Colour Vision and relative colour coordinates used in Image Technology and Colorimetry

Version 1.1, 060720, www.ps.bam.de/VARS06.PDF

Technical University - Varna (BG), 2006-05-29

paper presented by:
Prof. Dr. Klaus Richter, BAM and TU Berlin
Federal Institute for Materials Research and Testing (BAM),VIII.1,
Unter den Eichen 87, D-12205 Berlin
Tel. +49 30 8104 1834; Fax +49 30 8104 1807
klaus.richter@bam.de

For many ISO/IEC-test charts and other publications see the URL
http://www.ps.bam.de
of the Working Group “Visual methods and image reproduction”
For this paper see (48 pages, 2,5 Mbyte)
http://www.ps.bam.de/VARS06.PDF

Overview

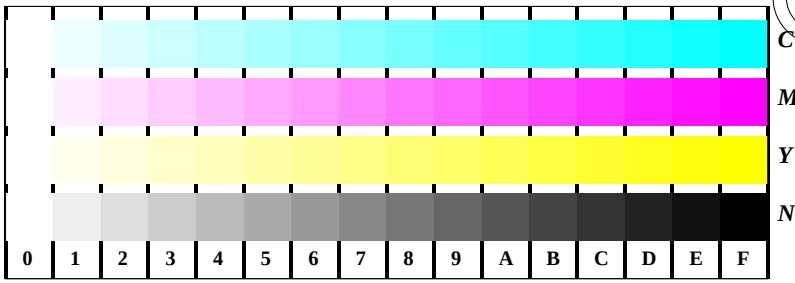
- ISO/IEC-test charts with 16 step colour series
- Colour circle, colour double cone and hexagon
- Relative colorimetric Image Technology (RCIT)
- Spectrum and CIE tristimulus values
- JB- and RG-response functions of Hurvich/Jameson
- Colour metric for scaling and threshold data
- Definition of relative colorimetric data *lab**
- *lab*olv* = *olv** and *lab*rgb* = *rgb** data
- Relation of *olv** and *rgb** to CIELAB
- *olv** input and output of device dependent hues
- *rgb** input and output of device independent hues
- 16 step equal spacing on monitors and printers

Colour Vision and Image Technology, Varna (BG), 2006-05-29

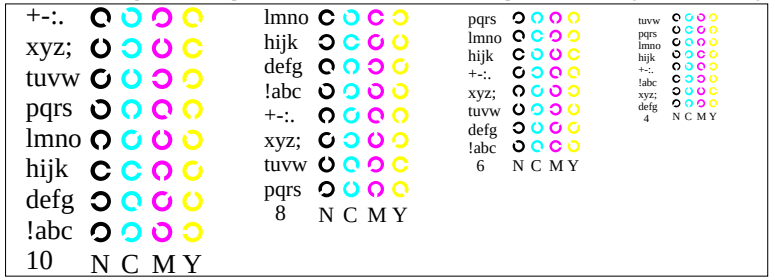
Figure 1: ISO/IEC-test chart for the test of monitor or printer output

www.ps.bam.de/DE97/10L/L97E00NP.PS/.PDF; start output
N: No Output Linearization (OL) data in File (F), Startup (S) or Device (D)

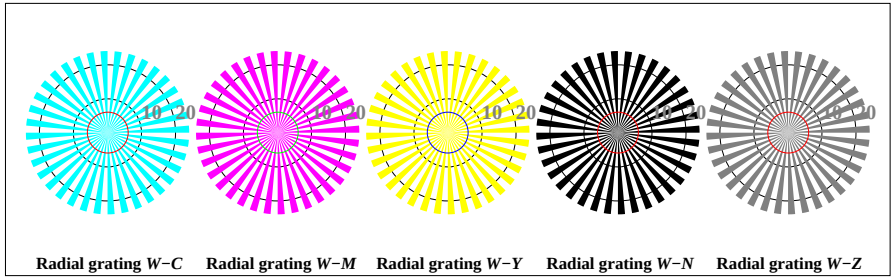
Picture B1: Flower motif, 14 CIE-test colours and 2 + 16 grey steps (sf); PS operators *settransfer*, *3 colorimage*



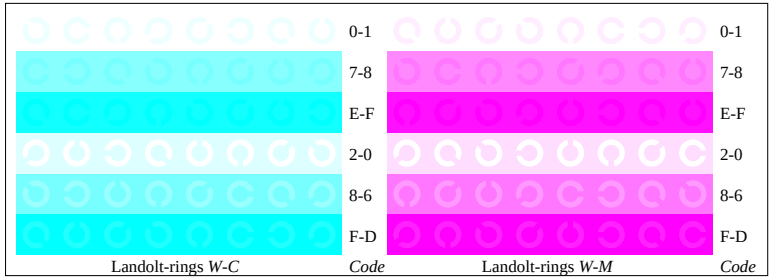
Picture B4: 16 equidistant steps ***W-C, W-M, W-Y*** and ***W-N***; PS operator *olv* setrgbcolor / w* setgray*



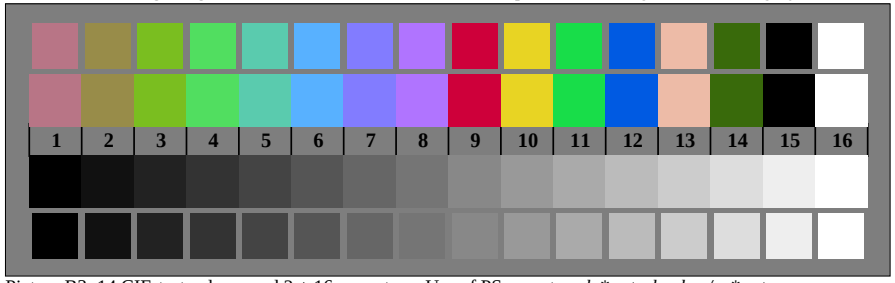
Picture B5: Script and Landolt-rings ***N, M, C*** and ***Y***; Use of PS operator *olv* setrgbcolor / w* setgray*



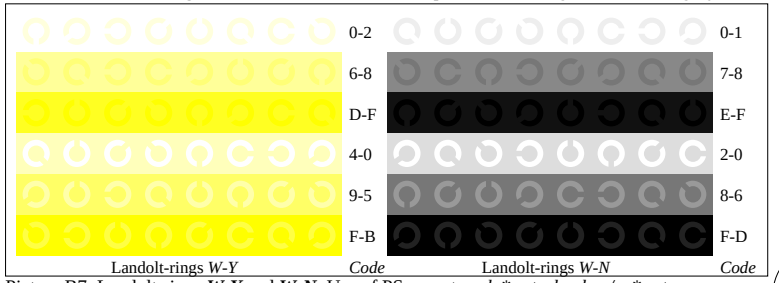
Picture B2: Radial gratings ***W-C, W-L, W-Y, W-N,*** and ***W-Z***; PS operator *olv* setrgbcolor / w* setgray*



Picture B6: Landolt-rings ***W-C*** and ***W−-M***; Use of PS operator *olv* setrgbcolor / w* setgray*



Picture B3: 14 CIE-test colours and 2 + 16 grey steps; Use of PS operator *olv* setrgbcolor / w* setgray*



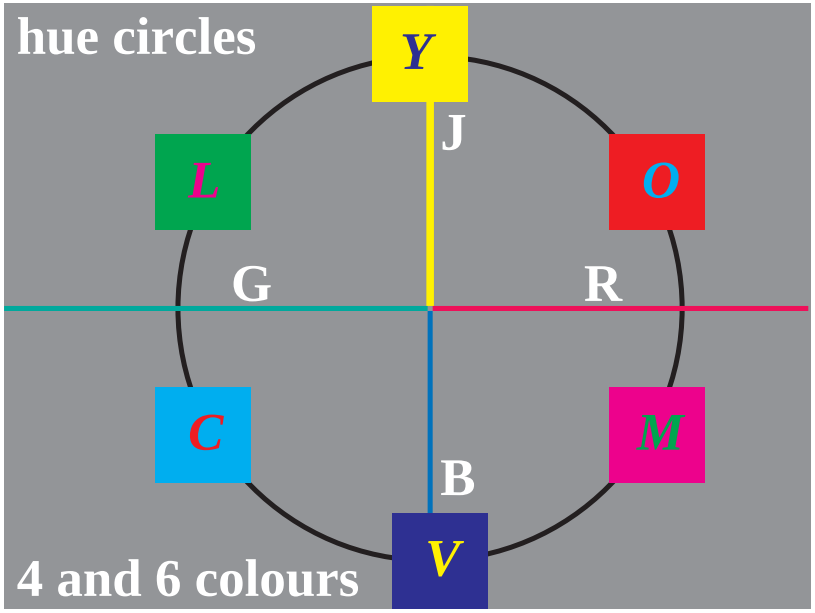
Picture B7: Landolt-rings ***W-Y*** and ***W-N***; Use of PS operator *olv* setrgbcolor / w* setgray*

Fig. B1 to B7 of ISO/IEC-test chart 2; ISO/IEC 15775 and TR ISO/IEC 24705;
input: *olv* setrgbcolor / w* setgray*
output: *no change compared to input*

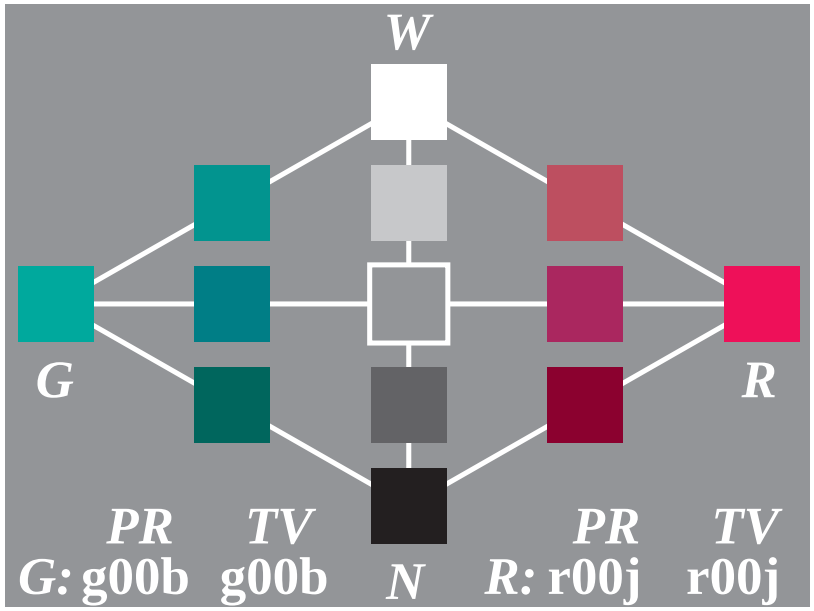
See for similar files: http://www.ps.bam.de/DE97/
Information and Order: http://www.ps.bam.de Version 2.0, io=1,1

BAM registration: 20030101-DE97/10L/L97E00NP.PS/.PDF BAM material: code=rha4ta
application for monitors (Yr=2.5) and printers

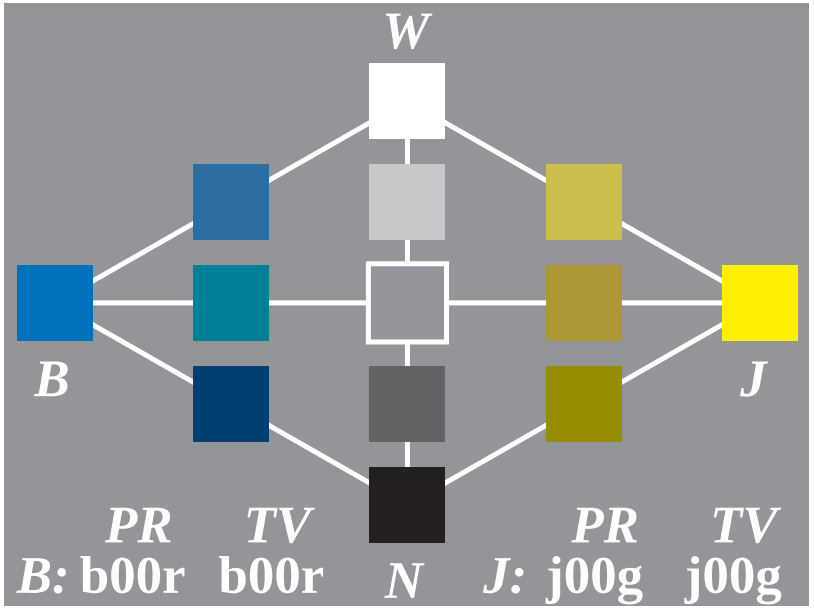
Figure 2: Colour Circle, Colour Double Cone and Colour Hexagon



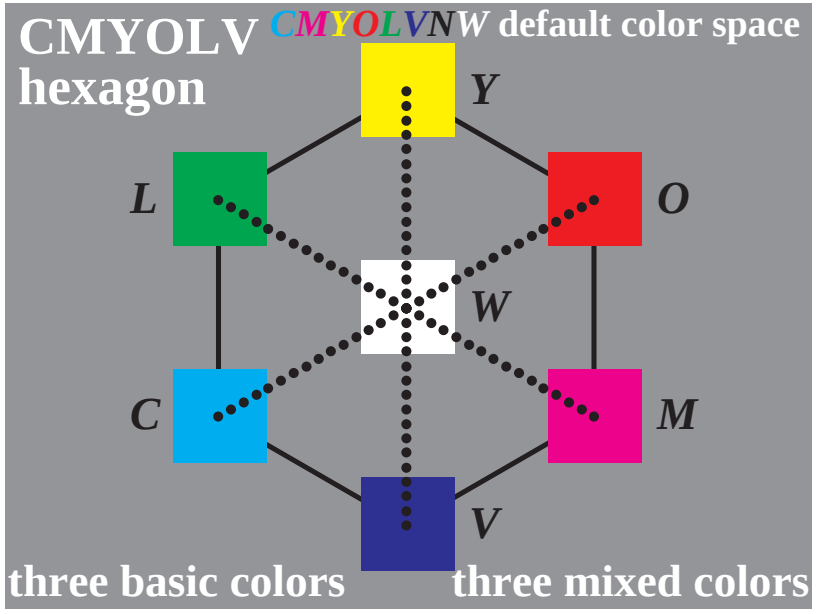
LE410−3, 4 and 6 colours in hue circle



LE410−7, Double cone: Hue planes R and G



LE410−8, Double cone: Hue planes J and B



LE410−1, 16 step colours in regular hexagon

Figure 3: Colour order Systems and Colorimetric Image Technology (CIT)

Application of colour in daily life or in Information Technology (IT):

Design, architecture, art, industrial products
Measured for CIE standard illuminant D65

colour order system: name and coordinates

RAL Design System (CIELAB):
LCH*, lightness, chroma, hue

Munsell Colour System:
VCH*, lightness (Value), Chroma, Hue

Natural Colour System (NCS):
nce*: blackness, chromaticness, elementary hue

Information technology of printers
Measured for CIE illuminant D65 or D50

Device system name and coordinates:

Printer system (illuminant D65 or D50):
cmy, content of "cyan", "magenta", "yellow"

Display system (standard illuminant D65):
rgb/sRGB, content of "red", "green", "blue"

IT colour coordinates confuse the users!
Nearly no connection to colour order systems!

New: Application connection by coordinates *olv*, cmy*, tce*, ... und linear relation to LAB*

CIELAB: ***LAB**** : lightness, red-green and jellow-blue chroma; ***LCH**** : lightness, chroma, hue

Definition of *relative* device coordinates similar to coordinates of colour order systems
lab*lch: relative lightness ***l**** , chromaticness , Buntheit ***c**** , hue ***h****
lab*lch, lab*tce: triangle lightness ***t**** , chromaticness , Buntheit ***c**** , hue or elementary hue ***h*, e****
lab*nce: blackness ***n****, chromaticness ***c****, elementary hue***e****
lab*olv*$_3$ = *rgb*: orange−red ***o***$_3$*, leaf−green ***l***$_3$*, violet−blue***v***$_3$*

LE430−3, Application connection with coordinates *olv*, cmy*, tch*, tce*, nce*, ...* and linear relationship to *LAB**

Figure 4: 3 step colour scales and colorimetric coordinates for device hue Orange Red O

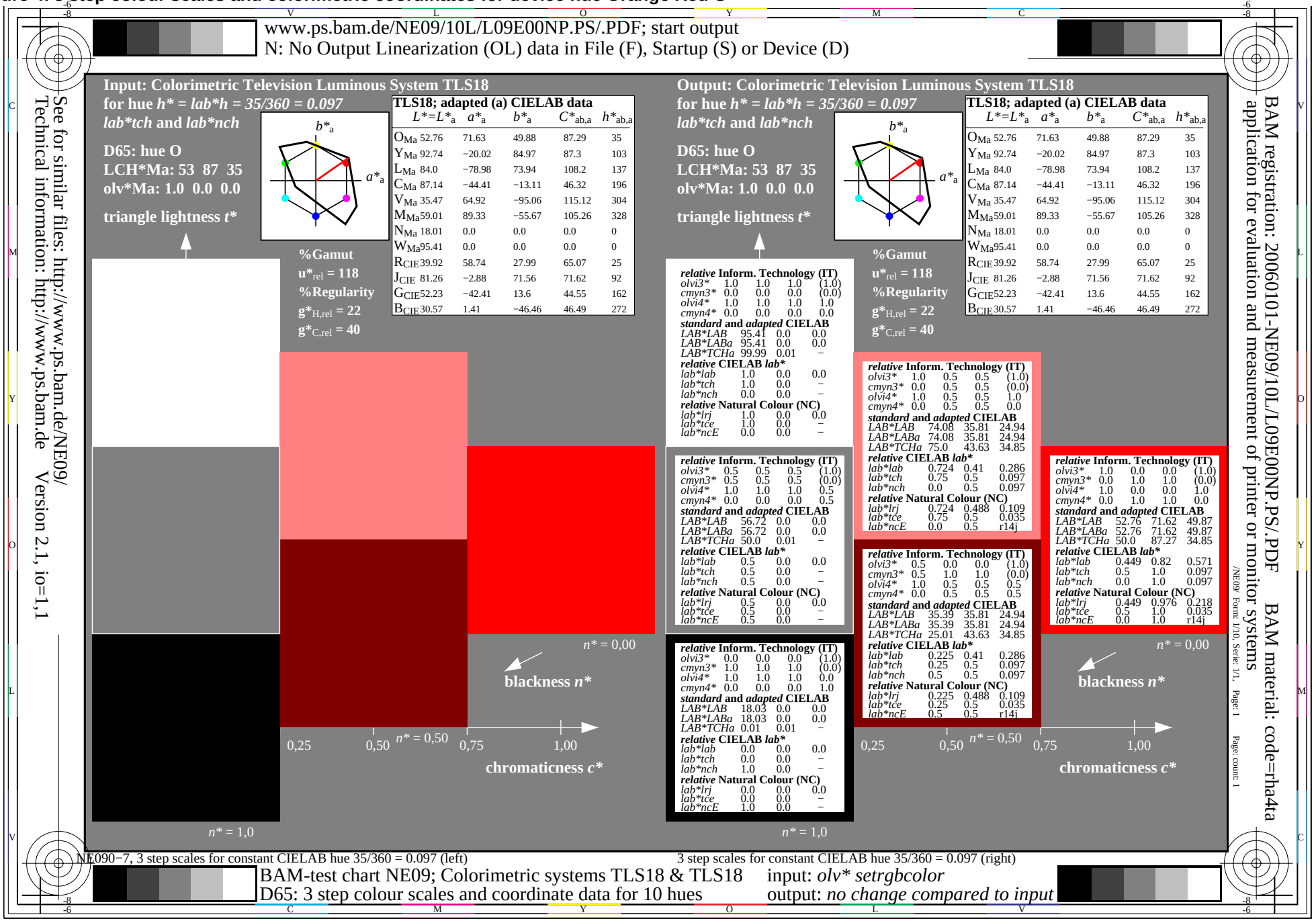


Figure 5: 3 step colour scales and colorimetric coordinates for elementary hue Green G

www.ps.bam.de/NE09/10L/L09E08NP.PS/.PDF; start output
N: No Output Linearization (OL) data in File (F), Startup (S) or Device (D)

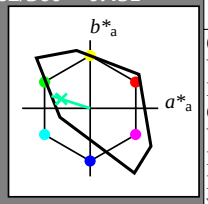
See for similar files: http://www.ps.bam.de/NE09/
Technical information: http://www.ps.bam.de Version 2.1, io=1,1

BAM registration: 20060101-NE09/10L/L09E08NP.PS/.PDF BAM material: code=rha4ta
application for evaluation and measurement of printer or monitor systems
/NE09/ Form: 9/10, Serie: 1/1, Page: 9 Page: count: 9

Input: Colorimetric Television Luminous System TLS18
for hue *h = *lab*h* = 162/360 = 0.451**
lab*tch* and *lab*nch

D65: hue G
LCH*Ma: 86 60 162
olv*Ma: 0.0 1.0 0.64

triangle lightness *t**



%Gamut
u^*_{rel} = 118
%Regularity
$g^*_{H,rel}$ = 22
$g^*_{C,rel}$ = 40

TLS18; adapted (a) CIELAB data

	$L^*=L^*_a$	a^*_a	b^*_a	$C^*_{ab,a}$	$h^*_{ab,a}$
O_{Ma}	52.76	71.63	49.88	87.29	35
Y_{Ma}	92.74	−20.02	84.97	87.3	103
L_{Ma}	84.0	−78.98	73.94	108.2	137
C_{Ma}	87.14	−44.41	−13.11	46.32	196
V_{Ma}	35.47	64.92	−95.06	115.12	304
M_{Ma}	59.01	89.33	−55.67	105.26	328
N_{Ma}	18.01	0.0	0.0	0.0	0
W_{Ma}	95.41	0.0	0.0	0.0	0
R_{CIE}	39.92	58.74	27.99	65.07	25
J_{CIE}	81.26	−2.88	71.56	71.62	92
G_{CIE}	52.23	−42.41	13.6	44.55	162
B_{CIE}	30.57	1.41	−46.46	46.49	272

***relative* Inform. Technology (IT)**

*olvi3**	1.0	1.0	1.0	(1.0)
*cmyn3**	0.0	0.0	0.0	(0.0)
*olvi4**	1.0	1.0	1.0	1.0
*cmyn4**	0.0	0.0	0.0	0.0

***standard* and *adapted* CIELAB**

*LAB*LAB*	95.41	0.0	0.0
*LAB*LABa*	95.41	0.0	0.0
*LAB*TCHa*	99.99	0.01	–

relative* CIELAB *lab*

*lab*lab*	1.0	0.0	0.0
*lab*tch*	1.0	0.0	–
*lab*nch*	0.0	0.0	–

***relative* Natural Colour (NC)**

*lab*lrj*	1.0	0.0	0.0
*lab*tce*	1.0	0.0	–
*lab*ncE*	0.0	0.0	–

***relative* Inform. Technology (IT)**

*olvi3**	0.5	0.5	0.5	(1.0)
*cmyn3**	0.5	0.5	0.5	(0.0)
*olvi4**	1.0	1.0	1.0	0.5
*cmyn4**	0.0	0.0	0.0	0.5

***standard* and *adapted* CIELAB**

*LAB*LAB*	56.72	0.0	0.0
*LAB*LABa*	56.72	0.0	0.0
*LAB*TCHa*	50.0	0.01	–

relative* CIELAB *lab*

*lab*lab*	0.5	0.0	0.0
*lab*tch*	0.5	0.0	–
*lab*nch*	0.5	0.0	–

***relative* Natural Colour (NC)**

*lab*lrj*	0.5	0.0	0.0
*lab*tce*	0.5	0.0	–
*lab*ncE*	0.5	0.0	–

***relative* Inform. Technology (IT)**

*olvi3**	0.0	0.0	0.0	(1.0)
*cmyn3**	1.0	1.0	1.0	(0.0)
*olvi4**	1.0	1.0	1.0	0.0
*cmyn4**	0.0	0.0	0.0	1.0

