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COMMISSION INTERNATIONALE DE L'ECLAIRAGE
INTERNATIONAL COMMISSION ON ILLUMINATION
INTERNATIONALE BELEUCHTUNGSKOMMISSION

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Visual Appearance

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THE INTERNATIONAL COMMISSION ON ILLUMINATION

The International Commission on Illumination (CIE) is an organisation devoted to international co-operation and exchange of information among its member countries on all matters relating to the art and science of lighting. Its membership consists of the National Committees in about 40 countries.

The objectives of the CIE are:

1. To provide an international forum for the discussion of all matters relating to the science, technology and art in the fields of light and lighting and for the interchange of information in these fields between countries.
2. To develop basic standards and procedures of metrology in the fields of light and lighting.
3. To provide guidance in the application of principles and procedures in the development of international and national standards in the fields of light and lighting.
4. To prepare and publish standards, reports and other publications concerned with all matters relating to the science, technology and art in the fields of light and lighting.
5. To maintain liaison and technical interaction with other international organisations concerned with matters related to the science, technology, standardisation and art in the fields of light and lighting.

The work of the CIE is carried on by seven Divisions each with about 20 Technical Committees. This work covers subjects ranging from fundamental matters to all types of lighting applications. The standards and technical reports developed by these international Divisions of the CIE are accepted throughout the world.
A plenary session is held every four years, at which the work of the Divisions and Technical Committees is reviewed, reported and plans are made for the future. The CIE is recognised as the authority on all aspects of light and lighting. As such it occupies an important position among international organisations.

LA COMMISSION INTERNATIONALE DE L'ECLAIRAGE

La Commission Internationale de l'Eclairage (CIE) est une organisation qui se donne pour but la coopération internationale et l'échange d'informations entre les Pays membres sur toutes les questions relatives à l'art et à la science de l'éclairage. Elle est composée de Comités Nationaux représentant environ 40 pays.

Les objectifs de la CIE sont :

1. De constituer un centre d'étude international pour toute matière relevant de la science, de la technologie et de l'art de la lumière et de l'éclairage et pour l'échange entre pays d'informations dans ces domaines.
2. D'élaborer des normes et des méthodes de base pour la métrologie dans les domaines de la lumière et de l'éclairage.
3. De donner des directives pour l'application des principes et des méthodes d'élaboration de normes internationales et nationales dans les domaines de la lumière et de l'éclairage.
4. De préparer et publier des normes, rapports et autres textes, concernant toutes matières relatives à la science, la technologie et l'art dans les domaines de la lumière et de l'éclairage.
5. De maintenir une liaison et une collaboration technique avec les autres organisations internationales concernées par des sujets relatifs à la science, la technologie, la normalisation et l'art dans les domaines de la lumière et de l'éclairage.

Les travaux de la CIE sont effectués par 7 Divisions, ayant chacune environ 20 Comités Techniques. Les sujets d'études s'étendent des questions fondamentales, à tous les types d'applications de l'éclairage. Les normes et les rapports techniques élaborés par ces Divisions Internationales de la CIE sont reconnus dans le monde entier.
Tous les quatre ans, une Session plénière passe en revue le travail des Divisions et des Comités Techniques, en fait rapport et établit les projets de travaux pour l'avenir. La CIE est reconnue comme la plus haute autorité en ce qui concerne tous les aspects de la lumière et de l'éclairage. Elle occupe comme telle une position importante parmi les organisations internationales.

DIE INTERNATIONALE BELEUCHTUNGSKOMMISSION

Die Internationale Beleuchtungskommission (CIE) ist eine Organisation, die sich der internationalen Zusammenarbeit und dem Austausch von Informationen zwischen ihren Mitgliedsländern bezüglich der Kunst und Wissenschaft der Lichttechnik widmet. Die Mitgliedschaft besteht aus den Nationalen Komitees in rund 40 Ländern.

