

Using HDR Display Technology & Color Appearance Modeling to Create Display Color Gamuts that Exceed the Spectrum Locus

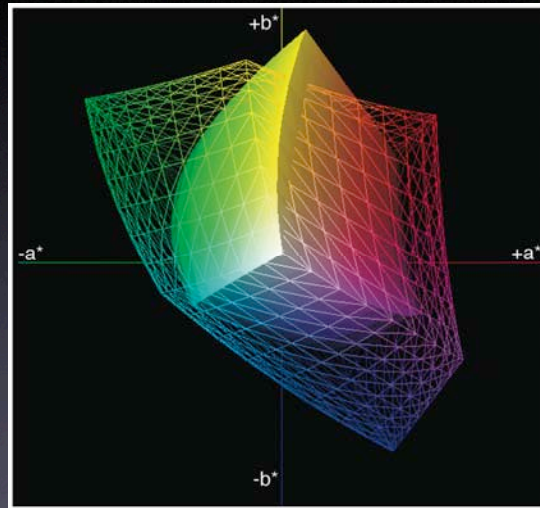
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High-Dynamic-Range (HDR) Imaging



If you had an HDR display, what would you do with it?

Measuring Gamuts



Lightness/Chroma Boundaries for a Display Technology

Lightness

The brightness of an area judged relative to the brightness of a similarly illuminated area that appears to be white or highly transmitting.

Note. — Only related colours exhibit lightness.

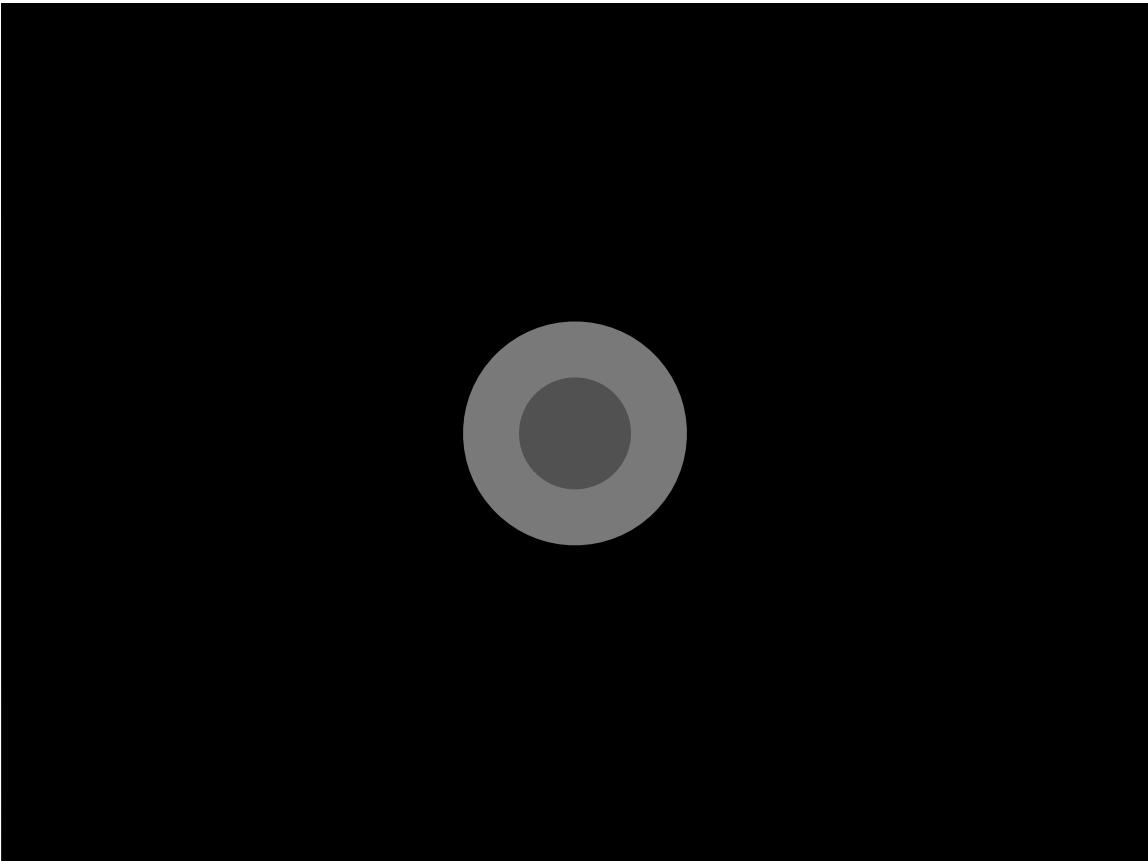
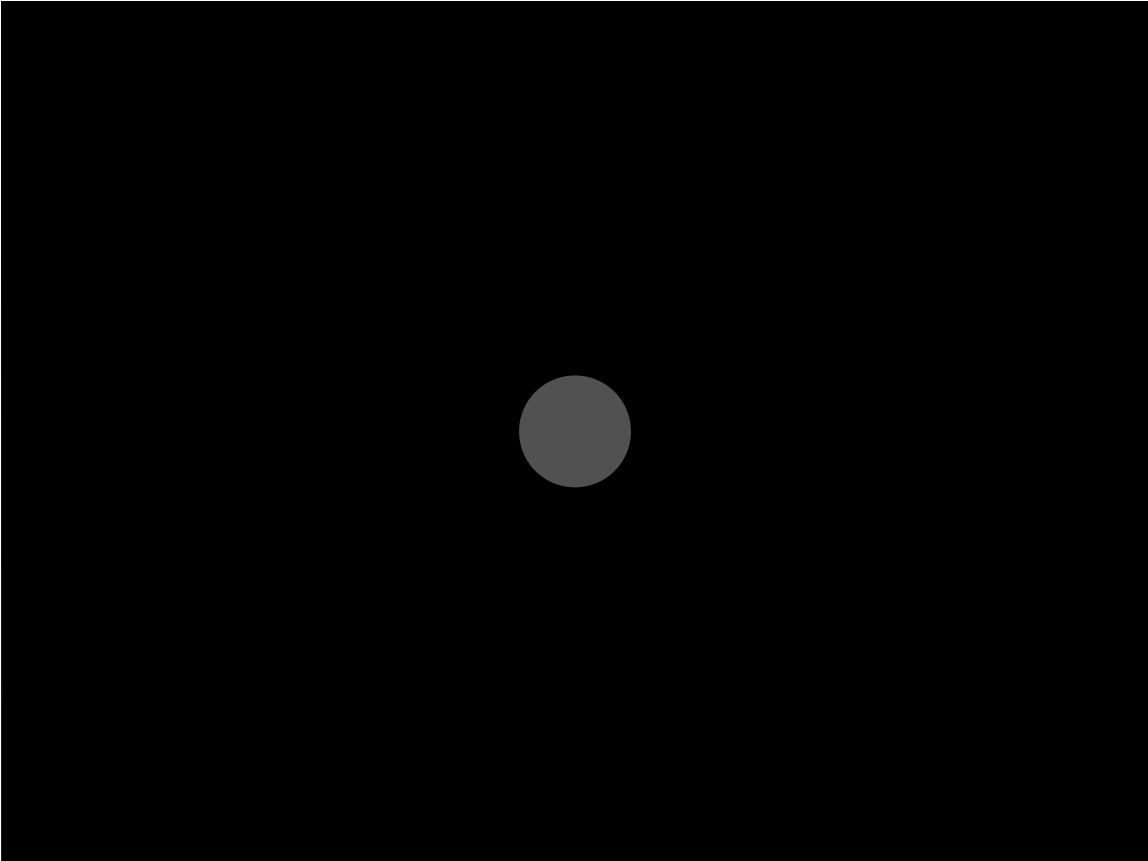