***standard* and *adapted* CIELAB**

*LAB*LAB*	18.03	0.0	0.0
*LAB*LABa*	18.03	0.0	0.0
*LAB*TCHa*	0.01	0.01	–

relative* CIELAB *lab*

*lab*lab*	0.0	0.0	0.0
*lab*tch*	0.0	0.0	–
*lab*nch*	1.0	0.0	–

***relative* Natural Colour (NC)**

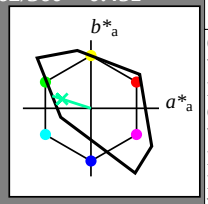
*lab*lrj*	0.0	0.0	0.0
*lab*tce*	0.0	0.0	–
*lab*ncE*	1.0	0.0	–

$n^* = 0{,}00$
blackness *n**
0,25 0,50 $n^* = 0{,}50$ 0,75 1,00
chromaticness *c**
$n^* = 1{,}0$

Output: Colorimetric Television Luminous System TLS18
for hue *h = *lab*h* = 162/360 = 0.451**
lab*tch* and *lab*nch

D65: hue G
LCH*Ma: 86 60 162
olv*Ma: 0.0 1.0 0.64

triangle lightness *t**



%Gamut
u^*_{rel} = 118
%Regularity
$g^*_{H,rel}$ = 22
$g^*_{C,rel}$ = 40

TLS18; adapted (a) CIELAB data

	$L^*=L^*_a$	a^*_a	b^*_a	$C^*_{ab,a}$	$h^*_{ab,a}$
O_{Ma}	52.76	71.63	49.88	87.29	35
Y_{Ma}	92.74	−20.02	84.97	87.3	103
L_{Ma}	84.0	−78.98	73.94	108.2	137
C_{Ma}	87.14	−44.41	−13.11	46.32	196
V_{Ma}	35.47	64.92	−95.06	115.12	304
M_{Ma}	59.01	89.33	−55.67	105.26	328
N_{Ma}	18.01	0.0	0.0	0.0	0
W_{Ma}	95.41	0.0	0.0	0.0	0
R_{CIE}	39.92	58.74	27.99	65.07	25
J_{CIE}	81.26	−2.88	71.56	71.62	92
G_{CIE}	52.23	−42.41	13.6	44.55	162
B_{CIE}	30.57	1.41	−46.46	46.49	272

***relative* Inform. Technology (IT)**

*olvi3**	1.0	1.0	1.0	(1.0)
*cmyn3**	0.0	0.0	0.0	(0.0)
*olvi4**	1.0	1.0	1.0	1.0
*cmyn4**	0.0	0.0	0.0	0.0

***standard* and *adapted* CIELAB**

*LAB*LAB*	95.41	0.0	0.0
*LAB*LABa*	95.41	0.0	0.0
*LAB*TCHa*	99.99	0.01	–

relative* CIELAB *lab*

*lab*lab*	1.0	0.0	0.0
*lab*tch*	1.0	0.0	–
*lab*nch*	0.0	0.0	–

***relative* Natural Colour (NC)**

*lab*lrj*	1.0	0.0	0.0
*lab*tce*	1.0	0.0	–
*lab*ncE*	0.0	0.0	–

***relative* Inform. Technology (IT)**

*olvi3**	0.5	1.0	0.82	(1.0)
*cmyn3**	0.5	0.0	0.18	(0.0)
*olvi4**	0.5	1.0	0.82	1.0
*cmyn4**	0.5	0.0	0.18	0.0

***standard* and *adapted* CIELAB**

*LAB*LAB*	90.7	−28.42	9.11
*LAB*LABa*	90.7	−28.42	9.11
*LAB*TCHa*	75.0	29.85	162.23

relative* CIELAB *lab*

*lab*lab*	0.939	−0.475	0.153
*lab*tch*	0.75	0.5	0.451
*lab*nch*	0.0	0.5	0.451

***relative* Natural Colour (NC)**

*lab*lrj*	0.939	−0.499	0.0
*lab*tce*	0.75	0.5	0.5
*lab*ncE*	0.0	0.5	g00b

***relative* Inform. Technology (IT)**

*olvi3**	0.0	0.5	0.32	(1.0)
*cmyn3**	1.0	0.5	0.68	(0.0)
*olvi4**	0.5	1.0	0.82	0.5
*cmyn4**	0.5	0.0	0.18	0.5

***standard* and *adapted* CIELAB**

*LAB*LAB*	52.01	−28.42	9.12
*LAB*LABa*	52.01	−28.42	9.12
*LAB*TCHa*	25.01	29.86	162.22

relative* CIELAB *lab*

*lab*lab*	0.439	−0.475	0.153
*lab*tch*	0.25	0.5	0.451
*lab*nch*	0.5	0.5	0.451

***relative* Natural Colour (NC)**

*lab*lrj*	0.439	−0.499	0.0
*lab*tce*	0.25	0.5	0.5
*lab*ncE*	0.5	0.5	j99g

***relative* Inform. Technology (IT)**

*olvi3**	0.0	1.0	0.64	(1.0)
*cmyn3**	1.0	0.0	0.36	(0.0)
*olvi4**	0.0	1.0	0.64	1.0
*cmyn4**	1.0	0.0	0.36	0.0

***standard* and *adapted* CIELAB**

*LAB*LAB*	86.0	−56.85	18.23
*LAB*LABa*	86.0	−56.85	18.23
*LAB*TCHa*	50.0	59.71	162.23

relative* CIELAB *lab*

*lab*lab*	0.878	−0.951	0.305
*lab*tch*	0.5	1.0	0.451
*lab*nch*	0.0	1.0	0.451

***relative* Natural Colour (NC)**

*lab*lrj*	0.878	−0.999	0.0
*lab*tce*	0.5	1.0	0.5
*lab*ncE*	0.0	1.0	g00b

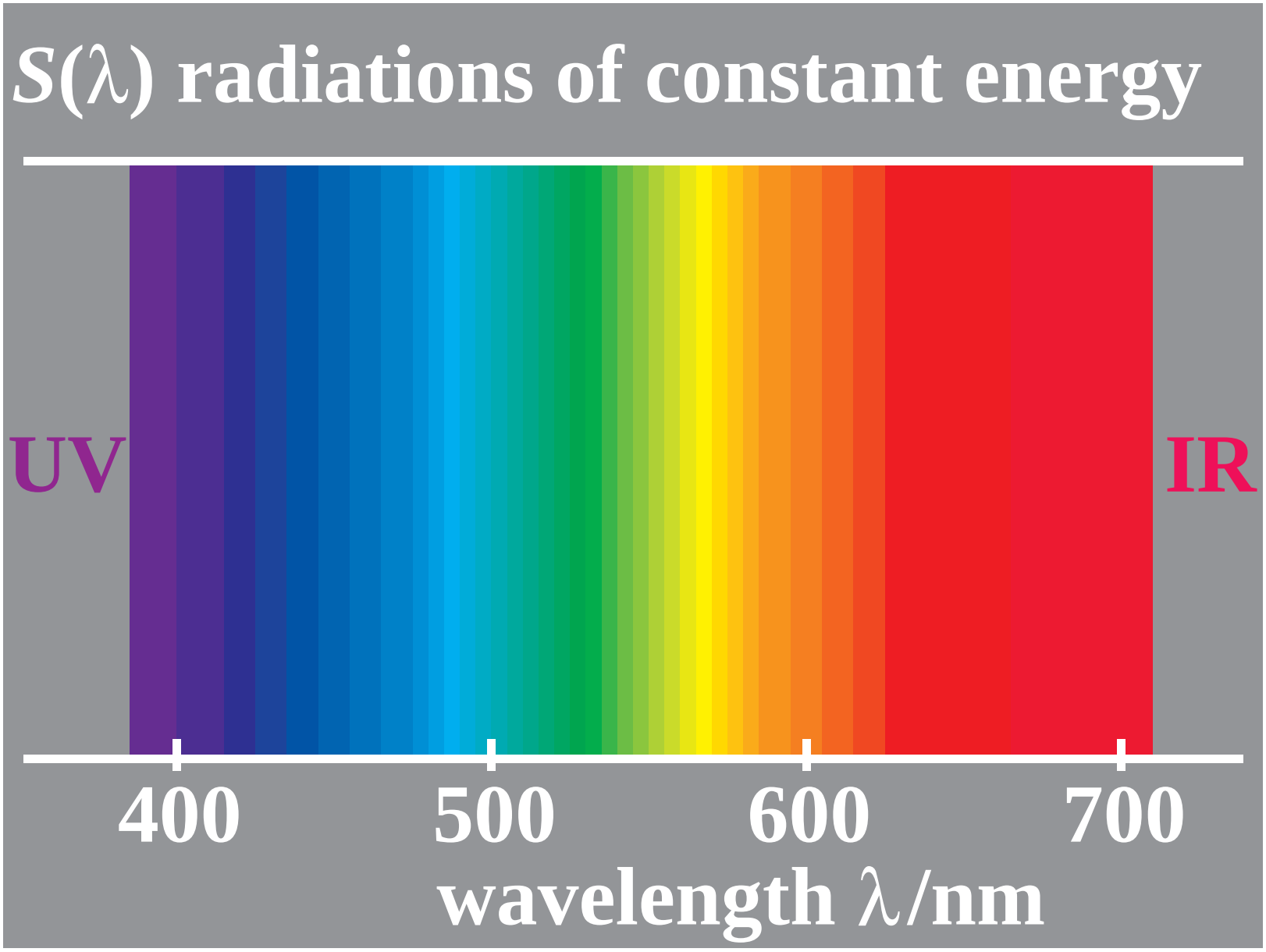
$n^* = 0{,}00$
blackness *n**
0,25 0,50 $n^* = 0{,}50$ 0,75 1,00
chromaticness *c**
$n^* = 1{,}0$

NE090−7, 3 step scales for constant CIELAB hue 162/360 = 0.451 (left)
3 step scales for constant CIELAB hue 162/360 = 0.451 (right)

BAM-test chart NE09; Colorimetric systems TLS18 & TLS18
D65: 3 step colour scales and coordinate data for 10 hues

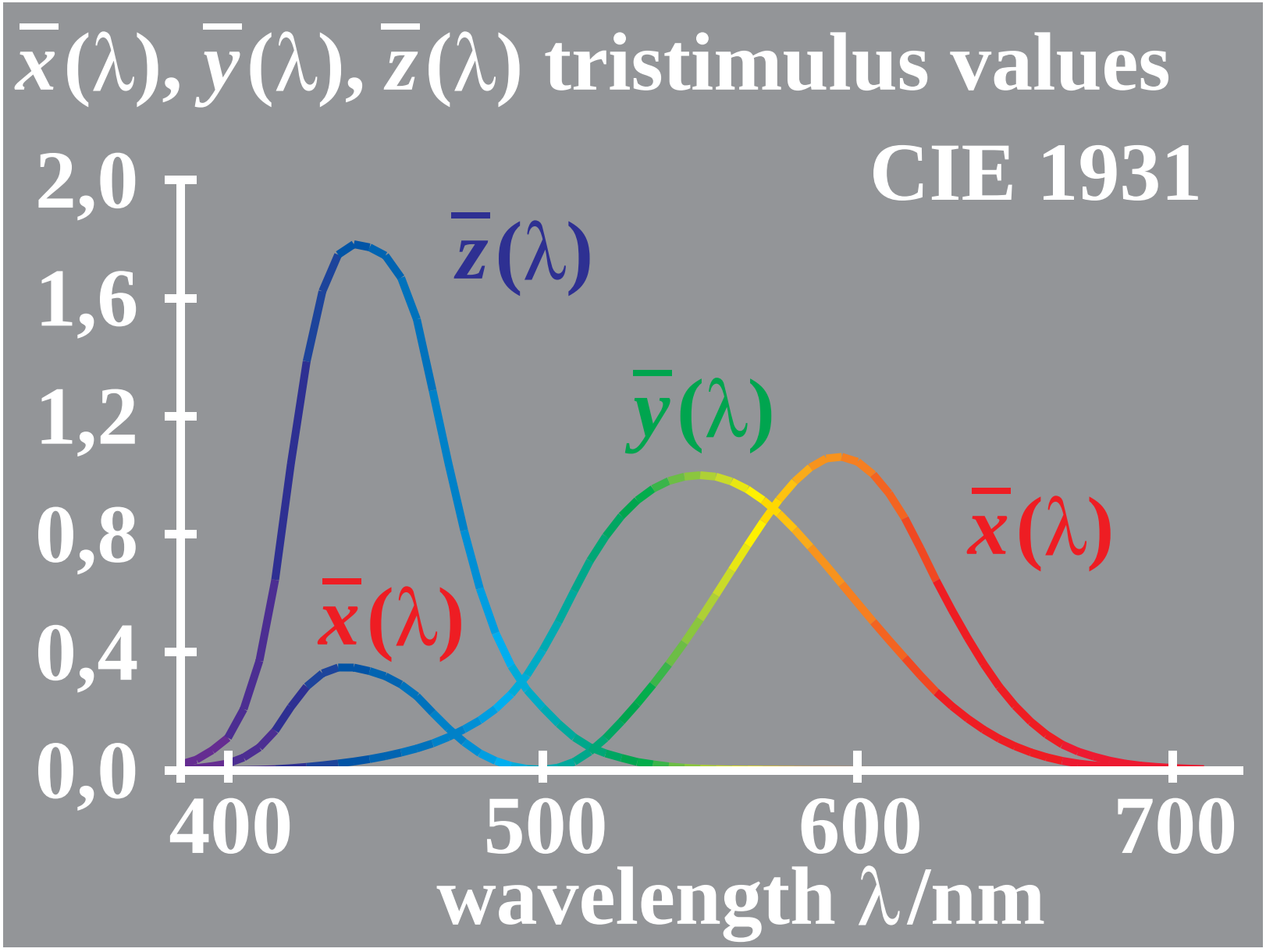
input: *olv* setrgbcolor*
output: *no change compared to input*

Figure 6: Visible radiation between 400nm and 700nm



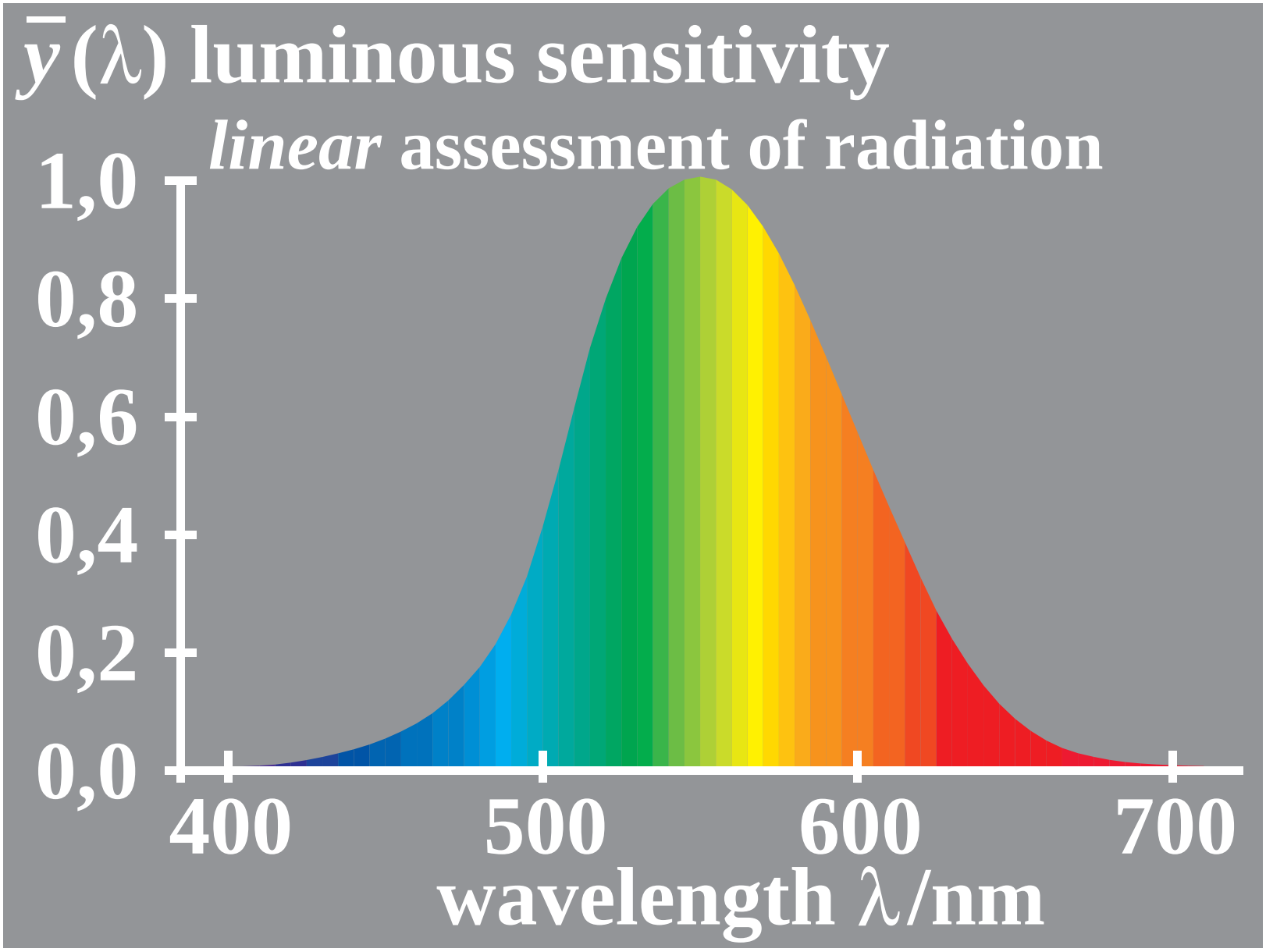
B8521_7, E8140−5, B2_20, N=2_20

Figure 7: CIE tristimulus values for colours of equal spectral radiation



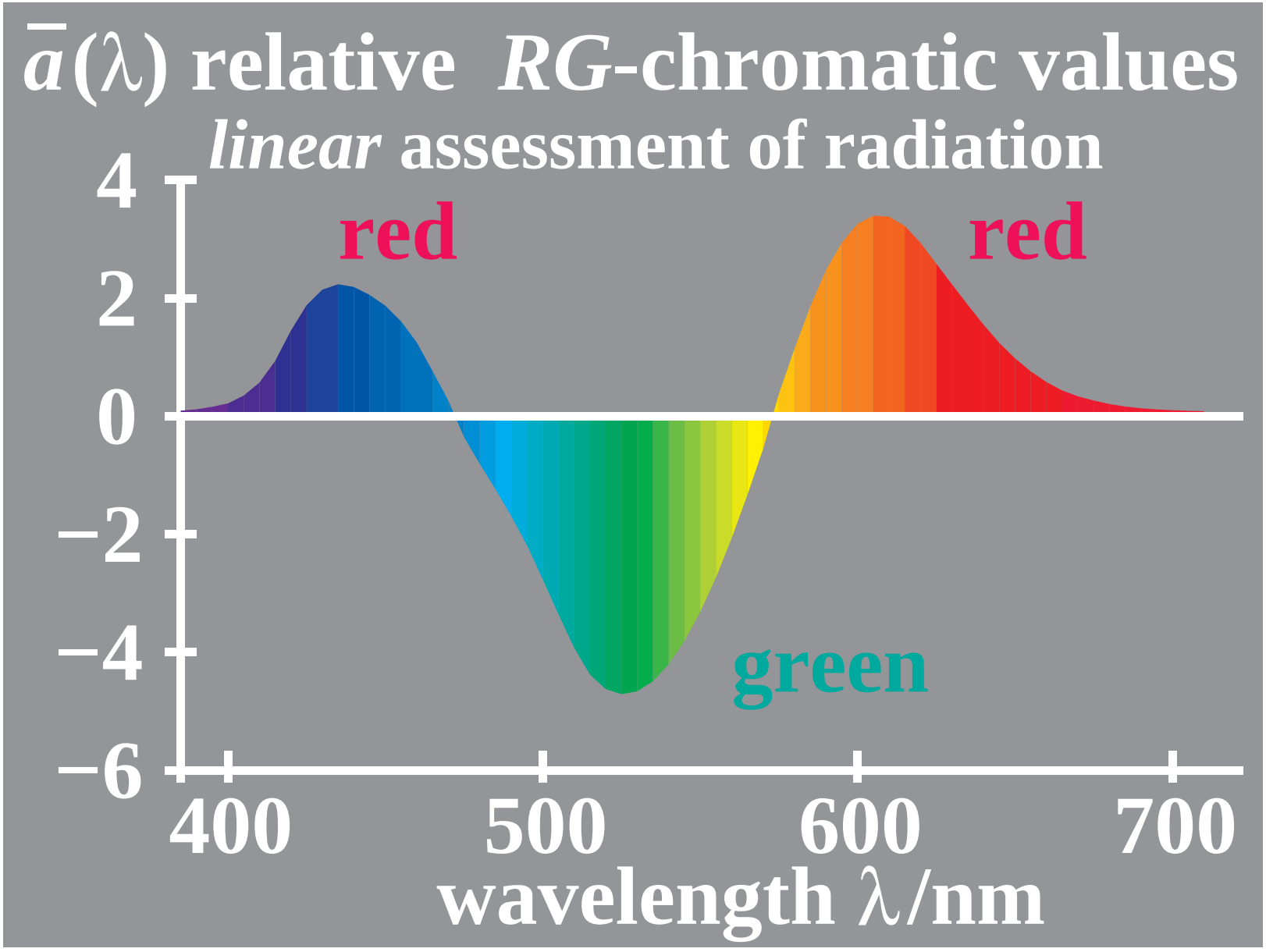
B8540_5, E8150−8, B2_37, N=2_37

Figure 8: CIE tristimulus values ybar(lambda) for colours of constant radiation



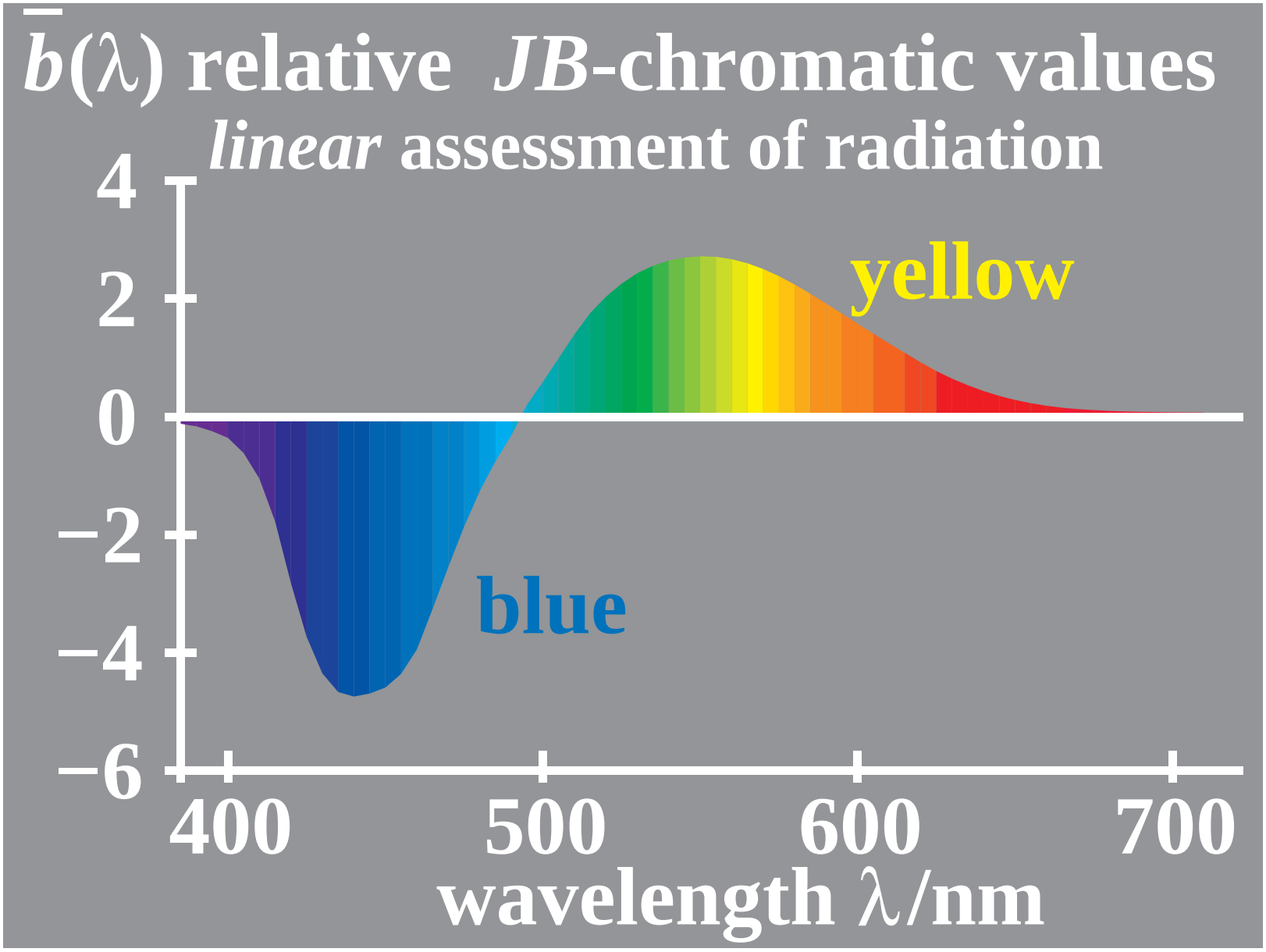
B8530_1, E8140−6, B2_21, N=2_21

Figure 9: RG-values xbar(lambda) – ybar(lambda) used by Hurvich and Jameson (1955)



