

**Bureau International des Poids et Mesures**

# **Comité International des Poids et Mesures**

90th meeting (October 2001)

#### Note on the use of the English text

To make its work more widely accessible the International Committee for Weights and Measures publishes an English version of its reports.

Readers should note that the official record is always that of the French text. This must be used when an authoritative reference is required or when there is doubt about the interpretation of the text.

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**MEMBER STATES OF THE METRE CONVENTION AND  
ASSOCIATES OF THE GENERAL CONFERENCE**

as of 12 October 2001

**Member States of the Metre Convention**

Argentina	Korea (Dem. People's Rep. of)
Australia	Korea (Rep. of)
Austria	Malaysia
Belgium	Mexico
Brazil	Netherlands
Bulgaria	New Zealand
Cameroon	Norway
Canada	Pakistan
Chile	Poland
China	Portugal
Czech Republic	Romania
Denmark	Russian Federation
Dominican Republic	Singapore
Egypt	Slovakia
Finland	South Africa
France	Spain
Germany	Sweden
Greece	Switzerland
Hungary	Thailand
India	Turkey
Indonesia	United Kingdom
Iran (Islamic Rep. of)	United States
Ireland	Uruguay
Israel	Venezuela
Italy	Yugoslavia
Japan	

**Associates of the General Conference**

Cuba	Latvia
Ecuador	Lithuania
Hong Kong, China	Malta



## **THE BIPM AND THE METRE CONVENTION**

The International Bureau of Weights and Measures (BIPM) was set up by the Metre Convention signed in Paris on 20 May 1875 by seventeen States during the final session of the diplomatic Conference of the Metre. This Convention was amended in 1921.

The BIPM has its headquarters near Paris, in the grounds (43 520 m<sup>2</sup>) of the Pavillon de Breteuil (Parc de Saint-Cloud) placed at its disposal by the French Government; its upkeep is financed jointly by the Member States of the Metre Convention.

The task of the BIPM is to ensure worldwide unification of physical measurements; its function is thus to:

- establish fundamental standards and scales for the measurement of the principal physical quantities and maintain the international prototypes;
- carry out comparisons of national and international standards;
- ensure the coordination of corresponding measurement techniques;
- carry out and coordinate measurements of the fundamental physical constants relevant to these activities.

The BIPM operates under the exclusive supervision of the International Committee for Weights and Measures (CIPM) which itself comes under the authority of the General Conference on Weights and Measures (CGPM) and reports to it on the work accomplished by the BIPM.

Delegates from all Member States of the Metre Convention attend the General Conference which, at present, meets every four years. The function of these meetings is to:

- discuss and initiate the arrangements required to ensure the propagation and improvement of the International System of Units (SI), which is the modern form of the metric system;
- confirm the results of new fundamental metrological determinations and various scientific resolutions of international scope;
- take all major decisions concerning the finance, organization and development of the BIPM.

The CIPM has eighteen members each from a different State: at present, it meets every year. The officers of this committee present an annual report on the administrative and financial position of the BIPM to the Governments of

the Member States of the Metre Convention. The principal task of the CIPM is to ensure worldwide uniformity in units of measurement. It does this by direct action or by submitting proposals to the CGPM.

The activities of the BIPM, which in the beginning were limited to measurements of length and mass, and to metrological studies in relation to these quantities, have been extended to standards of measurement of electricity (1927), photometry and radiometry (1937), ionizing radiation (1960), time scales (1988) and to chemistry (2000). To this end the original laboratories, built in 1876-1878, were enlarged in 1929; new buildings were constructed in 1963-1964 for the ionizing radiation laboratories, in 1984 for the laser work and in 1988 for a library and offices. In 2001 a new building for the workshop, offices and meeting rooms was opened.

Some forty-five physicists and technicians work in the BIPM laboratories. They mainly conduct metrological research, international comparisons of realizations of units and calibrations of standards. An annual report, the *Director's Report on the Activity and Management of the International Bureau of Weights and Measures*, gives details of the work in progress.

Following the extension of the work entrusted to the BIPM in 1927, the CIPM has set up bodies, known as Consultative Committees, whose function is to provide it with information on matters that it refers to them for study and advice. These Consultative Committees, which may form temporary or permanent working groups to study special topics, are responsible for coordinating the international work carried out in their respective fields and for proposing recommendations to the CIPM concerning units.

The Consultative Committees have common regulations (*BIPM Proc.-Verb. Com. Int. Poids et Mesures*, 1963, **31**, 97). They meet at irregular intervals. The president of each Consultative Committee is designated by the CIPM and is normally a member of the CIPM. The members of the Consultative Committees are metrology laboratories and specialized institutes, agreed by the CIPM, which send delegates of their choice. In addition, there are individual members appointed by the CIPM, and a representative of the BIPM (Criteria for membership of Consultative Committees, *BIPM Proc.-Verb. Com. Int. Poids et Mesures*, 1996, **64**, 124). At present, there are ten such committees:

1. The Consultative Committee for Electricity and Magnetism (CCEM), new name given in 1997 to the Consultative Committee for Electricity (CCE) set up in 1927;

2. The Consultative Committee for Photometry and Radiometry (CCPR), new name given in 1971 to the Consultative Committee for Photometry (CCP) set up in 1933 (between 1930 and 1933 the CCE dealt with matters concerning photometry);
3. The Consultative Committee for Thermometry (CCT), set up in 1937;
4. The Consultative Committee for Length (CCL), new name given in 1997 to the Consultative Committee for the Definition of the Metre (CCDM), set up in 1952;
5. The Consultative Committee for Time and Frequency (CCTF), new name given in 1997 to the Consultative Committee for the Definition of the Second (CCDS) set up in 1956;
6. The Consultative Committee for Ionizing Radiation (CCRI), new name given in 1997 to the Consultative Committee for Standards of Ionizing Radiation (CCEMRI) set up in 1958 (in 1969 this committee established four sections: Section I (X- and  $\gamma$ -rays, electrons), Section II (Measurement of radionuclides), Section III (Neutron measurements), Section IV ( $\alpha$ -energy standards); in 1975 this last section was dissolved and Section II was made responsible for its field of activity);
7. The Consultative Committee for Units (CCU), set up in 1964 (this committee replaced the “Commission for the System of Units” set up by the CIPM in 1954);
8. The Consultative Committee for Mass and Related Quantities (CCM), set up in 1980;
9. The Consultative Committee for Amount of Substance (CCQM), set up in 1993;
10. The Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV), set up in 1999.

The proceedings of the General Conference, the CIPM and the Consultative Committees are published by the BIPM in the following series:

- *Report of the meeting of the General Conference on Weights and Measures;*
- *Report of the meeting of the International Committee for Weights and Measures;*
- *Reports of the meetings of Consultative Committees.*

The BIPM also publishes monographs on special metrological subjects and, under the title *The International System of Units (SI)*, a brochure, periodically updated, in which are collected all the decisions and recommendations concerning units.

The collection of the *Travaux et Mémoires du Bureau International des Poids et Mesures* (22 volumes published between 1881 and 1966) and the *Recueil de Travaux du Bureau International des Poids et Mesures* (11 volumes published between 1966 and 1988) ceased by a decision of the CIPM.

The scientific work of the BIPM is published in the open scientific literature and an annual list of publications appears in the *Director's Report on the Activity and Management of the International Bureau of Weights and Measures*.

Since 1965 *Metrologia*, an international journal published under the auspices of the CIPM, has printed articles dealing with scientific metrology, improvements in methods of measurement, work on standards and units, as well as reports concerning the activities, decisions and recommendations of the various bodies created under the Metre Convention.

## **CURRENT MEMBERS OF THE INTERNATIONAL COMMITTEE FOR WEIGHTS AND MEASURES**

as of 12 October 2001

### **President**

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on 1 January 2002

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Mrs D. Spelzini Etter, Mrs M.-J. Martin, Mrs D. Saillard\*\*\*

*Caretakers:* Mr and Mrs Dominguez, Mr and Mrs Neves

*Domestic help:* Mrs R. Prieto, Mrs R. Vara

*Gardeners:* Mr C. Dias-Nunes, Mr A. Zongo\*\*\*\*

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Mr E. Dominguez\*\*\*\*\*, Mr C. Neves\*\*\*\*\*

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\*\*\*\* Also Workshop.

\*\*\*\*\* Also caretaker.



**International Committee  
for Weights and Measures**

**Proceedings of the sessions  
of the 90th meeting**  
(10–12 October 2001)

## **Agenda**

1. Opening of the meeting; quorum; agenda.
2. Report of the Secretary and activities of the bureau of the CIPM (October 2000 – September 2001).
3. Membership of the CIPM.
4. Member States of the Metre Convention and Associates of the CGPM.
5. Administrative and financial affairs.
6. Consultative Committees and working groups.
7. The Mutual Recognition Arrangement.
8. New study of future needs for metrology.
9. OIML/Metre Convention Joint Working Group.
10. Contacts with other international organizations.
11. Joint Committee for Guides in Metrology.
12. Work of the BIPM.
13. Other business.
14. Date of next meeting.

## **1 OPENING OF THE MEETING; QUORUM; AGENDA**

The International Committee for Weights and Measures (CIPM) held its 90th meeting from Wednesday 10 October till Friday 12 October 2001 at the Pavillon de Breteuil at Sèvres.

Present: K.H. Brown, Chung Myung Sai, Gao Jie, E.O. Göbel, E.S.R. Gopal, F. Hengstberger, B. Inglis, L.K. Issaev, R. Kaarls, J. Kovalevsky, S. Leschiutta, G. Moscati, P. Pâquet, T.J. Quinn (Director of the BIPM), M. Tanaka, H. Ugur, J. Valdés, A.L. VanKoughnett and A.J. Wallard.

Also attending: P. Giacomo (Director emeritus of the BIPM); J. Lusztyk (Director of the NRC, Canada, present for part of the meeting), B. McGuinness (Director of the NPL, United Kingdom, present for part of the meeting), I.M. Mills (President of the CCU, present for part of the meeting), Mrs F. Joly and Dr J.R. Miles (secretariat).

Prof. Kovalevsky, President of the CIPM, opened the meeting by welcoming all present, and particularly the two new members, Drs Hengstberger and Tanaka. With all members present, the quorum was satisfied according to Article 12 of the Rules annexed to the Metre Convention.

On behalf of the CIPM and the BIPM he expressed his sincere sympathy to Dr K.H. Brown in the wake of the recent events in the United States.

The agenda for the meeting was adopted.

The President then invited the Secretary of the Committee, Dr R. Kaarls, to present his report.

## **2 REPORT OF THE SECRETARY AND ACTIVITIES OF THE BUREAU OF THE CIPM (October 2000 – September 2001)**

Note that all the important matters arising in the report of the Secretary are taken up later in the meeting and references to the later discussion are given.

The bureau of the CIPM met three times during the year: twice at the Pavillon de Breteuil and once in Japan in May 2001 on the occasion of the inauguration of the new National Metrology Institute of Japan (NMIJ).

### **2.1 Member States of the Metre Convention**

The number of Member States of the Metre Convention has increased to fifty-one by the adhesion of Greece, Malaysia and Yugoslavia. Following the decision of the CIPM in 1999 related to non-paying Member States, letters were written on 6 April 2000 to the Embassies in Paris of the Dominican Republic and the Islamic Republic of Iran informing them that they will be excluded from the Convention unless arrangements can be made for the payment of overdue contributions. No replies were received. In July 2001, letters were written again but transmitted through the French Foreign Minister directly to the Foreign Ministers of the two countries. At the time of the CIPM meeting no replies have been received to these final communications but subsequently correspondence has begun directly with the authorities of the Dominican Republic on how to resolve the problem.