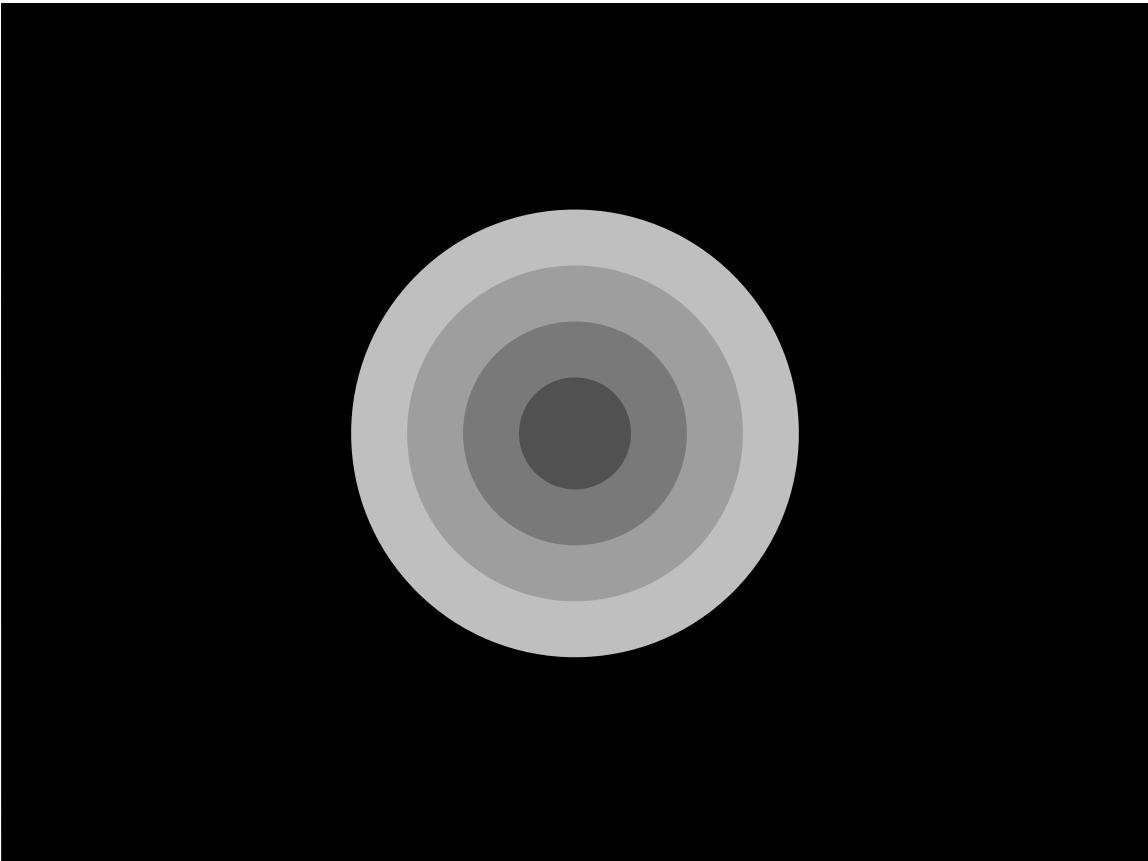
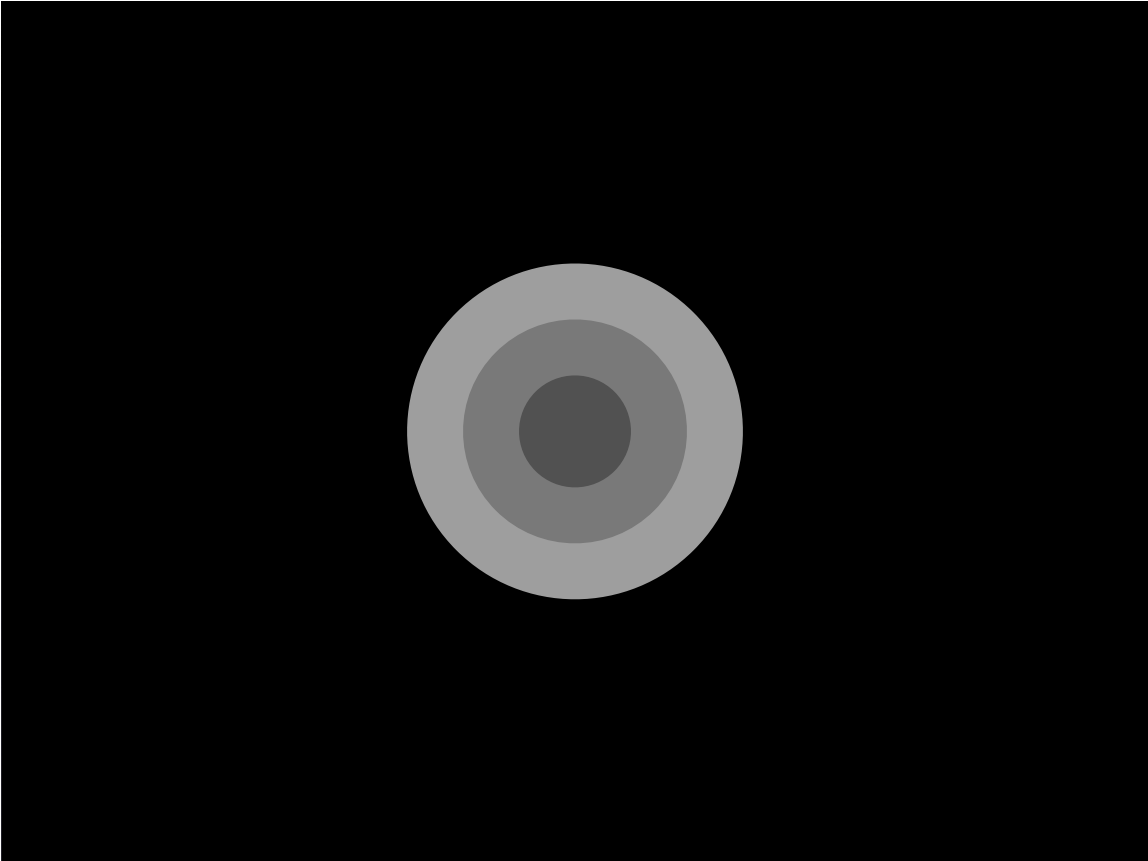
Chroma

