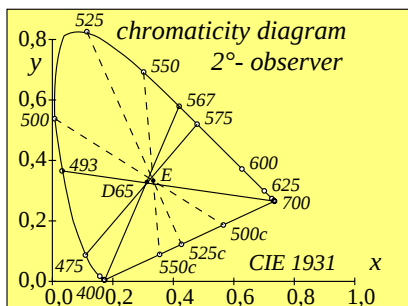


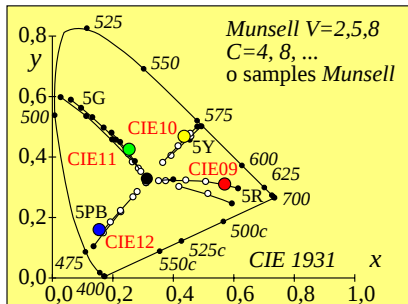
CIELAB 1976 $L^*a^*b^*$ color space definition and reversal

$$\begin{aligned} L^* &= 116 (Y/Y_n)^{1/3} - 16 \\ a^* &= 500 [(X/X_n)^{1/3} - (Y/Y_n)^{1/3}] \\ b^* &= 200 [(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}] \\ X &= X_n [(L^* + 16) / 116 + a^*/500]^3 \\ Y &= Y_n [(L^* + 16) / 116]^3 \\ Z &= Z_n [(L^* + 16) / 116 - b^*/200]^3 \end{aligned}$$

CES20-1N



CES20-3N



CES20-5N

CIELAB 1976 $L^*a^*b^*$ color space definition and derivation ($X_u/X_n=Y_u/Y_n=Z_u/Z_n=0,18$)

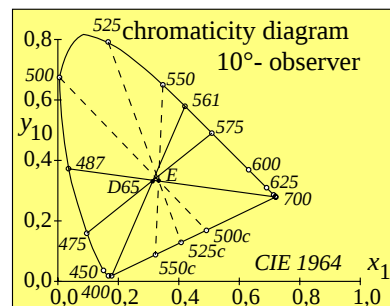
$$\begin{aligned} L^* &= 116 (Y/Y_n)^{1/3} - 16 \quad [Y/Y_n]^{1/3} > 24/116 \\ a^* &= 500 [(X/X_n)^{1/3} - (Y/Y_n)^{1/3}] \quad Y > 0,885 \\ b^* &= 200 [(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}] \\ dL^*/dY &= 116 [(Y/Y_n)^{-2/3} / (3Y_n)] \quad Y_n=100 \\ da^*/dY &= 500 [(X/X_n)^{-2/3} / (3X_n) - (Y/Y_n)^{-2/3} / (3Y_n)] \\ db^*/dY &= 200 [(Y/Y_n)^{-2/3} / (3X_n) - (Z/Z_n)^{-2/3} / (3Z_n)] \\ c_u &=[Y_u/Y_n]^{1/3} = 0,18^{1/3} = 0,5647, \text{ similar for } X, Z \\ u_1 &= 116c_u=65,51, u_a=500c_u=282,35, u_b=200c_u=112,94 \end{aligned}$$

CES20-7N

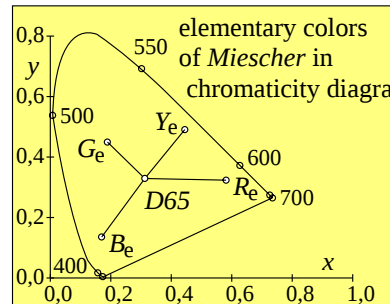
Q-function changes; transition from light- to color metrics

scaling function of **light metrics**:
 $Q[k(x - u)] = Q[k(\log L - \log L_u)]$
log L -> log P for **color metrics**:
 $Q[k(\log P - \log L_u)] = Q[k(\log L - \log L_u + \log P - \log L)]$
with saturation $p = \log P - \log L$
for color metrics: $Q[k(x - u + p)]$

CES20-2N



CES20-4N



CES20-6N

CIELAB_u 2022 $L^*a^*b^*$ color space definition and derivation ($X_u/X_n=Y_u/Y_n=Z_u/Z_n=0,18$)

$$\begin{aligned} L^*u &= 65,51 (Y/Y_u)^{1/3} - 16 = L^*_{CIELAB} - 0,49 \\ a^*u &= 282,35 [(X/X_u)^{1/3} - (Y/Y_u)^{1/3}] = a^*_{CIELAB} \\ b^*u &= 112,94 [(Y/Y_u)^{1/3} - (Z/Z_u)^{1/3}] = b^*_{CIELAB} \\ dL^*u/dY &= 65,51 [(Y/Y_u)^{-2/3} / (3Y_u)] \quad Y_u=18 \\ da^*u/dY &= 284,56 [(X/X_u)^{-2/3} / (3X_u) - (Y/Y_u)^{-2/3} / (3Y_u)] \\ db^*u/dY &= 113,78 [(Y/Y_u)^{-2/3} / (3X_u) - (Z/Z_u)^{-2/3} / (3Z_u)] \\ c_u &=[Y_u/Y_n]^{1/3} = 0,18^{1/3} = 0,5647, \text{ similar for } X, Z \\ u_1 &= 116c_u=65,51, u_a=500c_u=282,35, u_b=200c_u=112,94 \end{aligned}$$

