Definition of Neutral Grey Using ICC Media-Relative Colorimetry

William B. Birkett
Charles Spontelli

CGATS/USTAG Meeting
Grand Rapids, MI
July 29, 2009

Main Topics

- The **Background**
- The **Current Proposal**
- The **Problems** with it
- Our **Recommendations**

Current ISO Grey Definition

ISO 12647-7
Section 5 Test Methods
NOTE 1 There are two practical definitions for grey which are sometimes in conflict: "A colour having the same a* and b* CIELAB values as the print substrate" and "A colour having the same a* and b* CIELAB values as a half-tone tint of similar L* value printed with black ink". The latter definition is believed to be useful in the mid-tone and upwards whereas the former is believed to work best with highlight tones. The colorimetric definition of grey is where the CIELAB a* and b* values both equal 0.

Other ISO Documents

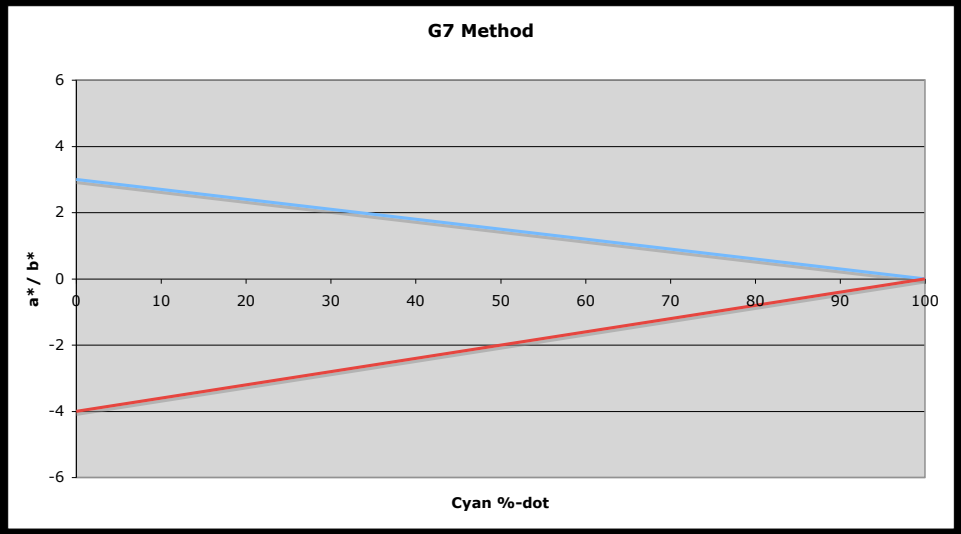
The following documents also contain “practical definitions of grey” terminology:

- 12647-1
- 12647-2
- TS-10128

There may be others.

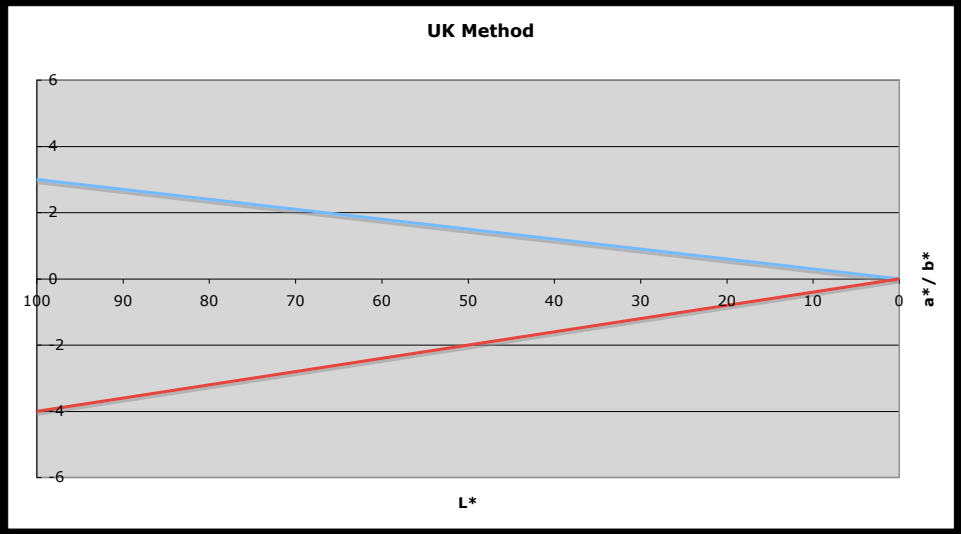
Alternate Definition

- G7 Method
  - Linearly scale a* and b* from paper values to 0 at cyan = 100%.