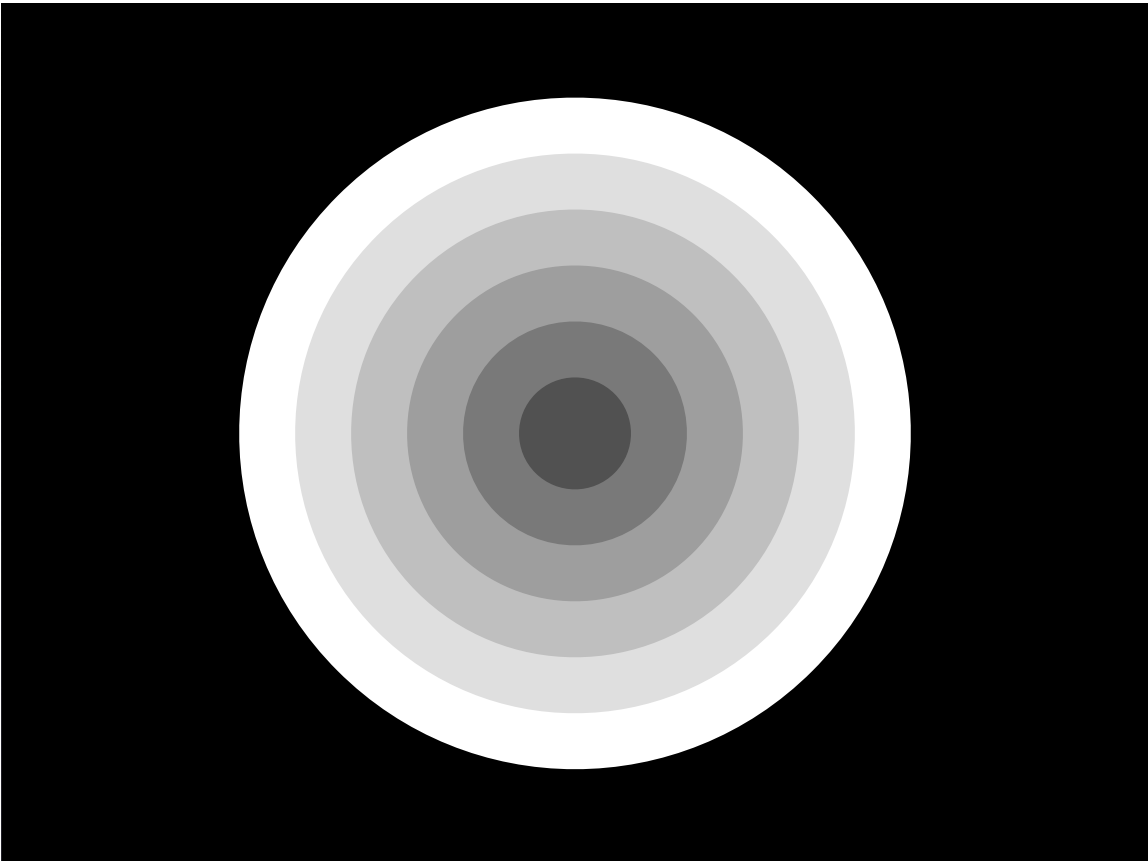
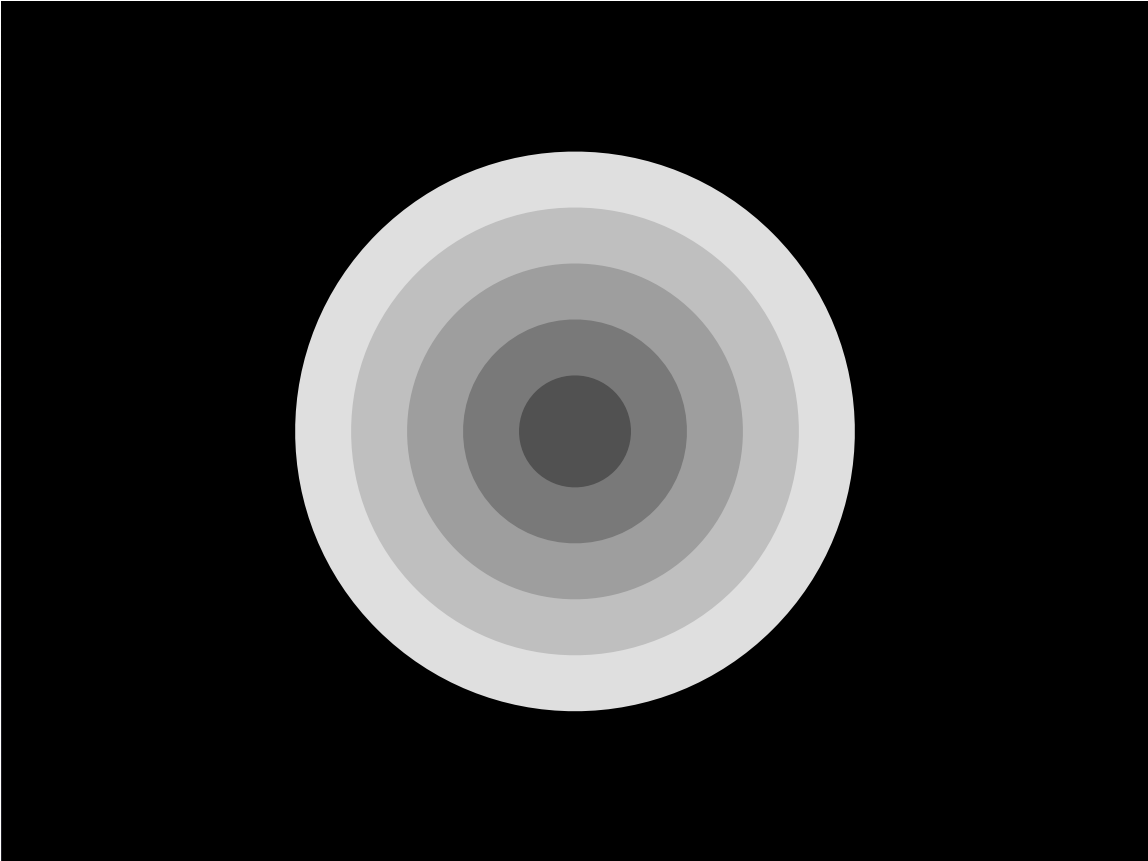
Colorfulness, chromaticness, of an area judged as a proportion of the brightness of a similarly illuminated area that appears white or highly transmitting.