CES20-8N

CIELAB 1976 $L^*a^*b^*$ color space and CIELAB_u 2022 $L^*a^*b^*$ color space

$$\begin{aligned} L^* &= 116 (Y/Y_n)^{1/3} - 16 \quad [Y/Y_n]^{1/3} > 24/116 \\ a^* &= 500 [(X/X_n)^{1/3} - (Y/Y_n)^{1/3}] \quad Y > 0,885 \\ b^* &= 200 [(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}] \\ L^*u &= 116 c_u (Y/Y_u)^{1/3} - 16 = L^* - 0,49 \quad Y_u=18 \\ a^*u &= 500 c_u [(X/X_u)^{1/3} - (Y/Y_u)^{1/3}] = a^* \\ b^*u &= 200 c_u [(Y/Y_u)^{1/3} - (Z/Z_u)^{1/3}] = b^* \\ c_u &=[Y_u/Y_n]^{1/3} = 0,18^{1/3} = 0,5647, \text{ similar for } X, Z \\ u_1 &= 116c_u=65,51, u_a=500c_u=282,35, u_b=200c_u=112,94 \end{aligned}$$

CES21-1N

CIELAB_u 2022 $L^*a^*b^*$ color space definition and reversal ($X_u/X_n=Y_u/Y_n=Z_u/Z_n=0,18$)

$$\begin{aligned} L^*u &= 116 c_u (Y/Y_u)^{1/3} - 16 = L^*_{CIELAB} - 0,49 \\ a^*u &= 500 c_u [(X/X_u)^{1/3} - (Y/Y_u)^{1/3}] = a^*_{CIELAB} \\ b^*u &= 200 c_u [(Y/Y_u)^{1/3} - (Z/Z_u)^{1/3}] = b^*_{CIELAB} \\ X &= X_u [(L^*u + 16) / (116c_u) + a^*u / (500c_u)]^3 \\ Y &= Y_u [(L^*u + 16) / (116c_u)]^3 \quad Y_u=18 \\ Z &= Z_u [(L^*u + 16) / (116c_u) - b^*u / (200c_u)]^3 \\ c_u &=[Y_u/Y_n]^{1/3} = 0,18^{1/3} = 0,5647, \text{ similar for } X, Z \\ u_1 &= 116c_u=65,51, u_a=500c_u=282,35, u_b=200c_u=112,94 \end{aligned}$$

CES21-3N

CIELAB_u 2022 $L^*a^*b^*$ color space definition and reversal ($X_u/X_n=Y_u/Y_n=Z_u/Z_n=0,18$)

$$\begin{aligned} L^*u &= u_1 (Y/Y_u)^{1/3} - 16 = L^*_{CIELAB} - 0,49 \\ a^*u &= u_a [(X/X_u)^{1/3} - (Y/Y_u)^{1/3}] = a^*_{CIELAB} \\ b^*u &= u_b [(Y/Y_u)^{1/3} - (Z/Z_u)^{1/3}] = b^*_{CIELAB} \\ X &= X_u [(L^*u + 16) / u_1 + a^*u / u_a]^3 \\ Y &= Y_u [(L^*u + 16) / u_1]^3 \quad Y_u=18 \\ Z &= Z_u [(L^*u + 16) / u_1 - b^*u / u_b]^3 \\ c_u &=[Y_u/Y_n]^{1/3} = 0,18^{1/3} = 0,5647, \text{ similar for } X, Z \\ u_1 &= 116c_u=65,51, u_a=500c_u=282,35, u_b=200c_u=112,94 \end{aligned}$$

CES21-5N

CIELAB_u 2022 $L^*a^*b^*$ color space definition and reversal ($X_u/X_n=Y_u/Y_n=Z_u/Z_n=0,18$)

$$\begin{aligned} L^*u &= 65,51 (Y/Y_u)^{1/3} - 16 = L^*_{CIELAB} - 0,49 \\ a^*u &= 282,35 [(X/X_u)^{1/3} - (Y/Y_u)^{1/3}] = a^*_{CIELAB} \\ b^*u &= 112,94 [(Y/Y_u)^{1/3} - (Z/Z_u)^{1/3}] = b^*_{CIELAB} \\ X &= X_u [(L^*u + 16) / 65,51 + a^*u / 282,35]^3 \\ Y &= Y_u [(L^*u + 16) / 65,51]^3 \quad Y_u=18 \\ Z &= Z_u [(L^*u + 16) / 65,51 - b^*u / 112,94]^3 \\ c_u &=[Y_u/Y_n]^{1/3} = 0,18^{1/3} = 0,5647, \text{ similar for } X, Z \\ u_1 &= 116c_u=65,51, u_a=500c_u=282,35, u_b=200c_u=112,94 \end{aligned}$$