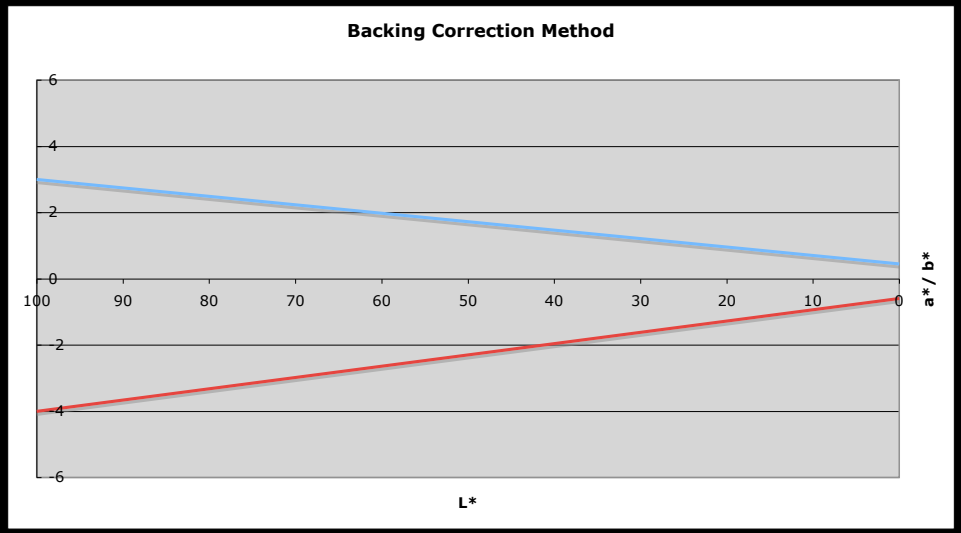
Alternate Definition

- UK Method
  - Linearly scale a* and b* from paper values to 0 at L* = 0.



Alternate Definition

- Backing Correction Method
  - Convert L*a*b* values to XYZ, make some linear adjustments, then convert back to L*a*b*.



Proposed Definition
Ft. Worth (May 2009)

- 85% Adaptation Method
  - Linearly scale a* and b* from paper values to 15% of these values at L* = 0.
  - Good agreement with visual assessments.
  - Identical results using both 85% adaptation and backing correction methods.

Problems with the Proposed Definition

- A compromise of various opinions - no solid technical basis.
- Fails for $L^* < 8$.
- Conflicts with ICC media-relative colorimetry, in use since the early 1990's.

What is ICC Media-Relative Colorimetry?

- xyz measurement values are factored so the L*a*b* value of paper white is 100, 0, 0.
- All A2B and B2A tags within an ICC output profile use this color representation.
- The actual paper color is in the media white-point tag.

Defining Grey with M-R Colorimetry

- Paper L*a*b* = 100, 0, 0.
- Grey L*a*b* = L*, 0, 0.
- Absolute L*a*b* is computed by multiplying the media-relative xyz values by the media white-point xyz values, then converting to L*a*b*.

(note: x = X/Xn, y = Y/Yn, z = Z/Zn)

A Simple and Accurate Grey Definition

$$X_g = Y_g \cdot X_p/Y_p$$

$$Z_g = Y_g \cdot Z_p/Y_p$$

where:

