ABOUT COLOR RENDERING

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Color is important. It provides us with information about visual environment:

- Are the bananas ripe?
- You look pale, are you not feeling well?
- Is that a blue or black suit?

Light sources are usually expected to provide that information, but they do so to various degrees depending on the SPD of the source.

Correlated color temperature (CCT) is an indication of the color appearance of the light emitted by light source.

Presently, the lighting industry formally refers to "warm white" (3000 K), "white" (3500 K), "cool white" (4000/4100 K) and "day light" (6500 K).

CCT is defined in terms of the chromatisity of reference source, a blackbody radiator of a given absolute temperature with the same color appearance.

Lighting standards that rely on colorimetry (which are, in fact, all of them) cannot be expected to accurately describe color appearance.

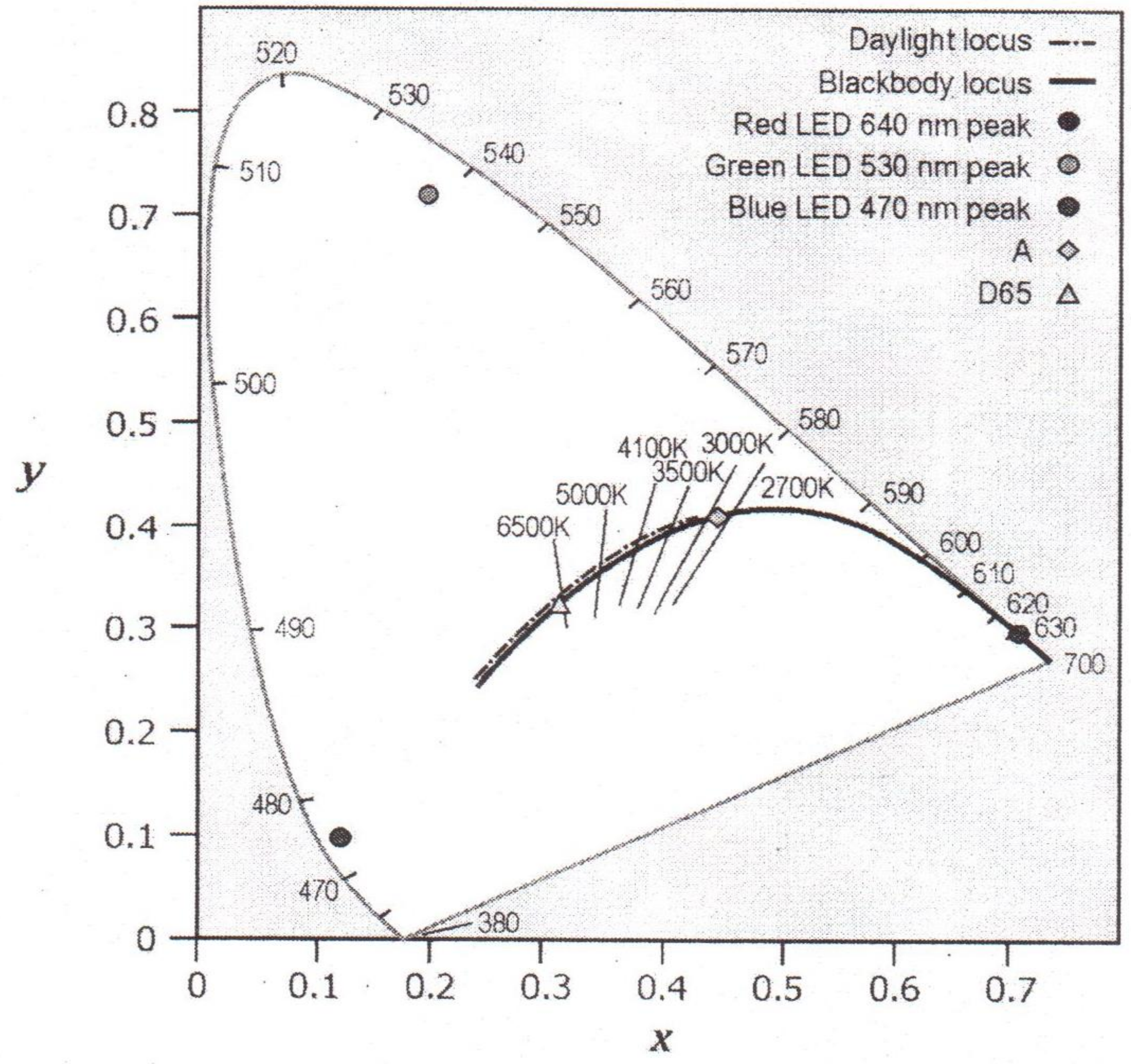
Therefore, to have the most valuable lighting we should not rely exclusively on CRI and CCT when trying to maximize color information.

Where the fine of illumination is impotent CRI and CCT do not accurately characterize the apparent colors of objects and the tint of illumination.

COLOR RENDERING INDEX

CRI is measure of how eight (or sometimes fourteen) special ships of different spectral reflectance change color (chromaticity) when illuminated by a fabricated light source compared to a reference light source. By definition, the reference source has a CRI of 100.

The maximum value CRI is a measure of the amount of shift in the chromaticities of eight special chips when they are illuminated by a fabricated light source compared to the reference light source of the same temperature. In general, the larger the chromaticity shifts, the lower the numerical value of CRI.