CES21-7N

CIELAB 1976 $L^*a^*b^*$ color space and CIELAB_v 2022 $L^*a^*b^*$ color space

$$\begin{aligned} L^* &= 116 (Y/Y_n)^{1/3} - 16 \quad [Y/Y_n]^{1/3} > 24/116 \\ a^* &= 500 [(X/X_n)^{1/3} - (Y/Y_n)^{1/3}] \quad Y > 0,885 \\ b^* &= 200 [(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}] \\ L^*v &= 116 c_v (Y/Y_v)^{1/3} - 16 = L^* \quad Y_v=18,41 \\ a^*v &= 500 c_v [(X/X_v)^{1/3} - (Y/Y_v)^{1/3}] = a^* \\ b^*v &= 200 c_v [(Y/Y_v)^{1/3} - (Z/Z_v)^{1/3}] = b^* \\ c_v &=[Y_v/Y_n]^{1/3} = 0,1841^{1/3} = 0,5689, \text{ similar for } X, Z \\ v_1 &= 116c_v=66, v_a=500c_v=284,56, v_b=200c_v=113,78 \end{aligned}$$

CES21-2N

CIELAB_v 2022 $L^*a^*b^*$ color space definition and reversal ($X_v/X_n=Y_v/Y_n=Z_v/Z_n=0,1841$)

$$\begin{aligned} L^*v &= 116 c_v (Y/Y_v)^{1/3} - 16 = L^*_{CIELAB} \\ a^*v &= 500 c_v [(X/X_v)^{1/3} - (Y/Y_v)^{1/3}] = a^*_{CIELAB} \\ b^*v &= 200 c_v [(Y/Y_v)^{1/3} - (Z/Z_v)^{1/3}] = b^*_{CIELAB} \\ X &= X_v [(L^*v + 16) / (116c_v) + a^*v / (500c_v)]^3 \\ Y &= Y_v [(L^*v + 16) / (116c_v)]^3 \quad Y_v=18,41 \\ Z &= Z_v [(L^*v + 16) / (116c_v) - b^*v / (200c_v)]^3 \\ c_v &=[Y_v/Y_n]^{1/3} = 0,1841^{1/3} = 0,5689, \text{ similar for } X, Z \\ v_1 &= 116c_v=66, v_a=500c_v=284,56, v_b=200c_v=113,78 \end{aligned}$$

CES21-4N

CIELAB_v 2022 $L^*a^*b^*$ color space definition and reversal ($X_v/X_n=Y_v/Y_n=Z_v/Z_n=0,1841$)

$$\begin{aligned} L^*v &= v_1 (Y/Y_v)^{1/3} - 16 = L^*_{CIELAB} \\ a^*v &= v_a [(X/X_v)^{1/3} - (Y/Y_v)^{1/3}] = a^*_{CIELAB} \\ b^*v &= v_b [(Y/Y_v)^{1/3} - (Z/Z_v)^{1/3}] = b^*_{CIELAB} \\ X &= X_v [(L^*v + 16) / v_1 + a^*v / v_a]^3 \\ Y &= Y_v [(L^*v + 16) / v_1]^3 \quad Y_v=18,41 \\ Z &= Z_v [(L^*v + 16) / v_1 - b^*v / v_b]^3 \\ c_v &=[Y_v/Y_n]^{1/3} = 0,1841^{1/3} = 0,5689, \text{ similar for } X, Z \\ v_1 &= 116c_v=66, v_a=500c_v=284,56, v_b=200c_v=113,78 \end{aligned}$$

CES21-6N

CIELAB_v 2022 $L^*a^*b^*$ color space definition and reversal ($X_v/X_n=Y_v/Y_n=Z_v/Z_n=0,1841$)

$$\begin{aligned} L^*v &= 66 (Y/Y_v)^{1/3} - 16 = L^*_{CIELAB} \\ a^*v &= 284,56 [(X/X_v)^{1/3} - (Y/Y_v)^{1/3}] = a^*_{CIELAB} \\ b^*v &= 113,78 [(Y/Y_v)^{1/3} - (Z/Z_v)^{1/3}] = b^*_{CIELAB} \\ X &= X_v [(L^*v + 16) / 66 + a^*v / 284,56]^3 \\ Y &= Y_v [(L^*v + 16) / 66]^3 \quad Y_v=18,41 \\ Z &= Z_v [(L^*v + 16) / 66 - b^*v / 113,78]^3 \\ c_v &=[Y_v/Y_n]^{1/3} = 0,1841^{1/3} = 0,5689, \text{ similar for } X, Z \\ v_1 &= 116c_v=66, v_a=500c_v=284,56, v_b=200c_v=113,78 \end{aligned}$$

CES21-8N