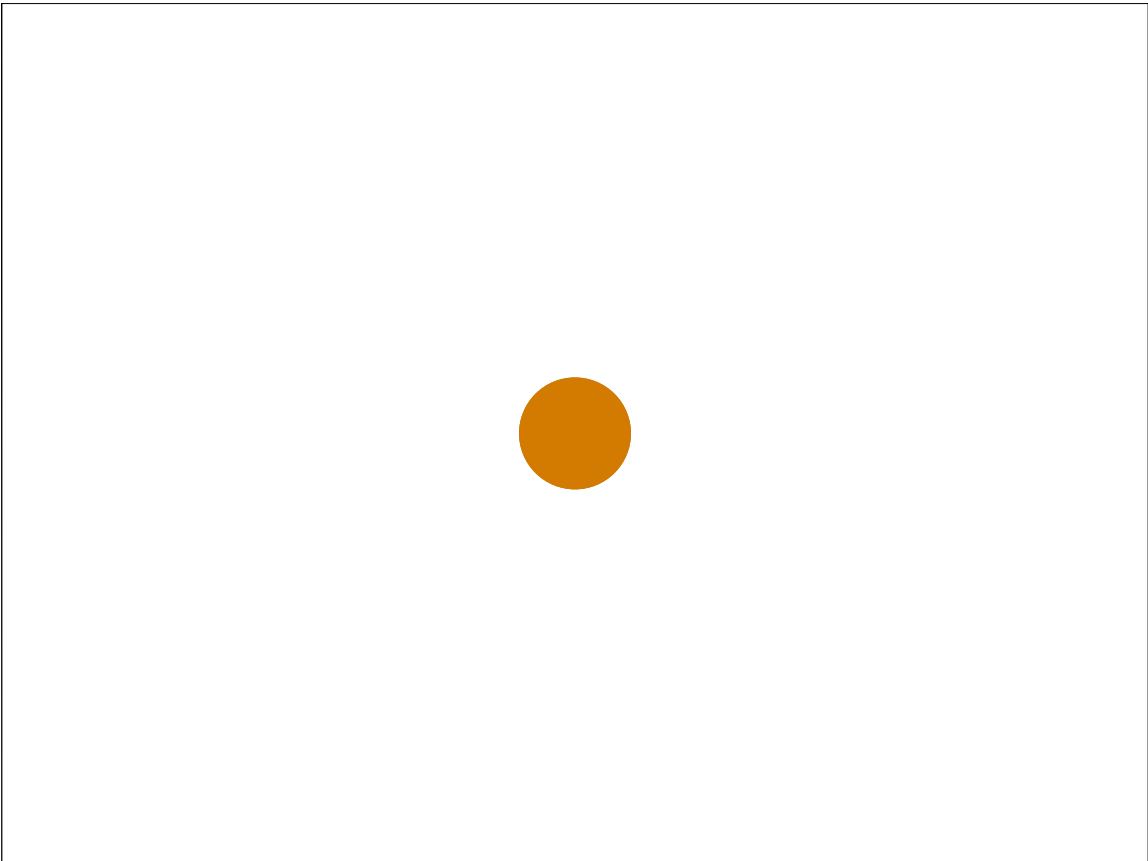
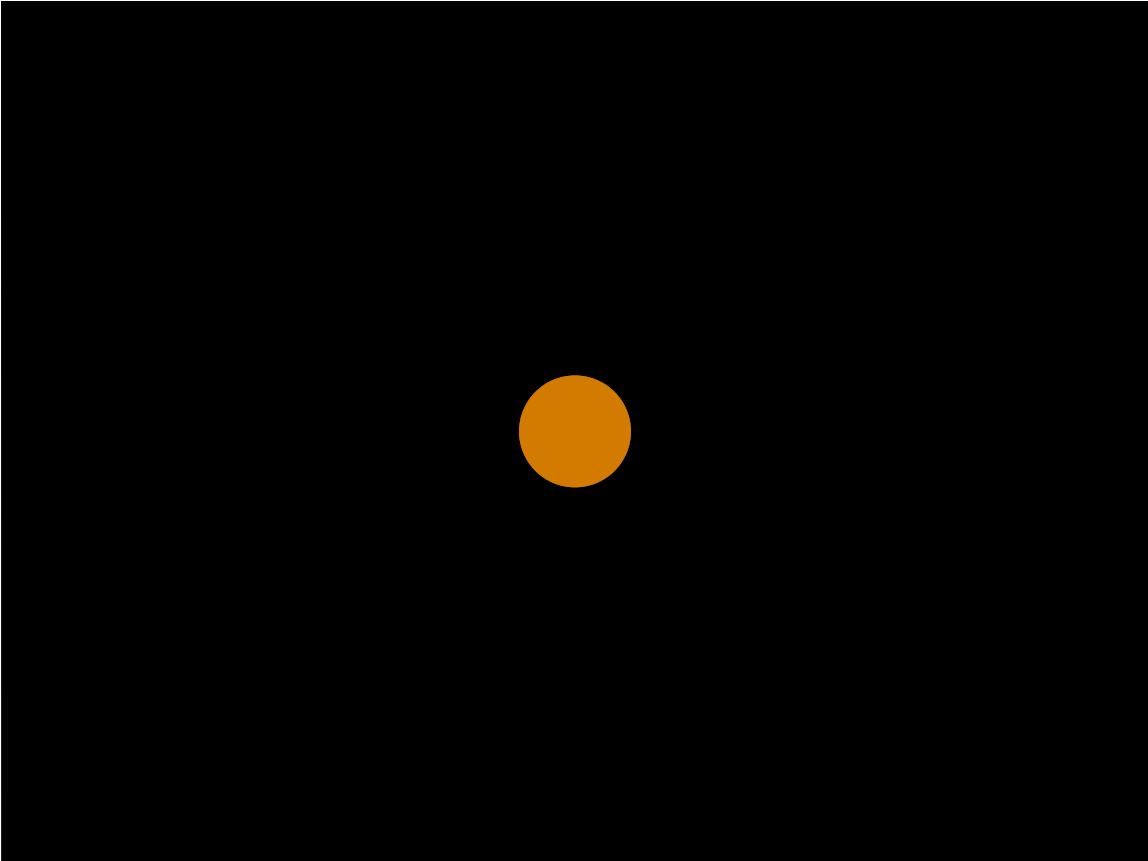
Importance of White