Daylight locus
Blackbody locus
Red LED 640 nm peak
Green LED 530 nm peak
Blue LED 470 nm peak
A
D65
520
530
540
550
560
570
580
590
600
610
620
630
700
510
500
490
480
470
380
4100K
3000K
3500K
5000K
2700K
6500K
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
y
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
x

CRI was developed in 1960s through a consensus process similar to that which led to the internationally accepted definition of the photopic and scotopic luminous efficiency functions. Daylight was observed to be an excellent source of illumination for revealing colors, for color discrimination and for making natural objects appear natural.

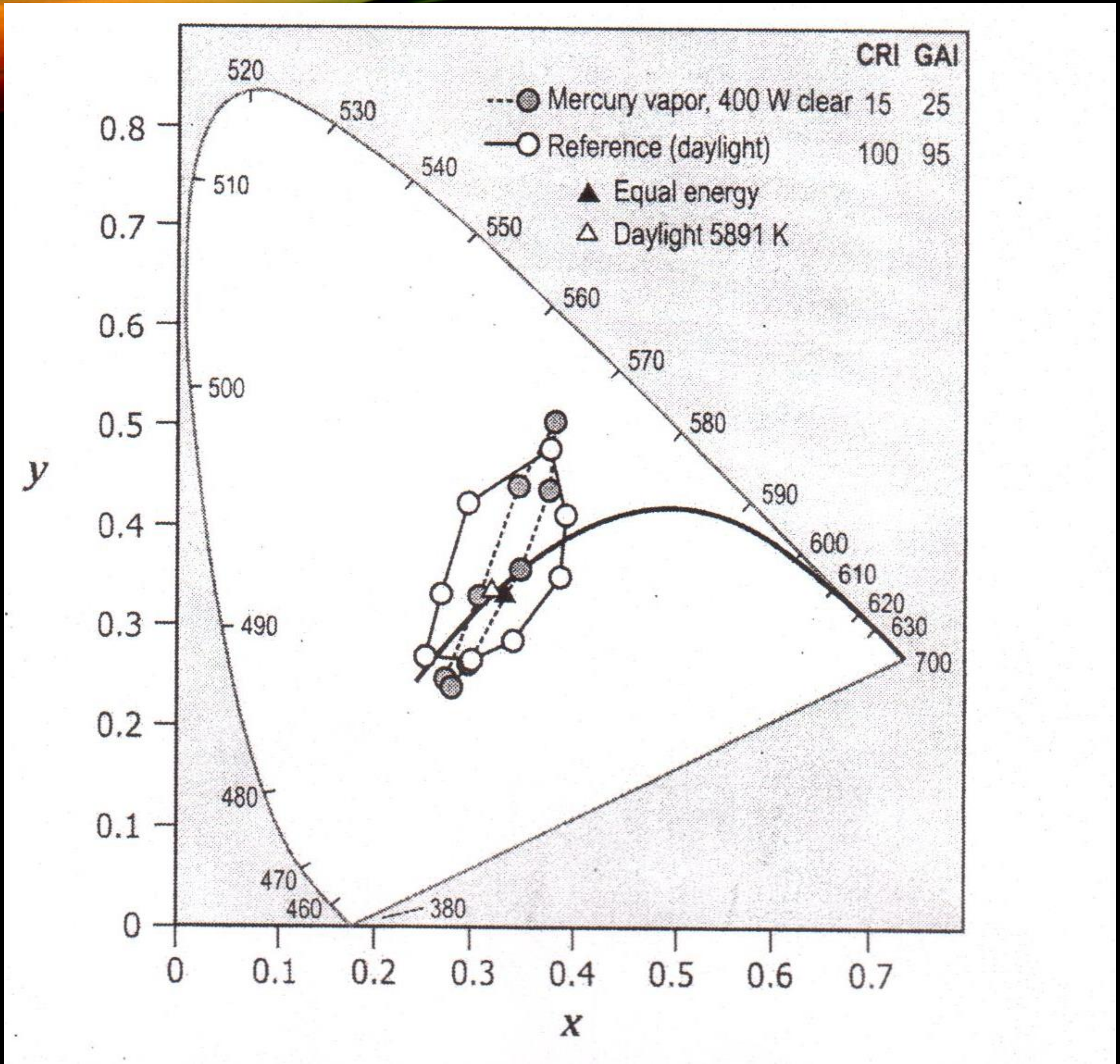
For mathematical convenience a range of ideal reference spectra, based on many measurements of daylight, was adopted by international consensus for determination of CRI.

Several recent studies have shown that CRI is a poor predictor of how well people like appearance of fruits, and vegetables, skin and wood (Bodrogi and Shanda, 2003; Davis and Ohno 2009, Rea and Freyssnier, 2010).

Indeed some studied have shown a negative correlation between CRI and color preference. The inability of CRI to predict color discrimination (i.e. seeing the subtle difference in hue) or color preference was acknowledged be the developers.

The inability of CRI to characterize color rendering has become more apparent to members of the lighting community with the development of light-emming diodes (LEDs) for general lighting applications.

Recently, following much earlier work. Thorton, Rea and Freyssinier demonstrated that gamut area index (GAI) was much better thant CRI as predictor of color discrimination, one important aspect of color rendering.



CRI GAI
Mercury vapor, 400 W clear 15 25
Reference (daylight) 100 95
Equal energy
Daylight 5891 K
520
530
540
550
560
570
580
590
600
610
620
630
700
510
500
490
480
470
460
380
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
y
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
x

GAI is convenient way of characterizing in chromaticity space how saturated the illumination makes objects appear.

GAI is relative number whereby an imaginary equal-energy spectrum is scored as 100. Unlike CRI, which has maximum value of 100, GAI can exceed 100, meaning that some sources saturate colors more than an equal-energy spectrum saturates color.

The results support the conclusion that a two-metric system of color rendering is needed for general illumination applications.

Thank your for attention!