B8530_5, E8140−8, B2_23, N=2_23

Figure 10: JB-values ybar(lambda) – zbar(lambda) used by Hurvich and Jameson (1955)



B8530_6, E8141−1, B2_24, N=2_24

Figure 11: 3 -dimensional colour values (linear colour metric)

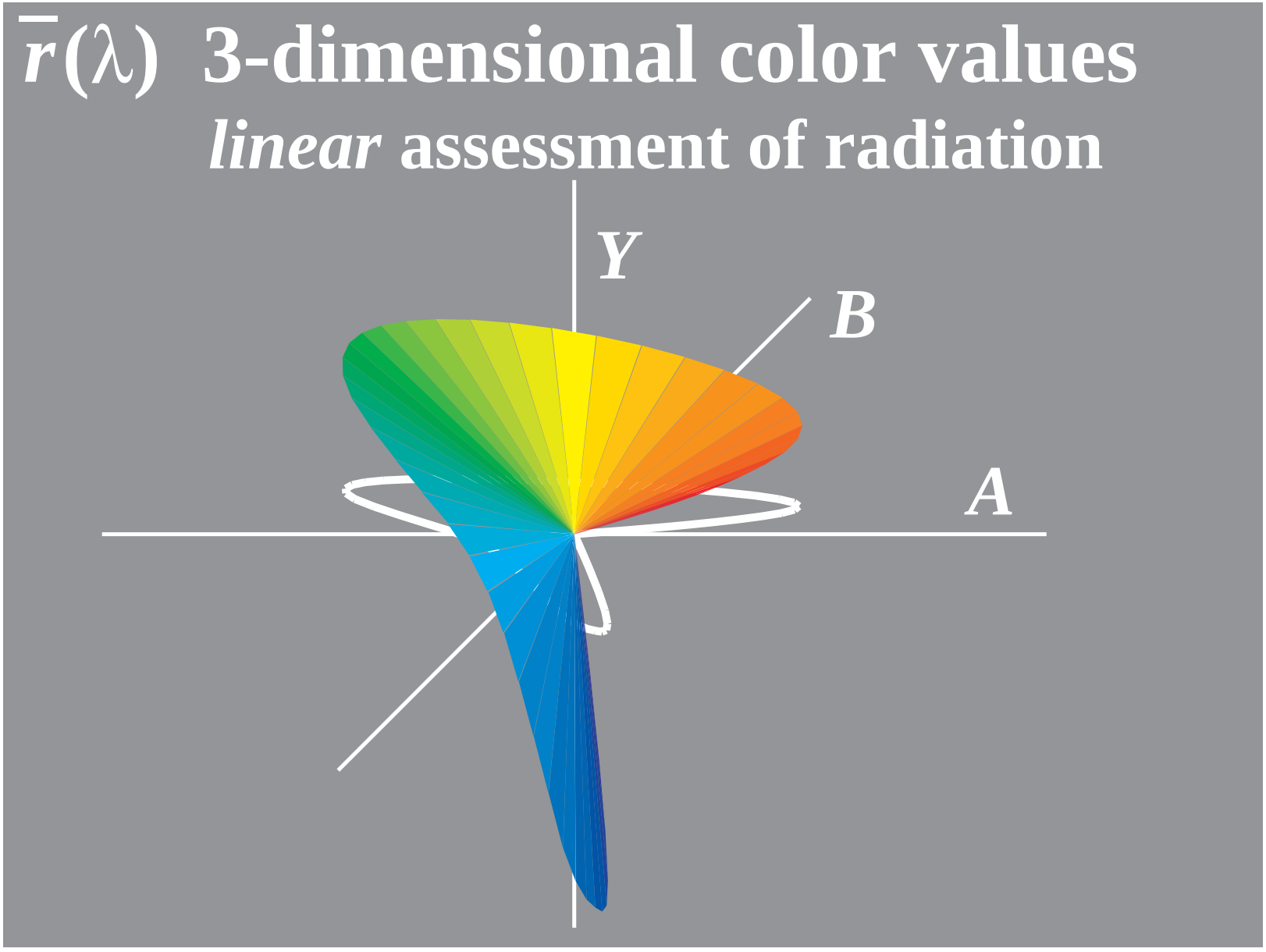
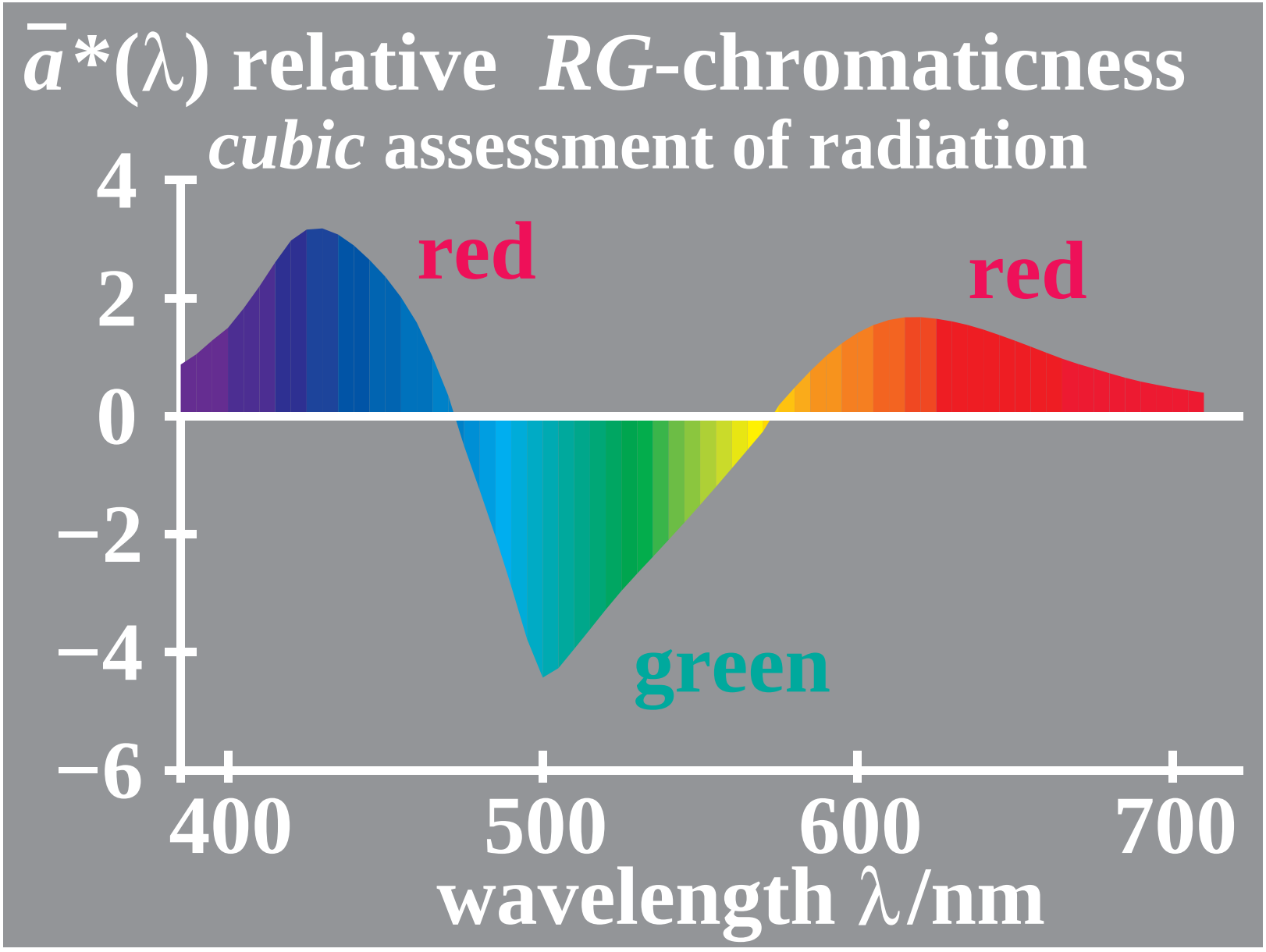


Figure 12: 3 -dimensional colour values (linear colour metric)

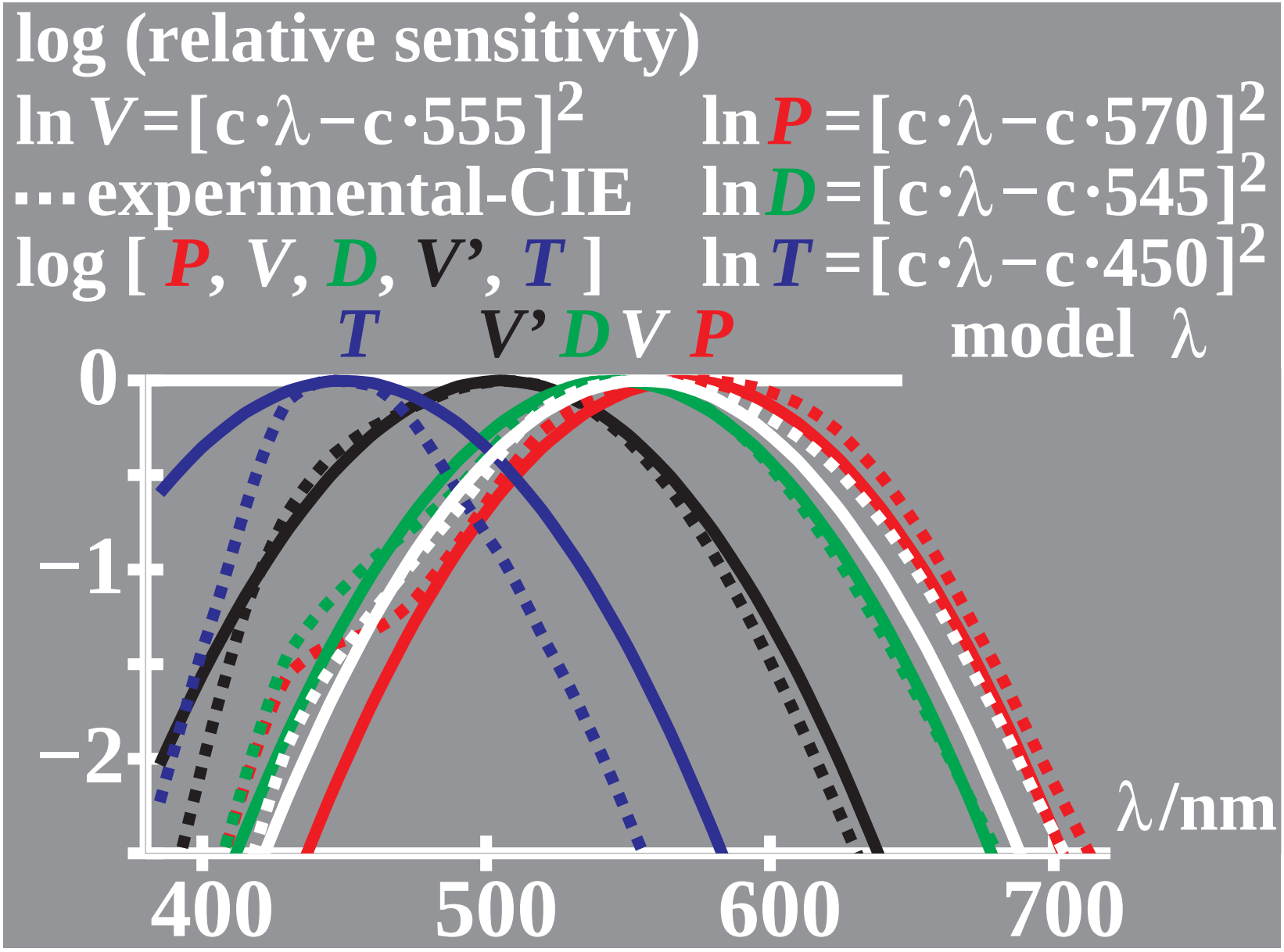
color valence metric (color data: linear relation to CIE 1931 data)		
linear color terms	**name and relationship to CIE tristimulues or chromaticity values**	**notes:**
luminous value	$Y = y\,(\,X + Y + Z\,)$	
chromatic value	*for linear chromatic value diagram (A, B)*	
red−green	$A = [\,X / Y - X_n / Y_n\,]\,Y = [\,a - a_n\,]\,Y$	*n=D65 (backgr.)*
	$= [\,x / y - x_n / y_n\,]\,Y$	
yellow−blue	$B = -\,0{,}4[\,Z / Y - Z_n / Y_n\,]\,Y = [\,b - b_n\,]\,Y$	
	$= -\,0{,}4[\,z / y - z_n / y_n\,]\,Y$	
radial	$C_{ab} = [\,A^2 + B^2\,]^{1/2}$	
chromaticity	*for (linear) chromaticity diagram (a, b)*	*compare to linear*
red−green	$a = X / Y = x / y$	*cone exitation*
yellow−blue	$b = -\,0{,}4\,[Z / Y\,] = -\,0{,}4\,[z / y\,]$	$L / (L+M)$
radial	$c_{ab} = [\,(\,a - a_n\,)^2 + (\,b - b_n\,)^2\,]^{1/2}$	$S / (L+M)$

Figure 13: RG-chromaticness and linear relation in the range 470 to 600nm



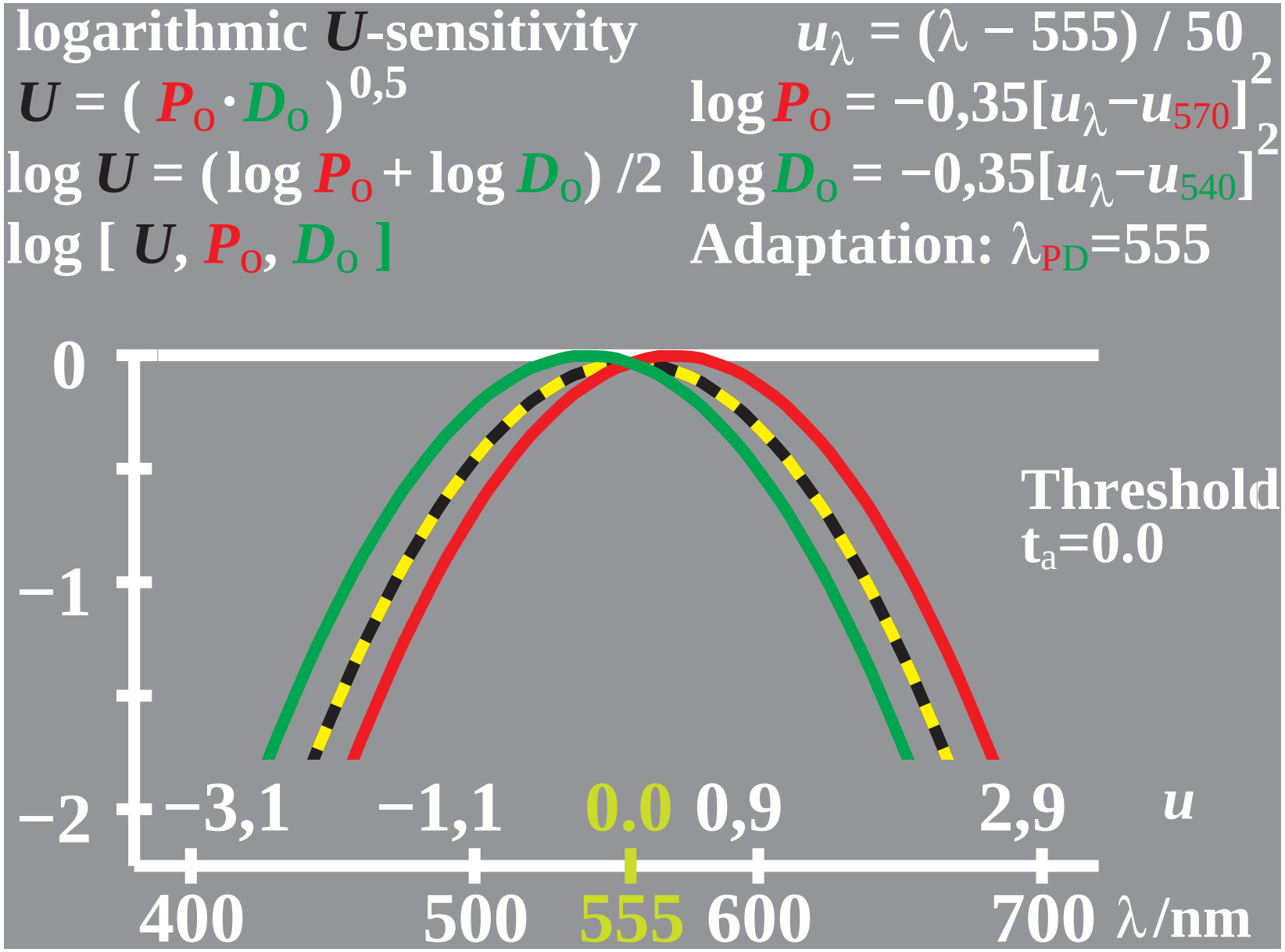
B8530_7, E8141−3, B2_26, N=2_26

Figure 14: log P, D, T cone sensitivities and sensitivities V and V'; parable curve approximation