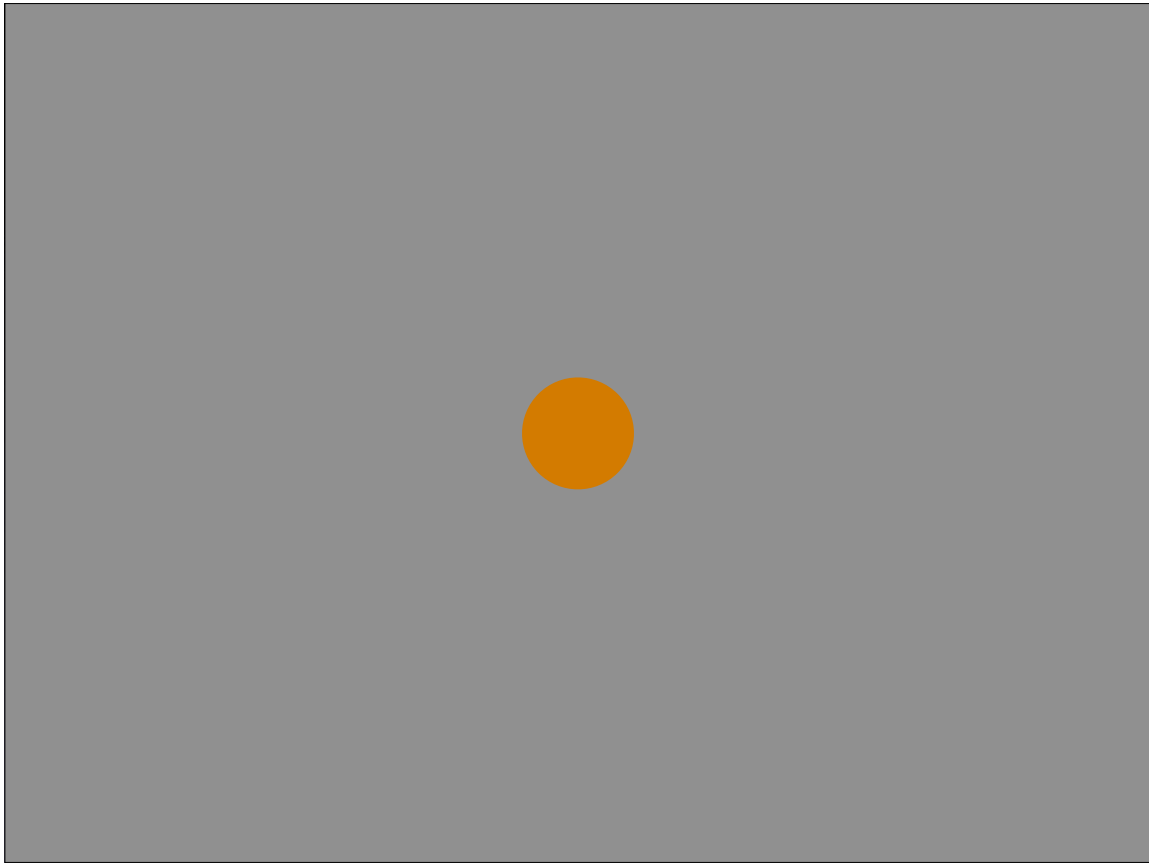
- Both lightness and chroma (perceptions) are relative to an area that appears white.
- Change the white for a constant physical stimulus — lightness and chroma change.
- Can we use this to our advantage in image displays?