Die Ziele der CIE sind:

1. Ein internationaler Mittelpunkt für Diskussionen aller Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik und für den Informationsaustausch auf diesen Gebieten zwischen den einzelnen Ländern zu sein.
2. Grundnormen und Verfahren der Meßtechnik auf dem Gebiet der Lichttechnik zu entwickeln.
3. Richtlinien für die Anwendung von Prinzipien und Vorgängen in der Entwicklung internationaler und nationaler Normen auf dem Gebiet der Lichttechnik zu erstellen.
4. Normen, Berichte und andere Publikationen zu erstellen und zu veröffentlichen, die alle Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik betreffen.
5. Liaison und technische Zusammenarbeit mit anderen internationalen Organisationen zu unterhalten, die mit Fragen der Wissenschaft, Technik, Normung und Kunst auf dem Gebiet der Lichttechnik zu tun haben.

Die Arbeit der CIE wird in 7 Divisionen, jede mit etwa 20 Technischen Komitees, geleistet. Diese Arbeit betrifft Gebiete mit grundlegendem Inhalt bis zu allen Arten der Lichtanwendung. Die Normen und Technischen Berichte, die von diesen international zusammengesetzten Divisionen ausgearbeitet werden, sind von der ganzen Welt anerkannt.
Tagungen werden alle vier Jahre abgehalten, in der die Arbeiten der Divisionen überprüft und berichtet und neue Pläne für die Zukunft ausgearbeitet werden. Die CIE wird als höchste Autorität für alle Aspekte des Lichtes und der Beleuchtung angesehen. Auf diese Weise unterhält sie eine bedeutende Stellung unter den internationalen Organisationen.

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COLOUR APPEARANCE OF METAMERIC LIGHTS AND POSSIBLE COLORIMETRIC DESCRIPTION

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ABSTRACT

Based on earlier [1] experiences of the colour mismatch phenomenon we investigated the colour matching with two types of visual experiments. First we confirmed the phenomenon with a white colour matching experiment using narrow band and broadband light sources illuminating white reflection patches. Secondly we made a colour matching experiment with more saturated colour stimuli. During both experiments the observers had the task to set the colour stimuli coming from the test side to that coming from the reference side of the arrangement.

Using spectroradiometric measurement data we calculated chromaticities using the CIE standard colour matching functions and using a slightly modified set of CMFs kindly received from Dr. Wold [2]. The calulations showed that using the modified colour matching functions the calculated colour differences will be smaller. This result is true in both matching situations. After the second series we came to the conclusion that the value of calculated colour difference is the function of the blue amount in the radiation.

Keywords: metamerism, LED, colour matching function, cone fundamentals.

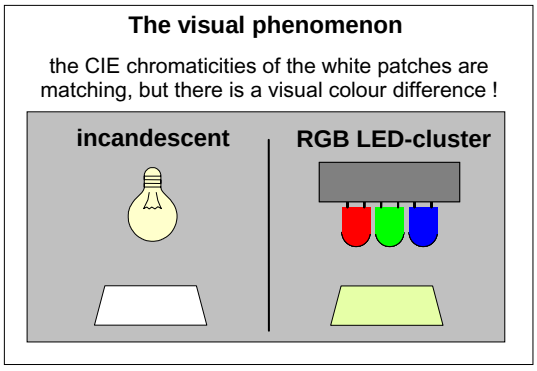

Figure 1. The visual phenomenon experienced during instrumental matching.

1. INTRODUCTION

Among the different dimensions of appearance analysis colour is one that has been studied for the longest time, but still in colour appearance analysis there are a number unsolved questions. One of the most basic one is the appearance of white. The phenomenon of white has in itself many facets, and one can discuss it from a number of viewpoints, should it be colour constancy, the white point on a scene or scaling the whiteness. But none of these can be evaluated correctly if the colorimetric determination of white is wrong.