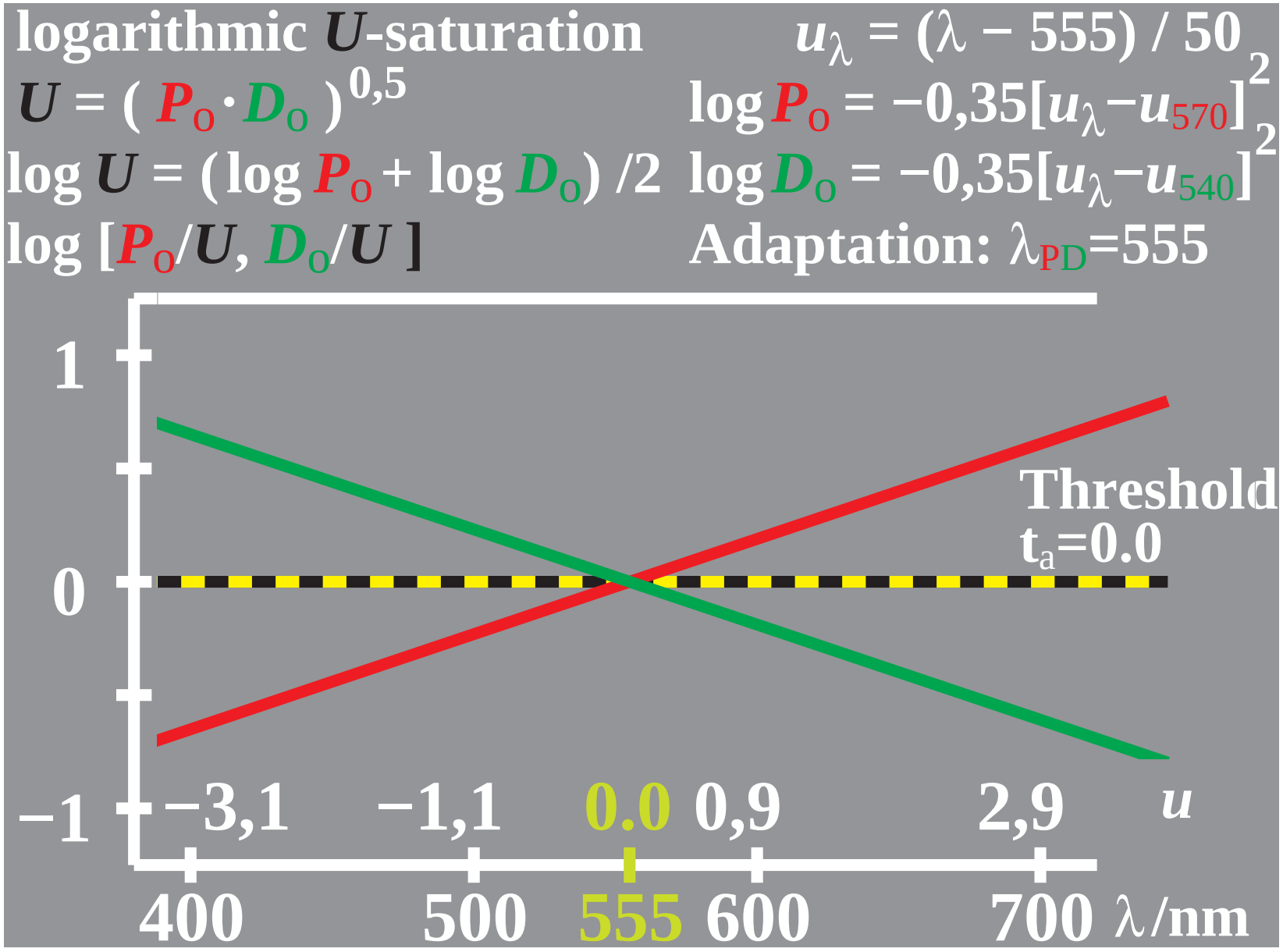
B8620_8, E8220−6, B4_33_2, N=4_33_2

Figure 15: log sensitivities of cones P and T sensitivities; threshold ta=0.0



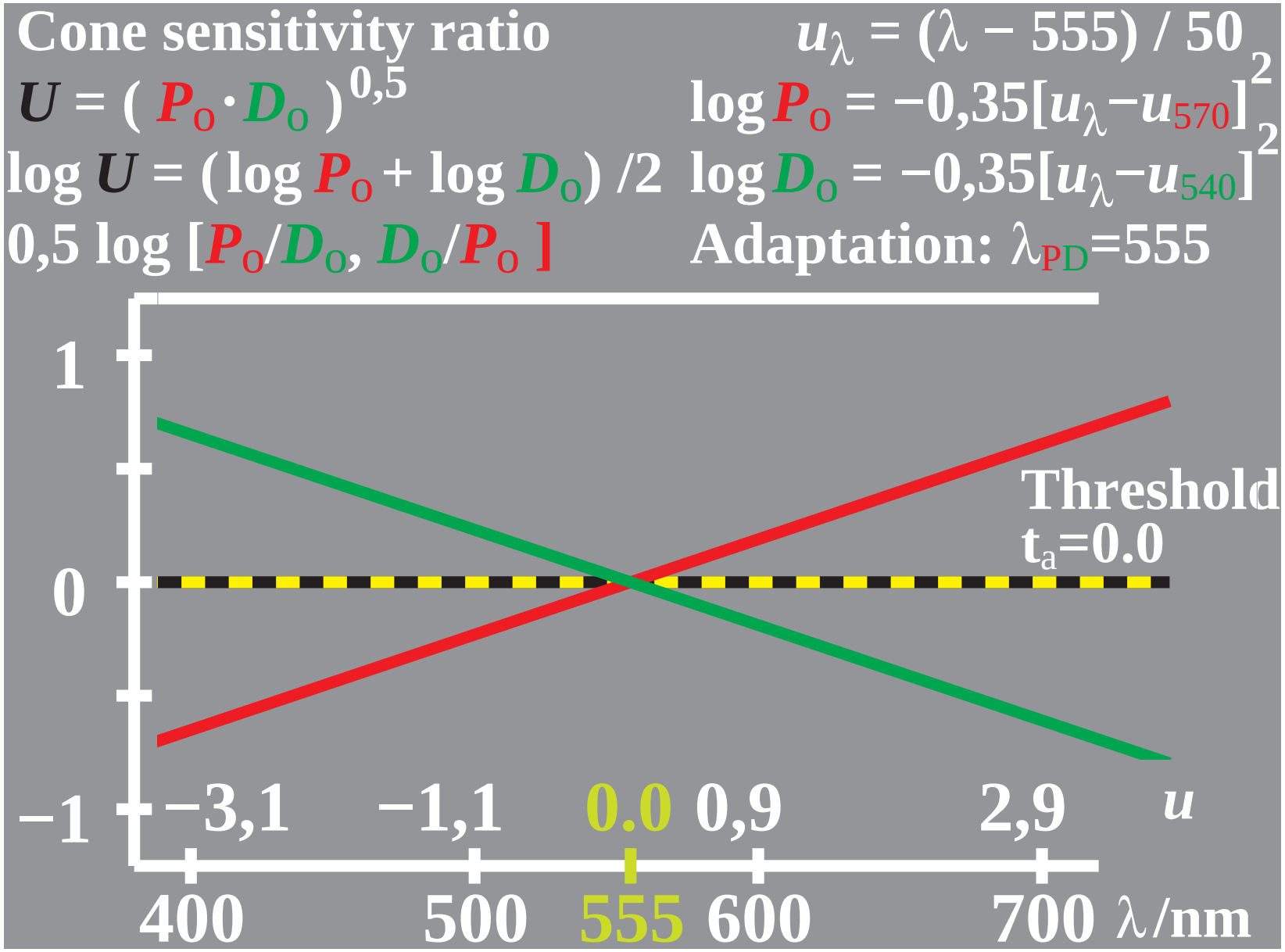
WE350−1, change of PDT in volour vision

Figure 16: log saturation of cones P and D; threshold ta=0.0



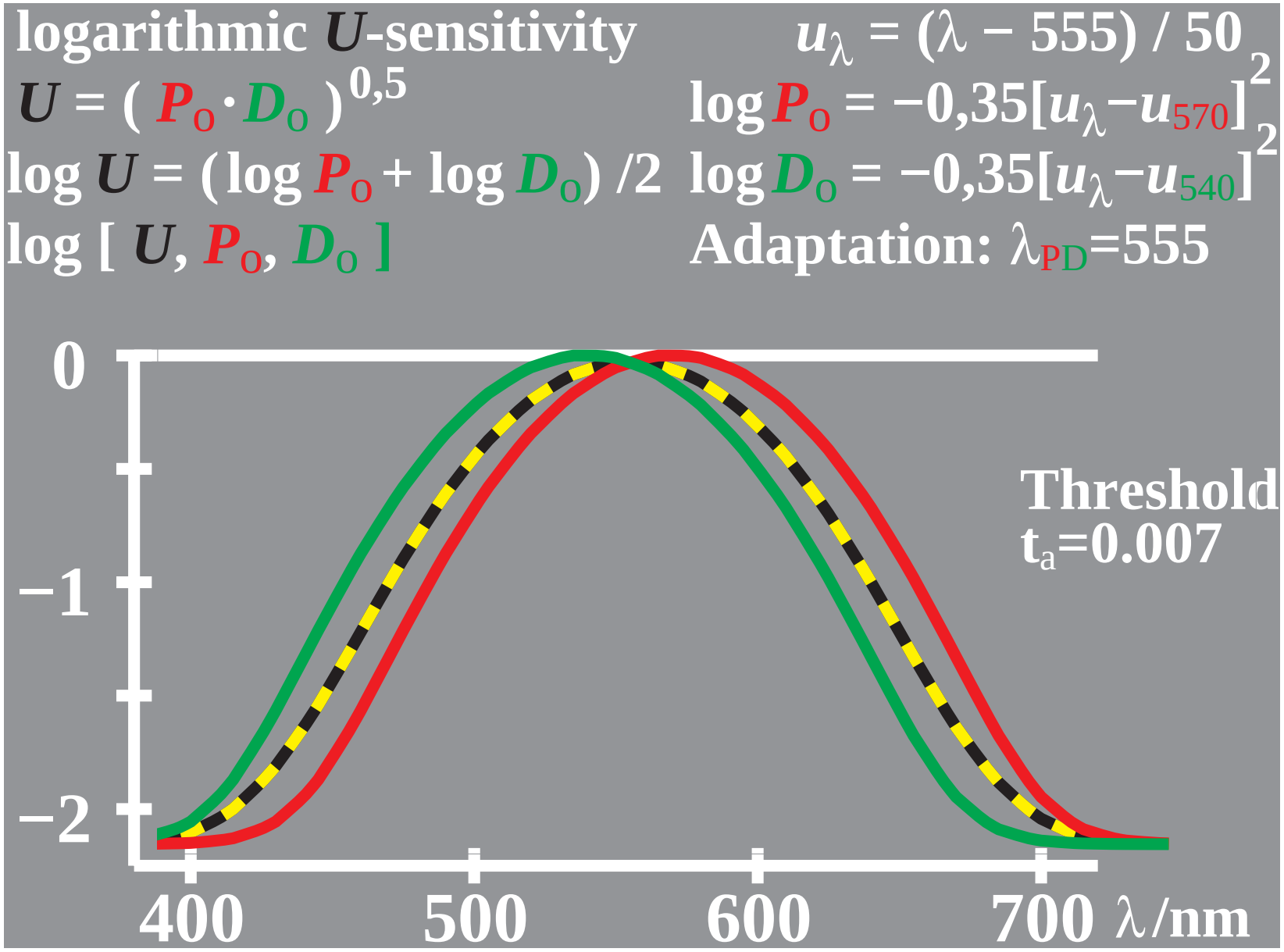
WE350−2, change of PDT in volour vision

Figure 17: 0.5 log differences of cones P and D; threshold ta=0.0



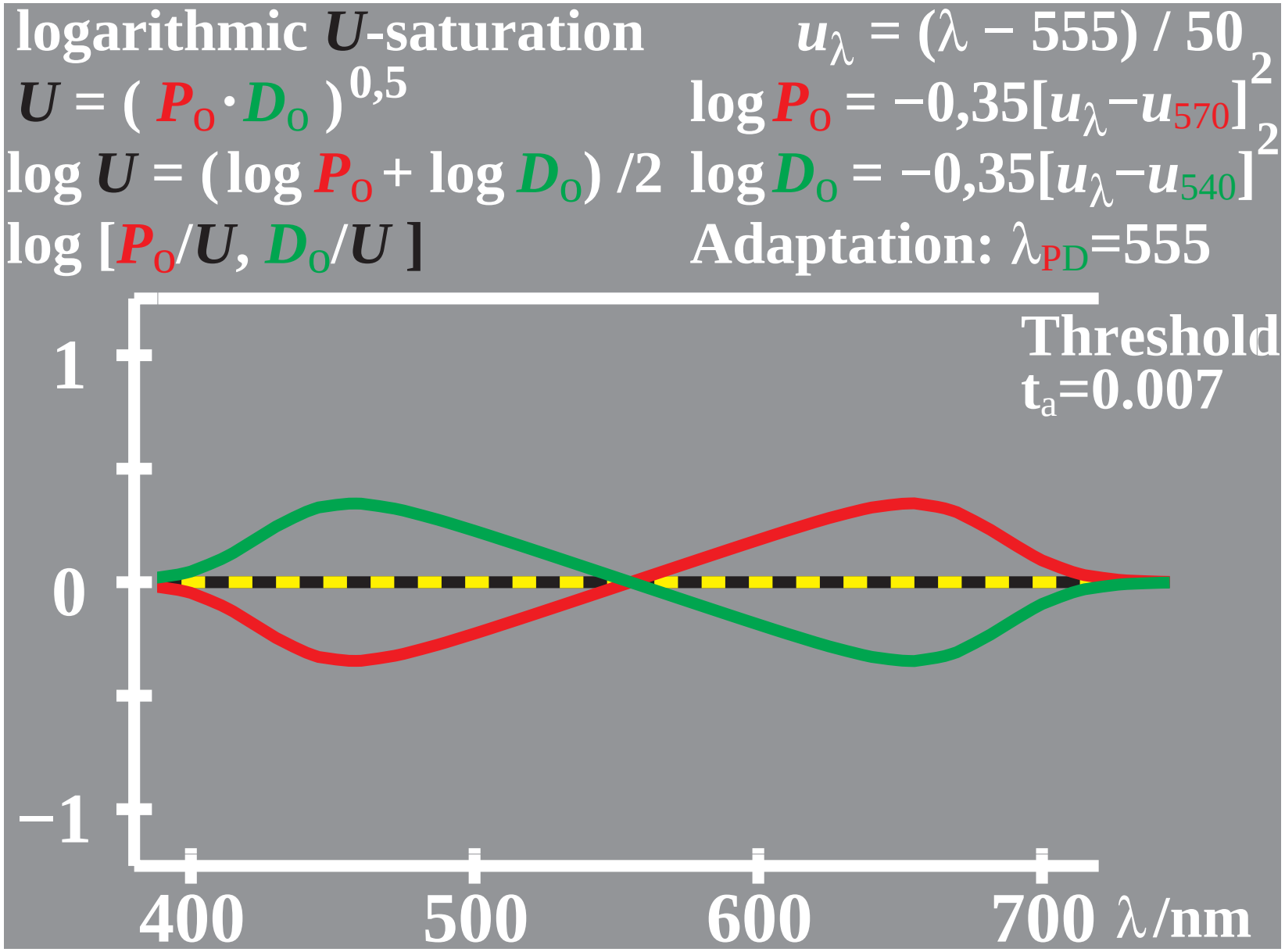
WE360−2, change of PDT in volour vision

Figure 18: log sensitivities of cones P and T sensitivities; threshold ta=0.007



WE351−1, change of PDT in volour vision

Figure 19: log saturation of cones P and D; threshold ta=0.007

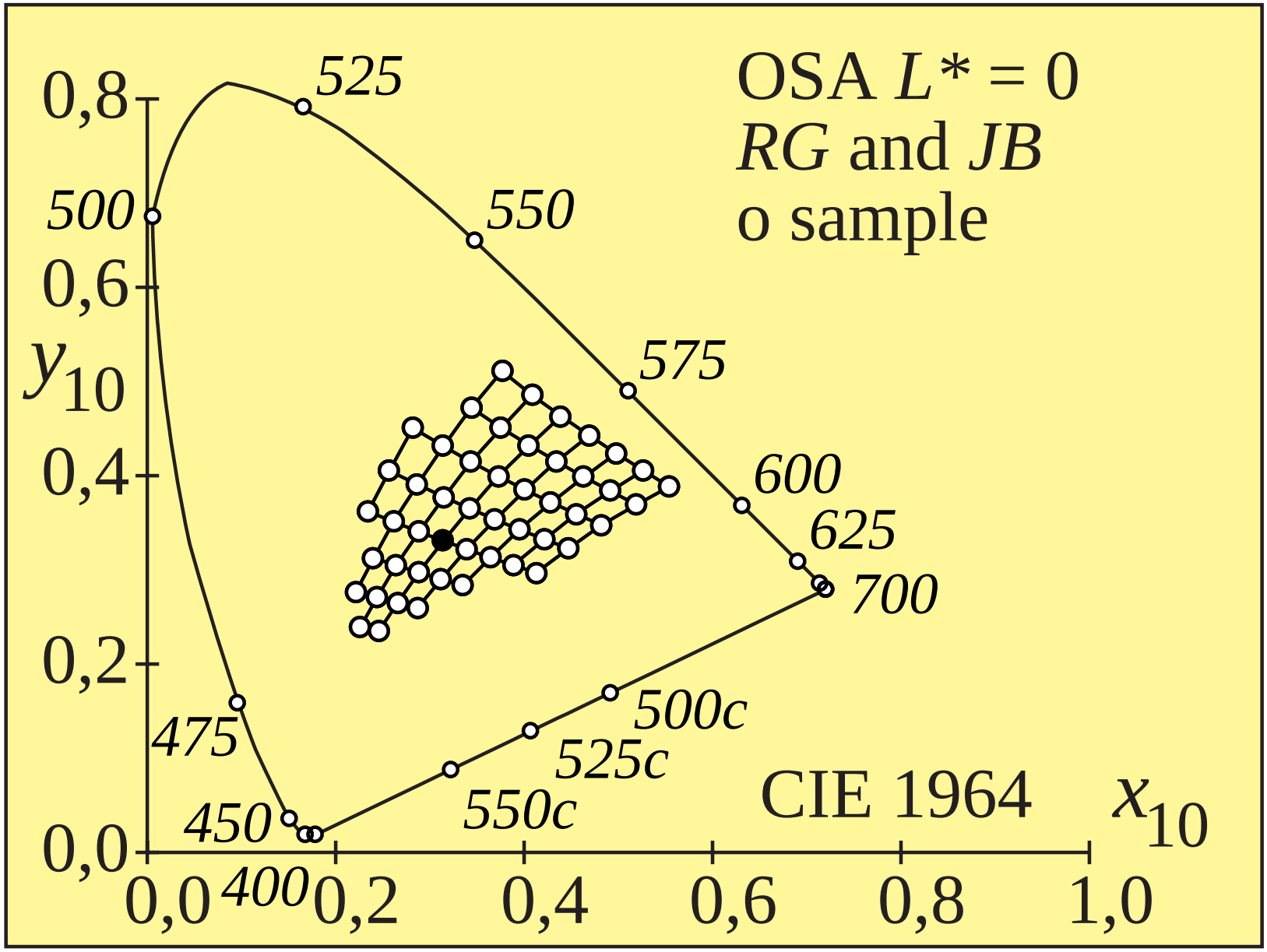


WE351−2, change of PDT in volour vision

Figure 20: CIELAB colour space and definition of colour diagrams (a', b')

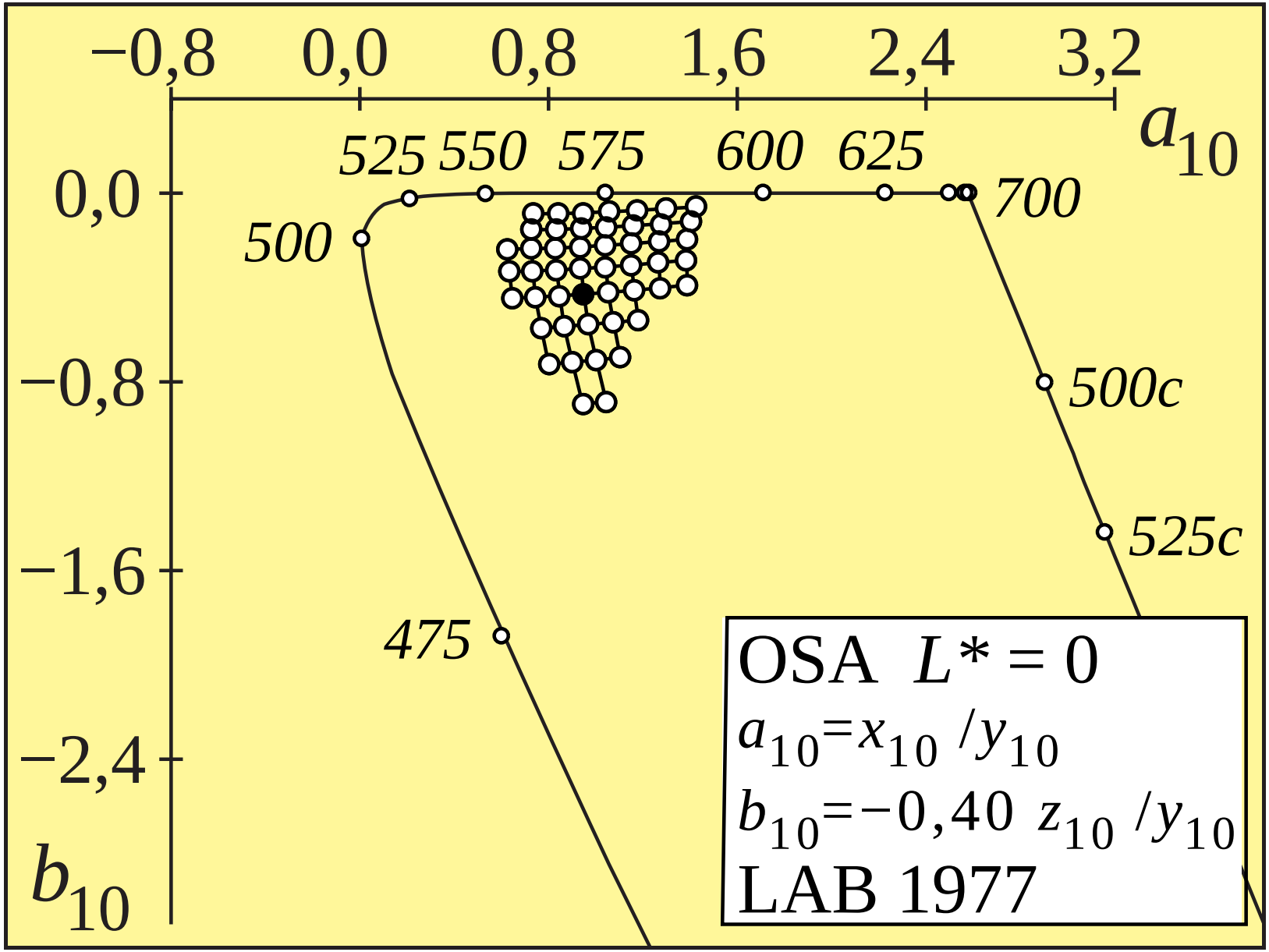
Higher colormetric (color data: nonlinear relation to CIE 1931 data)		
non linear color terms	**name and relationship with tristimulues or chromaticity values**	**notes:**
lightness	$L^* = 116\,(\,Y / 100\,)^{1/3} - 16 \quad (Y > 0{,}8)$	*CIELAB 1976*
	Approximation: $L^* = 100\,(\,Y / 100\,)^{1/2{,}4}$	
chroma	*non linear transform of chromatic values A and B*	
red−green	$a^* = 500\,[\,(X / X_n)^{1/3} - (Y / Y_n)^{1/3}\,]$	*CIELAB 1976*
	$= 500\,(a' - a'_n)\,Y^{1/3}$	*n=D65 (backgr.)*
yellow−blue	$b^* = 200\,[\,(Y / Y_n)^{1/3} - (Z / Z_n)^{1/3}\,]$	*CIELAB 1976]*
	$= 500\,(b' - b'_n)\,Y^{1/3}$	
radial	$C^*_{ab} = [\,a^{*2} + b^{*2}\,]^{1/2}$	
exitation ?	*nonlinear transform of chromaticities a=x/y and b=z/y*	
red−green	$a' = (\,1 / X_n\,)^{1/3}\,(\,x / y\,)^{1/3}$	*compare to log*
	$= 0{,}2191\,(\,x / y\,)^{1/3}$ for *D65*	*cone exitation*
yellow−blue	$b' = -\,0{,}4\,(\,1 / Z_n\,)^{1/3}\,(\,z / y\,)^{1/3}$	*log[L/(L+M)]*
	$= -\,0{,}08376\,(\,z / y\,)^{1/3}$ for *D65*	*log[S/(L+M)]*
radial	$c'_{ab} = [\,(a' - a'_n)^2 + (b' - b'_n)^2\,]^{1/2}$	

Figure 21: OSA colours in CIE (x, y) chromaticity diagram



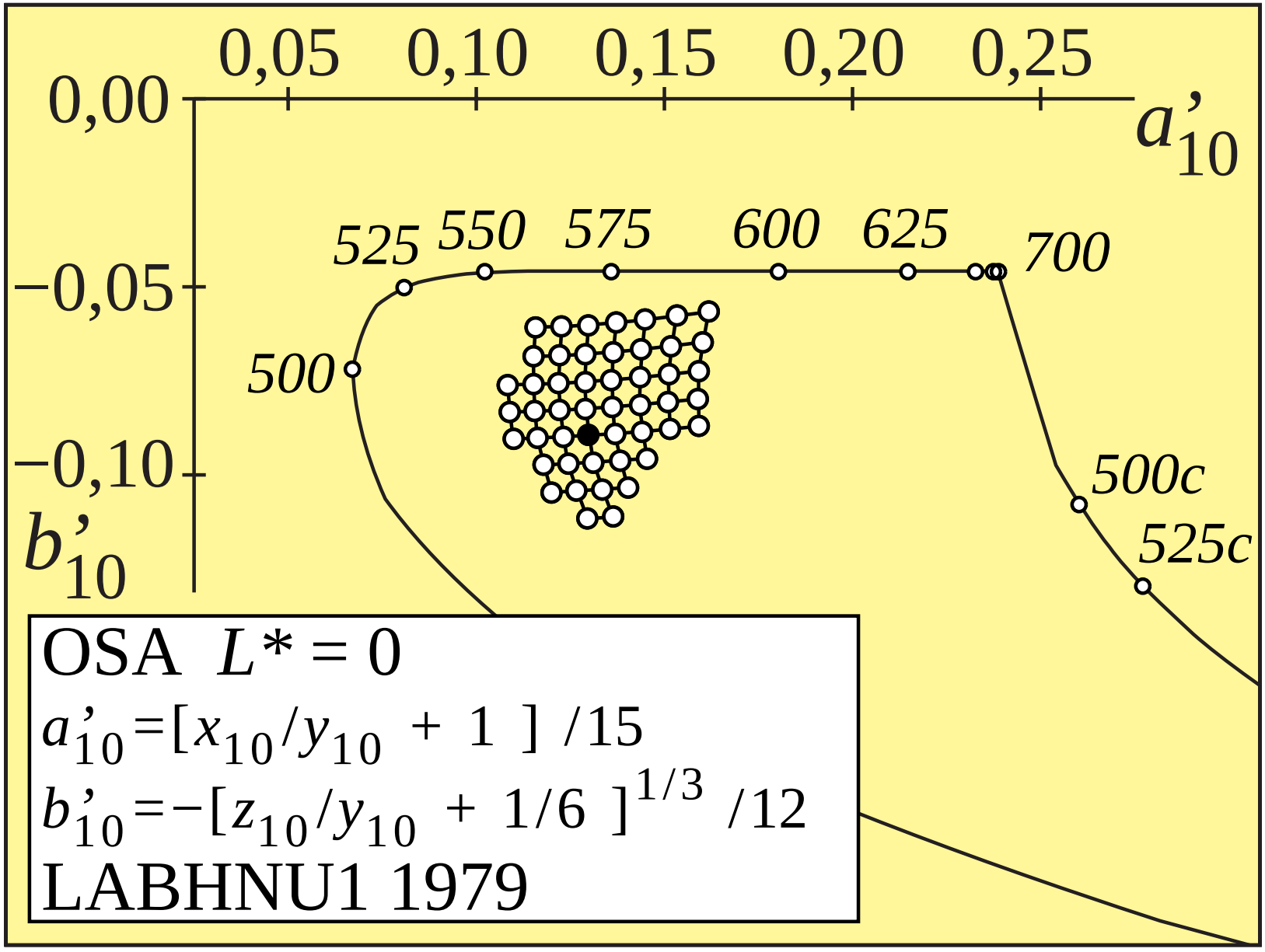
B8220_1, E8270−5, B4_13, N=4_13

Figure 22: OSA colours in (a, b) chromaticity diagram



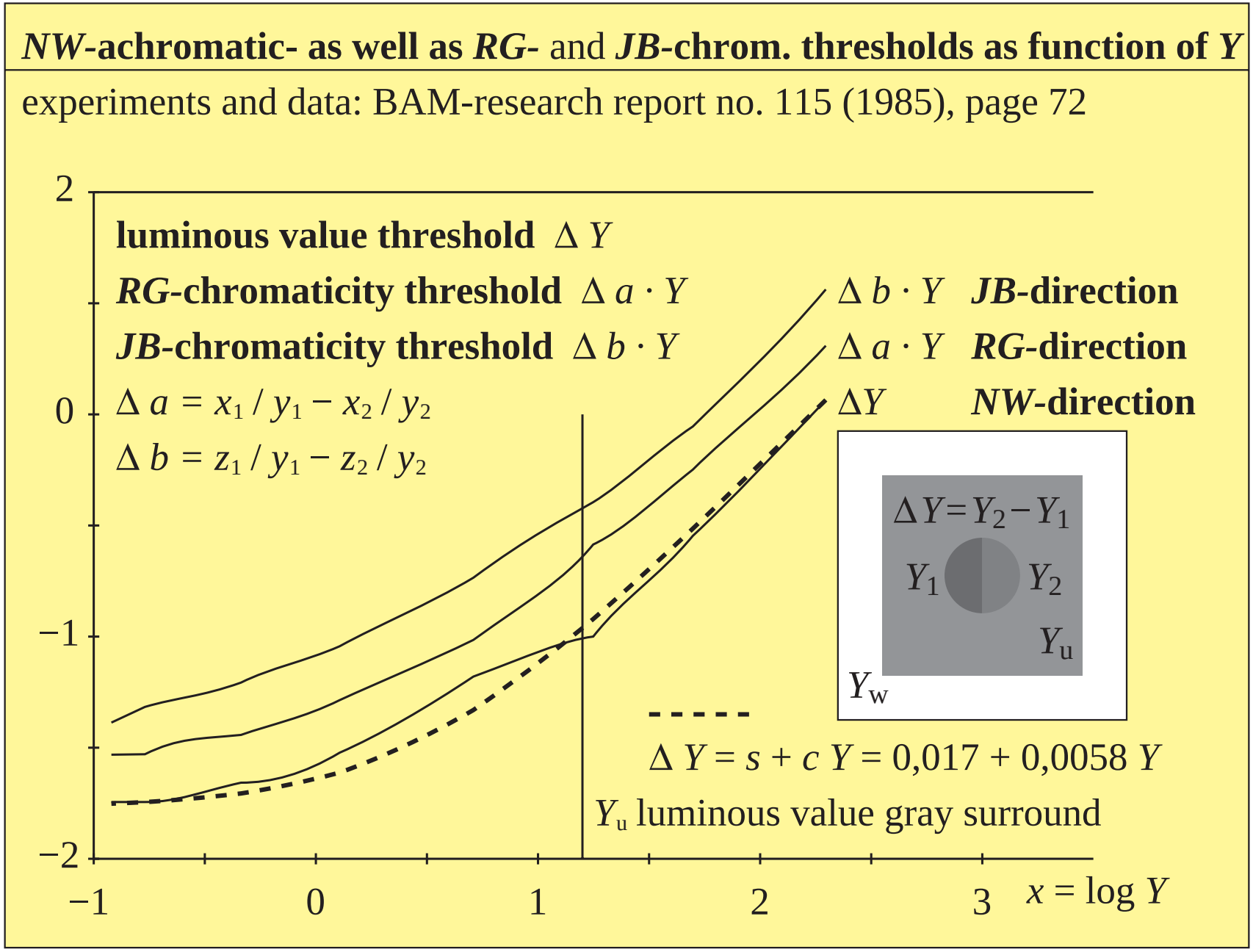
B8220_2, E8270−6, B4_14_1, N=4_14_1

Figure 23: OSA colours in (a', b') colour diagram (nonlinear chromaticity b')



