dfwg

Report 2/00

Deutsche farbwissenschaftliche Gesellschaft e.V.

Herausgegeben vom Vorstand der DfwG
Verantwortlich: Prof. Dr. Heinz Terstiege

Deutsche farbwissenschaftliche Gesellschaft e.V.
im Deutschen Verband Farbe

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Juni 2000

Liebe Farbgemeinde,

Die nächste DfwG-Tagung wird am 20. Oktober d.J. im Fachgebiet Lichttechnik der Technischen Universität Darmstadt stattfinden. Eines der Wahrzeichen Darmstadts – die Mathildenhöhe mit Kapelle – ziert das Titelblatt dieses Reports. Am Nachmittag vor der Tagung ist eine Besichtigung des Fachgebiets Lichttechnik (Prof. Dr. H.-J. Schmidt-Clausen) möglich. Abends treffen wir uns in einem Lokal zum abendlichen Beisammensein. Interessenten können schon am Freitag, den 7. Juli auf dem traditionellen Sommerfest des Fachgebiets, die Freunde des Fachgebiets Lichttechnik der Technischen Universität Darmstadt kennen lernen.

Bisher liegen neun Vortragsanmeldungen aus den Gebieten Farbabstandsbewertung, Farbphysiologie, Fluoreszenz, Verkehrszeichen und Kraftfahrzeugbeleuchtung vor. Weitere Vorträge können noch eingeplant werden.

Beim diesjährigen Versand der Rechnungen für den DfwG-Jahresbeitrag ist es zu einem für manchen peinlichen Irrtum gekommen: bei Benutzung der abgespeicherten Vorlage für den Serienbrief war irrtümlicherweise noch die alte Adresse unseres Schatzmeisters angegeben. Die neue und richtige Adresse lautet:

Dipl.-Ing. Lutz Grambow
Johannisthaler Damm 404

D - 12351 Berlin

Inzwischen liegen mir 32 E-Mail Adressen von DfwG-Mitgliedern vor. Ein weiterer Probebrief zum Austausch der Adressen ist inzwischen verschickt. Leider wechseln hier – wie bei den Postadressen – manche Mitglieder zuweilen ihren Provider, ohne dass es die Geschäftsstelle davon erfährt.

Im Herbst 1999 wurde in Berlin das 25 jährige Jubiläum des Normenausschuss Farbe (FNF) und das des Deutschen Nationalen Komitees der CIE (DNK) gefeiert. Eine Pressenotiz aus der „Welt der Farben" ist in diesem Report wiedergegeben. Die Festschrift ist demnächst von Frau Jutta Behrendt, Geschäftsstelle des Normenausschuss Farbe im DIN Deutsches Institut für Normung, 10772 Berlin erhältlich.

In der Reihe der regelmäßigen Berichte über CIE-Aktivitäten wird in diesem Report die Division 1 "Sehen und Farbe" vorgestellt. Die D1-Webseite war längere Zeit verweist, jetzt hat sich der Sekretär der Division 1, Herr Dr, Nakono ihrer angenommen und einen aktuellen Tätigkeitsbericht wiedergegeben. Die Division 1 hatte im Mai d. J. in Teddington getagt. Die Division 4 "Beleuchtung und Signale für den Verkehr" wird im nächsten Report vorgestellt. Sie wird vom 3. bis 8. September d. J. in Toronto, Kanada, tagen. Teilnahmegebühr für Tagung und Exkursion beträgt 170 C$. Programm und Anmeldeformular können von der Geschäftsstelle bezogen werden.

Vom 24. zum 29. Juni 2001 wird in den USA die nächste AIC-Tagung stattfinden. Manche können sich noch an die letzte in den USA von Fred Billmeyer in Troy organisierte Tagung AIC 77 erinnern. Diesmal wird die Tagung in Rochester, dem "Weltzentrum der Bildverarbeitung" (Kodak, Xerox, RIT...)stattfinden. Ein erster Prospekt über die Tagung mit Einzelheiten und dem Aufruf zur Vortragsanmeldung ist dem Report beigefügt.

Mit den besten Wünschen

Ihr Heinz Terstiege

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DfwG-Jahrestagung 2000

Termin:

20. Oktober 2000

Ort:

Technische Universität Darmstadt
Fachgebiet Lichttechnik
Hochschulstraße 4a

! ***Themen- und Referenten - Vorschläge werden noch entgegengenommen.*** **!**

Institutsbesichtigung am Nachmittag, den 19. Oktober

DfwG-Mitgliederentwicklung

* * *

Geburtstage II 00/ III 00

50 Jahre

Herr Dietmar Meisel	* 20.04.50
Herr Dr. Gerhard Rösler	* 17.05.50
Herr Werner Mieskes	* 10.06.50

60 Jahre

Herr Helmut Jansen	* 17.06.40
Herr Gerhard Pausch	* 27.06.40

65 Jahre

Herr Dr. Harald Krzyminski	* 08.07.35
Herr Prof. Dr. Gunther Kamm	* 01.10.35

70 Jahre

Herr Dr. Jürgen Weidemüller	* 19.04.30
Herr Dr. K. Stammen	* 18.08.30

75 Jahre

Herr Prof. Dr. Sigurd Lohmeyer	* 16.09.25

80 Jahre

Herr Hansel Loos	* 26.05.20

* * *

Der farbige Umschlag wurde freundlicherweise von der Firma GretagMacbeth übernommen.
Herzlichen Dank

Deutsche farbwissenschaftliche Gesellschaft e.V.
im Deutschen Verband Farbe

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Einnahmen - und Ausgabenrechnung
für die Zeit
vom 1.1.99 bis zum 31.12.99

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Berlin, den 26.05.2000

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Manfred-Richter-Gedenkpreis 2000

Als Vermächtnis und stete Erinnerung an Professor Dr.-Ing. habil. Manfred Richter, Gründungs- und Ehrenvorsitzender des Normenausschusses Farbe (FNF) im DIN, wurde vom FNF-Beirat anlässlich des 45jährigen Bestehens des FNF am 15. März 1994 die Stiftung des Manfred-Richter-Gedenkpreises für Verdienste um die Normungsarbeit und die technisch-wissenschaftliche Regelsetzung auf dem Gebiet der Farbe beschlossen.

Der Manfred-Richter-Gedenkpreis wird höchstens einmal innerhalb zweier Kalenderjahre an erfahrene Persönlichkeiten vergeben, die sich um die Normungsarbeit des FNF oder die technisch-wissenschaftliche Regelsetzung auf dem Gebiet der Farbe, z. B. in Gremien der Internationalen Gesellschaft für Farbe (Association Internationale de la Couleur (AIC) oder der Internationalen Beleuchtungskommission (Commission Internationale de l'Éclairage (CIE) verdient gemacht haben.

Der Manfred-Richter-Gedenkpreis 2000 wurde verliehen an:

Dr.-Ing. Gerhard Rösler

Dr.-Ing. Gerhard Rösler, der sich in besonderer Weise um die Normungsarbeit auf dem Gebiet der Farbe verdient gemacht hat, ist seit mehr als 20 Jahren an der Entwicklung und Verbesserung der Farbmesstechnik, insbesondere auch der Mehrwinkeltechnik, maßgeblich beteiligt und hat sie durch viele Vorschläge befruchtet. Seine oft richtungsweisenden Ideen hat er u. a. auf den internationalen Tagungen der Association Internationale de la Couleur (AIC) vorgetragen und in die Arbeit der American Society for Testing and Materials (ASTM) und des DIN Deutsches Institut für Normung e. V. eingebracht, wo er in den Gremien ASTM E 12 und FNF 4 „Farbabstand und Toleranzen" (dessen Obmann er ist) und FNF 24 „Farbtoleranzen in der Kfz-Lackierung" (dessen stellvertretender Obmann er ist) maßgeblich mitgewirkt hat.

Gerhard Rösler ist national und international ein anerkannter Fachmann auf dem Gebiet der Farbmesstechnik. Er wurde 1950 geboren und machte 1969 am Mathematisch-Naturwissenschaftlichen Klenze-Gymnasium in München sein Abitur. Anschließend studierte er an der TU München Elektrotechnik/Kybernetik und fertigte in diesem Zusammenhang bei der Firma Osram eine Diplomarbeit „Messwerterfassung eines Monochromators mit analoger Korrektur der spektralen Empfindlichkeit" an. Nach dem Studium arbeitete er als Entwicklungsingenieur bei der Firma Johne & Reilhofer Messtechnik, bevor er als wissenschaftlicher Assistent zu Professor Popp an den Lehrstuhl für Allgemeine Elektrotechnik und Elektrooptik der Ruhruniversität Bochum ging, wo er 1979 mit seiner Promotion zum Thema „Schnelle Farbmessung nach dem Spektralverfahren" zum Dr.-Ing. promovierte.

Nach der Gründung der Abteilung Elektrooptik bei der Firma Johne & Reilhofer im Jahre 1980 beschäftigte sich Gerhard Rösler maßgeblich mit der Markteinführung eines kom-

pakten, mobilen Farbmessgerätes mit Blitzlampe und 1 nm spektraler Auflösung sowie der anschließenden Erweiterung des Messgerätes zur Messung von Metalliclacken mit bis zu 9 unterschiedlichen Geometrien, bis er 1984 die Mitarbeit im FNF 24 und damit in der Normung auf dem Gebiet der Farbmetrik aufnahm.