### **2.2 Associates of the CGPM**

There are now six Associate States and Economies of the CGPM, namely Cuba, Ecuador, Hong Kong, Latvia, Lithuania, and Malta. Discussions are under way with a number of other countries with a view to their becoming Associates. So far, the directors of the national metrology institutes (NMIs) of all of the new Associates have signed the Mutual Recognition Arrangement.

### **2.3 Membership and officers of the International Committee**

At the last meeting of the CIPM, in October 2000, the Committee decided to leave unfilled one of the vacancies that had occurred during the previous year. A second vacancy resulted from the resignation on 30 June 2001 of Kozo Iizuka, Vice-President of the CIPM. Two elections have now been made; the new members are Mitsuru Tanaka from Japan and Franz Hengstberger from South Africa. Franz Hengstberger has dual South African and Austrian nationality and his election to the CIPM is taken to be in respect of his South African nationality. This follows the decision of the CIPM in 2000 on the matter of members having more than one nationality. The CIPM, therefore, does not consider that a future election of a member from Austria would in any way be affected by this election. One further resignation has been announced: that of Paul Pâquet, which takes effect just after the present meeting of the CIPM. There will thus be one vacancy on the Committee. Curricula vitae of various candidates will be presented.

The bureau continues to seek suitable candidates for membership of the CIPM and invites current members and other persons to submit the names and curricula vitae of suitable candidates to the Committee. The policy of the CIPM in relation to elections and details of how to apply for membership were presented at the 21st CGPM and are given on the BIPM web page.

The resignation of Kozo Iizuka means that the CIPM must consider the appointment of a new Vice-President of the CIPM. Roy VanKoughnett (Vice-President) informed the bureau that he intends to retire from the CIPM on 30 June 2002. The CIPM will thus have to consider the election of another Vice-President to replace him.

The President informed the bureau that in 2004 he will be resigning from the CIPM and that the Committee should consider candidates to succeed him. The bureau will make a proposal.

### **2.4 The Mutual Recognition Arrangement**

The bureau has been kept informed of progress in the implementation of the MRA, including the meetings of the Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB) and establishment of the BIPM key comparison database (KCDB). The CIPM will be informed of the results of the 7th meeting of the JCRB, which took place at the BIPM on 8 and 9 October 2001.

## **2.5 BIPM/OIML/ILAC discussions**

A meeting of the joint BIPM/OIML/ILAC discussion group took place at the BIPM on 21 February 2001. The principal activities proposed for joint action by the three organizations were the following:

### **2.5.1 Model law on metrology and the concept of traceability of measurements**

It was agreed that Mr Magaña, the new Director of the BIPM, will convene a working group comprising representatives of the three organizations to take forward a draft law on metrology and a definition of the concept of traceability of measurements.

### **2.5.2 A second symposium on the role of metrology in economic and social development**

Following the success of the meeting entitled “The role of metrology in economic and social development”, held at, and largely organized by, the PTB in June 1998, further discussions have been held with the NIST and it has been agreed that the NIST will organize a second such symposium in 2002, in collaboration with the PTB, the BIPM, ILAC, IMEKO and the OIML. The contact person at the NIST is Dr Carpenter.

### **2.5.3 ISO matters concerning metrology**

Drs Kaarls and Quinn will report back on their recent visits to the ISO and the IEC to discuss the question of high-level contacts between the metrology organizations and the ISO/IEC.

## **2.6 CIPM/ILAC Memorandum of Understanding (MOU)**

A draft MOU between the CIPM and ILAC has been proposed to the ILAC and is due to be discussed by the ILAC Executive. A copy of the latest version of the draft will be presented to the CIPM and the latest situation will be discussed. It is the opinion of the bureau that the existence of such an MOU will be advantageous in demonstrating to the outside world that the two organizations are working in close cooperation.

## **2.7 Agreement between the CIPM and the World Meteorological Organization (WMO)**

Resolution 4 of the 21st CGPM urged agencies responsible for climate and other studies of Earth resources to ensure that SI units are used in collecting data. The WMO is the most important world body in this field. In December 2000 the Director of the BIPM visited the headquarters of the WMO in Geneva and invited the Secretary General to consider possible links between the NMIs and the WMO data centres to facilitate the proper use of SI units in world weather and climate data. He received a very positive response and the WMO has suggested that a formal Agreement be signed between the CIPM and the WMO. A draft of such an Agreement is to be put to the CIPM for approval and it is hoped that both the CIPM and the WMO can accept the terms before the end of 2001. The principal consequence of the Agreement is that there will be reciprocal representation on the relevant technical committees of the two organizations, as well as close scientific contact between the WMO data centres and appropriate NMIs. In the case of the CIPM, WMO representation will be invited on the CCQM and its working group on gas metrology.

The bureau considers this to be an important initiative and is pleased that its approach received such an immediate and warm welcome.

## **2.8 ISO 17011**

Towards the end of 2000, the Director was informed that a draft of ISO 17011 contained clauses concerning the independence of calibration and accreditation activities that appeared to impinge on the responsibilities of the NMIs. In consultation with the Secretary, he immediately contacted the Secretary-General of the ISO and asked for these clauses to be reconsidered. At the same time he asked NMIs to write to their local ISO-member standards bodies to express their anxiety. As a result, the ISO has reconsidered the points at issue and the Director and Secretary of the CIPM visited Geneva and met with the Secretary-Generals of the ISO and the IEC as well as with the Chairmen of ISO CASCO and the ISO CASCO Working Group that drafted the text. The whole question is now under review and the position of the NMIs is being taken into account.

Following these discussions in Geneva, the BIPM was invited to apply for category A liaison status on ISO CASCO to ensure that, in the future, draft texts will be seen before they reach the advanced stage of the one that caused

these difficulties. The application has been made and has now been accepted by the member organizations of the ISO.

## **2.9 Traceability in laboratory medicine**

The European Directive on *in vitro* diagnostics is having an important effect on the medical instrumentation industry. From 2003 this Directive will require all instrumentation used in the EU to be calibrated against appropriate standards. The NMIs should be encouraged to work with the appropriate bodies to ensure that the standards used are traceable to the SI. The NIST has already organized an international meeting with industries, NMI regulators and other stakeholders, and it is clear that action is required on a world level. In collaboration with the IFCC, the IRMM and the CCQM, two meetings have taken place to discuss how best to proceed. The first of these took place at the BIPM at the initiative of the Director, and the second at the IRMM. It is planned to hold another international meeting at the BIPM on 19 November 2001 with a view to organizing a symposium in 2002 to which representatives of NMIs, regulatory agencies, the EU, medical instrument manufacturers, accreditors and others will be invited. The aim is to put in place a worldwide structure to ensure appropriate links of calibration of medical instrumentation to the SI through the NMIs, possibly through a joint committee of the BIPM and the IFCC. This is a major initiative and not one whose success is assured. The Director of the BIPM, accompanied by the Secretary and Prof. A. Wallard, visited the National Institute for Biological Standards and Control in London (the principal reference laboratory for the World Health Organization, WHO) for discussions on the possible involvement of the WHO in this joint committee.

## **2.10 World Trade Organization**

No progress has been made in our attempt to obtain Observer status in the World Trade Organization (WTO) Committee for Technical Barriers to Trade (TBT Committee). It appears that certain member states of the TBT Committee are refusing to accept any changes to the list of Observers as a negotiating tactic in a dispute concerning matters quite unrelated to membership of the Committee. This is a political matter upon which we have no influence.



### **2.11 Follow-up study of the CIPM report on national and international needs for metrology**

The Secretary is preparing a draft of a follow-up study to the 1998 CIPM report on national and international needs for metrology. This includes a study on the economic benefits of metrology. He sent a questionnaire to directors of NMIs and the replies have been distributed to members of the CIPM. The elements of a first draft of the new Report will be presented to the CIPM at this meeting. As regards the study of economic benefits of metrology, he has brought together a small working group made up of Messrs Hengstberger, Lusztyk, McGuinness, Ono and Semerjian. He has held discussions with some of the members of the working group as well as with a few people from the Department of Trade and Industry (United Kingdom), KPMG (Canada) and the NIST, involved in studies carried out in these countries. The preliminary results of this study will be presented to the CIPM.

### **2.12 Meeting of directors of NMIs in 2002**

The bureau has fixed the dates for a two-day meeting of directors of NMIs, to be held at the BIPM on 22-23 April 2002. The first day will be devoted to discussion of the draft text of the new report on needs for metrology and the results of the study of economic benefits of metrology, and the second day will be devoted to a discussion of future work of the BIPM.

### **2.13 Preparation for the 22nd CGPM**

The Director has had preliminary discussions with officials of the French Ministère des Affaires étrangères in preparation for the 22nd CGPM. The date has been fixed for the week beginning 13 October 2003. All the usual arrangements have been agreed and the Conference will take place at the newly refurbished International Conference Centre in the Avenue Kléber in Paris.

### **2.14 The Avogadro project**

The bureau considered a suggestion by Dr Inglis that the CIPM organize a worldwide coordinated project for advancing the work on the determination of the Avogadro constant using the silicon crystal method. The bureau is

much in favour of a discussion at the CIPM on this and Dr Inglis will make such a proposal.

## **2.15 BIPM affairs**

### **2.15.1 The Pavillon du Mail**

The new building known as the Pavillon du Mail was ready in time for the meeting of the CCQM in April 2001. Final finishing of the surroundings followed during the summer and the approach to the entrance is expected to be ready in time for the formal inauguration on Thursday 11 October 2001. The final cost remains that approved by the Committee at its meeting in October 2000, namely 20 210 000 FRF (3 080 995 euros). The mechanical workshop was moved to the new building in June and the offices were occupied in July. The new meeting room, which has already been used for meetings of the CCQM, CCPR, CCRI, CCTF, CCT, CCL, CCAUV and a large working group of the CCEM, has proved very satisfactory.

### **2.15.2 Recruitment to the Chemistry Section and preparation of the laboratories**

One new chemist was recruited in July 2001 and interviews for a second position took place in September. The laboratories were completed in July and the installation of equipment is now under way.

### **2.15.3 Replacement of J.-M. Chartier as head of the Length Section**

Mr J.-M. Chartier will retire from his post as head of the Length Section in February 2002. In view of the changes now taking place in the technology of laser length measurement, the Director has preferred not to make a new permanent appointment for the time being but instead has invited Prof. A. Wallard to take this post on a temporary basis when he arrives in March 2002.

### **2.15.4 New section for Information Technology and Quality Systems**

The Director has created a new section for Information Technology (IT) and Quality Systems, appointing R. Köhler as head of this new section. The new head of the Radiometry and Photometry Section is M. Stock. These changes took effect from 1 September 2001.

#### 2.15.5 Electronic distribution of Consultative Committee documents

The Director has decided that Consultative Committee (CC) documents will henceforth be distributed only through the BIPM website with password entry. This new system has operated since July 2001 and has been welcomed by delegates to CCs. In the new meeting room, provision has been made for connecting the laptop PCs of delegates to the internet to allow them access to their documents. Considerable quantities of paper are saved by this new system and rapid access is given to CC documents.

#### 2.15.6 BIPM summer school on metrology in 2003

The Director proposed that the BIPM consider organizing a summer school on metrology at the BIPM in 2003. The target audience would be younger members of NMIs and the subject matter would cover several areas of metrology. He made this proposal with the experience of having been co-director of the 2000 Varenna school, which was a great success. He is exploring the possibility of attracting a number of high-level lecturers.