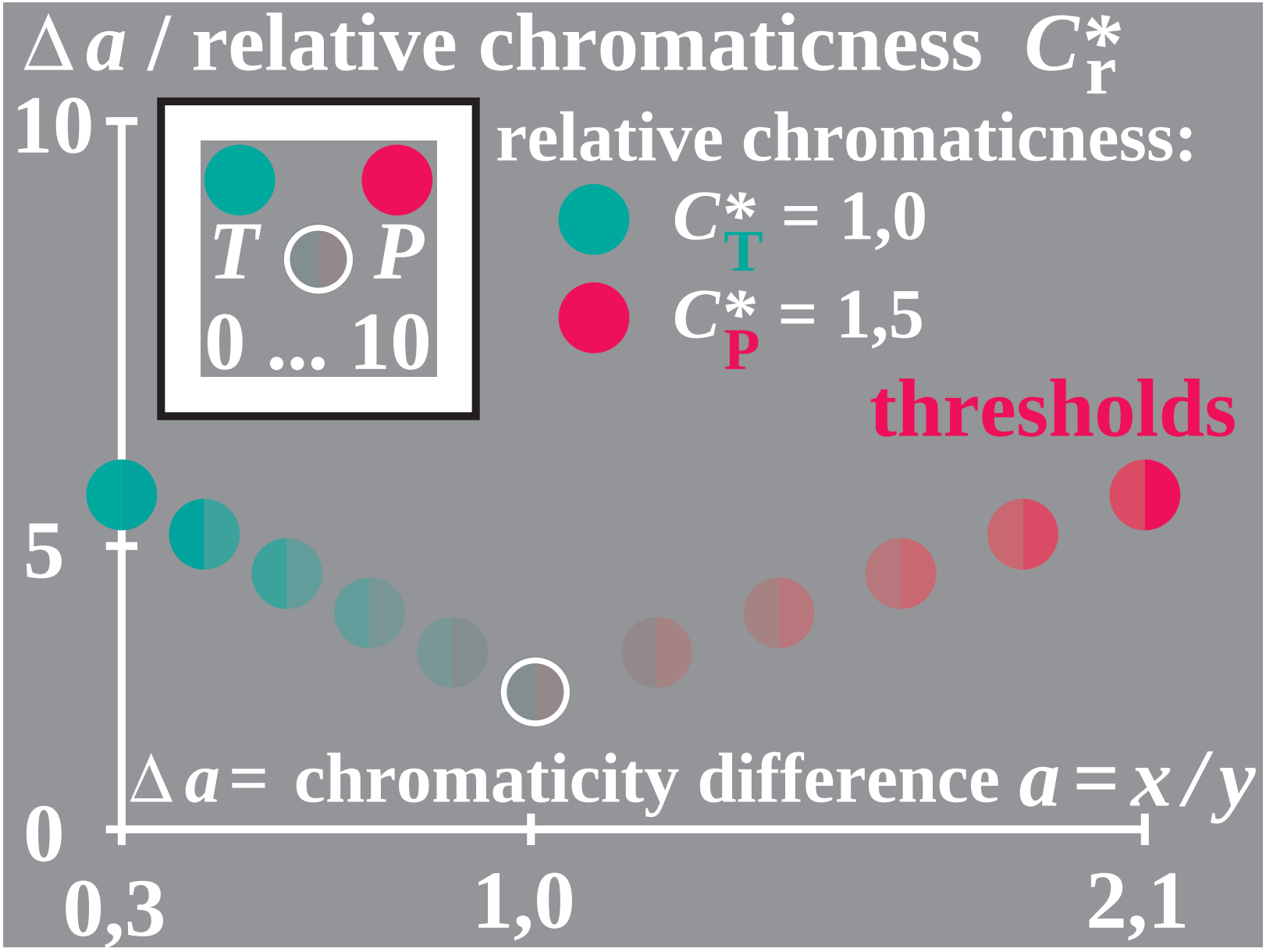
B8220_5, E8271−1, B4_14_4, N=4_14_4

Figure 24: Experimental threshold data for colours at the achromatic axis



B8190_7, E8311−7, B4_70, N=4_70 2x2

Figure 25: Threshold experiments for a T–P colour series of constant luminance



B8760_7, E8210−5, B4_05, N=4_5

Figure 26: Threshold results delta a for a T–P colour series of constant luminance

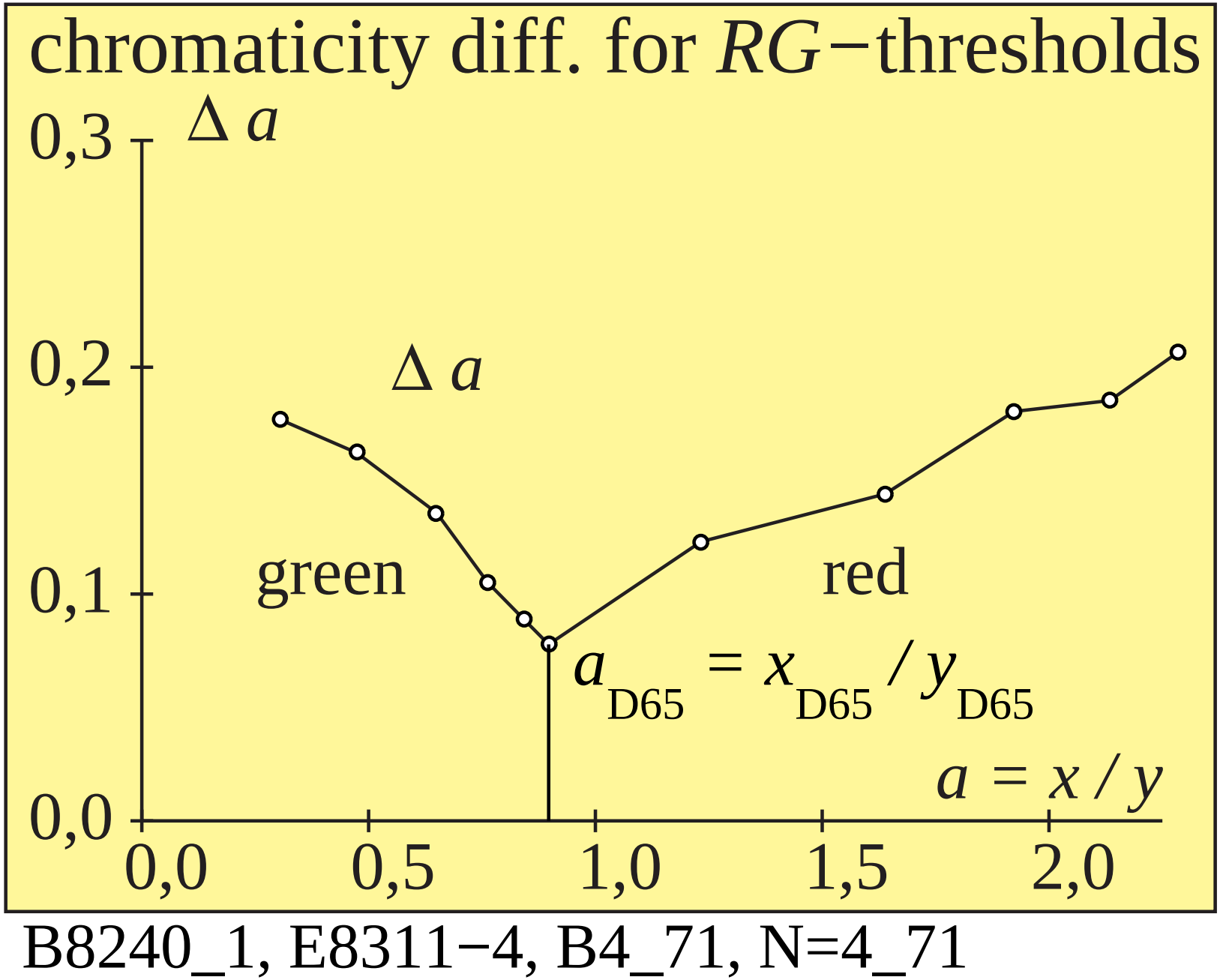
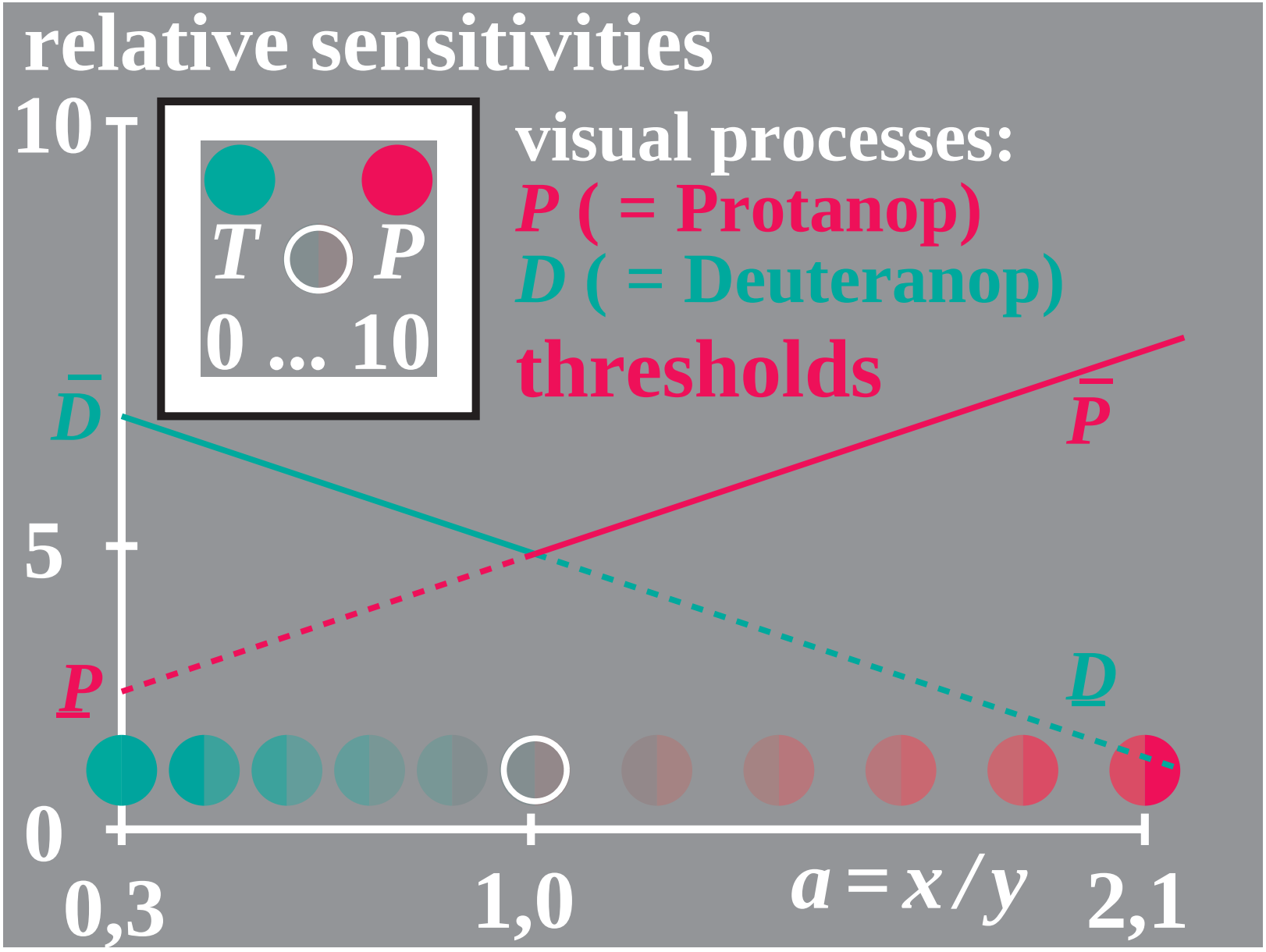
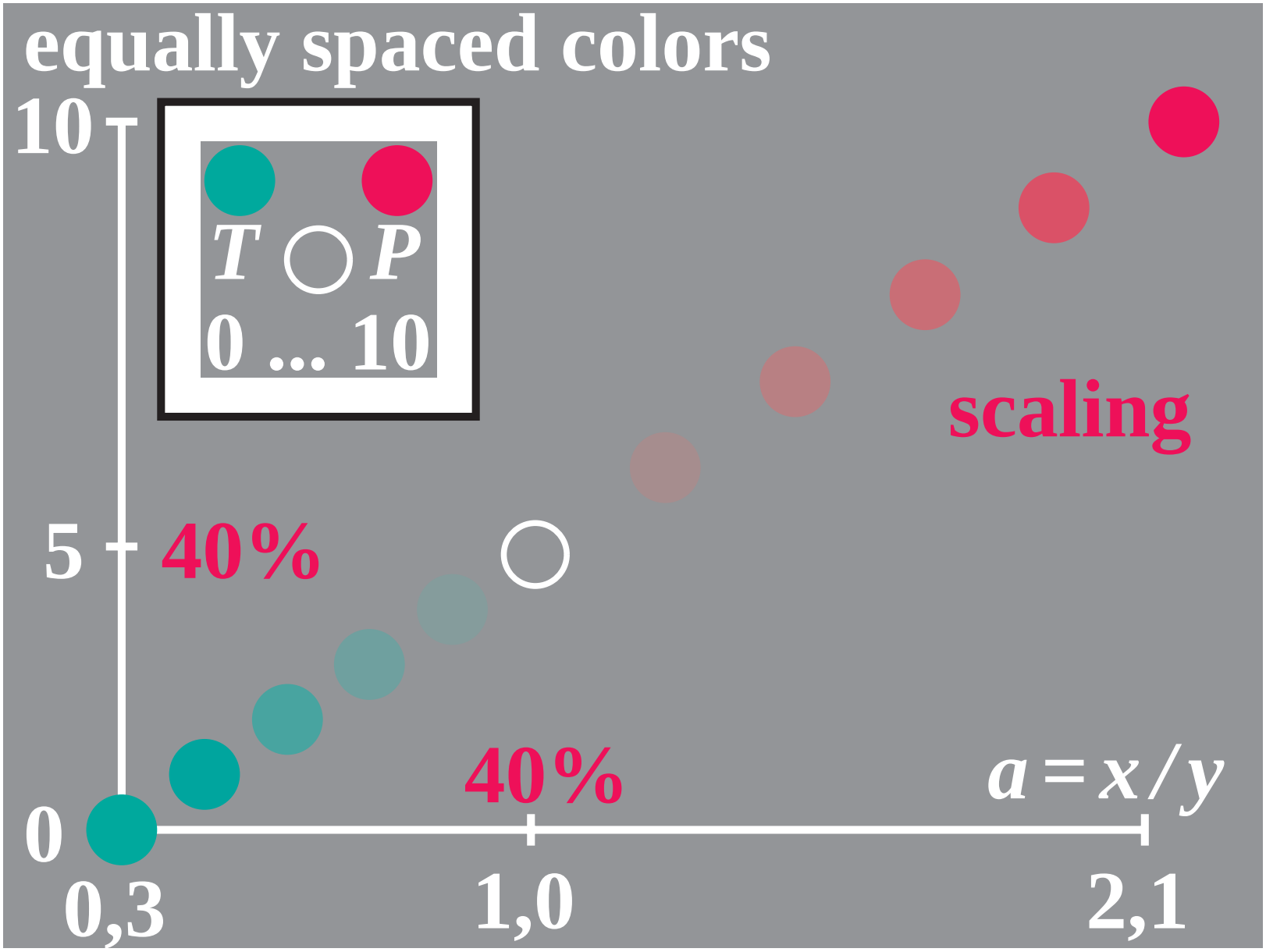