Die folgenden Jahre waren gekennzeichnet von einem stetig zunehmenden Engagement in den Gremien des FNF, in deren Verlauf er 1998 die Obmannschaft des FNF 4 übernahm und zugleich in den FNF-Beirat eintrat. Seine fachliche Arbeit widmete Gerhard Rösler weiterhin der Einführung von mobilen Farbmessgeräten in der Automobilindustrie sowie der Online-Farbmessung in der Papierindustrie, wozu er u. a. 1985 auf der AIC-Tagung in Monte Carlo über die Multigeometrie Farbmessung vortrug. In zahlreichen weiteren Vorträgen in den folgenden Jahren ließ Gerhard Rösler die Kollegen auf nationaler und internationaler Ebene an seinem Fachwissen teilhaben; zuletzt berichtete er 1999 anlässlich des 50jährigen Jubiläums des FNF ausführlich über „Normung der Farbmessung goniochromatischer Materialien".

Gerhard Rösler hat sein berufliches Engagement der Weiterentwicklung der industriellen Farbmesstechnik für neue Anwendungen zur nachhaltigen Steigerung des Wirkungsgrades der industriellen Wertschöpfung (Produktivität, Qualtität, Umweltschutz) gewidmet. Neben der bereits erwähnten aktiven Mitarbeit in zahlreichen Normungsgremien, zahlreichen Vorträgen, Seminaren und Veröffentlichungen hat sich Gerhard Rösler folgende Ziele seines beruflichen Engagements gesetzt:

- *Beiträge zur besseren Übereinstimmung der Messmethoden sowie der Auswertung der Messergebnisse mit dem visuellen Eindruck auch bei komplexen Proben wie Effektlacken oder genarbten Kunststoffen;*

- *Etablierung der Multigeometrie Farbmessung als nächste Stufe der Farbmessung mit noch besserer Korrelation zum visuellen Eindruck;*

- *Stabilisierung der Glaubwürdigkeit der Farbmessung von komplexen Proben auch durch methodisch bessere, systematische visuelle Verfahren, um das Risiko einer zu späten Fehlererkennung erst beim Kunden zu reduzieren;*

- *Verbesserung der industriellen Qualitätssicherung durch Farbmessung mit Ergebnissen, die in der Praxis relevant sind;*

- *Empfehlungen zur industriellen Farbmessung bei der Qualitätssicherung mit realistischen, empfindungsgemäßen Toleranzen, die eine effiziente Produktion ermöglichen;*

- *Farbmessung direkt im Produktionsprozess zur frühestmöglichen Erkennung von Abweichungen, schneller Einleitung von Korrekturschritten und damit Reduzierung von Ausschuss.*

Der Manfred-Richter-Gedenkpreis – in Form der goldenen FNF-Nadel – wurde Herrn Dr. Gerhard Rösler auf der Beiratssitzung des FNF am 16. März d. J. im DIN überreicht.

Über die Festveranstaltung zum

50jährigen Jubiläum

des FNF im DIN und des DNK der CIE
am 24. September 1999

Farbnormung feierte 50. Jubiläum

(Wiedergabe aus "Welt der Farben", Heft 10, Oktober 1999)

Am 24. September feierten der Normenausschuß Farbe (FNF) im DIN Deutsches Institut für Normung und das Deutsche Nationale Komitee der CIE (Commission Internationale de l'Eclairage oder Internationale Beleuchtungskommission) ihren 50. Geburtstag im Ludwig-Erhard-Saal der Bundesanstalt für Materialforschung und -prüfung (BAM) in Berlin. Schon die musikalische Eröffnung der Big-Band der Georg-Herwegh-Oberschule konnte als ein Indiz dafür genommen werden, dass Farbnormung beileibe kein trockenes Betätigungsfeld sein muss: Die Jugendlichen begeisterten mit Melodien von Dixieland bis "Smooth Operator". Auch bei den Grußworten und den Fachvorträgen des die offiziellen Festlichkeiten begleitenden Kolloquiums war deutlich zu spüren, dass alle der anwesenden mit Farbnormung Beschäftigten ihre zum großen Teil ehrenamtliche Fachausschussarbeit mit Kreativität und Herzblut füllen.

Der Vorsitzende des FNF und des DNK, Professor Dr.-Ing. Heinz Terstiege, begrüßte unter den Gästen weithergereiste: aus den USA, Großbritannien, Österreich, Italien, den Niederlanden, Slowenien und aus Trinidad. Der Ludwig-Erhard-Saal der BAM bot frisch renoviert der Veranstaltung ein würdiges Forum.

Der Präsident der BAM, Professor Dr.-Ing. Dr. h. c. Horst Czichos, beklagte in seinem Grußwort, die Technik habe nicht genug Stellenwert in Deutschland. Er beschrieb kurz die Geschichte und die derzeitigen und künftigen Aufgaben der BAM. Die Wurzeln der Bundesanstalt gehen in das Jahr 1870 zurück, als das preußische Ministerium für Handel, Gewerbe und öffentliche Arbeiten die Einrichtung einer mechanisch-technischen Versuchsanstalt mit der Aufgabe einrichtete, Versuche im allgemeinen wissenschaftlichen und öffentlichen Interesse sowie Festigkeitsprüfungen durchzuführen. Heute ist die BAM eine technisch-wissenschaftliche Bundesbehörde im Geschäftsbereich des Bundesministeriums für Wirtschaft und Technologie mit dem Auftrag, die Entwicklung der deutschen Wirtschaft zu fördern. Oberste Leitlinie ist dabei die Sicherheit und Zuverlässigkeit in Chemie- und Materialtechnik.

Der langjährige Berliner Bundestagsabgeordnete und Mitglied des Europäischen Parlamentes, Peter Kittelmann, überbrachte Grüße des Regierenden Bürgermeisters von Berlin, Eberhard Diepgen. Er nannte die Normungsarbeit sehr wichtig für die Zukunft und die Globalisierung. Kittelmann bekannte, die meisten Politiker hätten zu wenig Mut zur Neugierde. "Wieviel klüger würden Politiker handeln, wenn sie Gesetzgebung nicht anstelle von naturwissenschaftlichen Erkenntnissen setzen würden", sagte er und erntete den heftigen Applaus des Plenums.

Hans Allan Löfberg, Royal Institute of Technology, Gävle/Schweden, und Präsident der CIE, stellte die Kommission mit ihrer Geschichte, ihren Aufgaben und ihrer künftigen Arbeit vor. In ihrer Basisstruktur aus nationalen Verbänden und internationaler Dachvereinigung hat sich die CIE in den Jahren seit ihrer Gründung 1913 nicht sehr verändert, wohl aber in ihrer Arbeitsweise. Derzeit 40 Mitglieder betreiben Internationale Normung in 20 Arbeitskreisen. Und weil der Technologiewandel nicht langsamer, sondern schneller wird, befürchtet Löfberg für die CIE-Arbeitsgruppen keine Arbeitslosigkeit. Allerdings sieht er Gefahren für künftige Aktivitäten in der Tatsache, dass die Finanzierung von Standardisierungsbestrebungen durch immer knappere öffentliche Mittel auch im Bereich der europäischen Union schwieriger werden wird.

Dr.-Ing. Torsten Bahke, Direktor des DIN, dankte zunächst den ehrenamtlichen und hauptamtlichen Mitarbeitern des FNF und des DNK, aber auch der BAM als Förderer der Aktivitäten. Thema seines Vortrages war das Spannungsfeld aus nationaler und internationaler Normung. Bahke hält Normen für eine echte Ergänzung zu Gesetzen - Gesetze sorgen für den rechtlichen Rahmen und die Gewähr von Schutzzielen; Normen konkretisieren den technischen Standard und schreiben ihn fest. Normen könnten im europäischen Raum und global helfen, Handelshemmnisse abzubauen und eigenverantwortlich auferlegte Maßstäbe für rechtlich einwandfreies Handeln sein.

Dem ersten, offiziellen Teil schloss sich eine Kaffeepause an, mit der Möglichkeit zu Gesprächen, die lebhaft genutzt wurde.

Den Kreis der Fachvorträge begann Professor Dr. Ing. Heinz Terstiege mit seinem Referat "Anfänge farbmetrischer Normung in den 20er Jahren", in dem er einen Bogen der farbmetrischen Bemühungen von den Anfängen Wilhelm Ostwalds 1919/20 bis heute schlug. Ostwald hatte damals den ersten "Farbnormen-Atlas" herausgebracht, der von einem 24teiligen Farbkreis ausgehend durch Abtönung mit Weiß und Schwarz 2.500 Farbmuster enthielt. Ostwalds Bemühungen, eine (staatliche) Stelle zur Farbnormung zu schaffen, waren zu seinen Lebzeiten nicht mit Erfolg gekrönt. Doch kann man ihn in direkter Tradition des 1949 unter Leitung von Dr. Manfred Richter gegründeten FNF sehen. In Zukunft fürchtet Terstiege eine große Gefahr: die zunehmende Konzentration in der Lackindustrie. Er meint, dass die "Multis" (so Terstiege) mit ihrer finanziellen Macht und ihrer Manpower sich nach Belieben Normen kaufen könnten.