X_g, Y_g, Z_g = Grey XYZ

X_p, Y_p, Z_p = Paper XYZ

Parametric Form of Grey Definition

$$X_g = X_p \cdot r$$
$$Y_g = Y_p \cdot r$$
$$Z_g = Z_p \cdot r$$

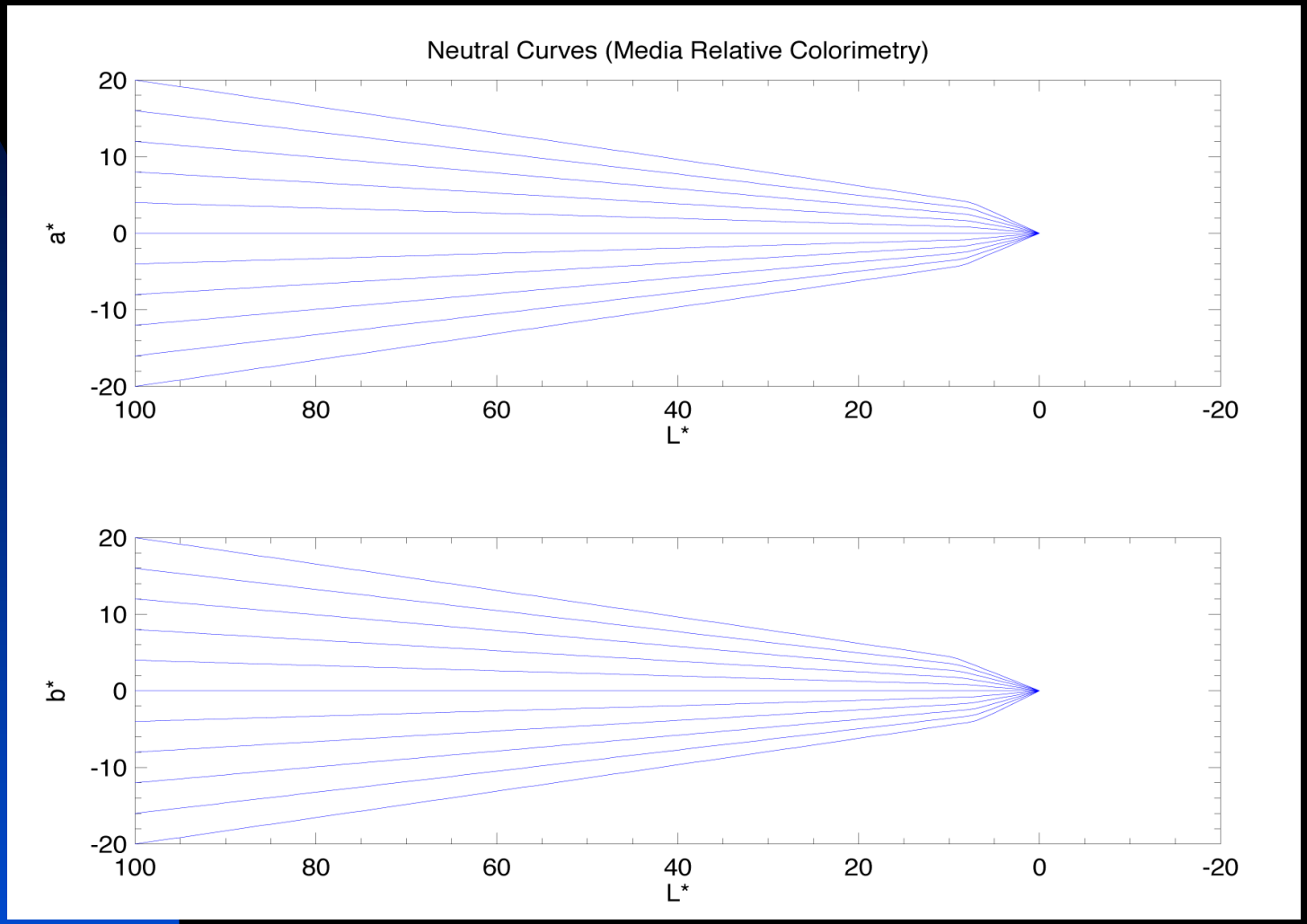
where:

r = tone parameter (0 - 1)