Figure 27: Sensitivity model for threshold of a T–P colour series



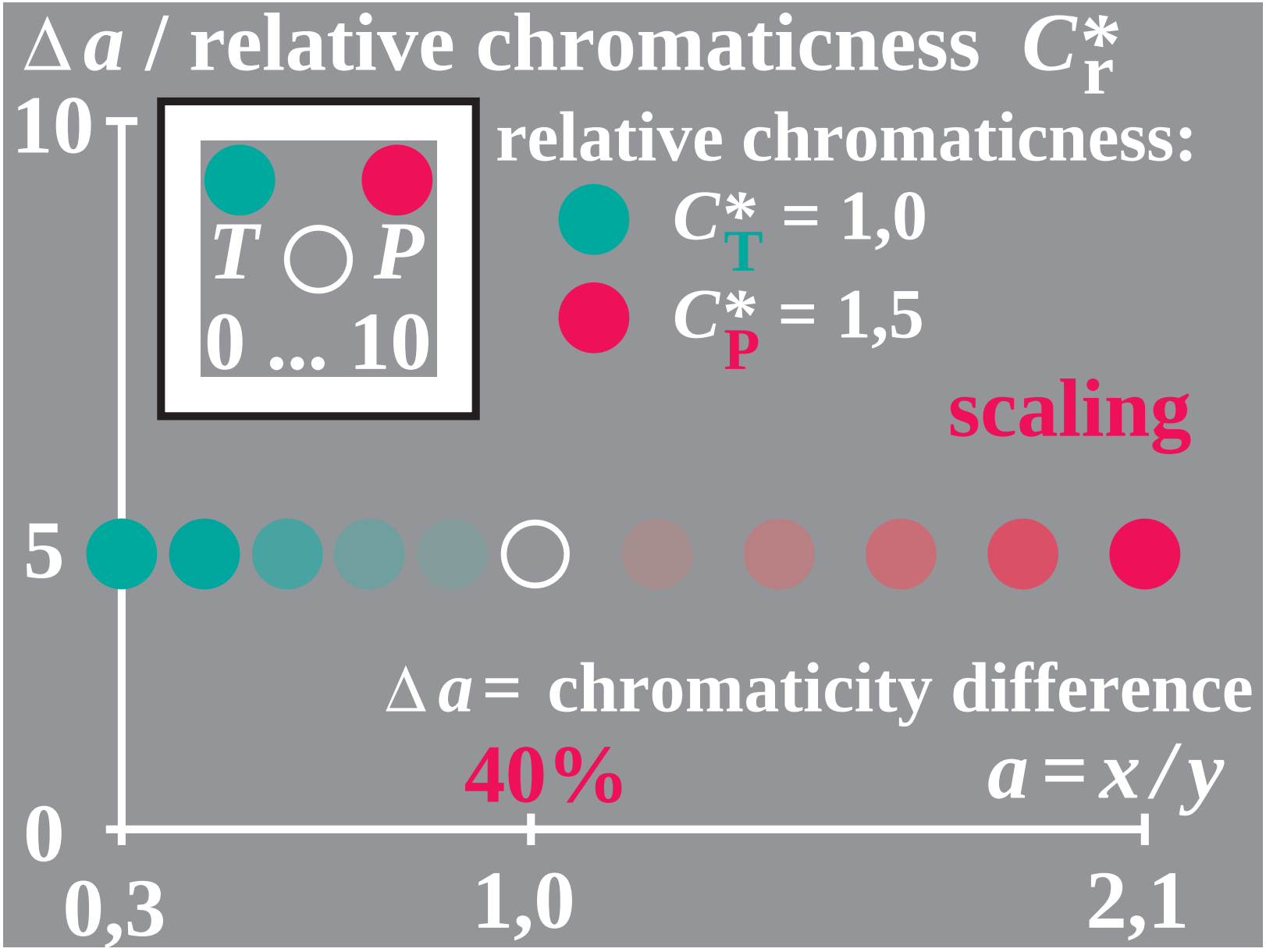
B8760_8, E8210−6, B4_06, N=4_6

Figure 28: Scaling experiment for a T–P colour series of constant luminance



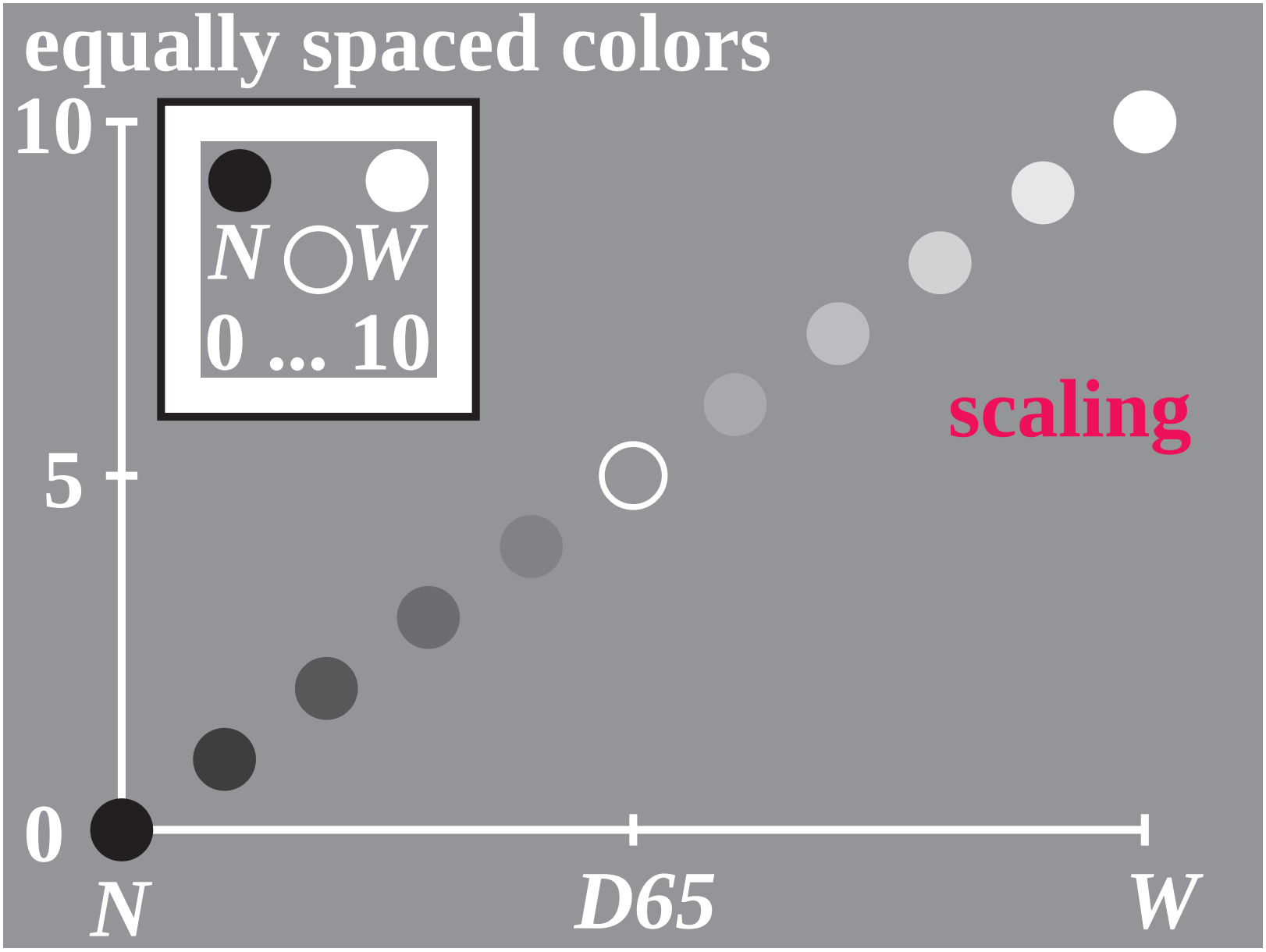
B8760_5, E8210−3, B4_03, N=4_3

Figure 29: Scaling results delta a for a T–P colour series of constant luminance



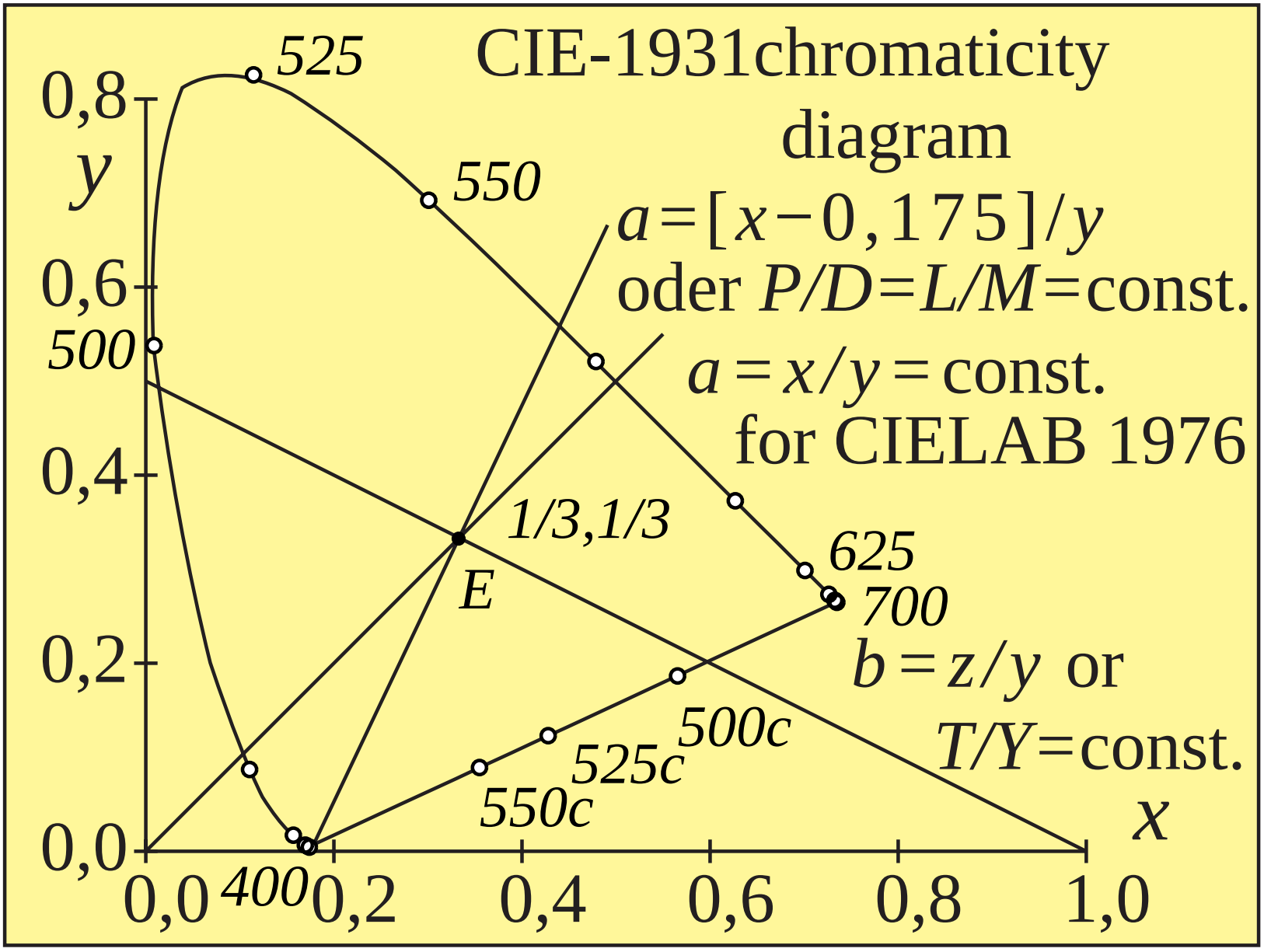
B8760_6, E8210−4, B4_04, N=4_4

Figure 30: Scaling experiment for a N-W colour series at the achromatic axis



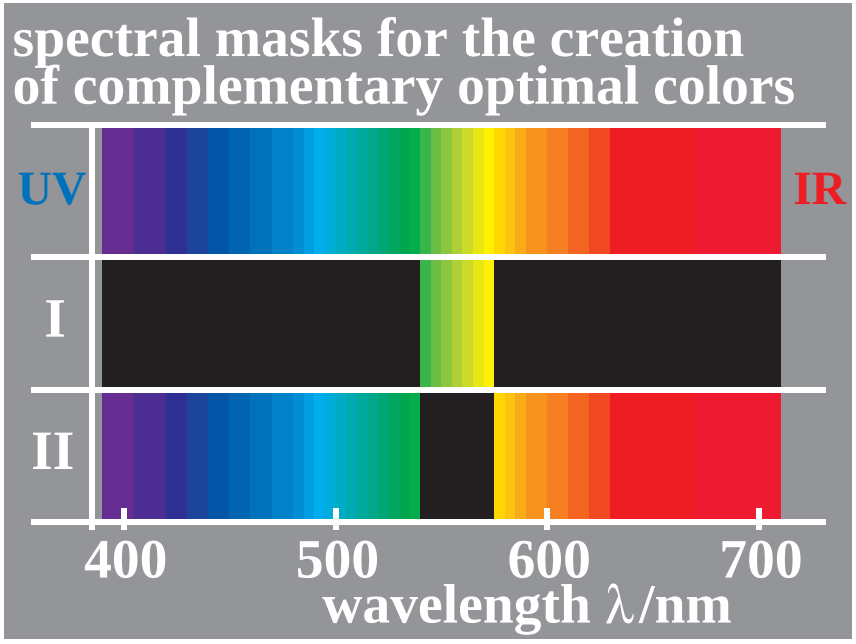
B8761_1, E8210−7, B4_07, N=4_7

Figure 31: Cone vision axis in CIE (x, y) chromaticity diagram

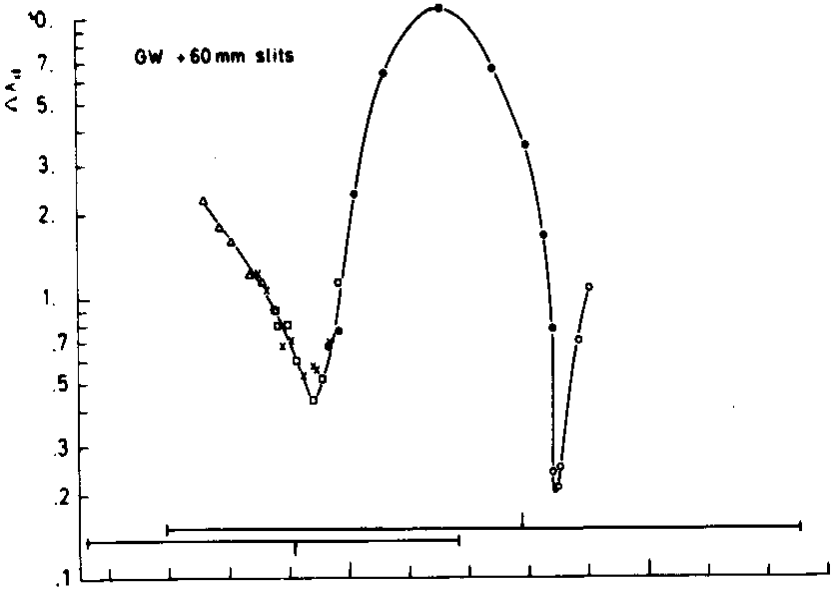


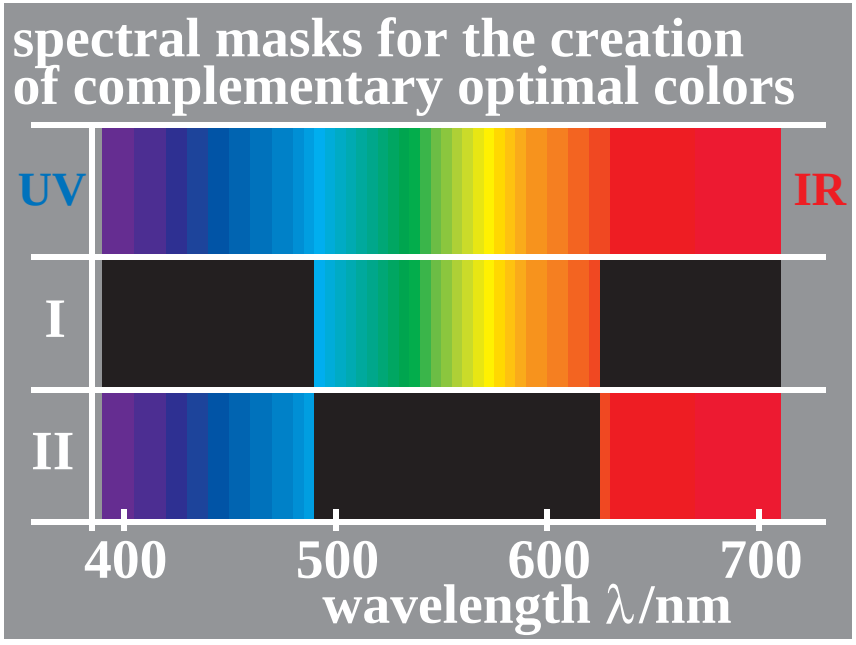
B8271_1, E8281−1, B4_21_1, N=4_21_1

Figure 32: Definition of complementary optimal colours and threshold discrimination



M8250−1N





M8250−2N

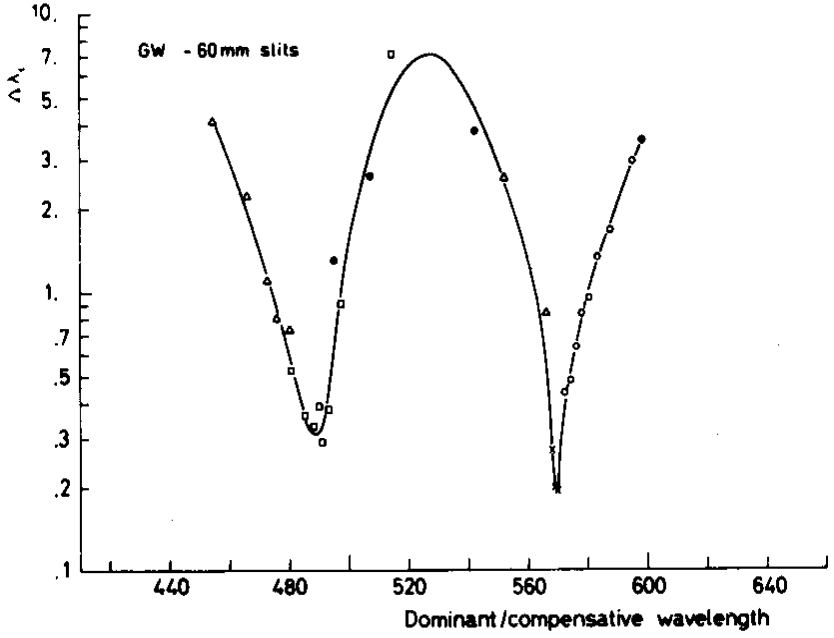


Figure 33: logarithmic sensitivity and JB- and RG-sensitivity differences

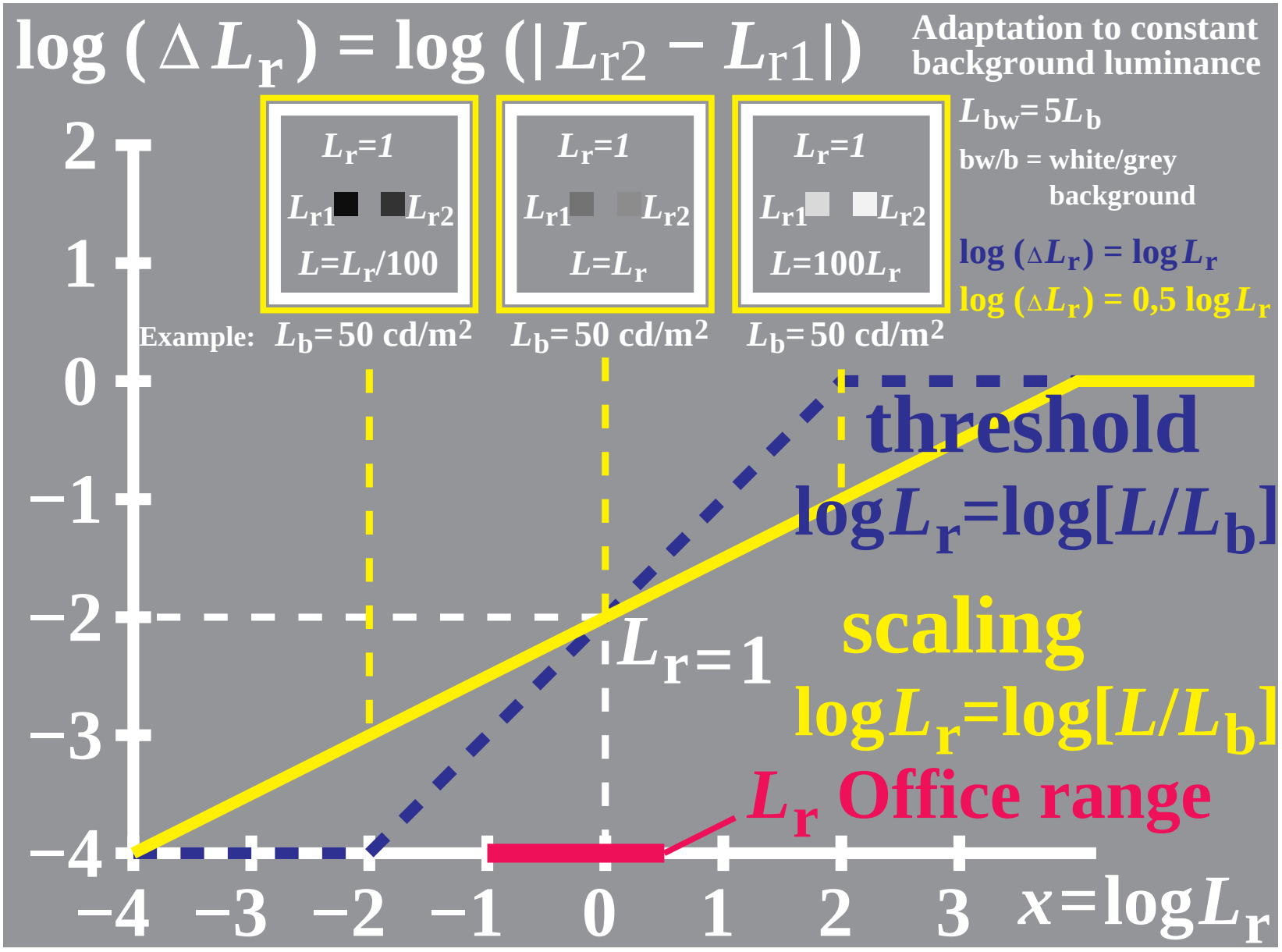
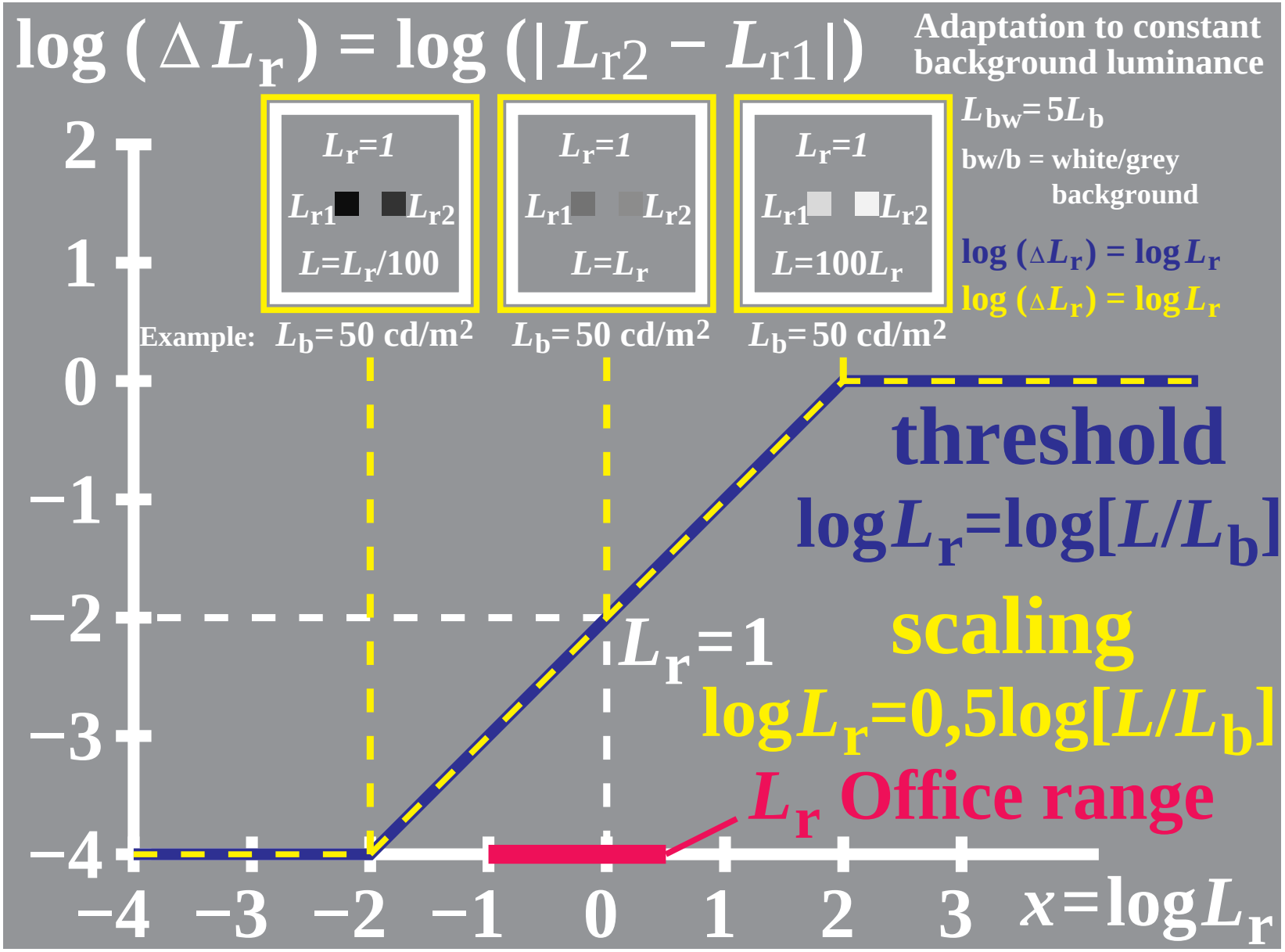
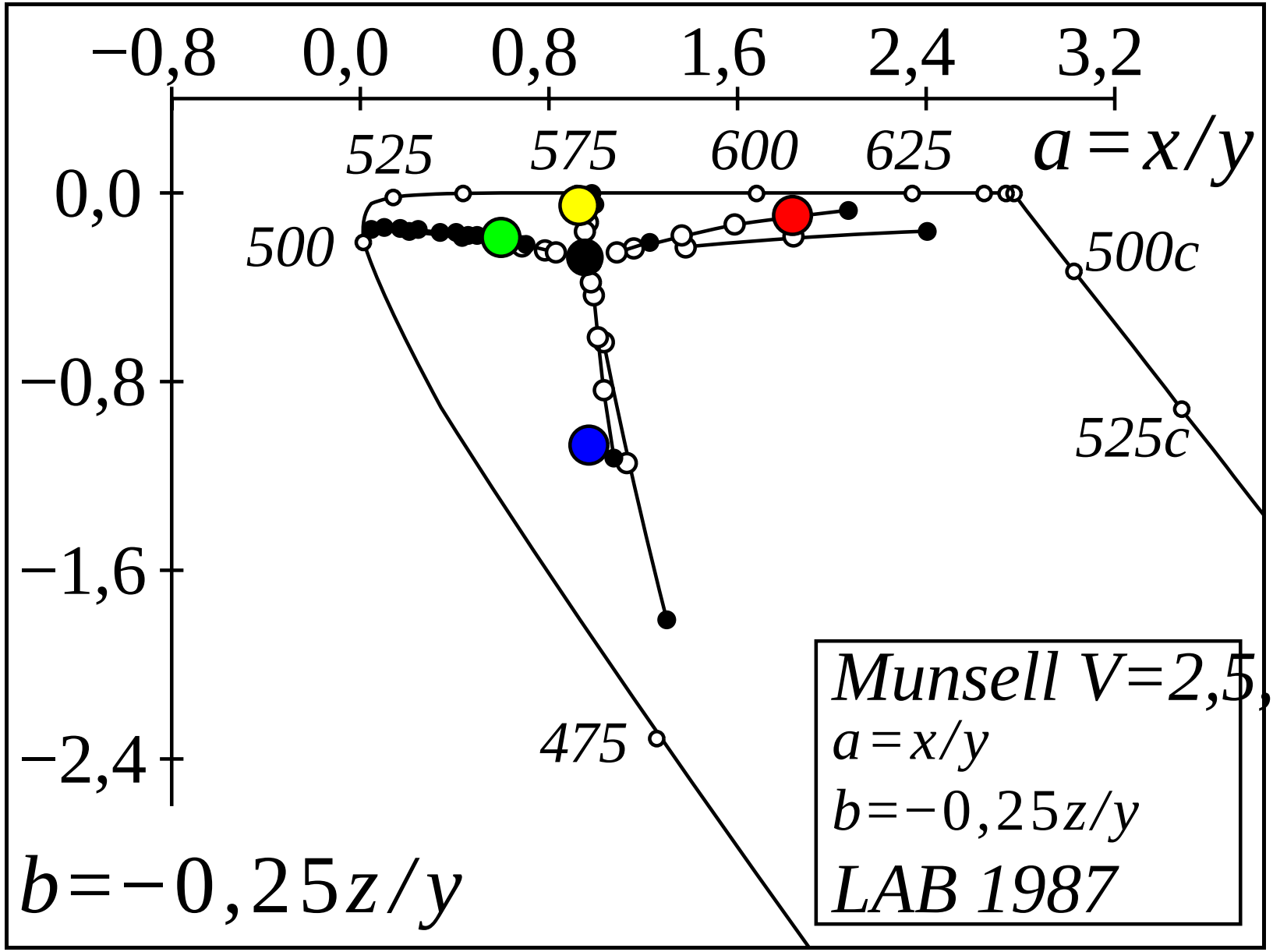