Dr.-Ing. Achim Willing, Inhaber der Dr.-Ing. Willing GmbH, Scheßlitz, und Obmann des ISO-Ausschusses "Sicherheitsleitsysteme", nannte seinen Vortrag "Normungsarbeit und technischer Fortschritt" und adressierte ihn an Professor Terstiege, der im Juni seinen 65. Geburtstag gefeiert hatte. Willing bezeichnete Normung nicht als Selbstläufer, sondern als intensive Zusammenarbeit kompromissbereiter Personen. Normen könnten prinzipiell zwar zur Knebelung, zum Feind guter Lösungen werden; trotzdem seien Normen sehr wichtig, wie die jüngsten Erdbeben und ihre Folgen in der Türkei und in Griechenland gezeigt hätten. Normen müssten immer eine Balance zwischen gesetzgeberischer und industrieller Einflussnahmen anstreben – besonders schwierig in Zeiten unsicherer Finanzierungsmöglichkeiten! Bleiben die Mittel aus, so dass die Normung eingestellt werden muss, würden die Normen zunehmend durch (quasi-)gesetzgeberische Aktivitäten ersetzt. Einen immensen Vorteil in der Arbeit mit Normen sieht Willing in der Tatsache, dass sie bewusst national gefärbt sein können, also als individuelle Richtlinien in den unterschiedlichen Ländern in die gleiche Richtung weisen. Willing legte auf die Personen in der Normungsarbeit als Konsensbildner und Träger kreativer Lösungen ein Schwergewicht.

Norbert Johnson, 3M/USA und Chairman des CIE-Arbeitsausschusses "Messung retroreflektierender Materialien", sprach über die Ergebnisse der Normungsarbeit in diesem Bereich. Aufgaben für die nähere Zukunft sieht er in den immer rigideren Anforderungen im Fahrzeugbereich sowie in der Normung für neue Lichtarten.

Dr.-Ing. Gerhard Rösler, GretagMacbeth GmbH, München, und stellvertretender Vorsitzender des FNF, präsentierte dann das Gebiet der "Normung der Farbmessung goniochromatischer Materialien". Dabei konzentrierte er sich auf den Autolackbereich (Metallic- und Interferenzlacke). 70 Prozent der Neuwagen sind inzwischen mit Effektlackierungen beschichtet. Normungsbedarf besteht dabei hauptsächlich in der Festlegung tolerierbarer Farbabweichungen und ihrer effizienten Messung. Für die nächste Zukunft sieht Rösler in der visuellen Abmusterung für Effektlacke ein Betätigungsfeld sowie in der Ergänzung der Multi-Messgeometrie für Interferenzfarben.

Den Vortragsnachmittag beschloss Dr.-Ing. Dieter Anselm, Leiter des Allianz-Zentrums für Technik, Ismaning, und Mitglied im FNF-Ausschuß 24. Bei diesem Referat wurde ein ganz anderer Ansatz für die Notwendigkeit von Normung sichtbar: Die Autoversicherer wollen in ihrem Engagement in der Normungsarbeit eine Reduzierung der Materialkosten im Reparaturlackbereich unterstützen.

Der Festakt wurde durch ein Festessen beschlossen, bei dem die eingeschworene Gemeinschaft der mit Normungsarbeit Beschäftigten bis Mitternacht weiter "tagte".

Eva E. Berger

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

DIVISION 1 ACTIVITY REPORT 1999

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Derzeitige Technische Komitees (V=Vision, C=Colour)

TC Nr.	TC	Vorsitz	Bereich
TC1-19	Specification of visibility for real tasks	Werner Adrian	V
TC1-21	Testing of supplementary systems of photometry	Ken Sagawa	V
TC1-26	Individual variation of heterochromatic brightness matching	Hirohisa Yaguchi	V
TC1-27	Specification of colour appearance for reflective media and self-luminous display comparisons	Paula . Alessi	V
TC1-30	Luminous efficiency functions	Mitsuo Ikeda	V
TC1-33	Colour Rendering	Janos D. Schanda	C
TC1-34	Testing of colour appearance models	Mark D. Fairchild	C
TC1-36	Fundamental chromaticity diagram with physiologically significant axes	Francoise Vienot	V
TC1-37	Supplementary system of photometry	Ken Sagawa	V
TC1-38	Compatibility of tabular spectral data for computational purposes	Calvin S. McCamy	C
TC1-40	Critical flicker frequency	Open	V
TC1-41	Extension of $V_M(\lambda)$ beyond 830nm	Pieter L. Walraven	V
TC1-42	Colour appearance in peripheral vision	Miyoshi Ayama	V
TC1-43	Rod intrusion in metameric colour matches	Roy Berns	C
TC1-44	Practical daylight sources for colorimetry	Robert Hirschler	C
TC1-45	Revision of CIE publication 51 to include D50 simulators	Calvin S. McCamy	C
TC1-46	Concept and application of equivalent luminance	Yasuhisa Nakano	V
TC1-47	Hue & lightness dependant correction to industrial colour difference equation	D.H. Alman	C
TC1-48	Revision of CIE document 15.2 Colorimetry	Janos D. Schanda	C
TC1-49	Liaison with ISO/TC 35 Paint and Varnishes	Mike Pointer	C
TC1-50	Disability glare formula	J. J. Vos	V
TC1-51	Visual Acuity	H.-J. Schmidt Clausen	V
TC1-52	ChromaticaAdaptation transform	M Ronnier Luo	C
TC1-53	A standard method of assessing the quality of daylight simulators	Calvin S. McCamy	C
TC1-54	Age-related change of visual response	Ken Sagawa	V
TC1-55	Uniforin colour space for industrial colour difference evaluation	J. Nobbs	C
TC1-56	Improved colour matching functions	M. H. Brill	C

Reporter

Rep.Nr.	Titel	Reporter	Bereich
R1-03	Engineering applications of brightness scales	Tetsuji Takeuchi	V
R1-06	Transient adaptation	Siegfried Kokoschka	V
R1-11	Cognitive aspects of colour	Gunilla Derefeldt	C
R1-14	Visual observation of blood-oxygen levels	W.G. Julian	C
R1-15	Lighting Terminology	Mike Pointer	V
R1-16	Visual adaptation to complex luminance distribution	Hiroyuki Shinoda	C
R1-17	Improved colorimetry	Janos D. Schanda	C
R1-18	The use of colour identification under various illuminance levels	Taiichiro Ishida	V
R1-19	Specification on individual variation in heterochromatic brightness matching	Hirohisa Yaguchi	V
R1-20	Visual performance in the mesopic range	Julie Taylor	V
R1-22	Contrast sensitivity function for detection and discrimination	E. Martinez-Uriegas	V
R1-23	Guidelines on planning a mesopic photometry Investigation	Pat Trezona	V
R1-24	Colour appearance models	Mark Fairchild	C
R1-25	Liaison with ISO/TC 35: Paint and Varnishes	Klaus Witt	C
R1-26	Encyclopaedia on Colour	Pieter Walraven	C

Publikationen der Division 1

Nr.	Titel	Jahr
13.3	Method of measuring and specifying colour rendering properties of light sources	1995
15.2	Colorimetry, 2nd ed.	1986
19.21	An analytic model for describing the influence of lighting parameters upon visual performance, 2nd ed. Vol. 1: Technical foundations	1981
19.22	An analytic model for describing tile influence of lighting parameters upon visual performance, 2nd ed., Vol. 2: Summary and application guidelines	1981
41	Light as a true visual quantity: Principles of measurement	1978
51	A method for assessing the quality of daylight simulators for colorimetry	1981
60	Vision and the visual display unit work station	1984
75	Spectral luminous efficiency functions based upon brightness matching for	
76	Monochromatic point sources, 2 degree and 10 degree fields	1988
78	Brightness -luminance relations: Classified bibliography	1988
80	Special metamerism index: Change in observer	1989
81	Mesopic photometry: History, special problems and practical solutions	1989
86	CIE 19882 degree spectral luminous efficiency function for photopic vision	1990
87	Colorimetry of selfluminous displays - A bibliography	1990
95	Contrast and visibility	1992
101	Parametric effects in colour-difference evaluation	1993
103/1	Colour appearance analysis	1993
109	A method of predicting corresponding colours under different chromatic and illuminance	1994
116	Industrial colour-difference evaluation	1995
118	CIE Collection in colour vision	1995
135	CIE Collection 199 / Vision and Colour	
10526	International standard ISO/CIE 10526: CIE standard colorimetric illuminants	1991
10527	International standard ISO/CIE 10576: CIE standard colorimetric observers	1991
D001	Disc version of CIE photometric and colorimetric data (Publ. 18.2, 86, SOO1 and S002 tables)	1988
D002	CIE colorimetry and colour rendering tables	1991
D005	A method for assessing the quality of D65 daylight simulators for colorimetry (based on Publ. 51)	1994
D007	A method of predicting corresponding colours under different chromatic and illuminance adaptations (Computer program to Publ. CIE 109	1994

Zusammenfassungen aller CIE Publikationen sind in der CIE-Webseite nachzusehen.