#### 2.15.7 Future plans for scientific work

The Director has proposed a number of new projects, or extensions of present projects, that should be considered for future scientific work at the BIPM. These include a watt-balance experiment, femtosecond laser technology (already in progress), a calculable capacitor, and a transportable clock, either microwave or optical, for comparison of primary frequency standards. All of these are projects that have been or will be discussed at meetings of the Consultative Committees.

#### 2.15.8 BIPM pension fund

An actuarial study of the BIPM pension fund has been carried out and the results will be presented to the Committee.

## 2.16 Financial report

The table below shows the situation of the assets of the BIPM, in gold francs, on 1 January of the year noted at the head of each column.

	Account	1998	1999	2000	2001
I.	Ordinary funds	23 990 225.29	18 494 175.33	22 742 765.80	22 405 342.14
II.	Pension fund	26 652 840.07	27 359 350.60	29 090 575.69	34 377 371.96
III.	Special fund for the improvement of scientific equipment	115 883.76	114 069.27	117 905.96	0.00
IV.	Staff loan fund	554 508.01	591 451.46	628 931.99	671 397.91
V.	Building reserve fund	5 635 646.30	9 383 731.19	10 051 645.90	4 397 363.20
VII.	Medical insurance reserve fund	1 918 336.70	1 966 053.11	2 113 650.36	2 259 683.71
	Total	58 867 440.13	57 908 830.96	64 745 475.70	61 111 158.92

## 3 MEMBERSHIP OF THE CIPM

### 3.1 Elections

Prof. Kovalevsky reminded the Committee of the forthcoming vacancies on the CIPM. Prof. Pâquet's resignation takes effect at the end of the present meeting. Dr VanKoughnett will resign in June 2002, and Prof. Wallard will be resigning before taking up the position of Director Designate at the BIPM in March 2002.

As regards the bureau of the CIPM, a vacancy for a Vice-President had been left by the departure of Dr Iizuka; in 2002 a second vacancy for a Vice-President will be left by the resignation of Dr VanKoughnett, and the President has announced his own intention to resign in 2004. He said that the bureau had already discussed his replacement as President and had

approached Prof. Göbel, who accepted in principle. Prof. Göbel's candidature was briefly discussed by the Committee and the election of the next President will be put to the vote next year.

Concerning the current vacancy for a Vice-President, Prof. Kovalevsky presented two candidates for the position: Dr Gopal and Prof. Moscati. After a brief presentation by both members and a lengthy discussion by the CIPM, Prof. Moscati was elected by secret ballot.

### 3.2 Possible future candidates

The CIPM proceeded to its confidential discussion on possible future candidates.

Dr Quinn reminded the Committee of the document previously discussed by the CIPM and presented to the 20th CGPM, summarizing the membership of the CIPM in terms of the geographical distribution and financial contributions of the Member States. He presented an updated version of the table attached to the afore-mentioned document, to illustrate the current position. (Note: the figures given in this Table are approximate and for indication only.)

A	B	C	D	E
RMO	No. of Member States	Dotation (% of total)	No. of CIPM members (% of total)	Dotation of member States having a CIPM member (% of total)
EUROMET (Europe)	23	54%	5 (29 %)	53 %
COOMET	1 (?)	1.7%	1 (6 %)	2.2 %
SIM	8	21 %	4 (23 %)	18 %
NORAMET	3	15 %	2 (11 %)	14 %
SURAMET	5	5 %	2 (11 %)	4 %
SADCMET	1	0.6 %	1	0.5 %
MENAMET	3 (?)	1.7 %	1 (6 %)	0.66 %

He noted that the current geographical distribution of CIPM members represents fairly closely the financial contributions from the various regional metrology organizations (RMOs). The previous absence of members from Africa had been rectified by the presence of Dr Hengstberger. It was

generally agreed that this geographical distribution should continue to be respected as far as possible.

Prof. Kovalevsky reminded the Committee that by tradition there are members of the CIPM from France, as host nation of the Metre Convention, and from all Member States paying at the maximum level of contribution (9.84 %). This applies to Germany, Japan and the United States. During the recent decades, the aim of the CIPM has been to have almost continuously a member from each country that pays over 2 % of the dotation. These countries are: Australia, Brazil, Canada, China, Italy, the Republic of Korea, the Netherlands, Spain and the United Kingdom. However, various other considerations have prevented this from being fully implemented (geographic distribution, necessary presence of smaller countries, etc.). At present, among these countries, it is only from Spain that there is no member on the CIPM.

Prof. Kovalevsky encouraged members to continue to seek and suggest scientists of high standing as candidates for future membership of the CIPM, particularly with a view to including members from developing countries.

### **3.3 Election of Honorary Members**

The CIPM unanimously approved the suggestion that Dr Iizuka be elected Honorary Member of the CIPM. Dr Iizuka resigned from the CIPM in June 2001 after seventeen years' membership of the CIPM, having served as Vice-President since 1997.

## **4 MEMBER STATES OF THE METRE CONVENTION AND ASSOCIATES OF THE CGPM**

The impact of possible new Member States on the BIPM budget was discussed. Dr Quinn said that in 2002 the total contribution of the three new Members and the six Associates of the CGPM would be 2.5 % of the budget, a significant sum. Note that it is difficult to predict which other States, if any, might join in 2002.

It was agreed that the report being prepared by Dr Kaarls should consider the advantages offered to a country joining the Metre Convention or becoming

an Associate of the CGPM. The primary obstacle to becoming either a Member of the Convention or an Associate of the CGPM remains the level of funding required.

## **5 ADMINISTRATIVE AND FINANCIAL AFFAIRS**

Mrs B. Perent, Administrator of the BIPM, was invited to join the CIPM for the discussions on administrative and financial matters.

### **5.1 *Rapport aux Gouvernements* for 2001; *quietus* for 2000**

Dr Quinn confirmed that the annual *Rapport annuel aux Gouvernements des Hautes parties contractantes sur la situation administrative et financière du Bureau International des Poids et Mesures en 2000* had been distributed in March 2001, and the CIPM duly approved the accounts for 2000. The required formal discharge was given to the Director and administrator of the BIPM.

### **5.2 Progress report on the 2001 exercise**

Dr Quinn presented a summary of the BIPM's accounts for 2001, noting that staff costs were somewhat lower than expected because recruitments to the Chemistry Section had been delayed, and that the most significant laboratory expenses were related to the purchase of a new  $^{60}\text{Co}$  source for the Ionizing Radiation Section and to the development of a frequency comb in the Length Section. Although overall the expenses are approximately as predicted, they exceed at present the level of income because Italy has not yet paid its contributions to the BIPM for 1999, 2000 and 2001. Dr Quinn told the Committee he was confident that the Italian debt, of about 2 million euros in total, would be paid before the end of the year, and noted that, in the alternative case, Italy risked being excluded from Metre Convention activities in 2002.

### **5.3 Budget for 2002**

Dr Quinn presented the proposed budget for 2002, projecting a 4 % deficit that will reduce the BIPM's reserves. He reminded the Committee that the reserves have also been used to pay for the chemistry programme, and that the plan is to reduce them to the level of 40 % of the budget. This action is being taken in response to earlier criticisms that the level of the reserves was too high. Prof. Kovalevsky noted that if Italy paid its outstanding contributions, then the level of the reserves would in fact increase.

A number of members expressed concern that the BIPM was operating at a deficit, relying on a substantial increase in funding at the occasion of the next CGPM in order to maintain its present level of activity. It was agreed that next year two alternative budgets should be presented to the Committee: one showing the increase in budget needed in order to maintain equilibrium, and the other showing the reduction in activity that must result if the budget were kept constant in real terms.

After discussion, the CIPM approved the proposed budget for 2002, which follows the programme of work approved at the 21st General Conference.

### **5.4 Final report on the construction of the Pavillon du Mail**

Dr Quinn expressed his particular thanks to Mrs B. Perent and Mr J. Sanjaime (head of the BIPM workshop) for their contributions to the Pavillon du Mail project. He reminded the Committee that the new meeting room would be used the next day for the staff presentations to the CIPM.

The official inauguration was carried out by Prof. Kovalevsky during the evening of 11 October 2001.



## Budget for 2002

### Income

	euros
<i>Budgetary income:</i>	
1. Contributions from the States	9 003 376
2. Interest on capital	326 000
3. Miscellaneous income	43 200
4. Subscriptions from the Associates	82 074
5. <i>Metrologia</i>	190 000
<b>Total</b>	<b>9 644 650</b>

### Expenditure

<i>A. Staff expenses:</i>		
1. Salaries	4 180 000	} 5 565 100
2. Family and social allowances	928 600	
3. Social expenses	456 500	
<i>B. Contribution to the pension fund:</i>		1 315 000
<i>C. Operating expenses:</i>		
1. Heating, water, electrical energy	169 900	} 1 039 800
2. Insurance	31 200	
3. Publications	168 500	
4. Office expenses	124 200	
5. Meeting expenses	41 000	
6. Travel expenses and freight charges	328 000	
7. Library	144 000	
8. Bureau of the CIPM	33 000	
<i>C. Laboratories:</i>		1 612 000
<i>D. Buildings (major maintenance and renovation):</i>		489 600
<i>E. Miscellaneous and unforeseen expenses:</i>		60 000
<b>Total</b>		<b>10 081 500</b>

## 5.5 BIPM staff

The CIPM unanimously approved the promotion of Dr P.J. Allisy-Roberts, head of the Ionizing Radiation Section, to *Physicien Chercheur Principal*, and of Dr M. Stock, head of the Photometry and Radiometry Section, to *Physicien Principal*. These promotions will take effect as from 1 January 2002.

A new category of post was also created: that of *Senior Research Fellow*. The first Fellow to hold such a post will be Dr Long-Sheng Ma, currently a *Research Fellow* in the BIPM Length Section. The CIPM encouraged the Director to attract other high-level candidates to the BIPM to take up Senior Research Fellowships in other fields.

Mr Jean-Marie Chartier, head of the Length Section, who will be retiring from the BIPM in February 2002, was warmly thanked for all his work at the BIPM, and the prestige he has brought over the years to the BIPM's Length Section. Mr Chartier joined the BIPM as a *calculateur* at the age of fourteen, and continued education through evening classes while at the BIPM to achieve a Dipl. Eng. from the Conservatoire National des Arts et Métiers (CNAM) in 1970. Prof. Kovalevsky congratulated him on his exceptional career and said that Mr Chartier's name was well known throughout the world in all the national metrology institutes. Dr Quinn thanked him for being an exemplary head of section, sentiments applauded by the Committee.

## 5.6 BIPM pension fund

Dr Quinn presented the results of an actuarial study of the BIPM pension fund. A previous study had been carried out in 1994. Since 1994 the average age of retirement has decreased from the previously assumed sixty-five years to an average of about sixty-two years. The new study shows that the pension fund may run into problems in about forty years' time. Dr Quinn proposed that, in order to avoid these long-term difficulties, half of the repayment of Italy's outstanding contributions (i.e. about 1 million euros), should be paid immediately into the pension fund. Prof. Kovalevsky agreed with this proposal. If Italy's repayment has not arrived, the CIPM will consider taking this sum from the BIPM reserves and injecting it into the pension fund. (Note: A sum of 1.3 million euros was received from Italy at the BIPM in December 2001 and thus the transfer of 1 million euros to the pension fund was made).

Dr Quinn reported that Mrs Perent had attended a meeting of pension advisers of the coordinated organizations, and that this had been very useful. The CIPM decided at its 89th meeting to move about 25 % of the BIPM's pension fund from secure bonds to the stock market, and Dr Quinn confirmed that this policy was being followed and suggested that the percentage of funds in the stock market could gradually be increased. He recommended that a third actuarial study of the pension funds be undertaken in about ten years' time.