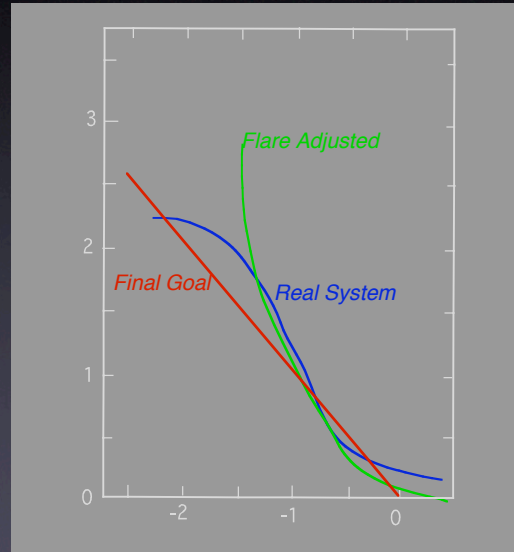




Changing the stimulus that appears white, impacts the appearance of all other stimuli in the scene.

Historical Examples

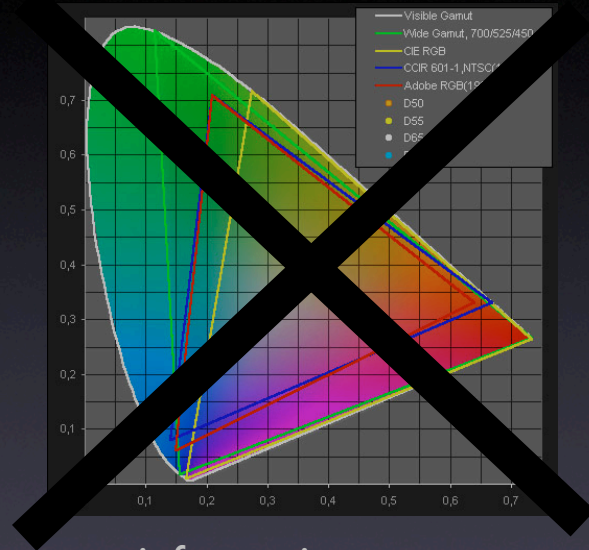
- Stained Glass Windows, Photographic Transparencies