Aktive Komites

TC1-19 Specification of Visibility for Real Tasks
Chair: Werner Adrian,CA
TR: To prepare a review of all methodologies for evaluating the visibility (threshold or suprathreshold) of real tasks.
ST: The final report has been sent out for ballot. As the report is completed, after eight years of work, the chair stepped down and invited Prof. Luisa Halonen, the former secretary to take over. Now Maijukka Elohoma, also from Helsinki University will serve as secretary.

TC1-21 Testing of Supplementary System of Photometry
Chair: K Sagawa, JP
TR: To test existing methods of photometry to evaluate lights for assessing comparative brightness relationships.
ST: 1.The fifth draft of the committee report, which contains testing results on the systems proposed for the assessment of lights in terms of brightness including mesopic range, was completed at the end of 1998, and the TC ballot was conducted immethately.
2.The report was approved by the majority of TC members but with one negative vote.
3.The comment of the negative vote was included in the report as a minority report, and the report is now in the final editing process for the Division Ballot.
4.The conclusion of the committee is that as long as the numerical testing is concerned all the proposed systems are better than the CIE photopic and scotopic photometric systems in describing heterochromatic brightness. However, the committee found no one best system among the proposed systems that could be recommended as a CIE supplementary system of photometry.

TC1-26 Individual Variation of Heterochromatic Brightness Matching
Chair: H Yaguchi, JP
TR: To analyze existing data on heterochromatic brightness matching in terms of individual variation.
ST: The chairman is now collecting data of the spectral luminous efficiency functions of aged people. He will prepare a draft report, distribute it members, and schedule a TC meeting in England this year.

TC1-27 Specification of Colour Appearance for Reflective Media and Self-Luminous Display Comparison
Chair: Paula Alessi, US
TR: To study and make recommendations for the specification of a colour appearance mateh between a reflective image and a self4urninous display image.
ST: A hardcopy/softcopy image comparison experiment featuring as much built-in consistency as possible to evaluate colour appearance models is being conducted at Derby University in the OB and at Kodak in the US. Experimental conditions feature the softcopy white point at 9300K and the hardcopy print illuminated with CIE 5000K simulators both at an equal luminance level of approximately 80 cd'm^2. Results will be available within the next three months. After complefion of this experiment, a second one will be conducted featuring different chromaticities and different lurninance levels across media.

TC1-30 Luminous Efficiency Functions
Chair: M Ikeda, JP
TR: To prepare a Technical Report on luminous efficiency functions which classifies and specifies the existing functions $V_{b,point}(\lambda)$, $V(\lambda)$, $V_{b,2}(\lambda)$,$V_M(\lambda$ and $V_{b,10}(\lambda)$ and the colour matching function $y_{10}(\lambda)$ if appropriate, in their photometric use.
ST: Dr. Nakano revised draft 3 according to the comments from TC members. The description of equivalent luminance was simplified. Some other small modifications are needed. The revised report will be sent to TC members for further comments to prepare a final report for Division ballot.

TC1-34 (C) Testing of Colour Appearance Modeis
Chair: M Fairchild US
TR: 1.To investigate the performance of models based on their ability to predict tile colour appearance of surface colours in simple and complex scenes under various illumination conditions.
2.To recommend one colour appearance model for interim use. This model should give due consideration to the findings of other relevant Technical Committees. The final Technical Report should include

summary details of all analyses carried out and all models investigated.
ST: This TC was disbanded in Warsaw and replaced by reporter RI-24 Colour Appearance Models

TC1-36 Fundamental Chromaticity Diagram with Physiologically Significant Axes
Chair: Francoise Viénot FR
TR: To establish a chromaticity diagram of which the coordinates correspond to physiologically significant axes.
ST: 1.The committee met at the Division meeting in Warsaw in June 1999.
2.Requirements on the photometric conditions for a supplementary System of photometry were discussed, and some agreements were obtained as a part of them. They were: use of a 10° field for a photometric field, and use of the 540 THz frequency monochromatic light as a reference light.
3.Two major problems have been addressed in constructing the supplementary system of photometry; one is the description of the chromatic contribufion (Helmholtz-Kohlrausch effect) in the photopic range and the other one is the introduction of rod contribution (Purkinje effect) in the mesopic range.
4.For the chromatic contribution, the committee is considering to adopt the Nakano conversion factor.
5.The chairman will propose a photometric model compromised of the concepts adopted in the already proposed models which were tested in TC 1-21, and further discussion will be made on the base of the chairman's proposal.

TC1-38 (C) Compatibility of Tabular Data for Computational Purposes
Chair: C McCamy US
TR: To prepare guidelines for tabulating *CIE* spectral data to provide compatibility of sets of data for computational purposes, considering such factors as spectral range, spectral interval, function, truncations, interpolation, extrapolation and number of digits.
ST: The committee met at the Technical University in Warsaw on June 30, 1999. There were few members present, and most of those actively pursuing an acceptable method of interpolation were unable to attend. Dr. Séve sent three proposals for consideration. Before the meeting, Dr. Schanda indicated he would favor adopting Lagrange interpolation. There was some discussion of various kinds of interpolation, and it was clear that methods of interpolation identified by names meant different things to different people. There was some discussion of the difference between standardizing the method of computing a table and standardizing the table itself. It had been proposed that when there is a method of computing a table, that method should be standardized instead of the table, to simplify programming and avoid transcribing errors. It was resolved that the chairman should prepare a third draft report and distribute it for comment. The third draft was prepared, and it was distributed on September 9, 1999, for comment by October 15, 1999. Comments on interpolation are being considered before preparation of a fourth draft to be balloted.

TC1-40 Critical Flicker Fusion Frequency
Chair: Open
TR: To investigate fundamental parameters affecting critical flicker fusion frequency (CFF) for the evaluation of flicker in CRT displays.
ST: This TC was closed in Warsaw, 1999 because a chairman could not be found.

TC1-41 Extension of $V_m(\lambda)$ Beyond 830 nm
Chair: P L Wairaven NL
TR: To write a report on the feasibility of extending the $V_m(\lambda)$ function beyond 830 nm.
ST: The one of the main activities of the TC this year was the organisation of the CIE Symposium for the celebration of the 75th anniversary of the CIE 1924 V(λ) in Budapest, 30 Sept. -2 Oct. 1999. At that symposium, a presentation was given by Pieter L. Walraven on the present status of the report. Though in principle the report is ready, the final publication waits for the outcome of the activities of TC 1-36, which is also dealing with the slope of the eye sensitivity curve at the red side of the spectrum. The report on TC 1-41 also contains a critical comment on the CIE 1924 V(λ) regarding the values at the red side of the spectrum. The meeting advised that a proposal would be made by TC 1-41 to amend $V_M(\lambda)$ for the long wavelength side according to the present insights regarding the absorption characteristics of visual pigments. A request with the same contents from the Hungarian NC to Division 1 was made. The Division will discuss this proposal at the next Division meeting.

TC 1-42 Colour Appearance in Peripheral Vision
Chair: M Ayama, JP

TR: To prepare a technical report on colour appearance zones for coloured lights in terms of unique hues in peripheral vision.
ST: The committee had a meeting in Warsaw on June 28, 1999 at the 24thCIE meeting. M. Ayama explained the experimental conditions and procedure proposed for measuring the colour appearance zones, which had been discussed in the previous meeting. The results of preliminary experiment done in Ayama's lab were shown. According to the results, the change of unique hue component as a function of eccentricity measured using CRT stimuli are within a distribution range of the results of monochromatic lights reported in previous studies when normalized at 0° (fovea). Dr. Derefeldt asked about the saturation judgement, whether observer judges perceived saturation by comparing with some reference stimulus, and the answer was no. Dr. Ayama replied that the instruction was to judge absolute amount of perceived saturation in a given stimulus, and although it was difficult at first, observer's judgement became stable after a few practice sessions. Number of observers needed for establishing colour zone map was discussed, but no conclusion reached. At the Division 1 Meeting on June 29, 1999, Dr. Ayama was approved to be a chairperson of this TC replacing Dr. Takase.

TC1-43 Rod Intrusion in Metameric Colour Matches
Chair: Roy Berns, US, No report
TR: 1. To write a report giving a step by step procedure for calculating the effect of rod intrusion on trichromatic colour matches.
2. To use the procedure to calculate the effect of rod intrusion on typical industrial metameric colour matches.

TC1-44 Practical Daylight Sources for Colorimetry
Chair: R. Hirschler, BR, No report
TR: 1. To intercompare existing daylight simulators for color measuring instruments and color matching booths
2. On the basis of this intercomparison, to recommend practical methods for simulating daylight sources.

TC 1-46 Concept and Application of Equivalent Luminance
Chair: Ynakano, JP
TR: To write a technical report describing the fundamental concept of equivalent luminance and to provide guidelines on how to apply these concepts.
ST: The chairman asked if the original members whom Dr Kokoschka had nominated were willing to continue their membership; one member resigned. The contents of the first draft report were presented at the Division meeting in Warsaw. The chairman has been asked to include some definitions (reference lights and visual performance) at the beginning of his report. The report that the chairman presented at the meeting will be distributed to the TC members for discussion. The word "concept" was modified to "concepts" in the terms of reference.