X_g, Y_g, Z_g = Grey XYZ

X_p, Y_p, Z_p = Paper XYZ

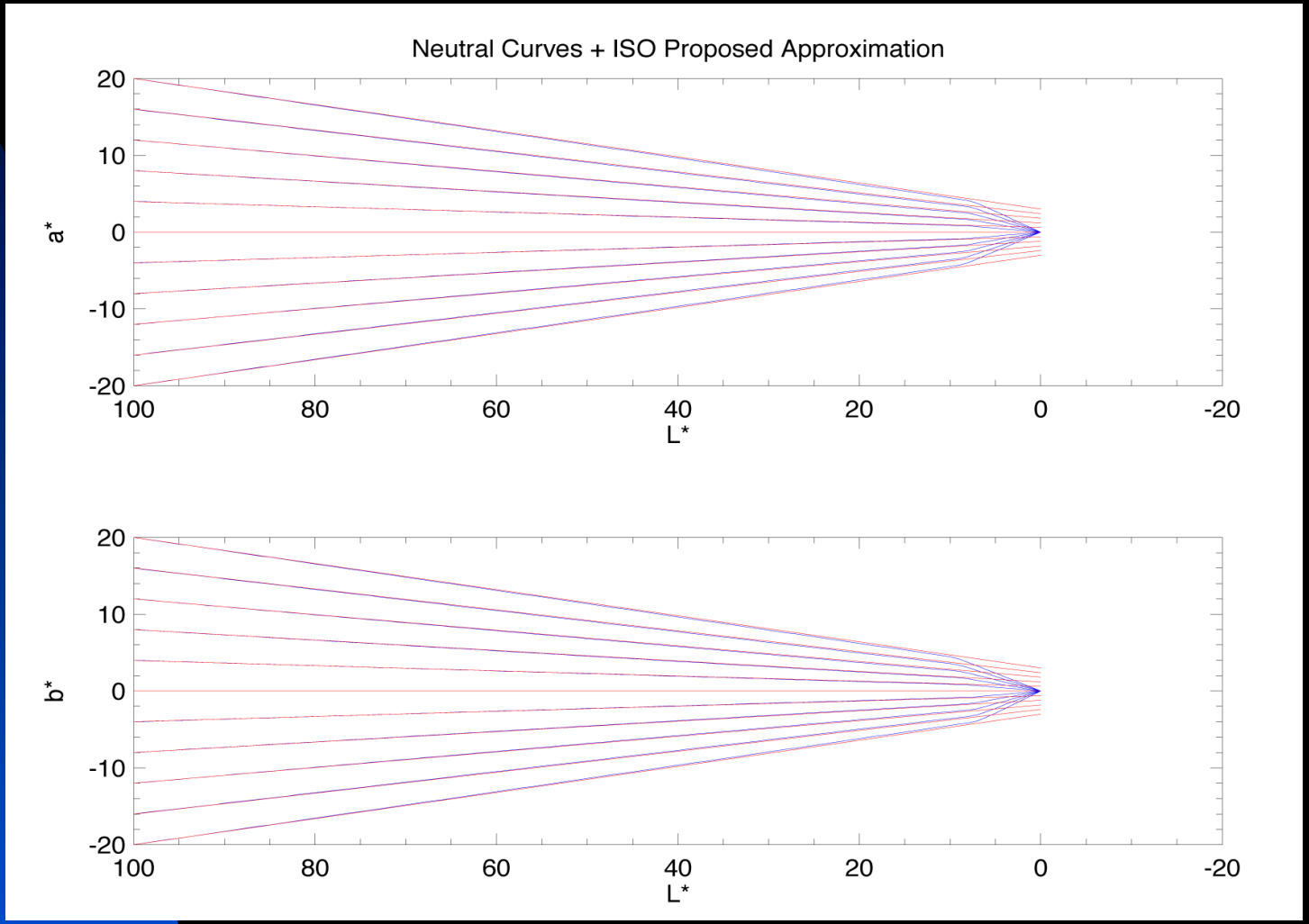
Plots of a* / b* vs L*



Commentary

- Plots are not straight lines!
- Knee at L* = 8, corresponds to transition of L* function from linear to cube root.
- All curves converge at point L*a*b* = 0, 0, 0.
- Similar to ISO proposal when L* > 8.