Computational Question

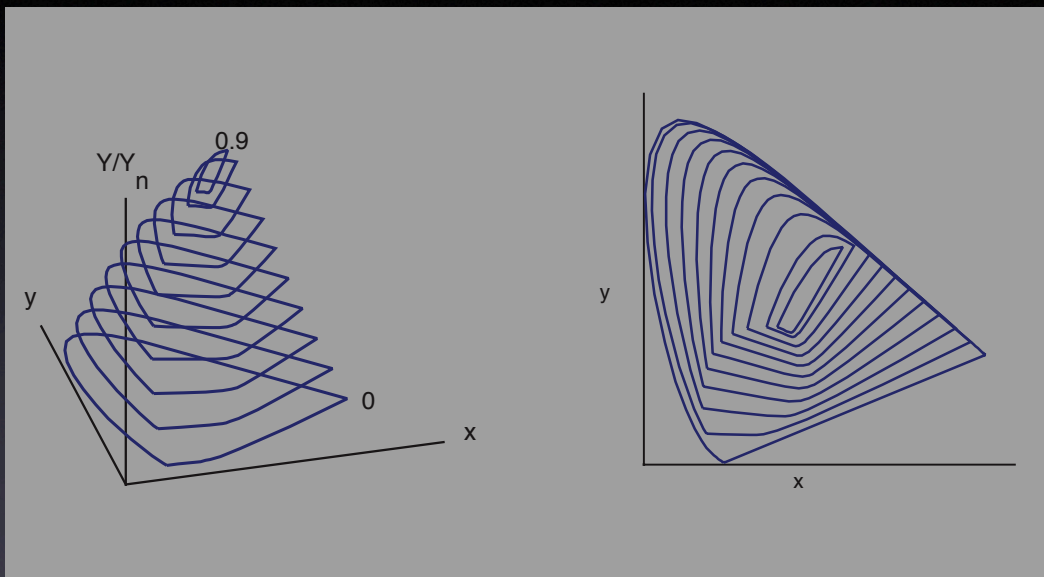
Can we design a display with a perceived color gamut that would exceed the perceived gamut of the spectrum locus on a traditional display?

Chromaticity Gamuts!



- Almost no information on appearance!

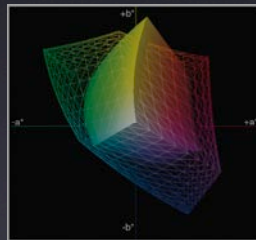
MacAdam Limits



Appearance Gamuts

CIECAM02

- Lightness - Chroma - Hue
- Brightness - Colorfulness - Hue



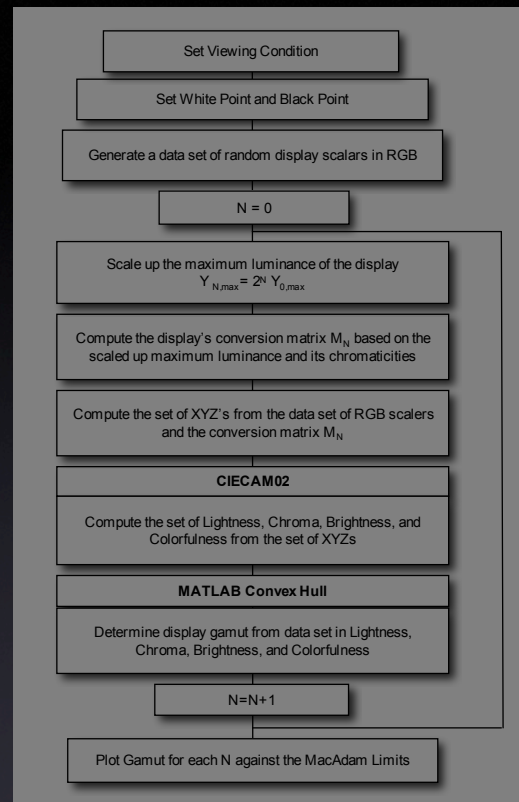
Our Procedure

- Change Diffuse White Point Relative to Display Primary Maxima
- Compute Affect on Appearance Gamut (CIECAM02)

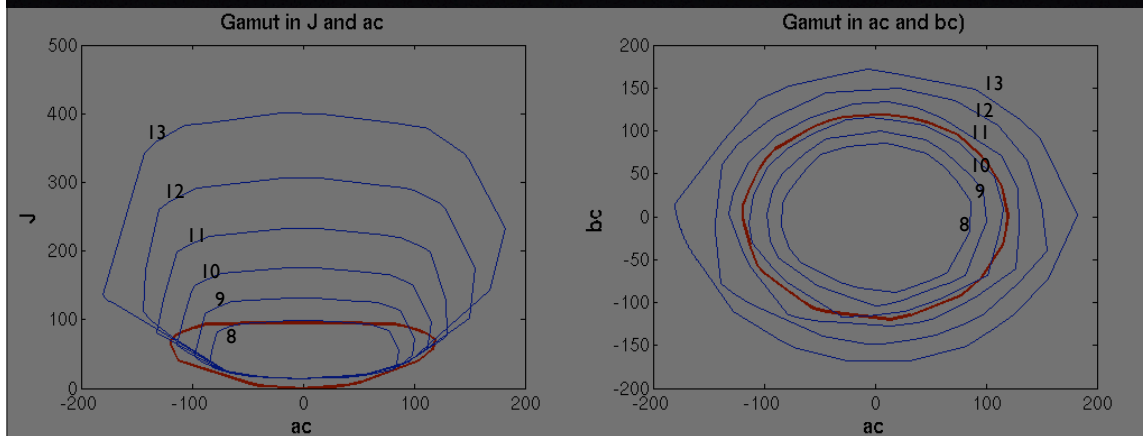
Some Details

- Typical CRT RGB Primaries
- Diffuse White Point 100 cd/m²
- Primary Max Luminances Increased by Factors of 2
- Diffuse White : Black = 100 : 1
- Various Surround/Flare Assumptions