TC1-47 Hue and Lightness Correction to Industrial Colour Difference Evaluation
Chair: D.H. Alman US
TR: To investigate the hue and lightness dependence of industrial colour difference evaluation using existing experimental data.
ST: Partial draft no.1 of the TC1-47 technical report was prepared and distributed to the TC for comment. This report includes a hue-dependent correction and a blue-region hue-chroma interaction correction to industrial color-difference evaluation. Subcommittees are continuing investigations of lightness-dependent correction and improved blue-region correction. A full draft report is expected by spring 2000.

TC1-48 Revision of CIE Document 15.2 Colorimetry
Chair: J Schanda, HU
TR: To produce a revised edition of CIE Document 15.2 taking into consideration other relevant CIE recommendations
ST: Chairman tabled his report sent to TC Members on 1999-06-17, with the summary of the voting results on CIE 15-34. He explained that in a number of cases the 10 returned votes showed 50% -50 % in favour of one solution or the other.
The following items were discussed at the meeting and agreements reached:
1. TCC tabled CIE 15-35, offering soft-copy versions for further comments. The draft will be placed on an FTP server. See Annex to the Minutes!
2. Colour matching functions: It has been clarified that with the new type of writing the functions, no confusion with tristimulus values can occur as the CMFs have to be written with lambda in brackets: $X(\lambda)$,

$Y(\lambda)$, $Z(\lambda)$, while the tristimulus values are X, Y, Z,.
3. Colorimetric geometry: It was agreed that for diffuse geometry distinction should be made between 0° and 8° (or non-normal irradiation/observation, enabling specular excluded measurement). D Rich promised to send the new geometry specification Part for inclusion (tolerances, etc. will be Part only of his TC Report).
4. CCT definition: 8 TC Members (from 15 in total) were of the opinion that no change should be made in the calculation method.
5. TCC's compromised resolution: TCC tabled a compromise resolution, circulated to TC Members with his Report of 1999-06-17. TC Members who did not commented on the proposal are kindly asked to do so by 1999-09-15.
6. Follow up publication: TC Members were of the opinion that CIE 15-3 should contain only those parts of the original publication which are still current and D1 should be asked to establish a follow up TC with the task to summarise the historic background and give tutorial explanations where necessary. This request will be given before the next meeting of D1.TCC thanked for the lively discussions and many important comments and closed the meeting after appr. 90 minutes.
Annex : CIE 15.35 is now on the ftp server. Deadline for comments to the 5th draft was 15 Sept.1999. I received only very few comments. I am sending out a reminder with this e-mail, and wait for another 2-3 weeks, before 1 prepare the next draft. Draft 6 should be in the hands of the TC before the end of the year, and if no major remarks come in I will send an updated draft to D1 early next year. As this draft should contain already the tables we would like to publish with 15.3, it will be bulky and will be distributed only via our FTP server, and WEB place (with password).

TC1-49 Liaison with ISO/TC 35: Paint and Varnishes Colorimetry
Chair: Mike Pointer, UK
TR: To cooperate with ISO/TC 35 in their production of a series of ISO standards for the colorimetry of paints and varnishes.
ST: This TC was disbanded in Warsaw and replaced by reporter R1-25 Liaison with ISOfl'C35: Paints and Varnishes - Klaus Witt.

TC1-50 Disability Glare Formula
Chair: J J Vos, NL
TR : To prepare a technical report describing a formula for disability glare that revises the StilesHolladay formula including dependencies of wider angular part and age.
ST: The members were supposed to comment before October 1, 1999, on the ,,Report on Disability Glare" written for CIE on a personal title by Thomas van den Berg and myself. In fact I received comments from three members. I will now proceed to write a formal report on behalf of the committee, proposing a CIE Standard Disability Glare Observer. It is my intention to circulate this hopefully final draft among the members early in 2000, with a request to vote on it. With that I think I will be able to conclude the work of our committee by the summer of 2000.

TC1-51 Visual Acuity
Chair: H J Schmidt Clausen, DE, No report
To write a technical report to provide, on the basis of data collected from the literature, standard functions on visual acuity defined by the Landolt-ring as a function of luminance, contrast, presentation time, age colour.

TC1-52 Chromatic Adaptation Transform
Chair: MRLuo, UK
TR: To review the chromatic adaptation transforms with a view to make a recommendation.
ST: The following steps of progress have been made:
1. Received letters of confirmation from 11 members including five countries.
2. Accumulated and made available fourteen corresponding-colour data sets from eight sources. These were available on the world wide web at the Derby website.
3. Published an article on Corresponding-Colour Data Sets in Color Research and Application (24: 295-296, 1999) to introduce the use of the collected data.
4. Received and studied two research papers by Sobagaki, Yano, Hashimoto, and Nayatani on "Proposal of an abridged colour-appearance model CIECAT94LAB and its field trials" (*Color research and application* **24**:422-438,1999) and "On the Field Trials of CIECAM97s and Its Model Structure" (*Color research and application* **24**:439-456, 1999).

5. Arranged a TC meeting at the 24th Session of the CIE, Warsaw. There were two presentations: (a) A comparison of predictions between CIECAM97s and CIECAT94LAB and (b) Testing performance of CIE-CAT94 and CMCCAT97 by Sobagaki and Luo, respectively.
6. A draft technical report to review a number of studies on chromatic adaptation is in preparation. The topics include experimental techniques, important experimental data sets, chromatic adaptation transforms, testing performance of transforms, and recommending a chromatic adaptation transform as the new CIE standard.

TC1-53 A Standard Method of Assessing tile Quality of Daylight Simulators
Chair: C McCamy, US
TR: To prepare a CIE Standard for the assessment of daylight simulators
ST: A draft standard was distributed for comment on April 27, 1999. The committee met at the Technical University in Warsaw on June 28, 1999. There were only four member present, but 21 guests. The chairman reviewed the history of CIE work in this field from the development of CIE Publication 51 to the present effort. He described his recent derivation of metamers defined over the wavelength range from 380 nm to 780 nm and a method of evaluating test metamers to assure that they grade illuminants on the same scale as those in CIE Publication 51, which has been in use since 1981. (That work was reported in *Color Research and Application* in September 1999.) It was resolved that a second draft be prepared and distributed for comment. Draft 2 was distributed for comment on August 25, 1999.On the basis of comments received, Draft 3 was prepared and distributed with a letter ballot on November 12, 1999. That ballot closes on December 15, 1999.

TC1-54 Age-Related Change of Visual Responses
Chair: Ken Sagawa, JP
TR: To establish luminous efficiency, visual acuity, and contrast sensitivity as a function of age.
Working Programme:
1. To survey relevant data in the literature and ongoing studies as well for establishing data bases for the age-related change in spectral luminous efficiency, visual acuity, and contrast sensitivity functions.
2. To establish fundamental data bases for those functions as a function of age.
3. To write a report with those data bases.
The committee was established at the Division meeting at Warsaw. The working programme was established by the chairman, and the TC is now in the process of forming the membership.

TC1-55 Uniform Colour Space for Industrial Colour Difference Evaluation
Chair: J Nobbs, UK
TR: To devise a new uniform colour space for industrial colour-difference evaluation using existing experimental data.
A brief initial meeting was held at Warsaw. Membership is currently being developed.

TC1-56 Improved Colour Matching Functions
Chair: M Brill US
TR: 1. To compare results based on the current CIE colour matching functions, colour matching functions proposed by Dr. W. Thornton's laboratory, and those of CIE TC1-36.
2. To initiate experiments to obtain data for such comparison in different laboratories.
3. To report to CIE Division 1 on the results of the above investigation and make an eventual recommendation for future CIE colour matching functions.
4. To report to CIE Division 1 an eventual recommendation for the use of the new colour matching functions in specifying colour spaces and colour-difference formulas.

Reports

R1-03 Engineering Applications of Brightness Scale
Reporter: T Takeuchi, JP, No report

R1-04 Colour Difference Evaluation
Reporter: Klaus Witt, DE
ST: The formation of CIE TC 1~7 aimed at quantifying possible hue and lightness dependent effects in CIELAB-space to be used for corrections in the CJE94 colour-difference formula. Scientific investigations, therefore, were concentrated to find significance of a modified version of CIE94. TC 147 reports on the results. A major event for discussions of different modelling in colour-difference evaluation was the

ISCC/OSA joint symposium "Colour differences and colour discrimination: perception and prediction" held at Baltimore, October 4, 1998. Here, not only CIE94 modelling was discussed, but also other ideas how to cope with colour-difference evaluation at small to moderate magnitude were presented. A new aspect to be considered by CIE is the idea, to leave the procedure of weighting of difference components in the formula in favour of a new definition of basic co-ordinates that form a uniform colour space. if we find a new basic co-ordinate system that includes all of the effects or at least a significant Part of the effects told with CIE94 corrections, a Euclidean colour difference can be formulated as was done in the original CIELAB definition. Two different routes of modelling are as follows:

a) Start with the model of Rohner & Rich in a modified version used in a draft standard of DIN called DIN99-formula and apply all existing data sets for optimisation of inherent parameters. The DIN99-formula was presented as a poster paper at the ISCC meeting in Vancouver by this reporter. This formula starts with CIELB coordinates, applies a grey correction, uses different logarithmic transformations of lightness and chroma, and uses only two parameters of external viewing conditions: a form factor that describes the relative change of lightness over chromatic hue/chroma and a size factor that describes the effect on total magnitude.

b) Follow the idea of R. G. Kuehni to start with modified transformations of colour matching functions that define a new opponent colour coordinate system. A full script of this idea was given to the reporter. The essentials are: cone sensitivity functions simply may be calculated from subtraction of colour matching functions. From here opponent colour coordinates are defined using different modes of mathematical rooting.