In conclusion, the Committee agreed that the policy adopted in 1994 to increase the annual budgetary contribution by 1 % per year up to 2008 should continue and that 1 million euros should be transferred to the fund.

## 6 CONSULTATIVE COMMITTEES AND WORKING GROUPS

### 6.1 Consultative Committee for Units

Prof. I.M. Mills, President of the Consultative Committee for Units (CCU), presented a summary of the 14th meeting of the CCU, held at the BIPM on 19 and 20 April 2001, for which the full report is in preparation. He highlighted in particular the following two topics, there not being sufficient time to discuss a third proposed subject, concerning possible names and symbols for the unit one.

#### 6.1.1 Proposal to adopt the neper as an SI unit

Prof. Mills renewed the CCU's recommendation to the CIPM to adopt the neper as the SI unit for logarithmic decay (Recommendation U 1 (2001)) and summarized the contents of a paper written by three members of the CCU, entitled "The radian, the neper, the bel and the decibel" (see Mills I.M., Taylor B.N., Thor A.J., *Metrologia*, 2001, **38**(4), 353-361). He asked that the revised Recommendation (a slightly reworded version of the draft resolution presented to the 21st CGPM in 1999) be presented to the CGPM again in 2003, and suggested that a copy of the article in *Metrologia* accompany the recommendation, by way of explanation.

Although some members still expressed concern, it was generally agreed that the addition of the neper would be a logical step, although probably without much practical impact. After brief discussion, and slight rewording of the first point under "considering", Recommendation U 1 (2001) was adopted by the CIPM as Recommendation 1 (CI-2001) with one vote against and one abstention (see page 153).

### 6.1.2 Different meanings of the names “SI unit” and “unit of the SI”

Prof. Mills then presented the results of the CCU’s discussion on the names “SI unit” and “unit of the SI”. He explained that, owing to historical reasons, but contrary to the rules of English grammar, these two terms currently mean different things. As specified in Section 1.2 of the 7th edition of the SI Brochure (p. 14 in the French text and p. 92 in the English text), it is recommended that the name “SI unit” be used only for the base units and coherent derived units of the SI, excluding any multiple or sub-multiple. In contrast, as specified at the 10th meeting of the CCU held in 1990, the more general name “units of the SI” should be used when it is desired to refer to all SI units, i.e. the coherent SI units as well as their multiples and sub-multiples obtained by combination with the SI prefixes.

In response to a number of requests, particularly from teachers of physics, the CCU approved the following:

“We suggest that “SI units” and “units of the SI” should be regarded as names that include both the base units and the coherent derived units, and also all units obtained by combining these with the recommended multiple and sub-multiple prefixes.

We suggest that the name “coherent SI units” should be used when it is desired to restrict the meaning to only the base units and the coherent derived units.”

Prof. Mills noted that this would call for minor changes in the wording of the next edition of the SI Brochure, and also in the *International Vocabulary of Basic and General Terms in Metrology* (the VIM). He listed various examples, and gave the CCU’s proposed wording in each case.

The CIPM welcomed the suggestion to clarify the language used. Dr Quinn drew attention to the importance of the CCU in this area, and asked members to nominate bright young scientists at their institutes to participate in the CCU.

## 6.2 Consultative Committee for Amount of Substance

Dr Kaarls, President of the Consultative Committee for Amount of Substance (CCQM), then gave a report on the 7th meeting of the CCQM, held at the BIPM from 4-6 April 2001. This was the first meeting to be held in the new Pavillon du Mail.

### 6.2.1 Progress in the implementation of the MRA

The CCQM discussed improvements to the format for entering calibration and measurement capabilities (CMCs) for chemistry into Appendix C of the MRA. It was noted that critical review of these CMCs by the NMIs is essential, since not every claim can be underpinned by a key comparison.

Criteria were also approved for the acceptance of certified reference materials (CRMs) into Appendix C. Among other issues, these criteria stipulate that the listed CRMs must be directly related to the claimed technical capabilities of the NMI concerned. They exclude those CRMs having values assigned through interlaboratory comparisons between non-NMIs.

The CCQM working group chairs together with the RMO contact persons for metrology in chemistry will organize meetings of groups of experts in order to harmonize the input to Appendix C. CMC claims for gas mixtures have already been included in Appendix C, and claims for other areas of chemical measurements are currently under review.

So far about forty-three pilot studies and thirty-three key comparisons have been carried out, are under way, or have been proposed for action in the near future.

It is now clear that, in relation to CMCs, the Consultative Committees, particularly through their key comparison working groups, play an important coordinating role among the RMOs. At some time in the future this should be formalized.

### 6.2.2 CCQM working groups

The CCQM operates mainly through its working groups, of which there are now seven. All have met since the 6th meeting of the CCQM, and each group presented a report on its studies and key comparisons, along with proposals for future work.

Two new groups are the CCQM Working Group on Bioanalysis, chaired by the LGC/NIST, and an *ad hoc* Working Group on Surface Analysis, chaired by the NPL. The former will study work on proteomics and genomics, and the latter concerns chemical-specific measurements of the number of atoms/molecules on a surface, using advanced spectroscopic techniques. Some aspects of the work of this group may be of interest to the CCL and also to the CCM.

### 6.2.3 Reference materials

There is growing awareness that sources of primary pure reference materials are essential as the practical basis for the preparation of traceable certified reference materials, and the CCQM discussed the question of a world centre for primary pure reference materials. This subject will require further discussion and may lead to proposals for future work on purity analysis to be carried out by the Chemistry Section at the BIPM.

### 6.2.4 International cooperation and contacts

Much of the work carried out under the CCQM is of direct importance to other international, national and regional organizations. The Director of the BIPM and the President of the CCQM have established contacts with the IFCC (already a formal member of the CCQM) and, together with Prof. Wallard, with the National Institute for Biological Standards and Control in the UK (the WHO reference laboratory for biological standards). It is intended to create a new Joint Committee on Traceability in Laboratory Medicine, including representatives from these three organizations.

Formal cooperation between the WMO and the CIPM/BIPM is also strongly welcomed by the CCQM. In particular, the CCQM WG on Gas Analysis is now creating a programme of cooperation with experts from the WMO.

In the near future the CCQM plans to start discussions with the authorities and reference laboratories in food testing. Further discussions will also take place with the ISO REMCO with respect to the qualification of CRMs.

### 6.2.5 Future directions

The work to be carried out by the CCQM covers an enormously wide field, and the priorities are determined mainly by the direct needs of trade, industry, regulators and society (principally in the areas of environmental, health care, and food safety measurements).

Many NMIs are not at all equipped to address all the problems and types of measurements in metrology in chemistry. Inasmuch as many of the problems have to be addressed urgently, it is strongly recommended that the NMIs designate other national chemical analysis laboratories where appropriate as the NMI for certain chemical quantities and measurement ranges. The NMIs are also encouraged to cooperate and share work on the regional level.

It has been agreed that at the time of their next meeting the CCQM will hold another workshop on the dissemination of traceability in measurements in chemistry as realized or desired in the different countries/economies and disciplines (environment/clinical/food).

The chairs of the CCQM working groups met with the CCQM President and the Director of the BIPM in December 2000, March 2001 and April 2001 with the aim of preparing, harmonizing and coordinating the work of the CCQM. Whenever possible and appropriate, it is proposed that the relevant RMO working group chairs also be invited to attend future meetings in order to facilitate discussion and keep information lines as short as possible.

#### 6.2.6 Proposal to add “metrology in chemistry” as a subtitle

In response to a request from the CCQM to modify its title to reflect more closely the subject area of interest, the CIPM agreed to rename it “Consultative Committee for Amount of Substance – Metrology in Chemistry” keeping the acronym CCQM.

### 6.3 Consultative Committee for Photometry and Radiometry

Prof. Wallard, President of the Consultative Committee for Photometry and Radiometry (CCPR), gave a report on the 16th meeting of the CCPR, held at the BIPM in April 2001.

#### 6.3.1 Present and future directions

In addition to its traditional work in characterizing filters and detectors (particularly trap detectors and fast-response detectors), the field of interest of the CCPR is expanding to reflect new areas of activity in its member laboratories, including facilities for the measurement of appearance (gloss, etc.), and applications in medicine, space and more applied areas such as laser power measurement and fibre optics. Other priorities for improved standards lie in the ultraviolet and infrared regions, and many NMIs are developing and extending their capabilities to cater for needs in these regions. The CCPR will respond to stated needs and requests for its input. The CCPR Key Comparisons Working Group will meet to discuss requirements for activity and possible comparisons in more applied areas at the occasion of the next NEWRAD conference (May 2002).

More and more NMIs are using cryogenic radiometers and are developing confidence in detector-based scales and measurement systems. Work between the CCPR and the CCT has now resumed on a comparison of filter radiometers that will indicate the temperature range within which absolute radiometry can provide better accuracy than the International Temperature Scale of 1990 (ITS-90). The group will also consider the need for a best-practice guide on filter radiometric temperature measurement.

The CCPR agreed that there was a need for the BIPM to maintain its research interests and capabilities in detector characteristics and also to offer calibrations against scales and quantities for which it has a unique and agreed responsibility.

Prof. Wallard welcomed collaboration between the World Meteorological Organization (WMO) and the BIPM, and said that the WMO was now a member of the CCPR.

#### 6.3.2 Air-UV radiometry

The air-uv group led by Prof. Wende of the PTB produced several important recommendations for future work, which were accepted by the CCPR. The CCPR agreed to extend the terms of reference of the group to cover work at wavelengths less than 200 nm, and the group will meet again at the time of the next NEWRAD conference. The postponement of the latter from October 2001 to May 2002 will slow down some of the projects, but these will pick up again after NEWRAD'2002.

#### 6.3.3 Key comparisons and recommendation on photometric standards of the BIPM

The CCPR key comparisons are under way, largely following their planned timescales. Where additional NMIs, not originally declared as participants, express an interest in participating in a key comparison, the CCPR has decided to include them in the comparisons if possible, but not to include their results in the key comparison reference value or the official report.

The CCPR has adopted a pragmatic approach to analysing key comparison results where there are spectrally and power-varying measurements: spectral data are treated separately, to yield a key comparison reference value and uncertainty at each wavelength used in the comparison. It welcomes, however, collaboration with a new working group created by the Director of



the BIPM, charged with studying the mathematical and statistical processing of key comparison data.

The implications of the results of the key comparisons CCPR-K3.a and -K4 (in luminous intensity and luminous flux) were considered. These results provided world means that were 0.30 % and 0.36 %, respectively, lower than the results of the last comparison in 1985, which had provided the basis for the scale maintained and disseminated by the BIPM. The discussions resulted in Recommendation P 1 (2001), on photometric standards of the BIPM, which Prof. Wallard presented to the CIPM with the proposal to align the BIPM scales with the CCPR-K3.a and -K4 reference values. After a brief discussion on the robustness of the CCPR-K3.a and -K4 reference values, the CIPM approved the CCPR's recommendation and agreed that the BIPM will make the appropriate changes. Dr Quinn confirmed that the BIPM would modify its calibration certificates accordingly.

#### 6.3.4 Personnel

On the occasion of his retirement from the NML, the CCPR expressed its gratitude to Dr Gardner of the NML CSIRO for his careful work as Rapporteur for the CCPR and for his wise advice over many years.

The CCPR also thanked Dr Köhler for his work with them, and congratulated Dr Stock on his appointment as head of the BIPM Photometry and Radiometry Section.