In modern lighting one tries to use more efficient sources as the traditional incandescent lamp. Clusters of red (R), green (G) and blue (B) LEDs could be the most efficient way to set any shade of white light by adjusting the intensity of the R, G, B LEDs. Anecdotic information is available that visual investigations showed colour mismatch if e.g. an incandescent lamp set to CIE standard illuminant A is matched by the additive mixture of the light of an R, G, B LED cluster, the colorimetric match will appear to be greenish in colour as shown in Figure 1.

Thornton in his multipart paper discussed colour appearance differences of even less metameric lights[3].

2. EXPERIMENTAL SET-UP

We have set up two independent investigations at the Technical University of Ilmenau (Germany) and the University of Pannonia (Hungary), comparing visual matches between reflected lights produced by RGB LEDs and incandescent as well as high intensity discharge lamps. The photographs in Figure 2 and 3 are showing the visual fields of both arrangements. Figure 4. and 5 shows the relative spectral power distributions of the used illuminants. Instrumental matches (performed using two independently well calibrated PR-705 spectroradiometers) were judged by the

observers to have a greenish tint. If the averages of visual matches were measured colorimetrically between the RGB LED cluster and a number of light sources with more smooth spectrum we found $\Delta(u',v')$ deviations of one to two units in the second decimal place, in case of equal luminance, for two juxtaposed visual fields of approximately 2° field size.

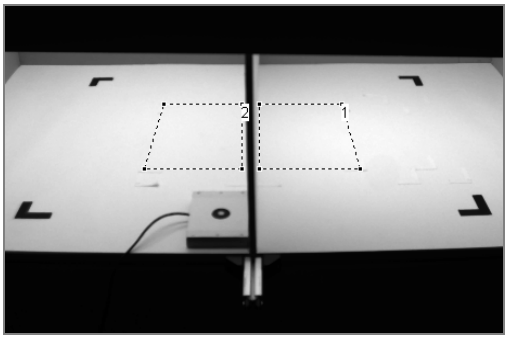

Figure 2. The visual field of experiment I.

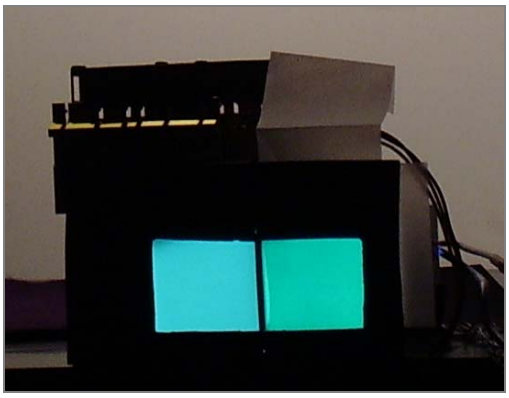

Figure 3. The visual field of experiment II.

3. RESULT OF EXPERIMENT I.

Figure 6. shows that by applying of the fundamental colour matching functions calculated by Wold [2] using the L, M, S cone fundamentals now suggested by CIE TC 1-36 [4] we got a better colour match. If the modified colour matching functions are used the difference between the chromaticity of the reference (incandescent) and matching (RGB LED) stimuli become smaller then using the original CIE 1931 CMFs.

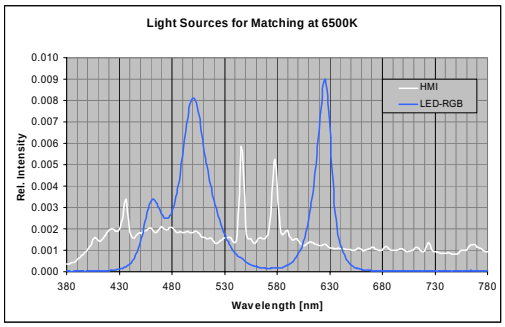

Figure 4. The SPDs of the used illuminants in Experiment I.