Both ideas may be combined to find a new model of a uniform colour space for industrial colour-difference evaluation. I propose that CIE Division 1 form a new TC with the title of "Uniform colour space for industrial colour-difference evaluation". This was done at Warsaw and is designated TC 1-55. R1-04 was closed at Warsaw after completing the report on recent activities in the field, which was published in the CIE Collection 1999 (CIE Publ. 135).

Attached is a list of recent papers on colour-difference evaluation that came to the attention of the reporter. However, this list may be incomplete as there was no assistance by other scientists.

1996:

W. 0. Kuo and M. R. Luo, Methods for quantifying metamerism. Part 1 - Visual assessment, *J. Soc. Dyers Col.* **112**, 312-3220(1996).

Some 76 metameric pairs of dyed wool were produced and their apparent colour difference assessed against a grey scale under seven different lightsources by a panel of observers. In a second experiment observers had to judge on three components of colour difference wider three different light sources. Observer variability was analysed. Crossover wavelengths of spectral reflectance curves of metamers were found to converge on three wavelengths.

W. 0. Kuo and M. R. Luo, Methods for quantifying metamerism. Part 2- Instrumental methods, *J. Soc. Dyers Col.* **112**, 354-360(1996).

Three types of metameric indices were studied using the experimental findings of Part 1 of this series of articles. CMC, BFD or CIE94 formulae were quite satisfactory in relation to observer variability and can be confidently used for evaluating the degree of metamerism for industrial applications. Some Part of scatter could be explained by changes in the CIE 1964 colour matching functions, due to deviations of the colourmatching functions of actual observers from the standard one. This new set could be used to predict observer metamerism.

1998

Y. Qiao, R. 5. Berns, L. Reniff and E. Montag, Visual determination of hue supra threshold color-difference tolerances, *Color Res. Appl.* **23**, 302-313 (1998).

This is an extended version of a paper presented at the *MC* Congress 1997 in Kyoto. Three complete hue circles were sampled at two lightness levels and two chroma levels including three of the five recommended CIE colours resulting in 39 different colour centres. At these centres colour-difference samples were produced and scaled against a 1.03 CIELAB unit near neutral anchor pair. Analysis was performed for hue discrimination. The 50% tolerance values varied with hue angle in a manner that was not predicted by any of the existing colour-difference formulae. Advice is given to implement the results for an improved version of a CIELAB based colour-difference formula.

R O. Kuehni, Hue uniformity and the CIELAB space and color difference formula, Color Res. Appl. **23**, 314-322 (1998).

Hue difference steps in the Munsell system are not well reproduced by CIELAB. other colour space systems underline this context. Visual experiments should be performed to define a "standard hue observer" as a base for developing an improved colour-difference formula.

H. O. Völz, Die Berechnung großer Farbabstände in nichteuklidischen Farbräumen, *Die Farbe* **44**, 1-45 (1998).
The problem of calculating large colour differences with non-Euclidean distance formulae is stressed. The CIE94 formula is taken as an example: the nearest distance between any two points is curved in CIELAB-space as described by a geodesic line. Curvatures are deduced for a simple factorial weighting of the components of the CIELAB4ormula and for CIE94. Finally a set of five threshold ellipsoids in CIE-LAB-space (at CIE colour centres) is used to optimise a weighted CIE944-formula. Large colour differences beyond 5 CIELAB units are calculated incorrect with CIE94 in relation with those calculated along the correct geodesic line.

1999
T. Indow, Predictions based on Munsell notation. I. Perceptual colour differences, *Color Res. Appl.* **24**, 10-18(1999).
A new study on the spacing of colours in the atlas of Munsell-chips using grey-scale assessment provides insight in linear relationships between perceptual and predicted colour differences in different ranges of the Munsell solid. However, the slope of such relationship depends on the region of the solid selected. Correlating the data with predictions by 4 different colour-difference formulae brought CIE94 in the best position, though it was developed for much smaller magnitudes. This means, non-linear curvature may be existing in chroma and hue scales of Munsell.

R. O. Kuehni, Hue scale adjustment derived from the Munsell system, *Color Res. Appl.* **24**, 33-37 (1999).
The relation of hue spacing in CJELAB co-ordinates with that in the Munsell System is studied and hue scale adjustment factors are derived to improve colour-difference predictions. A new formula to calculate hue differences in CIELAB is proposed that was tested against new visual results in the literature.

M. Melgosa, M. M. Pérez, A. E. Moraghi & E. Hita, Color discrimination results from a CRT device: influence of luminance, *Color Res. Appl.* **24**, 38-44 (1999).
Colour-discrimination ellipsoids were obtained for two observers using a CRT device for different luminances. The aim was to test whether an internal weighting factor for luminance-differences in the CIE94 formula would be advisable. There was no robust trend detected to change the formula However, external parametric factors may well be active.

K. Witt, Geometric relations between scales of small colour differences, *Color Res. Appl.* **24**, 78-92 (1999).
Starting from threshold ellipsoids of colour difference at five CIE colour centres painted samples were prepared to represent equal steps of magnitude along the main axes. Pairs of samples were formed to represent small to moderate magnitude of colour difference along the axes and between them, and scaled by observers using grey scale assessment. Scale functions were near to linear but different in all five colour centres. Diagonal pairs between axes made tilting effects of underlying "physiological" axes apparent that in most cases are not explained by existing models of colour difference.

E. D. Montag & R. S. Berns, Visual determination of hue supra threshold color-difference tolerances using CRT-generated stimuli, *Color Res. Appl.* **24**, 164~176 (1999).
CRT-generated stimuli are a quick method for determining colour tolerances. In relation to object-colour samples the uncertainties of judgements are reduced. The investigated hue tolerancing in CIELAB space for two different experimental conditions produced results that in general were similar to those found in object colour experiments, however, diverging details were explained by some underlying parametric effects of stimulus presentation. These effects can be studied more economically by using CRT generated displays.

R1-06 Transient Adaptation:
Reporter: S. Kokoschka, DE, No report

R1-11 Cognitive Aspects of Colour
Reporter: Gunilla Derefeldt, SE
ST: The manuscript for the report has been prepared. We are now setting up some experiments regarding (cognitive) memory aspects of colour. We also are about to start some experiments on colour ap-

pearance in the peripheral vision in line with the terms of reference of TC 1-42.

R1-13 Revision of Wyszecki and Stiles

Reporter: P. Walraven NL

TR: To report on the need and possible mechanisms for revising the book "Color Science" by Wyszecki and Stiles by considering which parts need updating, what is available in other books and who might contribute to the work.

ST: This reportership was disbanded in Warsaw, but succeeded by R 1-26 CIE Encyclopaedia on Colour - Pieter Walraven.

R1-14 Visual Observation of Blood Oxygen Levels

Reporter: Warren Julian, AU

TR: To report on problems associated with the use of narrow band phosphors in high efficiency discharge lamps for clinical observations including visual assessment of a patient, based on rapid changes in blood oxygen levels, and whether this may require one or more additional test colours to be used for a special CRI or for inclusion in a new general CRI.

ST: The work has been completed, and a method is being sought to publish report. In Warsaw it was voted to disband this reportership

R1-15 Lighting Terminology

Reporter: Mike Pointer, UK

TR: To provide liaison between Division 1 and TC7-06 "International Lighting Vocabulary" and support the preparation of a new edition of the "Lighting Vocabulary".

ST: The final revised versions of Sections 2 and 3 of the International Lighting Vocabulary were submitted to the CIE Central Bureau at the end of August 1999. These will now proceed to international voting. It is envisaged that further changes will be necessary to bring tile vocabulary in line with the revised CIE Document 15.3 Colorimetry. There are also several new terms that are being discussed by tile Working Group. It is planned to keep this Group active so that further new terms can be discussed and added to the Vocabulary as required.

R1-I6 Visual Adaptation to Complex Luminance Distribution

Reporter: H Shinoda JP

TR: To survey state-of-the-art research on visual adaptation to complex luminance distribution and to judge whether CIE should establish a new Technical Committee on this issue.

ST: The state of art report was published in the CIE Collection 1999 (CIE Publ. 135).

R1-17 Improved Colorimetry:

Reporter: J Schanda, HU

TR: 1. To inform Division 1 of work carried out by researchers in the area of additive colour matching, breakdown of trichromatic generalization, and improved systems of colorimetry and to report progress at Division 1 meetings;

2. To advise on the feasibility of establishing a Technical Committee.

ST: This reportership was disbanded in Warsaw, and replaced by TC 1-56 Improved Colour Matching Functions - Michael Brill.