### 6.4 Consultative Committee for Ionizing Radiation

Prof. Moscati, President of the Consultative Committee for Ionizing Radiation (CCRI), presented the following report on the 17th meeting of the CCRI, held at the BIPM in May 2001.

The CCRI profited from the new system of distributing working documents from the BIPM website, and a total of eighty-six documents were discussed. New chairmen were elected for Sections I and III: these are Dr P. Sharpe (NPL) and Dr H. Klein (PTB), respectively. Dr B.R.S. Simpson (CSIR-NML) continues as Chairman of Section II. Points of common interest between the three Sections included the format of results for the KCDB, the submission of CMCs, and the procedures for regional comparisons. The Committee also discussed the future programme of the BIPM's Ionizing Radiation Section.

Prof. Moscati detailed the various activities of the three Sections of the CCRI, which reviewed the results of a large number of key comparisons and compiled a significant amount of data for the KCDB. Section I, which already includes the International Commission on Radiation Units and Measurements (ICRU) and the International Atomic Energy Agency (IAEA) as official observers, also plans to establish formal liaisons with the International Organization for Medical Physics (IOMP) and the International Radiation Protection Association (IRPA). In Section II a review of high-efficiency detection systems is under way, and it is hoped that a prototype stable ionization chamber to realize the becquerel at the basic level will particularly help smaller NMIs.

The CCRI also made two proposals to the CIPM: one concerning the transport of radioactive samples, and the other regarding the recruitment of a new member of staff in the Ionizing Radiation Section of the BIPM.

The CCRI has noted the increasingly restrictive regulations in place for international transport of even small amounts of radionuclide activity. The CCRI(II) is concerned that these regulations are in turn restricting the ability of NMIs to compare their activity measurements, although such comparisons are needed to provide the SI traceability necessary to ensure that the regulations can be observed. Initial discussions have taken place with those involved with transport regulations at the IAEA to identify the areas of difficulty with national legislation. The discussions have already resulted in some clarification of the issues. If the problem cannot be resolved, however, it might be helpful for the CIPM also to participate in the discussion.

Secondly, the IAEA is being encouraged to support a position at the BIPM, and the Director has also agreed to support a temporary Research Fellow. This is in response to the considerable increase in the workload of the Ionizing Radiation Section, particularly in running BIPM and CIPM comparisons, as well as in calibrating secondary standards for many NMIs. The BIPM staff are also charged with producing the comparison reports, including the draft A and B reports, and preparing data for the KCDB. To alleviate these problems, and support also the new areas of work and comparisons that have been proposed, the CCRI encourages the recruitment of an additional permanent member of staff.

Prof. Göbel asked about the status of neutron metrology. Prof. Moscati said that the field was of importance for nuclear reactors rather than medical care, and that fewer organizations participate in it. However, immediate needs are being satisfied by the small number of large institutions involved, namely the

NIST, the NPL and the PTB. He commented that the recent comparison held at the PTB was much appreciated.

Prof. Wallard asked why all the draft A and draft B reports were being produced at the BIPM. Dr Quinn explained that the BIPM has acted as pilot laboratory for most of the comparisons carried out to date. Prof. Moscati added that most of the data are also analysed at the BIPM, which runs key Monte Carlo calculations for a number of comparisons. This contributes to the delays that have been incurred in the preparation of reference values for the KCDB. A significant effort is being made to finish them and enter a large number of values into the KCDB before the end of 2001. It is hoped that this task will be completed by the end of 2002.

## **6.5 Consultative Committee for Time and Frequency**

Prof. Leschiutta, President of the Consultative Committee for Time and Frequency (CCTF), presented a report on the 15th meeting of the CCTF, held at the BIPM on 20 and 21 June 2001.

More than forty working documents were presented and discussed.

### **6.5.1 Primary frequency standards and link with the length community**

Two caesium fountains were reported to be in operation, with another three nearly ready or under evaluation, seven in an advanced stage of construction and a couple more being designed. The success of this new type of frequency standard should not divert efforts from thermal beams with optical state selection or other atoms trapped in a variety of ways. New approaches were reported for the hydrogen maser, which is used as a local oscillator for the fountains.

Another recent development is the femtosecond-comb frequency system, which enables measurement of the absolute frequency of optical radiation. This advance calls for closer links between the length and time communities. Such links were discussed, and Recommendation CCTF 1 (2001), concerning secondary representations of the second, was presented to the CIPM, pending further discussions within the CCL and the CCTF.

### **6.5.2 International Atomic Time (TAI): status and developments**

The Recommendations adopted at the 14th meeting of the CCTF (1999) are being implemented: the calculations at the BIPM Time Section are being

automated and the stability of TAI on a monthly basis is now about 6 parts in  $10^{16}$ .

The construction of TAI is the major task of the BIPM Time Section. This activity engenders a large number of projects, ranging from the weighting of clocks, to methods of time- and frequency-transfer methods, to the calibration of timing links, and to more general studies of general relativity and space-time references. The CCTF adopted recommendations concerning time and frequency comparisons using GPS phase and code measurements, the calibration of timing links used for TAI, and technical guidelines for GNSS timing receivers. It also discussed a number of additional subjects, including the meaning of the designation “ $k$ ” in UTC( $k$ ) and TAI( $k$ ) (for which a recommendation was adopted), future developments in the calculation of UTC and TAI, and the algorithms used in the calculations. An international symposium on time-scale algorithms is being organized by the Sub-Group on Algorithms and will be held at the BIPM on 18 and 19 March 2002.

A possible redefinition of UTC was discussed. Three options are possible concerning the leap second: maintain the status quo, modify the procedure for, or the frequency of, the introduction of leap seconds, or use another time scale. This choice does not belong directly to the CCTF. The International Telecommunication Union (ITU) has formed a Special Rapporteur Group to discuss the matter and to seek the opinion of other interested bodies. The Group is expected to present its recommendations in October 2002.

The outgoing chairman of the CCTF Working Group on TAI, Prof. Pâquet, was warmly thanked by the CCTF for his guidance and for the links he has developed with related communities. Dr P. Tavella (IEN) was nominated as his successor.

### 6.5.3 Clocks in space and future satellite navigation systems

Two sets of atomic clocks are planned on board the International Space Station, and an active programme of research is under way. The CCTF was briefed about these programmes, which, as well as performing tests of fundamental physics, will demonstrate the possibility of operating the most accurate clocks in space and provide an unprecedented way of distributing and comparing time for earth-bound users. The problem of accurate comparison between the new fountains is indeed unresolved. Studies are ongoing in Europe to establish the requirements and the timing performances of the Galileo timing system.

#### 6.5.4 Key comparisons and the mutual recognition arrangement in the time and frequency domain

The CCTF Working Group on the MRA, chaired by Dr G. de Jong, made a number of recommendations to the CCTF. Some of the issues raised by the Group are politically sensitive ones, such as the participation in the MRA of non-NMI laboratories, of countries that are not signatories of the Metre Convention, or of countries with more than one NMI.

New terms of reference of the working group were adopted.

The CIPM discussed CCTF Recommendation 1 (2001) and approved it with a slight modification: the phrase “optical frequency standards” was generalized to simply “frequency standards”. Prof. Göbel suggested that the CCTF should define criteria for transitions suitable for use as secondary representations of the second, and communicate these to the CCL. Dr Quinn replied that it was important to take a broader view and decide how best to mix work on optical frequency standards and primary frequency standards. Dr Chung agreed that the future of the CCL lies in dimensional metrology rather than the definition of the metre. The traditional guidelines for the practical realization of the metre (the *mise en pratique*) will soon be of only historical interest. Dr Quinn noted that responses from the CCTF generally indicate that it is too early to start a new working group on optical frequency standards, but said that he would discuss the issue with Dr Chung and Prof. Leschiutta to try to establish guidelines for such a group. Meanwhile, he would invite experts from the CCL and CCTF to meet at the BIPM on an *ad hoc* basis.

The CIPM discussed briefly the question of the leap second and Prof. Leschiutta emphasized that it was a very difficult decision and that opinions were divided, even amongst the experts on the CCTF. Dr Quinn commented that, in his view, it was not a technical decision, but rather a question of whether the time scale is such that the Sun is overhead on the Greenwich meridian at noon. Since this is no longer required for navigation purposes, the reason for leap seconds no longer exists. The decision, however, rests with the ITU, within which the CCTF is represented.

Prof. Pâquet praised the significant progress made in the IGS/BIPM pilot project. Receivers common to both the geodetic and timing communities are now in use and he hopes that timing groups will perhaps become more involved with geodetic activities.

Dr Kaarls drew attention to the complications that can arise when more than one institute in a country shares responsibility for time, and commented that

such circumstances called for great diplomacy. Prof. Leschiutta noted that designated laboratories not yet included in the MRA can be added by exchange of letters between the directors of the signatory institutes and the Director of the BIPM.

## 6.6 Consultative Committee for Thermometry

Prof. Ugur, President of the Consultative Committee for Thermometry (CCT), presented a report on the 21st meeting of the CCT, held at the BIPM from 12-14 September 2001.

### 6.6.1 Key comparisons

The CCT Working Group 6, on humidity measurements, submitted a protocol for the CCT key comparison of dew point meters (CCT-K6), and the CCT approved a list of ten participants: three from the APMP, six from EUROMET and one from the SIM.

The status of the other five CCT key comparisons, and related regional comparisons, was reviewed. All measurements for these comparisons have been completed. Drafts B of the reports on CCT-K2 and -K3 were approved by the CCT, and drafts A of the reports on CCT-K1, -K4 and -K5 are being prepared or circulated among the participants.

It was decided that a new CCT key comparison, CCT-K7, will be organized on water triple-point cells. The BIPM will act as pilot laboratory, with the assistance of the BNM-INM, UME and a member of SIM, yet unnamed.

There has been a call for the CCT to organize comparisons in the field of thermophysical properties. A new working group (CCT Working Group 9) has been formed to advise the CCT on this area and assess the needs for a key comparison.

### 6.6.2 Working groups

The terms of reference and membership of each of the CCT working groups were reviewed. Note that in most cases the chairmanship of working groups is given to member NMIs, but occasionally individuals are nominated.

CCT members were asked to submit any suggestions related to the revision of the *Supplementary Information to the ITS-90* to Working Group 1, which plans to produce a draft document listing the identified deficiencies of the ITS-90 by the middle of next year. Working Group 2 will produce

documents related to the *Techniques of Approximation to the ITS-90* as relevant information becomes available. It was generally accepted that the uncertainty budgets for secondary realizations of the ITS-90 are an important tool for RMOs evaluating the CMCs submitted to Appendix C of the MRA.

The CCT approved a *CCT Guidance Document on Uncertainties of SPRTs*, prepared by Working Group 3. In February 2001 this working group organized a workshop on uncertainties in temperature measurements.

Working Group 4 has called upon laboratories that use thermodynamic gas thermometers to review their measurement results in the light of a recent study on virial coefficients.

Working Group 5 organized a workshop on uncertainties in radiation thermometry, immediately prior to the CCT meeting. This resulted in a document containing the conclusions of the workshop and recommendations to the working group.

Working Group 6 submitted the draft protocol for CCT-K7, mentioned below. The working group decided to continue their activity on humidity measurements under the auspices of the CCT rather than transferring to the CCQM, as had been requested by the VNIIM. At least one of the principal techniques in the field of humidity is reliant on temperature measurement, and the recent expansion of the TempMeko conference series to include topics in humidity has proven very successful.