Figure 34: logarithmic sensitivity and JB- and RG-sensitivity differences



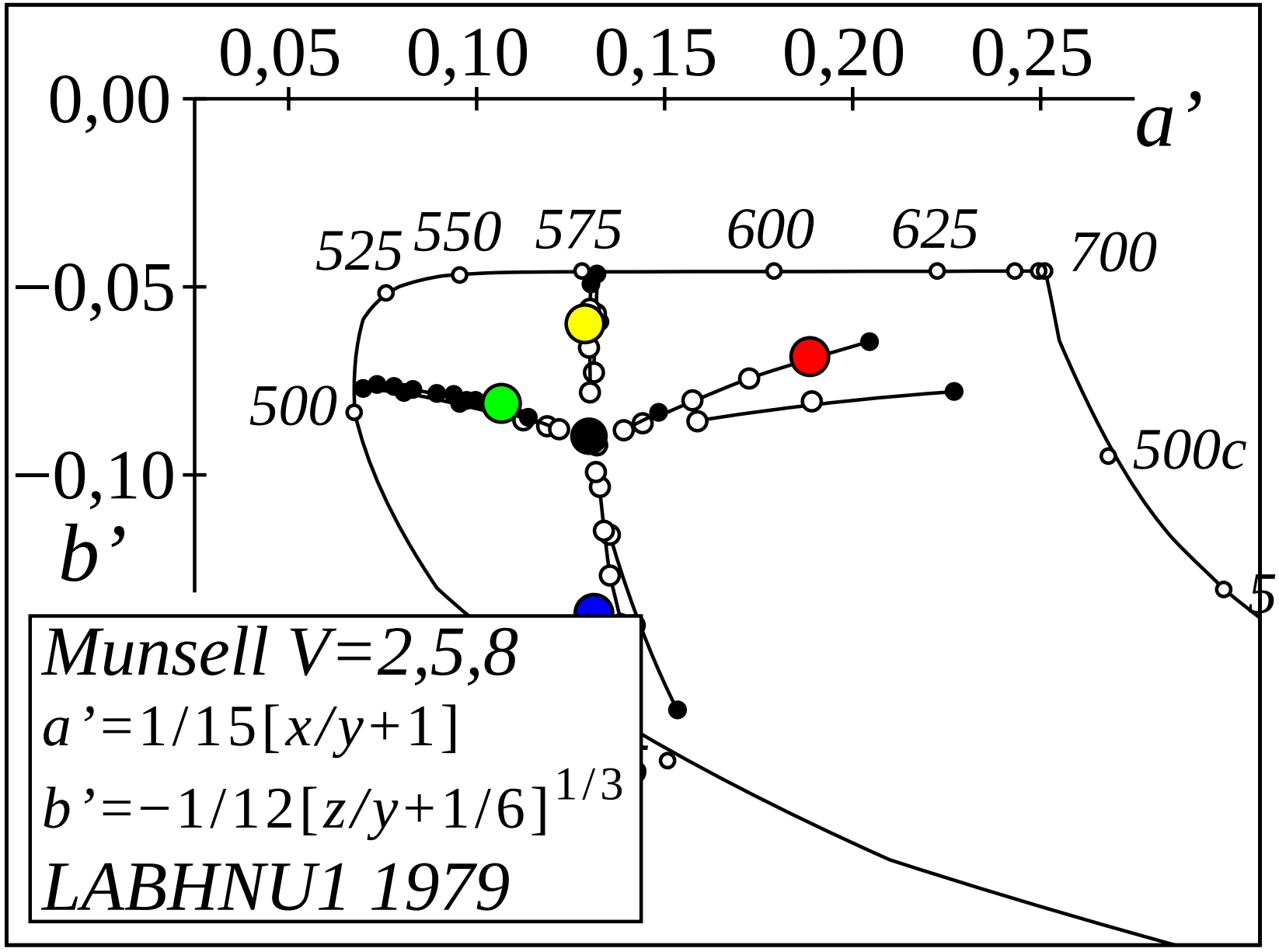
VE811−21

Figure 35: Elementary hues 5R, 5Y, 5G and 5PB of Munsell System (V=2,5,8) in (a, b) chromaticity diagram



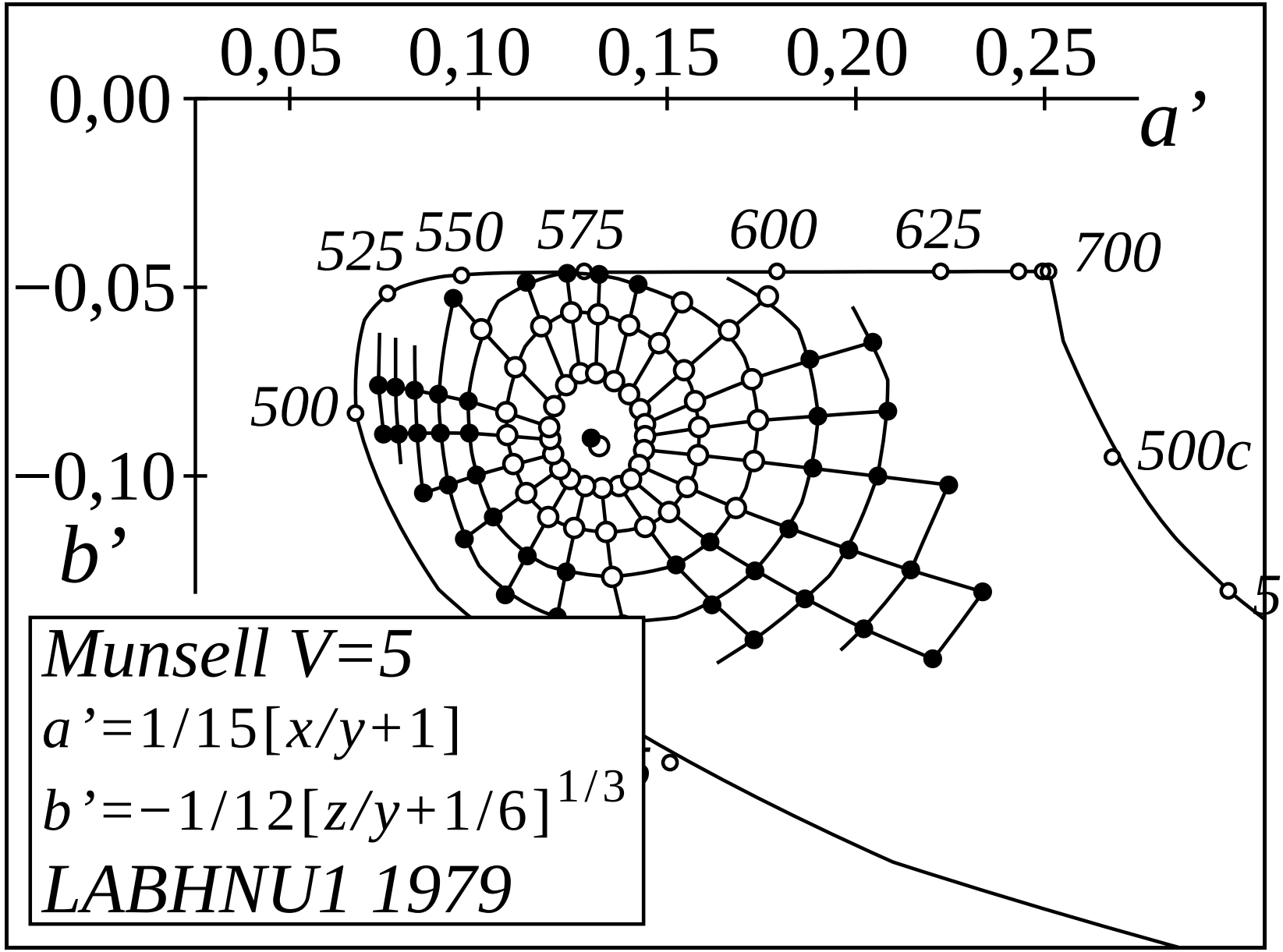
WE591−3, Colours in *(a,b)* chromaticity diagram

Figure 36: Elementary hues 5R, 5Y, 5G and 5PB of Munsell System (V=2,5,8) in (a', b') colour diagram



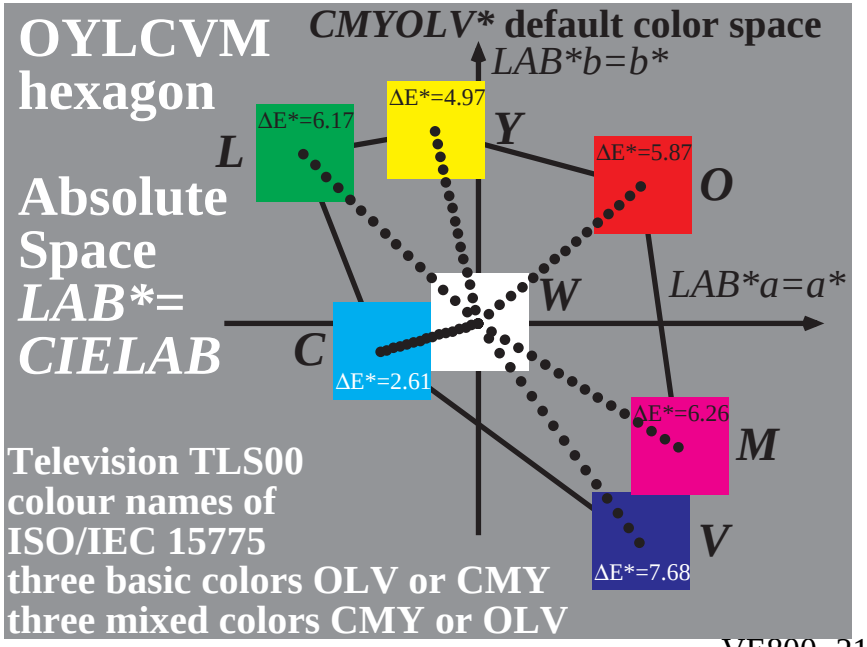
WE590−5, Colours in *(a',b')* colour diagram

Figure 37: Munsell colours of Value 5 in (a', b') colour diagram

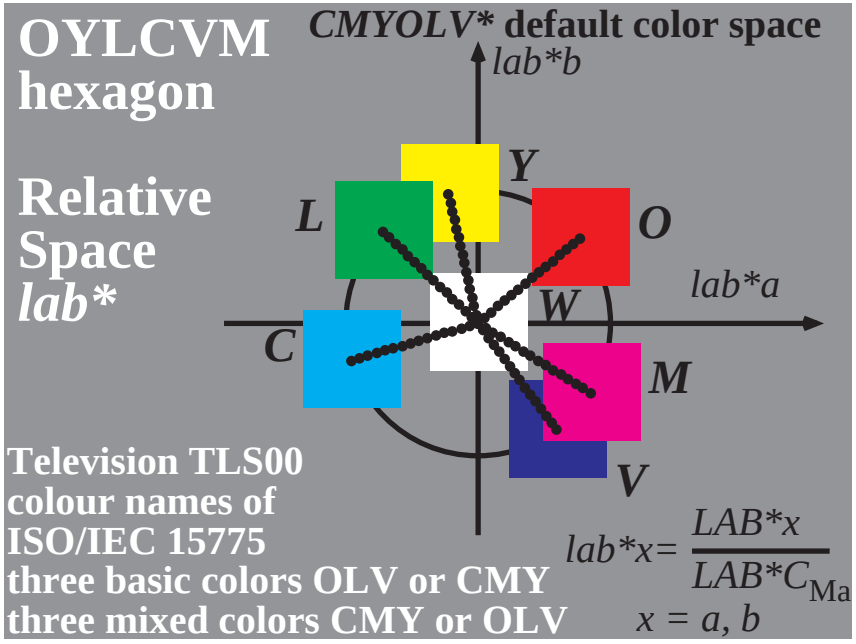


WE520−5, Colours in *(a',b')* colour diagram

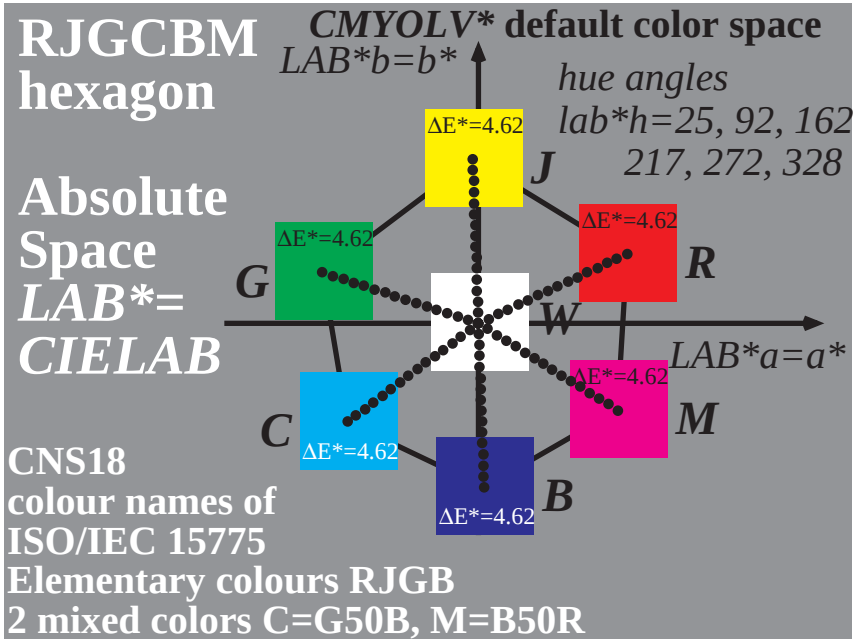
Figure 38: CIELAB (a*, b*) diagram for TLS00 and CNS18



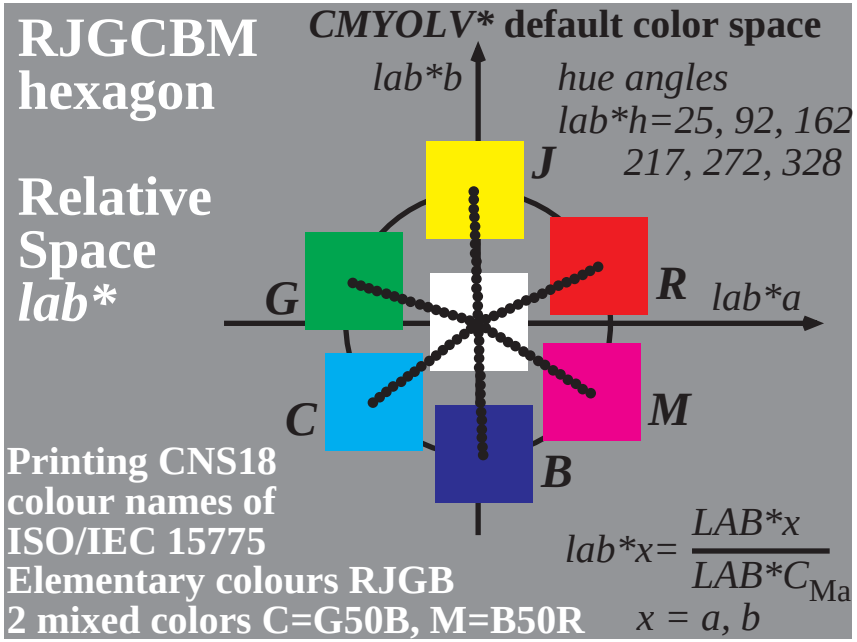
VE800−21



VE800−41

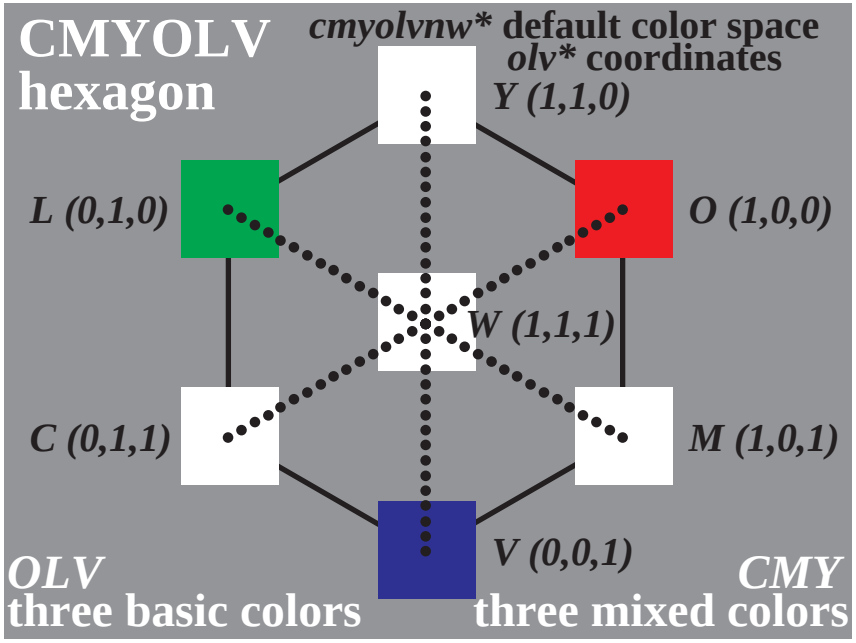


VE800−61

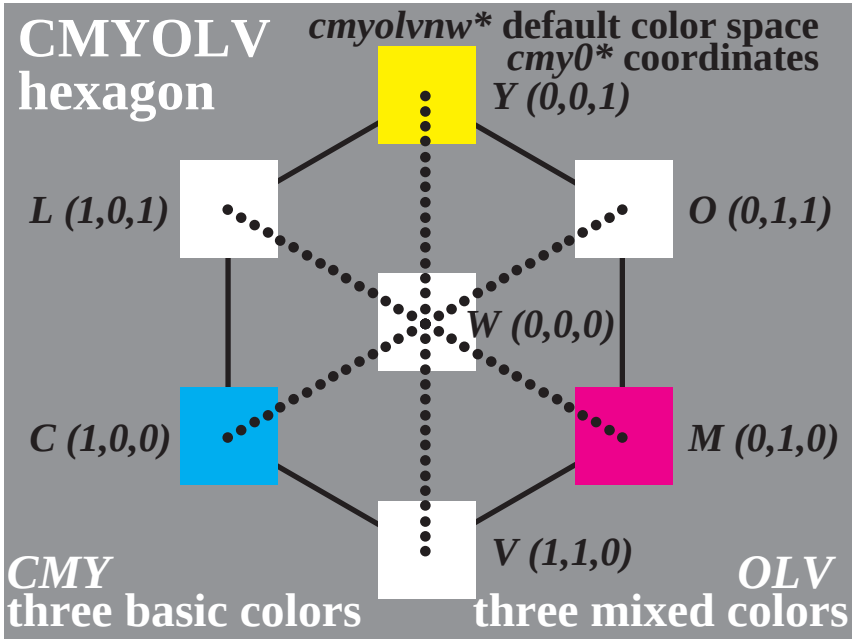


VE800−81

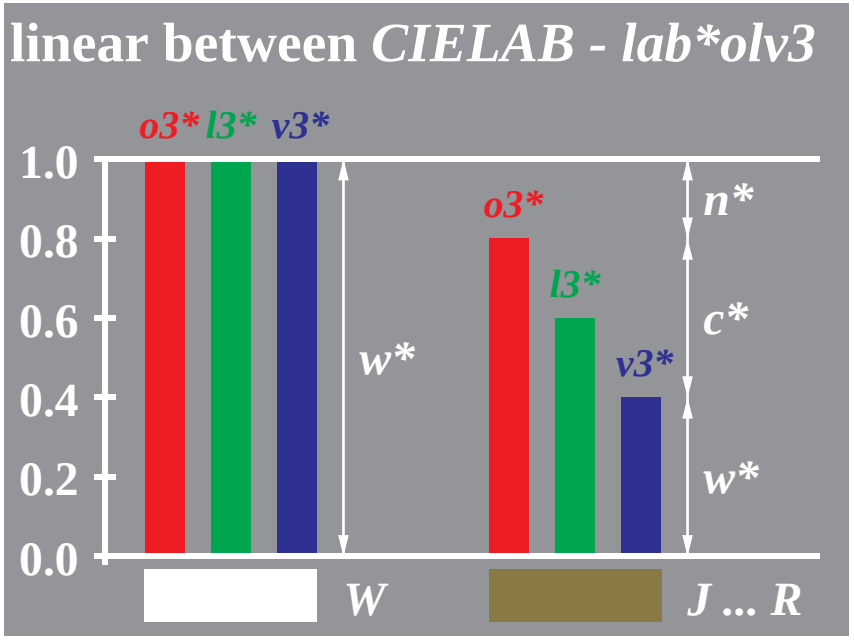
Figure 39: 1-minus relation of olv* and cmy* coordinates and examples