R1-18 The Use of Colour Identification under Various Illuminance Levels :

Reporter: T Ishida, JP

TR: 1. To survey the state-of-the-art of colour codes under various illuminance levels

2. To judge whether the CIE should establish a Technical Committee on this topic

3. To establish liaisons with CIE Divisions 3 and 4.

ST: The survey of the related studies was reported in Warsaw. More extensive report will be available by the next division meeting.

R1-19 Specification on Individual Variation in Heterochromatic Matching

Reporter: H Yaguchi, JP

TR: To report on the possibility to develop a simple test of individual characteristics for hetero-chromatic brightness matching.

ST: The reporter examines the possibility to develop a simple test of individual characteristics for heterochromatic brightness matching. The report will be made at the next Division meeting.

R1-20 Visual Performance in the Mesopic Range

Reporter: J Taylor, UK

TR: 1. To survey researchers specifying visual performance in the range of mesopic vision

2. To report to Division1 whether a TC on some specific visual performance should be established.

ST: There has been a lot of activity and interest over the last ye& in developing a standard for visual performance, particularly in the mesopic range. It has long been understood that a spectral luminous efficiency function for the mesopic range would not only be complex but also inadequate for predicting task performance. Many quite hazardous and complicated tasks are performed under mesopic lighting conditions, and it is the efficiency of the lighting for these tasks that is important. During this year, two specific groups of researchers have proposed investigations into the development of performance based metrics for mesopic photometry. The first group, within the UK, have already started their research programme. The second group are currently seeking funding from the European Community. A conference, organised by the National Physical Laboratory, Colour 2000, will discuss aspects of mesopic scales and performance in April 2000. Information from this conference will be fed into this reportership and will aid in the formulation of appropriate recommendations.

R1-22 Contrast Sensitivity Function for Detection and Discrimination

Reporter: E Martinez-Uriegas US

TR: To survey the literature on human spatial contrast sensitivity function under defined viewing conditions including luminance levels, surround, adaptation state, and geometry.

SR: The literature survey is an ongoing effort and has been organized under the following issues:

1. Advantages of representing spatial visual stimuli by means of their spatial sinusoidal components.
2. Advantages and limitations of the use of Fourier analysis to predict visual responses.
3. Advantages and limitations of modelling visual processing on the basis of Fourier principles.
4. Spatial CSF under stabilized conditions and conjoint spatial-temporal CSF.
5. Distinctions between chromatic and achromatic CFS.
6. Distinctions between CSF for detection and discrimination.
7. Similarities and differences in experimental setups, viewing conditions, methods, and procedures.
8. Practical applications of CSF.

R1-23 Guidelines on Planning a Mesopic Photometry Investigation

Reporter: P Trezona, UK

TR: With several new mesopic photometry investigations being contemplated, the impact of theory of other considerations on the experimental design will be reported.

ST: It is hoped that this report will be completed in time for CIE Division 1 in April 2000.

R1-24 Colour Appearance Models

Reporter: M Fairchild, US

TR: To monitor the progress and development of colour appearance models.

ST: R1-24 was established in Warsaw, including setting the tide and terms of reference. The reporter has begun compiling relevant papers as they are published and expects to put together a first report for the next Division 1 meeting in April, 2000.

R1-25 (C) Liaison with ISO/TC 35: Paint and Varnishes Colorimetry

Reporter: K Witt, DE

TR: To cooperate with ISO/TC 35 in their production of a series of 150 standards for the colorimetry of paints and varnishes.

ST: I started my duties as a new reporter R1-25 in taking up contact with the person responsible for the German organisation of ISO/TC 35: Paint and Varnishes, Mr. Reinmüller of DIN. He promised to inform me before the next action in standardisation starts. He already was informed about the CIE position by Dr. Pointer's previous activities.

R1-26 CIE Encyclopaedia on Colour

Reporter: P Walraven NL

TR: To investigate the feasibility of producing an encyclopaedia on Colour as a CIE publication. The study should include the consequences of a publication by CIE, being its own publisher, and of a publication by CIE in cooperation with a well-known publisher.

ST: Negotiations with Wiley are continuing. A discussion with the Publications Board of CIE has taken place during the symposium on the 75th Anniversary of CIE 1924 V(λ) regarding the format of the publication. It is essential that the publication should be in the framework of the publication-strategy of CIE. This will be further negotiated with Wiley.

CONSIDERATIONS ABOUT CCD VIDEO CAMERA RADIOMETRIC CALIBRATION

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(Eingeladener Vortrag auf der Tagung NEWRAD, 26. Oktober 1999 in Madrid, Spanien)

Abstract.

CCD video cameras have become very important tools in the so called image science field, not only for their good performance as optical cameras but also for their feasibility in getting radiometric readings of pixels. This paper reviews calibration procedures used for these cameras, looking at the radiometric aspects rather than other optical aspects, and proposes new calibration methods as a matter of reducing the uncertainty of measurements made with these cameras.

1. Introduction.

CCD cameras are widely used in many fields of Science and Technology as a powerful tool for getting information from complex scenes. Changes in measured image irradiance have many physical causes and are the primary cue for several visual processes, such as edge detection and shape from shading. This popularity is a result of their high resolution, high quantum efficiency, wide spectral response, low noise, linearity, geometric fidelity, fast response, small size, low power consumption and durability. In addition, since a CCD is based on fixed sensing elements of equal size, the device provides precise spatial quantization that enables accurate spatial representation of images in a computer [1].

Examples of these fields are Quality Control in many industrial applications, Colour measurement [2, 3, 4], Astrophysics, Illumination [5, 6], where they have been used in the characterisation of spatial distribution of luminaries, and Artificial Vision [7], among other. Essentially they are used to measure differences in irradiance from pixel to pixel or to measure the irradiance over every pixel and from that the radiance of the object source. But in both cases the spectral distribution must be nearly the same over the whole detector matrix. Some people are starting to use cameras for spectral applications as those related to reflectance measurements [8], but this will not be considered in this paper.

The relation between sensor electrical response and irradiance over the pixels and the radiance of the object imaged on the pixel is obtained by a calibration process. Several methods are used for this purpose. They will be reviewed in this work and new proposals for calibration methods will be given in order to obtain measurements with a lower uncertainty.

2. CCD Camera Operation.

A CCD video camera is an optical system that produces an image of a complex scene over a detector matrix. As in any optical system, the relation between the object and the image depends on the optical components forming the objective of the camera, on the numerical aperture used to produce the image and on the time for registering the image.

The output of a CCD video camera is a video signal that can be carried to a TV monitor for visualisation or to a computer for treatment and later visualisation. The relation between the electrical output and the image irradiance on the detector matrix depends also on several factors. The measurement process relies on the fact that when light is absorbed in silicon, an electron-hole pair is generated [9].

The sensor is formed by a matrix of detectors where radiation can be absorbed separated from each other. Each detector is formed by growing a thin layer of silicon dioxide on the silicon and depositing a conductive gate structure over the oxide. Applying a positive potential to the gate creates the depletion region where photoelectrons may be stored. The process of charge coupling is used to move stored charge in a CCD. During charge coupling, charge packets are moved from one detector to another by manipulating the gate potentials. The separation of individual charge packets is preserved during these transfers. The charge transfer efficiency of a device quantifies the fraction of charge that can be effectively transferred from one collection site to an adjacent collection site.

An image is read out of the device by transferring the charge packets integrated at each collection site in parallel along electron channels connecting columns of collection sites. A serial output register with one element for each column receives a new row of charge packets after each parallel row transfer. Reliable techniques have been developed to prevent photoelectrons that might be generated during the read-out process from contaminating the charge packets being transferred.

The signal produced by every detector under illumination is given by the equation [1]:

$$S = \int\iiint E(x, y, \lambda) R(x, y, \lambda) dx dy d\lambda dt$$

Where $E(x,y,\lambda)$ is the irradiance on the detector plane, $R(x, y, \lambda)$ is the detector responsivity and x and y are the plane coordinates where the detector lays. Detector responsivity changes from pixel to pixel and also the irradiance may be different.

There are several noise sources in CCD imaging systems. Processing errors during CCD fabrication cause small variations of quantum efficiency and charge collection volume from collection site to collection site. This spatial non uniformity is often referred as fixed pattern noise. This site to site will exhibit some dependence on wavelength.

The assumption that charge generated in each detector is independent from the other can be violated when a single site is illuminated with sufficient irradiance to cause stored charge to overflow from a potential well and to mix with charge in other potential wells. This effect is called blooming.

The dark current is produced by electron thermally excited. The expected number of electrons excited is proportional to the integration time and is highly temperature dependent. Cooling may reduce the dark current to less than one electron per collection site per second, but this is not usually the case. For many devices there are small fluctuations in the dark current from detector to detector.

Shot noise is a result of the quantum nature of light absorption and produces an uncertainty in the number of electrons stored at a collection site. Shot noise is a fundamental limitation and cannot be eliminated.

The number of electrons integrated at each collection site is given by $KI + N_{DC} + N_S$, where KI are those produced by light absorption, N_{DC} dark current electrons and N_S shot noise electrons.

After charge is collected at each site, the CCD must transfer the charge to the output amplifier for readout. The charge transfer efficiency of a real CCD is less than 1. Charge that is not effectively transferred is either lost or deferred to subsequently transferred charge packets. This is of course a new source of noise, but actual current buried-channel CCD achieve charge transfer efficiencies greater than 0,99999. So, it is reasonable to neglect the effects of transfer inefficiency.