Working Group 7, on key comparisons, is mainly concerned with reviewing draft A and draft B reports of key comparisons, and reviewing draft protocols for new key comparisons. The working group could not decide on the definition of “significant unresolved deviation”, and have referred this question to Dr Quinn, who will take up the matter with the JCRB.

In place of Working Group 8, a working group, consisting of M. Ballico (NML CSIRO), M. de Groot (NMI VSL) and G. Strouse (NIST), is charged with compiling a list of CMCs for Appendix C of the MRA. This task should be completed by the end of October 2001, and Duan Yuning (NIM) will then replace Dr Ballico as a member of the group, which will advise the President of the CCT or members of the JCRB on any JCRB-related issues.

Dr Kaarls commented that humidity measurements remained of interest to the CCQM. He noted that it was likely that new working groups being set up to study derived measurements would be of interest to more than one Consultative Committee, citing also the example of flow, which concerns both the CCM and the CCQM.

## 6.7 Consultative Committee for Length

Dr Chung Myung Sai, President of the Consultative Committee for Length (CCL), presented a report on the 10th meeting of the CCL, held at the BIPM on 19 and 20 September 2001. Much of the meeting was taken up with discussions of the reports of the CCL working groups on dimensional metrology and on the *mise en pratique* of the definition of the metre. Both of these working groups had produced detailed reports.

### 6.7.1 Dimensional metrology and key comparisons

In dimensional metrology, six key comparisons were initiated at the 1997 meeting. So far one has been completed and the results are in Appendix B of the MRA on the KCDB. One is at the stage of a draft A report and the others are still under way.

The Working Group on Dimensional Metrology has taken a leading role in the preparation of the entries to the Appendix C of the MRA. As a result of its efficient work, it had been possible to reach agreement rapidly among all of the RMOs and participating NMIs on a common list of services in length metrology to be used as the basis of Appendix C entries. This is a good example of how a working group of a Consultative Committee can operate in coordinating the efforts of the RMOs. The working group meets regularly and follows very closely the progress of the key comparisons and matters related to Appendix C entries and reviews.

As regards the ongoing BIPM key comparison, BIPM.L-K10, an iodine-stabilized laser comparison at 633 nm, the CCL approved the set of results submitted by the BIPM and agreed that the reference value should be the value of the BIPM4 laser. The CCL did not decide on any new key comparisons.

### 6.7.2 *Mise en pratique* of the definition of the metre

The Working Group on the *Mise en Pratique* of the Definition of the Metre reported on the quickly changing situation regarding the use of femtosecond laser technology for linking optical and microwave frequency standards. This technology now looks capable of bridging the microwave to optical gap with high accuracy, in an effective and efficient manner, in contrast to the



frequency chains of recent years. The advent of this technology is having major implications in three areas:

1. The ease of measurement of any optical/near-infrared frequency or wavelength standard.
2. The new serious possibilities for optical frequency standards to provide microwave reference output linked to an optical standard, by means of this widespan comb technology. The follow-on implication of this provision is the potential use of optical standards to provide secondary representations of the SI second.
3. The methodology for future laser and optical frequency standard comparisons. Here, the development of small breadboard femtosecond-comb systems for measuring stabilized laser and cold atom and ion optical frequency references lead to the view that the BIPM can adapt their comb system to be a travelling measurement capability. Such a system could be used to measure optical references in various metrology institutes, and/or compare directly with the institute's own femtosecond-comb system. This approach has the capability to improve upon stabilized-laser comparisons carried out under the laser key comparison, but does not rule out such comparisons taking place in the normal way.

The working group met just prior to the CCL in order to draft proposals to the CCL which would take account of new measurements with the comb technology on existing and potentially new recommended radiations. As a result of this meeting, proposals were made to the CCL, the content of which is outlined as follows:

1. A change of name to the *mise en pratique* was suggested, in order to take account of applications in spectroscopy, telecommunications and time, in addition to dimensional metrology.
2. Research and investigation into femtosecond-comb technology should be encouraged in order to understand it properly and to extend the technique to the highest accuracy with simple application.
3. The addition to the recommended radiations list of new radiations from cold atoms and ions with frequency values measured to high accuracy, updated values of existing radiations of cold atom, ion and gas cell type, and new gas cell radiations for the optical telecommunication region.
4. The move of some iodine-stabilized radiations to the secondary list, where the likelihood of future improvements in measured values was small.

The CCL adopted the proposals, with the provisional status regarding the final verification of the detailed frequency values for the revised listings which is needed prior to the publication of a revised *mise en pratique*. In addition, the question was considered of a future joint working group between the *mise en pratique* group of the CCL and the CCTF to consider the relationship between some of the recommended radiations in the *mise en pratique* and their suitability as future secondary representations of the second, and Dr Quinn undertook to raise this issue with the appropriate delegates to the CCTF and CCL, in order to form a view before the CIPM meeting (see discussion that took place under the CCTF report above). It was agreed that a text of the final CCL recommendation for the new *mise en pratique* will be distributed to the CIPM for approval as soon as it is finalized by the CCL working group and approved by the CCL.

For future activities of the BIPM in the field of lasers, the CCL supports BIPM's work on the new femtosecond-comb technology in order to use these new frequency standards for international comparisons. The organization of such future comparisons has to be established in order to succeed the usual He-Ne laser comparison at 633 nm. The organization of the comparison on Nd:YAG lasers at 532 nm has also to be investigated by the BIPM.

## 6.8 Consultative Committee for Acoustics, Ultrasound and Vibration

Dr Valdés, President of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV), presented the following report of the second meeting of the CCAUV, held at the BIPM on 4 and 5 October 2001.

### 6.8.1 Key and supplementary comparisons

Dr Valdés summarized the status of the eight CIPM key comparisons running under the CCAUV. One on acoustics is completed (draft A of the report is in preparation), another will start in 2002, and two others will start in 2003. In ultrasonics, one is completed (draft A is in preparation) and the other is scheduled to be finished by the end of 2001. One vibration comparison is complete (draft B is being prepared) and another on underwater acoustics is in progress. These comparisons will result in a large amount of data for input to the KCDB, as each comparison represents a suite of values, usually over a wide frequency range.

There has been also significant activity within the regional organizations with respect to key and supplementary comparisons to support the CMCs

already in Appendix C of the MRA. The EUROMET and the SIM have both completed acoustics comparisons which they wish to link to the CCAUV comparison, and the COOMET is about to start one. These various regional key comparisons should produce a further 210 degrees of equivalence, to add to the 730 expected from the CIPM key comparisons.

#### 6.8.2 Other items

Various mathematical approaches to the calculation of reference values and uncertainties were considered. Dr von Martens (PTB) showed the implications of these on the results of measurements for the particular case of the CCAUV accelerometer comparison.

The possible need for further research into the nature of the fluctuation processes for standard artefacts and measuring systems used in AUV was highlighted. Dr T.J. Witt of the BIPM Electricity Section was invited to present the implications on uncertainty calculations of  $1/f$  noise in the power spectrum of the data.

It was decided to establish an informal e-mail working group with the aim of collecting ideas among the NMIs concerning future needs in AUV metrology. This will contribute to the CIPM document which is being prepared by the Secretary of the CIPM. The IMG, NPL and PTB delegates expressed their particular interest in collaborating. Dr B. Zeqiri (NPL) will act as contact person.

### 6.9 Working groups of the CCEM

Prof. Göbel, President of the Consultative Committee for Electricity and Magnetism (CCEM), presented reports on meetings that had taken place of the CCEM working groups. No meeting of the CCEM itself had been held this year. The groups that had met were the CCEM Key Comparison Working Group, the Working Group on the Measurements of the Quantized-Hall Resistance with Alternating Current, the Working Group on Radiofrequency Quantities (GT-RF) and the Working Group on Electrical Methods to Monitor the Stability of the Kilogram. The most active of these is the key comparisons working group. This group has taken a leading role in the organization of the submissions of CMC data for Appendix C of the MRA and in this has been very successful. As in the case of the length field, it has been the Consultative Committee working group that has taken the lead in drawing up a common list of services and in resolving the many technical

problems in reaching agreement on how to review submitted CMCs. An important step was taken by the Working Group on Key Comparisons when it approved the BIPM proposal for the method of linking the results of the EUROMET key comparison of 10 pF capacitors to the corresponding CCEM key comparison CCEM-K4. This procedure was straightforward and might provide a model for other such linkages. It had become clear during discussions within the CCEM key comparison working group that it was too difficult to draw up a fully generalized procedure for making such a link but by dealing with it on a case by case basis a satisfactory solution can be found. This is an example where undue rigour is counterproductive.

The reports of the meetings of all the CCEM working groups are to be found on the BIPM website under CCEM.

#### **6.10 CCM Working Group on Density**

Dr Tanaka presented a short report on the new density table of water recommended by the CCM Working Group on Density. A full report on the analysis of the working group will be published in *Metrologia* (see Tanaka M., Girard G., Davis R., Peuto A., Bignell N., *Metrologia*, 2001, **38**(4), 301-309). The report was endorsed by the CIPM.

#### **6.11 International comparison of gravimeters**

Dr Quinn reported that the International Comparison of Absolute Gravimeters (ICAG'2001) was successfully completed at the BIPM in July 2001. The comparison involved seventeen participants, making either absolute or relative measurements, and included measurements at a new site in the BIPM gravity network, situated in the Pavillon du Mail. He proposed that, following the discussions of the CIPM the preceding year, the new Working Group on Gravimeters be established under the umbrella of the CCM, and suggested that Dr Vitushkin be nominated the first Chairman. This suggestion was welcomed by Dr Tanaka and the other CIPM members.

## 6.12 Membership of Consultative Committees

Dr Quinn reported that the only new requests for membership of the Consultative Committees concerned the CCQM. The CIPM approved the following.

Committee	New member	New observers
CCQM	NML CSIRO/AGAL (Australia)	CEM (Spain)
		IMGC-CNR (Italy)

Prof. Kovalevsky proposed that Dr Hengstberger replace Prof. Wallard as President of the CCPR and Dr Tanaka replace Dr Iizuka as President of the CCM. Both nominations were approved by the Committee and accepted by the members concerned.

## 6.13 Future meetings

The following dates were established for future meetings of the Consultative Committees:

### 2002

CCQM:	18-19 April
working groups:	15-17 April
CCM:	23-24 May
working groups:	20-22 May
CCEM:	12-13 September
working groups:	9-11 September
CCAUV:	1-2 October
CIPM:	8-11 October
JCRB (8th meeting):	5-6 March (not at the BIPM)
JCRB (9th meeting):	3-4 October
Meeting of directors :	22-23 April

**2003**

CCPR:	early May
CCRI:	30 May
CCRI(I):	21-23 May
CCRI(II):	28-30 May
CCRI(III):	26-27 May
CCTF	
CCU	
CCL:	September
CGPM:	13-17 October

**7 THE MUTUAL RECOGNITION ARRANGEMENT**

Dr Quinn demonstrated the BIPM interactive website put in place for the RMO representatives to the JCRB, who use it to manage the review of the CMCs submitted by member NMIs. Dr Inglis commented that this service had been very well received by the RMOs.

He also reported on the opening of Appendix C on the BIPM website that had taken place since the last meeting of the CIPM. Thanks to a huge effort on the part of the signatory NMIs, and most particularly to the chairmen of the RMO technical committees, we now have more than ten thousand individual calibration and measurement capabilities in Appendix C. Many more are in an advanced stage of review and he said that by mid-2002 most fields of metrology will be well represented. The bulk of the work of the RMOs in reviewing CMCs will have been accomplished with the exception, perhaps, of general chemistry. This is a very large field and much work remains to be done although the very difficult process of reaching agreement on the formats in which the CMCs should be presented has been successfully accomplished. A presentation of Appendix C on the BIPM website was made to the Committee by Dr Thomas.