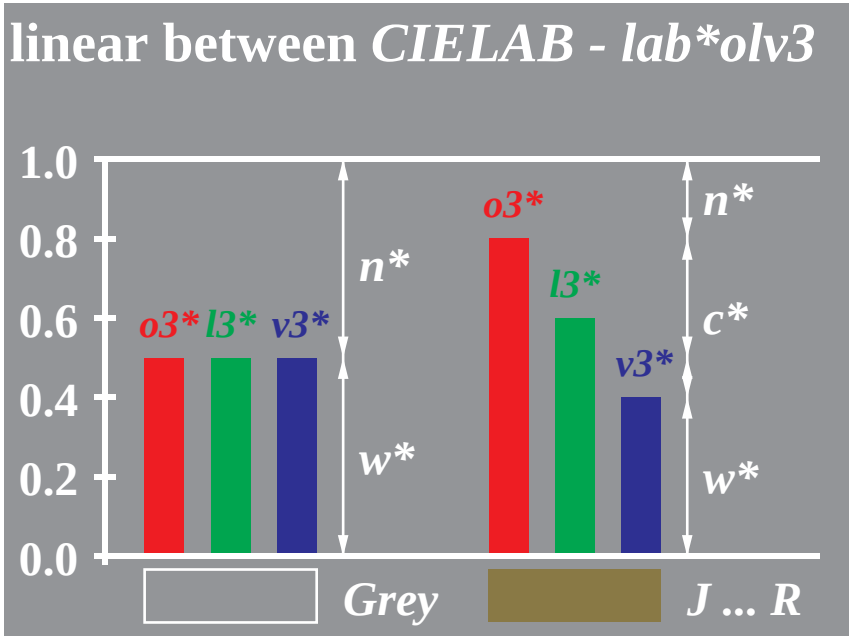
ME301−11



ME301−21

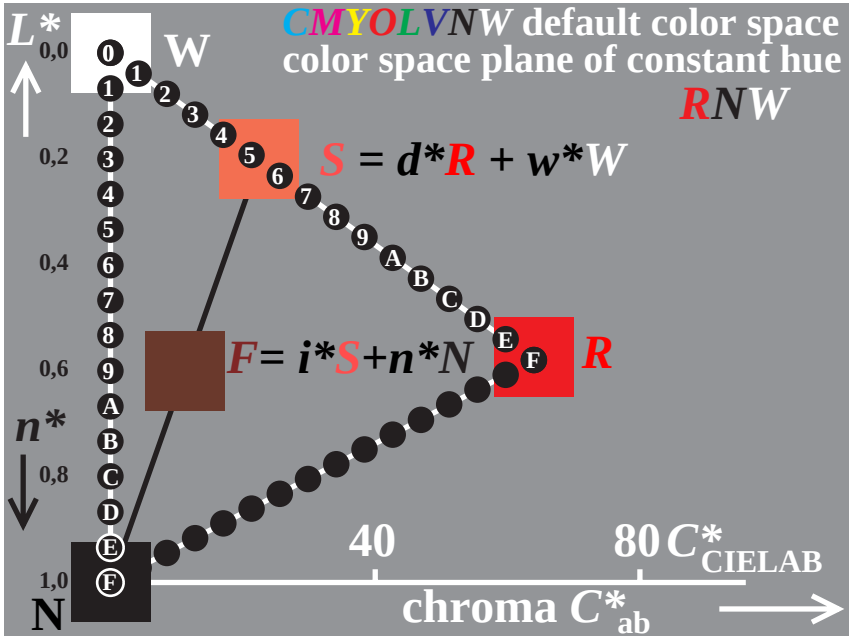


VE801−71

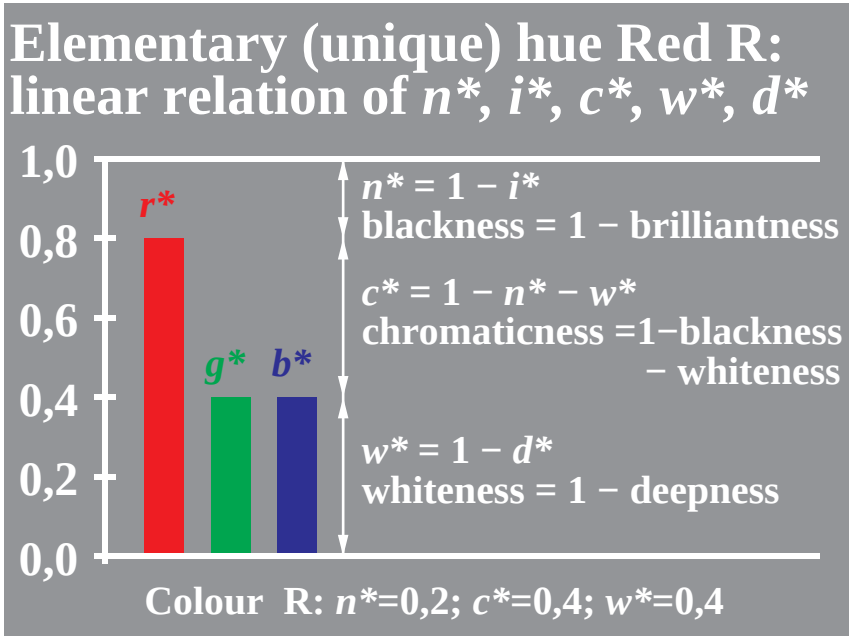


VE801−81

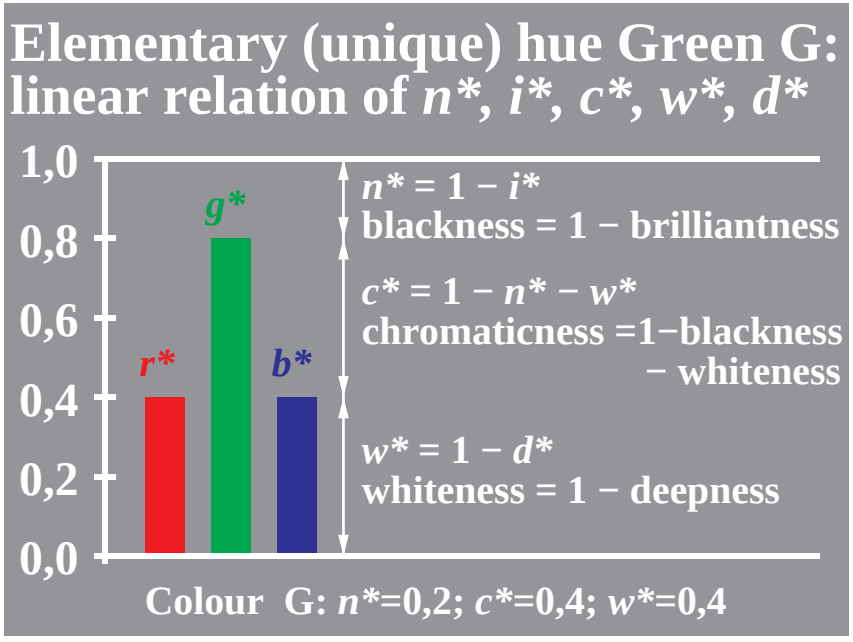
Figure 40: Mixture of Red R with White W and Black N; rgb* coordinates)



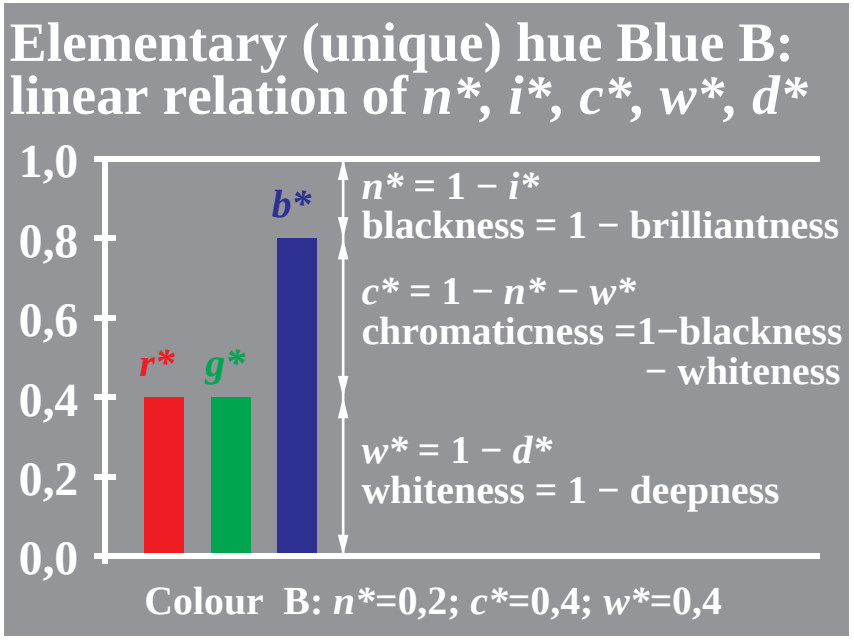
VE801−61



VE801−21



VE801−31



VE801−41

Figure 41: Relation olv* and CIELAB data

***relative* Inform. Technology (IT)**				
*olvi3**	0.0	1.0	0.0	(1.0)
*cmyn3**	1.0	0.0	1.0	(0.0)
*olvi4**	0.0	1.0	0.0	1.0
*cmyn4**	1.0	0.0	1.0	0.0
***standard* and *adapted* CIELAB**				
*LAB*LAB*	56.7	−73.59	23.91	
*LAB*LABa*	56.7	−73.59	23.91	
*LAB*TCHa*	50.0	77.38	162.0	
relative* CIELAB *lab*				
*lab*lab*	0.5	−0.95	0.309	
*lab*tch*	0.5	1.0	0.45	
*lab*nch*	0.0	1.0	0.45	
***relative* Natural Colour (NC)**				
*lab*lrj*	0.5	−0.999	0.005	
*lab*tce*	0.5	1.0	0.499	
*lab*ncE*	0.0	1.0	j99g	

Figure 42: Change of device *olv** coordinates to produce intended *rgb** colours)

***relative* Inform. Technology (IT)**				
*olvi3**	0.0	1.0	0.375	(1.0)
*cmyn3**	1.0	0.0	0.625	(0.0)
olvi3'*	0.135	0.724	0.305	(1.0)
cmyn3'*	0.865	0.276	0.695	(0.0)
***standard* and *adapted* CIELAB**				
*LAB*LAB*	42.59	−49.68	12.65	
*LAB*LABa*	42.59	−48.66	15.82	
*LAB*TCHa*	50.0	51.18	162.0	
relative* CIELAB *lab*				
*lab*lab*	0.424	−0.95	0.309	
*lab*tch*	0.5	1.0	0.45	
*lab*nch*	0.0	1.0	0.45	
***relative* Natural Colour (NC)**				
*lab*lrj*	0.424	−0.997	−0.059	
*lab*tce*	0.5	1.0	0.51	
*lab*ncE*	0.0	1.0	g03b	

Figure 43: Device hue V and Elementary hue B output

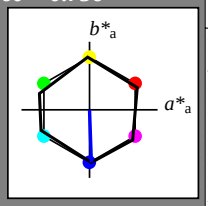
www.ps.bam.de/VE39/10L/L39E04NP.PS/.PDF; olv* device (left) and rgb* start (right) output
N: No Output Linearization (OL) data in File (F), Startup (S) or Device (D)

See for similar files: http://www.ps.bam.de/VE39/
Technical information: http://www.ps.bam.de Version 2.1, io=1,1

BAM registration: 20060101-VE39/10L/L39E04NP.PS/.PDF BAM material: code=rha4ta
application for evaluation and measurement of printer or monitor systems
/VE39/ Form: 5/10, Serie: 1/1, Page: 5 Page: count: 1

Input: Colorimetric Natural Reflective System CNS18

for hue *h = *lab*h* = 272/360 = 0.756**
lab*tch* and *lab*nch
D65: hue B
LCH*Ma: 57 77 272
olv*Ma: 0.0 0.0 1.0



CNS18; adapted (a) CIELAB data

	$L^*=L^*_a$	a^*_a	b^*_a	$C^*_{ab,a}$	$h^*_{ab,a}$
R_{Ma}	56.7	70.15	32.71	77.4	25
J_{Ma}	56.7	−2.69	77.35	77.4	92
G_{Ma}	56.7	−73.6	23.92	77.4	162
$G50B_{Ma}$	56.7	−71.24	−30.23	77.4	203
B_{Ma}	56.7	2.7	−77.34	77.4	272
$B50R_{Ma}$	56.7	63.4	−44.38	77.4	325
N_{Ma}	18.01	0.0	0.0	0.0	0
W_{Ma}	95.41	0.0	0.0	0.0	0
R_{CIE}	39.92	58.74	27.99	65.07	25
J_{CIE}	81.26	−2.88	71.56	71.62	92
G_{CIE}	52.23	−42.41	13.6	44.55	162
B_{CIE}	30.57	1.41	−46.46	46.49	272

triangle lightness *t**

%Gamut
u^*_{rel} = 100
%Regularity
$g^*_{H,rel}$ = 59
$g^*_{C,rel}$ = 100

1,00
0,75
0,50
0,25
0,00

*n** = 0,00
*n** = 0,25
*n** = 0,50
*n** = 0,75
*n** = 1,00

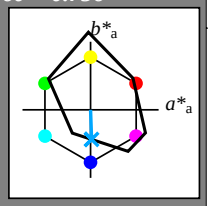
blackness *n**

0,25 0,50 0,75 1,00

chromaticness *c**

Output: Colorimetric Printer Reflective System FRS06

for hue *h = *lab*h* = 272/360 = 0.756**
lab*tch* and *lab*nch
D65: hue B
LCH*Ma: 35 44 272
olv*Ma: 0.0 0.65 1.0



FRS06; adapted (a) CIELAB data

	$L^*=L^*_a$	a^*_a	b^*_a	$C^*_{ab,a}$	$h^*_{ab,a}$
O_{Ma}	32.57	62.32	46.49	77.75	37
Y_{Ma}	82.73	−3.16	113.99	114.03	92
L_{Ma}	39.43	−61.79	45.84	76.95	143
C_{Ma}	47.86	−26.79	−34.24	43.49	232
V_{Ma}	10.16	55.12	−61.03	82.24	312
M_{Ma}	34.5	80.68	−33.92	87.52	337
N_{Ma}	6.25	0.0	0.0	0.0	0
W_{Ma}	91.97	0.0	0.0	0.0	0
R_{CIE}	39.92	59.8	31.05	67.38	27
J_{CIE}	81.26	−2.52	76.25	76.29	92
G_{CIE}	52.23	−41.56	17.14	44.96	158
B_{CIE}	30.57	2.63	−43.77	43.86	273

triangle lightness *t**

%Gamut
u^*_{rel} = 115
%Regularity
$g^*_{H,rel}$ = 28
$g^*_{C,rel}$ = 38

1,00
0,75
0,50
0,25
0,00

*n**=0,00
*n**=0,20
*n**=0,40
*n**=0,60
*n**=0,80
*n**=1,00

blackness *n**

0,00 0,20 0,40 0,60 0,80 1,00

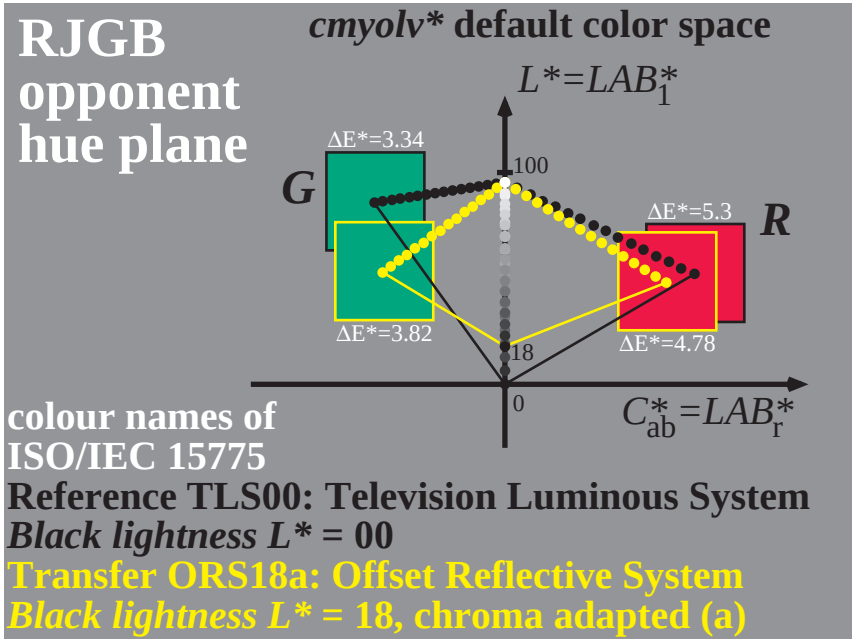
chromaticness *c**

VE390−7, 9 step scales for constant CIELAB hue 272/360 = 0.756 (left)
16 step scales for constant CIELAB hue 272/360 = 0.756 (right)

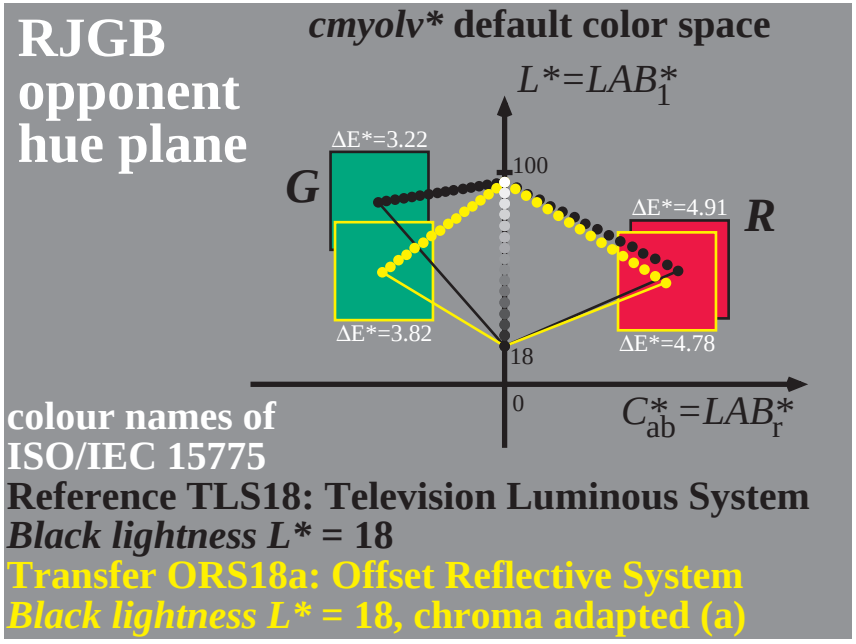
BAM-test chart VE39; Colorimetric systems CNS18 & FRS06
D65: 9 and 16 step colour scales for 10 hues

input: *olv* setrgbcolor*
output: *no change compared to input*

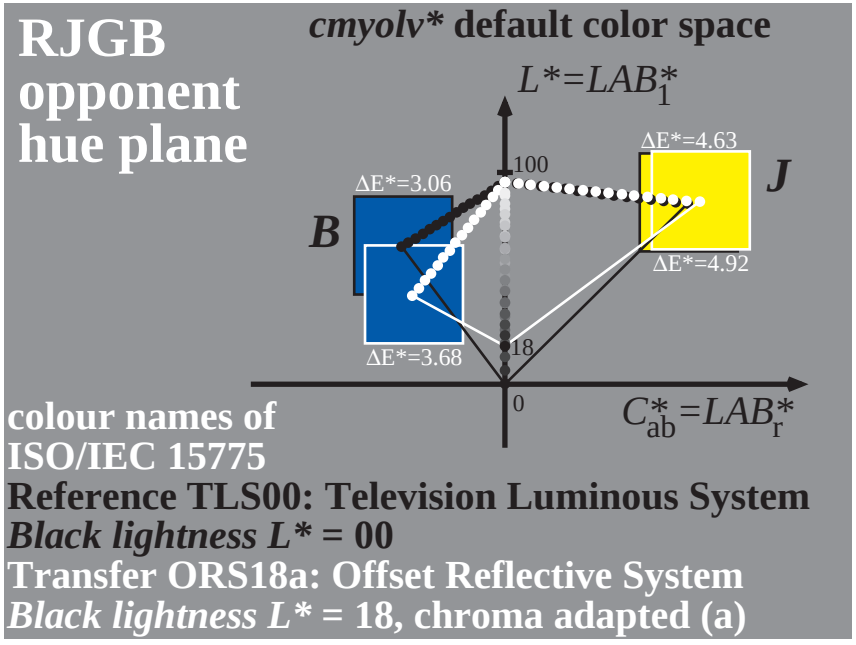
Figure 44: C*-L* diagram for output on monitors and printers)



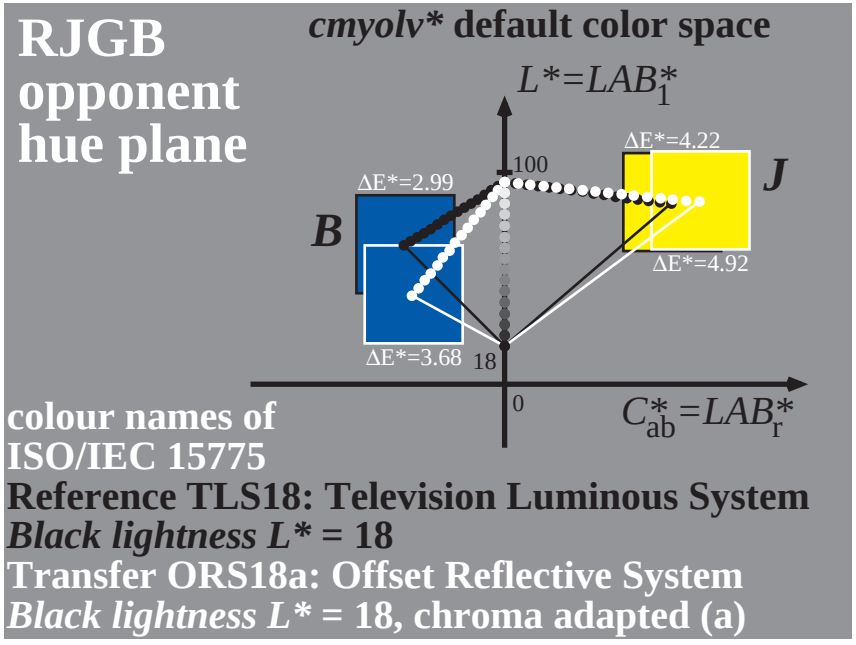
BE331−51



BE331−61



BE331−71



BE331−81

Summary

- A Colorimetric Image Technology (CIT) is needed
- Relative colorimetric data and relation to CIELAB
- Model for cone sensitivities and adaptation change
- Colour metric for scaling and threshold data
- Definition of relative colorimetric data *lab**
- *lab*olv* = *olv** and *lab*rgb* = *rgb** data
- Relation of *olv** and *rgb** to CIELAB
- *olv** input and output of device dependent hues
- *rgb** input and output of device independent hues
- 16 step equal spacing in CIELAB of device output
- 16 step equal spacing on monitors and printers

Standards, Technical Reports and other References

The author was active as a leader for the standards [1] to [3] and was editor of the International documents [4] to [6].

[1] **DIN 33870:2000:** Requirements and tests for the remanufacturing of used toner modules black for electrophotographic printers, copiers and fax machines (Anforderungen und Prüfungen für die Aufbereitung von gebrauchten Tonermodulen schwarz für elektrophotographische Drucker, Kopierer und Fernkopierer)

[2] **DIN 33871-1:2003:** Requirements for remanufacturing of used inkjet heads and inkjet tanks of inkjet printers (Aufbereitung von gebrauchten Tintendruckköpfen und Tintentanks für Tintenstrahldrucker)

[3] **DIN 33866-1 bis 5:2000**: Information technology – Office machines – Machines for colour image reproduction: Method for specifying image reproduction of colour devices by digital and analog test charts, This standard includes analog DIN-test charts no. 1 to 4.

[4] **ISO/IEC 15775:1999**; Information technology – Office machines – Machines for colour image reproduction - Method of specifying image reproduction of colour copying machines by analog test charts – Realisation and application

[5] **ISO/IEC TR 19797:2004**, Information technology - Device output of 16-step colour scales, output linearization method (LM) and specification of the reproduction properties, ISO/IEC JTC1/SC28 (21pages)

[6] **ISO/IEC TR 24705:2005**, Method of specifying image reproduction of colour devices by digital and analog test charts, (79 pages)

[7] Richter, K. (2004), Natural colour connection space (NCCS) between input and output for office systems, International Semina on Information Office Equipment Standardization, Korean Agency for Technology and Standards, pages 71-92, see the URL (1.4 MByte, 27 pages)

http://www.ps.bam.de/BAMAG1.PDF

[8] Richter, K. (2005), Linear relationship between CIELAB and device coordinates for Colorimetric Image Technology (CIT), see the URL (140 kByte, 6 pages)

http://www.ps.bam.de/CIE05.PDF

[9] Richter, K. (2005), Material efficiency for image output on colour printers. For an English version see the URL (6 pages, 88 kByte)

http://www.ps.bam.de/UBAE05.PDF

[10]Richter, K. (2005), Visual efficiency for image output on colour monitors, For an English version see the URL (10 pages, 1..4 MByte)

http://www.ps.bam.de/VISE05.PDF

[11]Richter, K. (2006), CIELAB definition and application of device independent *rgb** colour coordinates for output of elementary colours, see the URL (1 page, 20 kByte)

http://www.ps.bam.de/ISCC06.PDF

[12] Richter, K. (2005), Relative Colour Image Technology (RCIT) and RLAB lab* (2005) Colour Image Encoding, see (73 pages, 900 kByte)

http://www.ps.bam.de/RLABE05.PDF

Remark: For further publications and analog and digital BAM-, DIN-, CEN- and ISO/IEC-test charts, see (> 1 Million connections/per year since 2002) and many similar figures compared to the figures used in this paper:

http://www.ps.bam.de/WE.HTM