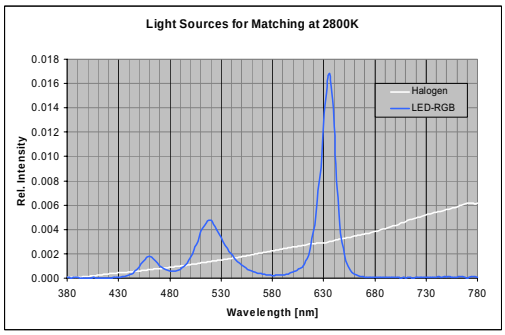

Figure 5. The SPDs of the used illuminants in Experiment II.

In the 2nd experiment the observed patches were primary light sources. Both sides were radiated from the backside. The reference radiation was produced by a halogen incandescent lamp filtered with colour glass filters (the right side of the visual field) and the test field was radiated with RGB-LEDs (the left side of the visual field). The observers had the task to set the same chromaticity on the test side as they perceived it from the reference side. The observers could change three - not perfectly independent - parameters of the test radiation: the hue, the brightness and the saturation.

4. RESULT OF EXPERIMENT II.

We can see in Figure 7 that the chromaticity differences between the filtered halogen reference radiation and the RGB-LED matching stimuli depend on the amount of blue light in the radiation.

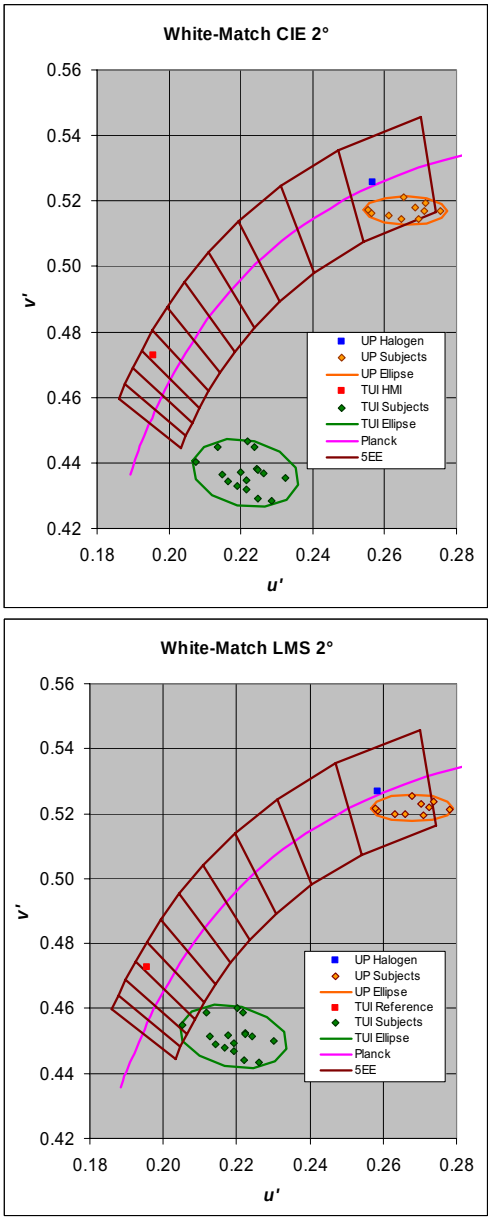

Figure 6. Chromaticities of matching white secondary light sources.

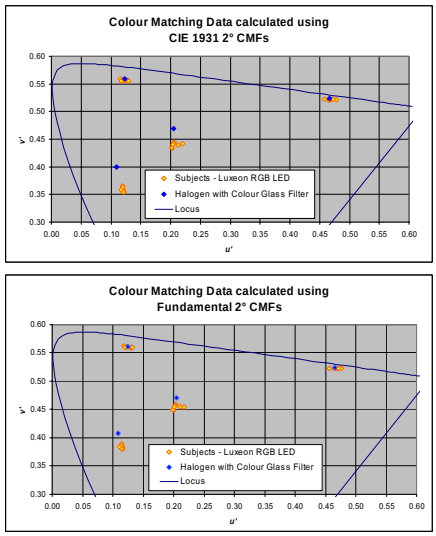

Figure 7. Results of matching colour primary light sources.

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