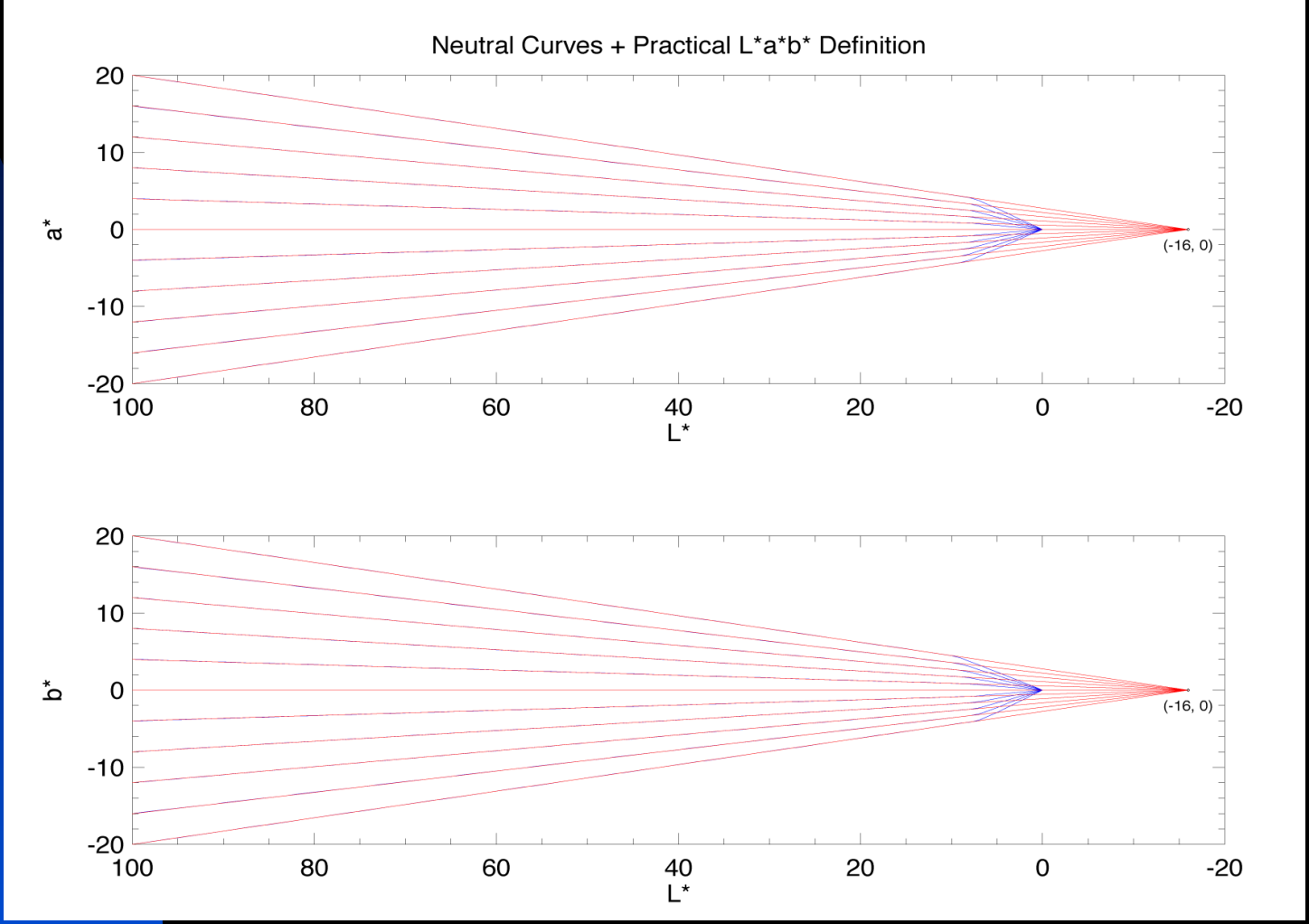
Comparison to ISO Proposal



A Practical L*a*b* Definition

- For L* > 8, the grey axis is a straight line passing through paper white L*a*b*, and the point L*a*b* = -16, 0, 0.
- This is an exact relationship, not an approximation.

A Practical L*a*b* Definition



Examples Conforming to MRC Grey Definition

- White sphere illuminated by a point source.
- B&W films (HT or CT) on a light table.
- B&W halftone printed with perfect black ink.
- RGB grey scale displayed on a correctly calibrated monitor.

Recommendations

- ISO print standards should define grey using the XYZ formulas presented here.
- ISO print standards should reference ISO 15076-1 for media-relative colorimetry.
- When L* > 8, the practical grey definition may be used.

Recommendations

- Our position paper, submitted to USTAG in April 2007, recommended using “media-relative colorimetry to allow for variation in the color of the paper stock, as in ICC profiles.”

Recommendations

- Consider that ALL printed colors are affected by the paper color, not just the neutrals.
- The method presented here can be applied to all colors specified in the standard.

References

- ISO 15076-1 or ICC.1:2004-10, Section 6.3.2 and Annex D for media-relative colorimetry.
- ISO 13655 for XYZ <—> L*a*b* calculations.
- “Position Paper On Proposed Revisions to ISO 12647-2:2004 - A Move to Colorimetry and Matching a Reference Printing Standard”

References

- A PDF of the grey plots and the software program that created it are provided separately.
- A mathematical derivation of the practical L*a*b* definition is provided separately.

Thank You!

William B.Birkett
Doppelganger, LLC
wbirkett@doplganger.com

Charles Spontelli
Bowling Green State University
csponte@bgsu.edu