Computational Procedure

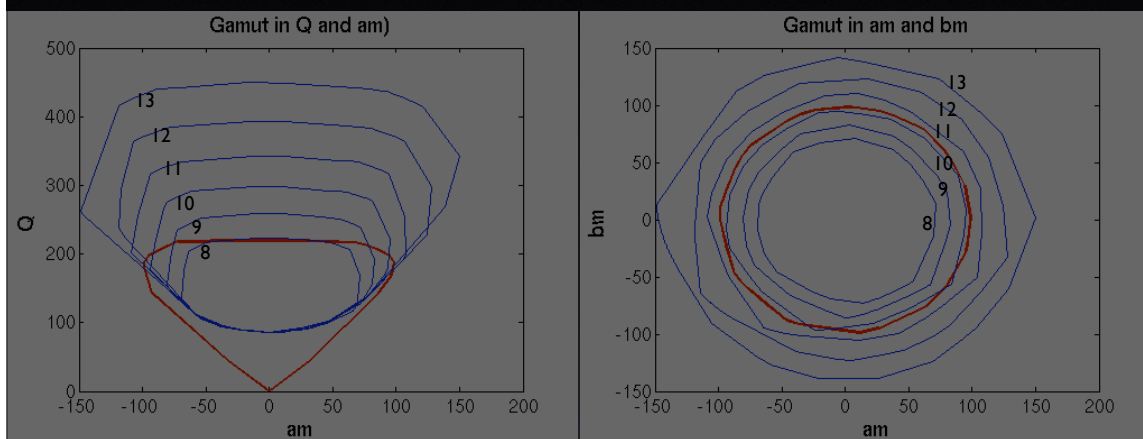


Lightness-Chroma Gamuts



Red = MacAdam Limits / Spectrum Locus

Colorfulness-Brightness Gamuts



Red = MacAdam Limits / Spectrum Locus

Gamut Summary

- 11-bits Exceeds Spectrum Locus in Appearance
- 8-bits below Diffuse White
- 3-bits above Diffuse White

- Diffuse White = 100 cd/m²
- Display Max = 800 cd/m²

Viewing Conditions

- Effect is Larger in Illuminated Surround
 - Dark Surround - Lower Perceived Contrast
- Effect of Flare on Gamut Volume Diminishes with Increased Luminance Headroom

- Details in Forthcoming *Color Research & Application Paper*

Image Examples

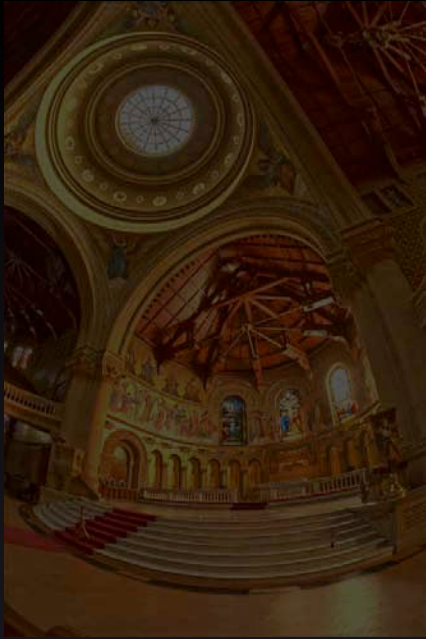


Image Examples



Image Examples



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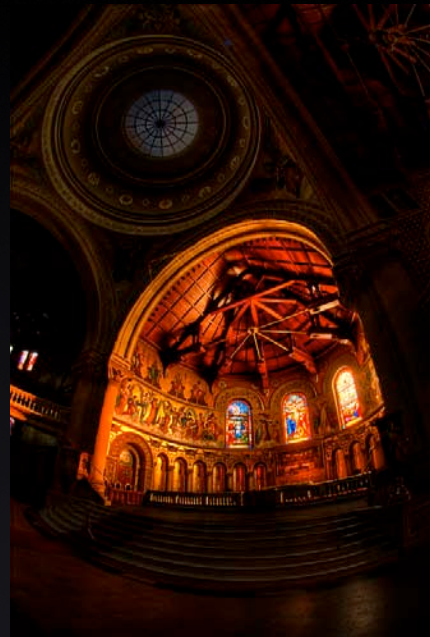
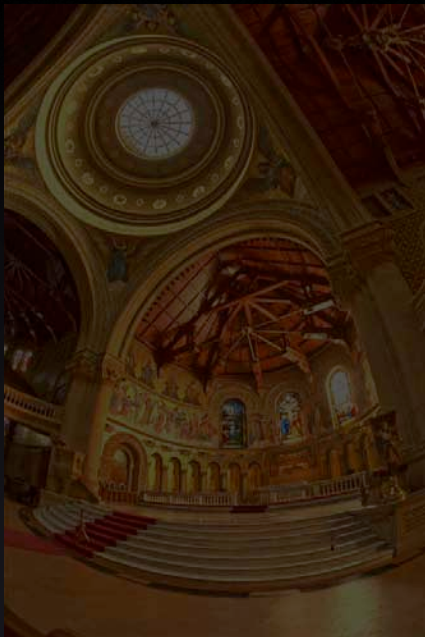


Image Examples



Image Examples



The Practicality

- High-Dynamic-Range Displays Required
- Becoming Available: e.g. Brightside Technologies
- New Image Encoding Also Required



Homebrewed HDR



3500 cd/m² : 0.01 cd/m²
(350,000:1 Contrast)

Measurements of Display Performance

- Color Appearance
- Not just Chromaticity Gamuts & Contrast Ratio
- BUT ... How Those are Used ... and the Impact of Viewing Conditions
- CIECAM02 Appears to be an Effective Tool

Thank You

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