Dr Quinn also noted that the transition stage of the MRA will come to an end in 2003 at the 22nd CGPM. He intends to ask at the meeting of directors in 2002 if there are any suggestions of modifications to be made to the MRA

text. Any such modifications will be discussed at the meeting of the CIPM in 2002.

## **8 NEW STUDY OF FUTURE NEEDS FOR METROLOGY**

Prof. Kovalevsky welcomed the presence of Dr Luszyk (NRC, Canada) and Dr McGuiness (NPL, United Kingdom), who were invited to join the CIPM for the discussion on long-term needs relating to metrology, and asked Prof. Mills also to stay. He then handed over to Dr Kaarls.

Dr Kaarls reported that a small CIPM Working Group had been established to study the subject, comprising the bureau of the CIPM, Dr Hengstberger, Dr Luszyk, Dr McGuiness, Dr Ono and Dr Semerjian. He himself had travelled widely for discussions, collecting various views, and he thanked the NMIs for their input. He then summarized the results of a confidential questionnaire on future needs distributed to directors of NMIs in May 2001. Twenty-one responses to this questionnaire had been received prior to the meeting, and a further two were received at the meeting, from a total of twenty-one Member States and one RMO. The responses were copied in full to the CIPM members. He noted that no responses had yet been received from the African continent or the Middle East.

Dr Kaarls then outlined the proposed structure of the report he will present at the next General Conference, and asked the CIPM for their comments and suggestions, emphasizing that it was important for consensus to be reached on the direction to take. He suggested that, on the basis of the CIPM's discussion, he prepare a draft report before the bureau meeting in February 2002, and that it be presented for comments at the meeting of directors in April. A more or less final draft will be presented to the CIPM next year (2002) and it is hoped that the final version can be approved by the directors of the NMIs at their meeting in 2003. The full Report will be presented at the 22nd CGPM in 2003.

A detailed discussion followed. It was agreed that the Report should be addressed to the governments of the Member States of the Metre Convention, to the directors of the NMIs, to politicians, and to other stakeholders. In order to make the best approach to these different audiences, the Report may be presented in two or three separate volumes, each targeted to its reader.

Overall, the Report should be needs driven, the needs being those defined by the regulators, trade, industry and society.

The CIPM agreed that it was important to address all areas of metrology, not just those classical areas covered in the SI. Thus the Report will also include metrological needs in areas such as biotechnology, laboratory medicine, the pharmaceutical industry, and food testing. The role and composition of the Consultative Committees will be studied in this light.

It was agreed that it was important for the section on the economic and social impact of metrology to deliver qualitative and quantitative arguments justifying the activities of the NMIs to governments and other stakeholders. Similarly, it must establish the value of the CIPM MRA, and present a qualitative and quantitative analysis of the value of the work of the BIPM to the Member States and the NMIs. Support in the quantification of these added values should be sought from a professional organization. Dr Kaarls noted that reports on the economic impact of metrology have only been made available by the NIST (United States), the NPL/DTI (United Kingdom) and, very recently, by the NRC (Canada). Denmark also has some case studies available in Danish.

The role of the BIPM was discussed at length. It is clear that its function is strongly budget-dependent, and the CIPM agreed that various models of its future role should be considered and presented as a function of the hypothetical dotation. It is important that the BIPM keep, and indeed strengthen, its position as the world's authority, spokesman, and coordinator in metrological matters. To do this, it clearly requires competent staff and active laboratories, undertaking applied scientific and technological research and development. The areas in which it should have a practical activity must be carefully chosen to reflect the needs of the Member States and future directions. It is important that the BIPM remain flexible, so that it can take on board new areas of metrology as required.

New forms of cooperation between the BIPM and NMIs and other institutes are desirable. The calculable capacitor was cited as an example of an area of work that could usefully be carried out at the BIPM, with input from various other laboratories including the NMIJ and the NML CSIRO. Dr Quinn agreed that this project would benefit from the skills in interferometry and design expertise of the BIPM, and bring know-how from other institutes to the BIPM for the benefit of many.

To further the qualitative analysis of the value added by the BIPM, and to help establish priorities for the services to be offered by the BIPM in the



future, an additional questionnaire will be distributed to directors of the NMIs, asking for their opinions of all the services currently delivered, or which they would like to see delivered, by the BIPM. Among others, existing services include the realization of unique standards and transfer standards, calibrations, comparisons, transfer of know-how, and representation and coordination on the international level. The BIPM will analyse the cost of these various services provided.

It was acknowledged that established NMIs and developing NMIs view the role of the BIPM differently, and that the needs of developing countries should be investigated further. The opinions on metrology of well-known business and industrial leaders will also be sought, as well as those of senior governmental staff.

The CIPM agreed that the role of the annual meeting of directors of the NMIs should be further strengthened. The Report will also consider the roles of the CIPM and the JCRB (concerning matters of policy and matters related to the CIPM MRA, respectively), and the positions of the RMOs and their relations to the BIPM and the CCs.

The CIPM approved Dr Kaarls' proposed timetable for preparation of the report. Draft versions of the report will be distributed to CIPM members and to Drs Hengstberger, Lusztyk, McGuiness, Ono and Semerjian in advance of each meeting, to allow comments to be returned for discussion.

## **9 OIML/METRE CONVENTION JOINT WORKING GROUP**

Prof. Kovalevsky told the Committee that the bureau of the CIPM would meet again with the OIML in February 2002. As introduced by the Secretary in his report, a number of subjects remain under discussion.

Dr Quinn noted that it was essential that the word traceability be defined in a way acceptable to the ILAC, the OIML and the BIPM. A revised definition is being drawn up by the Joint Committee for Guides on Metrology (JCGM) as part of the revision of the VIM. Dr Brown commented that the question of the definition has also been addressed at the NIST, and that their organizational policy on traceability is available on the NIST website.

Regarding the symposium for developing countries being organized at the NIST, Dr Brown warned that the NIST would be unable to pay the fares of delegates wishing to attend. Prof. Göbel noted that the travel costs had been provided for approximately half of the participants at the 1998 meeting. It was suggested that the CIPM should explore the possibility of UNIDO sponsoring the event. Dr Quinn agreed that he would take up contact with the UNIDO headquarters in Vienna, and that he would consider setting up an OIML/CIPM working group to coordinate the arrangements with Dr Carpenter at the NIST. The possibility of postponing the symposium for another year was not ruled out.

## **10 CONTACTS WITH OTHER INTERNATIONAL ORGANIZATIONS**

### **10.1 World Meteorological Organization**

Dr Quinn presented a draft Agreement between the World Meteorological Organization (WMO) and the CIPM. The draft was approved by the Committee, and Dr Quinn said that he would present it to the WMO for approval by its Executive Council in June 2002.

### **10.2 ILAC**

Dr Kaarls told the Committee that the ILAC was keen to establish an MOU with the CIPM. A draft MOU was presented, and the CIPM gave its approval after minor rewording.

### **10.3 Traceability in laboratory medicine, contacts with the World Health Organization**

Dr Quinn presented the draft agenda that will be considered by the Joint Committee on Traceability in Laboratory Medicine (JCTLM) when it meets at the BIPM in November 2001. The preliminary list of participants includes representatives of the BIPM, the IFCC, the IRMM, the European Commission, and a number of regulatory agencies and manufacturers of

medical instruments. Preliminary contacts have been made with the WHO through the National Institute for Biological Standards and Control in London, one of the principal WHO reference laboratories.

#### 10.4 ISO/IEC and ISO CASCO

The BIPM is now a Category A liaison organization with ISO CASCO and the Director will attend a meeting in November 2001.

### 11 JOINT COMMITTEE FOR GUIDES IN METROLOGY

Dr Quinn reported that Working Group 1 of the Joint Committee for Guides in Metrology, on the expression of uncertainty in measurement, had met twice since the last meeting of the CIPM. The Group had concluded that there was currently no need to revise the *Guide to the Expression of Uncertainty in Measurement*, but that supplementary documents should be written to support its use. Work on these is well advanced.

In contrast, the Working Group 2, on the revision of VIM, was still running into severe difficulties in reaching agreement on terms in Chapter 1, notably on the definition of the term “physical quantity”. Although considerable progress had been made on other parts of the *Vocabulary*, the difficulties with Chapter 1 must be resolved if the project is to progress.

Dr Quinn confirmed that if new versions of the documents were published, their copyright would be held by the JCGM, which would facilitate the distribution of the documents in the future.\*

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\* Note: at a meeting of Working Group 2 held at the BIPM on 28 and 29 November 2001 agreement was finally reached on all the terms for a revised Chapter 1 of the VIM. It is now planned to send a complete revised text of the VIM out for discussion in May 2002 with a view to producing a final text in November 2002.

## **12 WORK OF THE BIPM**

### **12.1 Director's report on the scientific work of the BIPM**

The Director introduced his report in the following terms:

This has been a very busy year at the BIPM. A close reading of this Report will show that much has been accomplished in the scientific work of the laboratories. Our participation in key comparisons has been high, as has been the visibility of the scientific staff: in terms of publications this Report cites twenty-five in refereed journals plus twenty-one in conference proceedings. We have been present and participated actively in many meetings of working groups, conferences or comparisons outside the BIPM: about one hundred trips by the scientific staff plus some twenty by the Director. Calibrations of standards for national metrology institutes continue to be an important part of our work although this year the renovation of laboratories has required the postponement of some of these. The BIPM key comparison database is now fully operational and contains some ten thousand individual calibration and measurement capabilities of national metrology institutes. Overall at the BIPM, as in national institutes, the MRA has led to a considerable increase in the workload of senior staff particularly in their contribution to the analysis of the results of key comparisons. The BIPM website continues to show increasing usage, the most recent count indicating visits from about nine hundred different sites per day.

This year has also been unprecedented in the number of meetings that have taken place at the BIPM. By the time of the CIPM in October 2001 we shall have had, since October 2000, meetings of eight Consultative Committees and some twenty-five working groups or other meetings. With the increased interest in Consultative Committees that has resulted from the MRA, the number of participants at these meetings is much larger than in the past. It is common now to have more than fifty people at Consultative Committee meetings. Since October 2000 some five hundred people have come to the BIPM for meetings or general visits plus about forty guest workers who came for periods of a few days up to a year. All of this indicates that, with its concomitant opportunities and responsibilities, the BIPM is an increasingly visible organization.

The opening of the new building, the Pavillon du Mail, in time for the meeting of the CCQM in April 2001, was an important event in the life of the

BIPM. The official inauguration will take place during the 90th CIPM meeting on 11 October 2001.

The scientific work carried out in the laboratories of the BIPM is the foundation for all its other activities. Without it, the staff would not have the competence to carry out the many tasks laid down for the BIPM by the CIPM and financed by the Member States of the Metre Convention. Planning of future work is an essential part of research activity. There are a number of areas of metrology in which scientific developments are taking place or where needs are changing that will influence the work at the BIPM. The most significant of these now is the development of femtosecond laser combs that allow direct comparisons to be made between optical and microwave frequency standards. It was immediately obvious that our work in the Laser Section would be significantly affected. We have now installed a comb system at the BIPM thanks to considerable help from our colleagues at the JILA and the NIST in Boulder (United States). With this system we expect soon to be able to make direct measurements of the frequencies of iodine-stabilized lasers at a wavelength of 633 nm, whereas for the past thirty years we have had to rely on the stability of a set of 633 nm lasers carefully maintained at the BIPM. This heralds only the beginning of the changes that comb technology will bring. There are sure to be other related developments, for example the possibility of optical frequency standards becoming candidates for a possible new definition of the second. We are following these developments closely.