The on-chip amplifier produces a measurable voltage from the charge collected at every pixel. This voltage also has got a noise. Amplifier noise dominates the other source noise at low signal levels and then determines the floor noise of the device. Then the voltage signal is transformed into a video signal and in many cases this video signal is digitised to be treated in a computer system.

3. Radiometric Characterisation of a CCD camera.

From a radiometric point of view, a camera can be seen as a multiple-elements detector system that produces an electrical response when it is excited, within a given solid angle, by optical radiation coming from a specific area of a light source. So it is a device that can be used to measure the radiance of a source and in particular the radiance of different areas of a large source.

As mentioned previously and it is usual in Radiometry, the relation between the response output and the radiance of the source is obtained by a calibration process that should be designed to measure all the quantities involved with the simplest possible radiometric system in order to obtain the lowest uncertainty in the final measurement result.

Considering the camera structure, the physical processes involved in the detection of light and the information wanted to obtain from camera measurements, the radiometric characteristics that have to be determined are the spectral responsivity and its variation from pixel to pixel, the linearity of the response, in order to obtain reading ratios, the dark response and an estimate of the noise. Dark current plays a special role in CCD detectors because in a sense they perform as opto-electronical capacitors. Charge is accumulated during the integration time period, so for long periods of integration time, that are used when the optical power is low, the dark current is high, producing the corresponding increase in shot noise [1].

Linearity also deserves special attention in CCD video cameras. It could be thought of this radiometric quantity that it is not worth it to pay much attention to it. Nowadays CCD detectors are produced with a good isolation between pixels, the charge is stored without leakage in every detector element and the charge transfer efficiency is very high. However the voltage response is converted to a digital value, cameras use to work in automatic gain in order to use the largest dynamic range and the video signal is produced as non linear in order to compensate the non linear response of TV monitors where images will be presented. So linearity measurements are necessary to evaluate these effects on every specific camera.

There are other calibrations needed for using properly a camera system. It is necessary to know the spatial resolution of pixels in order to extract spatial information of the source and it is also necessary to measure the modulation transfer function (MTF) in order to know the perturbation introduced in the image by the camera, which depends on the optical system and on the detector matrix. It is also convenient to know the point spread function in order to know whether a point source will excite one or more pixels. However these calibrations will not be considered here because they are not usually considered radiometric calibrations in a strict sense. Many calibrations methods have been developed for these quantities [10, 11].

4. Calibration methods.

The easiest form to obtain a radiance source with a certain degree of uniformity is to irradiate a diffuser plate with a stabilised incandescence lamp. The diffuser may be a transmission element or a reflective element, although the second one is found in much more cases, perhaps because reflective diffusers simulate better the perfect diffuser [12, 13]. This is the most commonly found experimental apparatus in the calibration of CCD video cameras [14, 15]. The radiance of the source is measured with a radiance meter or calculated from the irradiance of the lamp over the diffuser plate and the reflectance factor of the plate in the desired direction. The radiance is supposed to be constant for all elements within the CCD matrix and the responsivity is measured as the ratio between the camera response and the radiance of the source. Interference filters or any other broader band filters are introduced between the lamp and the reflectance plate when spectral responsivity values are desired. In this case the radiance of the source is measured with a radiance meter.

The responsivity variation from pixel to pixel is directly obtained from the response change, because the irradiance over the detector matrix is considered to be constant. Linearity is measured by attenuating the lamp flux reaching the reflectance plate and measuring the different radiance levels of the source with a radiance meter. This calibration method is frequently used in the Remote Sensing field. The problems in using this method are due to geometry: acceptance angle, reproducibility on the incidence direction of the beam coming from the plate, coincidence between the radiance meter direction and the camera being calibrated direction; and to relay on the calibration of the radiance meter, that usually is a camera type device with a relatively high uncertainty.

Some other methods have been developed to calibrate the detector matrix and the objective transmittance [16]. However they do not produce better results from a metrological point of view, which means measurements with a lower uncertainty.

Another interesting approach to the calibration problem is the development of the so called calibration algorithms. Based on the camera performance, a model is established relating a response change due to a parameter with a radiometric quantity change. An example of this is the calculation of the camera noise from the standard deviation of the measurement of all camera pixels [1]. This study showed that at low light levels the noise of the pixels average is due to non uniformity in response from one pixel to another. But at high light levels, the same standard deviation is dominated by scene variance.

Considering the good quality reached by CCD detectors and all the electronics present in the cameras, it is not crazy to think that the uncertainty of measurements made with these cameras could be improved if the uncertainty on the calibration procedure was reduced.

In contrast to what happens in the Remote Sensing Field, CCD video cameras used in the applications cited at the beginning of this work may be calibrated in laboratory conditions as many times as needed. So other calibration protocols affected by a lower uncertainty could be used.

5. Alternative calibration methods.

As it already happened in other areas of Radiometry, the line to follow to reduce calibration uncertainties is clear and consists in assuming as many as possible of the following criteria:

- Calibration should be easily performed.
- Calibration hardware should be stable.
- The technique should closely simulate the conditions of use of the instrument, including both optical beam geometry and spectral distribution of the test radiation.
- It should be a primary method traceable to physical principles, to avoid the necessity to transfer data from one set of conditions to another, increasing the resulting uncertainty.
- It should be usable over the entire spectral range of interest and applicable along the complete dynamic range with the same accuracy.
- To the greatest possible extent, it should measure only instrumental errors and be independent of sample handling techniques and human operator errors.

To fulfil all of them is not always possible, but some good approximations can be considered. In the case of CCD video camera calibrations, the subject would be to find a standard source of spectral radiance with the lowest uncertainty. Two options are available and their real chance could be tested. One option is a black body source and the other is an integrating sphere based source. Both sources are being or have been tested in the calibration of Remote Sensing cameras.

These two standard sources can be calibrated against very low uncertainty standard as silicon filter radiometer. Both have a spatial radiance distribution that simulate well a lambertian source in a solid angle wider than the usual camera acceptance angle. Then the irradiance over every pixel in the detector matrix could be differentiated. Both may have a real or imaginary emitting surface that can be considered uniform. In both cases the emitting surface is geometrically well defined, which might be useful for optical magnification calculation.

Unfortunately both systems have also drawbacks and are not the perfect solution. The main inconvenience of the black body is the area of the emitting surface that is usually too small to what is needed for calibrating CCD video cameras and the uniformity of this area. Making spectral measurements with a black body is also more complicated, because a spectral analysis system has to be introduced between the source and the camera and then geometrical and spectral characteristics are disturbed. Linearity measurements are not easy neither for the same reason: a filter has to be introduced in the calibration path. Finally, not many black bodies are available in reasonable well equipped calibration laboratories.

Integrating sphere sources with internal illumination have a very similar inconvenience, except for the source area that can be much larger than the black body one.

Integrating sphere sources with external illumination could be a solution to have an experimental apparatus to calibrate CCD video cameras wit lower uncertainty. This type of source has all the advantages that black bodies and internal lighting integrating spheres have and less drawbacks. Due to the external lighting system, spectral analysis, power attenuation or power monitoring can be done without disturbing the optical path between the source and the camera under test. Even shuttering of the beam can be done before the light enters the integrating sphere so that stray light, if present, could be evaluated.

Linearity measurements could be done using the addition method which yields the less uncertain results. Very high power levels could be spectrally achievable since laser sources could be used.

These sources are being used in the Remote Sensing field to calibrate sensors and cameras [17, 18].

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Künftige nationale und internationale Veranstaltungen

03. – 08. 09. 2000	CIE Divisuion 4, Toronto, Kanada
20. – 26. 09. 2000	Instr. Weißbew., Textil-, Papier-, Waschmittel, TA Hohenstein
09. – 12. 10. 2000	Farbmessung Kunststoff und Lackindustrie, TA Hohenstein
17. – 20. 10. 2000	Farbmessung Textil- und Bekleidungsindustrie, TA Hohenstein
06. – 07. 11. 2000	AIC Interim Meeting Color and Environment, Seoul, Korea
20.10. 2000	**DfwG-Jahrestagung 2000,** Lichttechn. Inst. der TU Darmstadt
16. – 18. 11. 2000	DfwG-Farbmesskursus 2000 in der TA Esslingen
19. – 21. 02. 2001	DfwG-Farbmesskursus 2001 in der TA Esslingen
13. – 17. 05. 2001	NIST 100-Jahr-Feier, Gaithersburg,Maryland, USA
14. – 16. 05. 2001	CORM im NIST, Gaithersburg, Maryland, USA
17. – 18. 05. 2001	CIE Division 2, NIST Gaithersburg, Maryland, USA
07. – 09. 06. 2001	Farbe im Gespräch, Radebeul
24. – 29. 06. 2001	AIC-Tagung, Rochester, NY, USA, Riverside Convention Center
Juli 2001	Tagung: International Color Vision Society in Cambridge
01. – 10. 07. 2003	CIE Tagung in San Diego, Kalifornien, USA
2003	Tagung: International Color Vision Society in Seattle, USA

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