In what follows, I first give a brief summary of the work being carried out in the laboratories of the BIPM; the Director's report itself presents more detailed accounts section by section. This report is written to give an impression of the state of the work on 1 July 2001. Publications are listed that have been published since the last Report, dated 1 July 2000.

**Length:** This year international comparisons concerned mainly lasers working at the recommended wavelength of  $\lambda \approx 532$  nm. The BIPM lasers were employed in comparisons with lasers of the following national laboratories: the BNM-INM, CMI, MIKES and the NMIJ/AIST (formerly NRLM). Using the transportable rubidium-stabilized diode laser at  $\lambda \approx 778$  nm belonging to the BNM-LPTF/OP, the BIPM participated at the NMIJ/AIST in an international comparison involving the standards of this laboratory. Although the activity of laser comparisons at  $\lambda \approx 633$  nm was less than usual this year, bilateral comparisons were still carried out at the BIPM with the CEM, the NCM and the OMH. The first BIPM comb generator was successfully compared with a similar apparatus belonging to the JILA, work

made possible with valuable assistance from the JILA staff. Collaboration with the Lebedev Institute was pursued with the construction and test of a new telescopic laser at  $\lambda \approx 3.39 \mu\text{m}$ .

**Mass:** The number of calibrations has increased this year, apparently to answer the question of stability of 1 kg national prototypes in platinum-iridium since they were cleaned and washed during the third verification of national prototypes of the kilogram (1988-1992). In view of this interest, we have recalibrated our own working standards. Extensive measurements designed to compare three methods to determine the density of air — CIPM equation-of-state, buoyancy artefacts, refractometer — have been completed. The first two methods determine the density of air while the third method measures relative changes in air density. The method of buoyancy artefacts requires that the volume of these artefacts be known, the determination of which by our colleagues at the PTB will complete the study. Since last year, our new apparatus for the hydrostatic determination of volumes has been fully instrumented. It is functional and undergoing commissioning. Interest remains strong in the magnetic susceptometer developed at the BIPM for checking the magnetic properties of mass standards, especially those made of stainless steel. A comparison of such measurements among four European mass laboratories and the BIPM was very successful.

The experiment to measure  $G$ , the Newtonian gravitational constant, has been completed. The relative standard uncertainty of our final result is well below our target of 1 part in  $10^4$ . However, a disagreement of about 2 parts in  $10^4$  with respect to another experiment claiming much lower uncertainty than our own has led us to continue this work with an improved apparatus.

**Time:** The medium-term stability of International Atomic Time TAI, expressed in terms of an Allan deviation, is estimated to be about  $0.6 \times 10^{-15}$  for averaging times of twenty to forty days. Since January 2001 a new procedure has been used for assigning the maximum relative weight of clocks in TAI according to the number of clocks participating in the calculation. It is expected that this will improve the future stability of the resulting time scale. The accuracy of TAI is based on eight primary frequency standards: three classical standards CS1, CS2 and CS3 from the PTB, operating continuously; three optically pumped standards CRL-01, LPTF-JP0 and NRLM-4, and two caesium fountains NIST-F1 and PTB CSF1. As a consequence of better stability and increase in the number of primary standards, the scale unit of TAI has been estimated to match the SI second to within 2 parts in  $10^{15}$  since August 2000. An important part of the activity of the section deals with studies of time and frequency comparison

using navigation satellite systems such as GPS and GLONASS, with particular emphasis on multi-channel multi-system techniques, and on the use of GPS carrier-phase measurements. Besides the classical GPS common-view technique based on C/A-code measurements obtained from one-channel receivers, three GPS multi-channel links and four two-way time-transfer links are used in the calculation of TAI. Research work is also dedicated to space-time reference systems, particularly to the relativistic framework for defining and realizing coordinate times. Since January 2001 the BIPM Time Section and the U.S. Naval Observatory (USNO) have jointly provided the Conventions Product Centre of the International Earth Rotation Service with the responsibility of establishing conventions for space-time reference systems. Other research subjects are pulsars, future clocks in space and atom interferometry.

**Electricity:** A new direct comparison of the two BIPM 10 V Josephson standards was carried out over a four-day period. The mean difference was 30 pV with a standard deviation of the mean of 40 pV. This is the smallest uncertainty we have ever achieved in direct comparisons of Josephson standards.

We followed up last year's achievement of significant improvements in the metrological quality of quantized Hall resistance (QHR) measurements at kHz frequencies by preparing two headers containing quantum Hall effect (QHE) devices and gates. With these, we successfully repeated our measurements demonstrating that by appropriate adjustment of the gate voltage the residual frequency coefficient of the QHR is of the order of 1 to 2 parts in  $10^8$  per kilohertz. An important improvement was made in the coaxial ac-dc resistor that provides the link between resistance measurements at 1 Hz and resistance measurements at kHz frequencies in the BIPM measurement chain linking 10 pF capacitance standards to the QHR.

Previous BIPM studies show that the uncertainty of voltage measurements of all Zener voltage standards is limited by  $1/f$  noise that we characterize by Allan deviations. This year we studied the statistical significance of these results by repeating measurement runs hundreds or even thousands of times to determine the experimental sampling distributions of the Allan variances. The results are useful in evaluating the statistical significance of small reproducible differences in the  $1/f$  noise floor of Zeners.

Calibration work in the Electricity Section continues to demonstrate the importance of this BIPM service for the NMIs. The following calibrations were completed: seven Zener voltage standards for three NMIs; fifteen resistance standards for five NMIs; and seven capacitance standards for two

NMIs. Four new BIPM ongoing comparisons of voltage standards were also carried out.

**Radiometry, photometry:** Work continued on the key comparison of spectral responsivity. The two rounds of measurement have been completed except for some late returns of detectors. Following CCPR-S3, the supplementary comparison of cryogenic radiometers, two laboratories asked for bilateral comparisons with the BIPM, one of which is still under way. In radiometry, the work which had started on the realization of near-infrared spectral irradiance using the sodium heat-pipe black body had to be stopped when the heat-pipe developed a leak. The system has in the meantime been repaired. The BIPM also took part in the CCPR supplementary comparison of aperture area. During these investigations we discovered and explained an interesting effect which was shown to depend on the shape of the laser beam. In another development, the control software for the spectro-radiometer was upgraded using graphical programming tools. In the photometry laboratory installations were completely renewed during the past year with the replacement of the old photometric bench and the introduction of an improved positioning and read-out system for the lamps. Also in photometry, a robust link for the transfer of the new key comparison reference values (KCRVs) to the BIPM was achieved through a bilateral comparison with the PTB, the pilot laboratory for the two key comparisons CCPR-K3 and CCPR-K4 using lamps. In thermometry a total of thirty-three platinum resistance thermometers were calibrated for five sections of the BIPM and the stability of water triple-point cells and gallium cells subsequently investigated. The Information Technology group continues to provide support and services for users at the BIPM. The number of visits to the BIPM home page continues to increase and databases for Appendices B and C have been developed and made available on-line.

**Ionizing Radiation:** The programme for the laboratory upgrade has been completed and the equipment renewal is continuing on schedule. The new  $^{60}\text{Co}$  source has been installed and will now be characterized. Despite the interruptions, nine dosimetry comparisons with seven NMIs have been carried out last year plus seventeen calibrations for secondary standards laboratories. The CCRI meeting held in May 2001 focused on the analysis of the BIPM and the CCRI key comparisons as well as the procedure for entering results in the BIPM key comparison database. A decision was taken to incorporate the new correction factors for the BIPM x-ray standards determined by the BIPM from Monte-Carlo calculations. In addition, the first CCRI(I) key comparison has almost been completed with the participation of



nine NMIs with primary standards. In the radionuclide field, the  $^{204}\text{Tl}$  working group reported their findings and proposed a new CCRI(II) comparison. The  $^{152}\text{Eu}$  and  $^{89}\text{Sr}$  comparisons have been successful with twenty-three and nineteen participants, respectively. The results are awaited from the  $^{238}\text{Pu}$  comparison. Four further comparisons are planned to start before the spring of 2002. Eight laboratories have submitted radionuclides to the International Reference System (SIR) this year and the total number of comparisons is now fifty-eight, one of which, for  $^{177}\text{Lu}$ , is new. The key comparison working group is preparing these data and the nine completed CCRI(II) key comparisons ready for entry in the BIPM key comparison database. Most of this work is based on the SIR monograph which will be published soon. The efficiency curves of the SIR have been re-characterized for both gamma and beta emitters. Using the BIPM Ge(Li) gamma spectrometer, impurity activity levels were measured for six radionuclides which had been submitted to the SIR and the NMIs have used these BIPM values when needed. Data acquisition has been upgraded for the primary measurement methods at the BIPM and a digital coincidence counting system is being tested. The triple-to-double coincidence method being developed should soon be ready for trials in the SIR extension to include pure beta emitters.

**Chemistry:** Following consultation with experts from the CCQM Working Group on Gas Analysis, a programme of comparisons and fundamental research in ozone measurements is planned in conjunction with the NIST. This will result in the transfer of responsibility for international comparisons of ozone reference photometers to the BIPM. Completion of laboratories for the Chemistry Section is foreseen by mid 2001, following which the installation and testing of two NIST ozone standard reference photometers is expected by the autumn 2001. The comparisons will be supported by a research programme at the BIPM to underpin the ozone photometry by gas-phase titration of NO and NO<sub>2</sub> and through the measurement of ozone cross-sections in the ultraviolet. The programme was presented during the EUROMET project 414 (Ozone) workshop, and will feature in the formulation of the CCQM pilot study on the comparability of standard ozone photometers (CCQM-P28).

**BIPM key comparison database:** The BIPM key comparison database is fully operational. It contains more than ten thousand calibration and measurement capabilities of national metrology institutes and an increasing number of results of key comparisons.

## 12.2 Depository of the metric prototypes

On 11 October 2001, at 17 h 15, in the presence of the President of the International Committee for Weights and Measures (CIPM), the Director of the International Bureau of Weights and Measures (BIPM) and the representative of the Curator of the Archives Nationales de France, the visit to the depository of the metric prototypes at the Pavillon de Breteuil took place.

The three keys necessary to open the depository had been assembled: the key entrusted to the care of the Director of the BIPM, the one deposited at the Archives Nationales in Paris which Mrs A. James-Sarazin, at the Direction of the Archives Nationales, had brought, and finally the one kept by the President of the International Committee.

The doors of the vault having been opened as well as the safe, we observed the presence in the safe of the international prototype of the kilogram and its official copies.

The following indications on the measuring instruments placed in the safe were noted:

temperature:	22 °C
maximum temperature:	24 °C
minimum temperature:	21 °C
relative humidity:	64 %

We then locked the safe as well as the doors of the vault.

The Director	for the Curator	The President
of the BIPM	of the Archives de France	of the CIPM
T.J. Quinn	A. James-Sarazin	J. Kovalevsky

## 13 OTHER BUSINESS

### 13.1 Technical Supplement to *Metrologia*

Dr Quinn proposed that a Technical Supplement to *Metrologia* be created on the web, with the aim of preventing the journal's scientific content being

swamped by the results of key comparisons. He confirmed that a list of the contents of this Technical Supplement would also be printed in the journal. The CIPM approved the suggestion, expressing the view that this supplement should be free of charge to all, because it represents part of Appendix B of the MRA.

### **13.2 The Avogadro project**

In the discussion related to the Secretary's report item 2.14, the Avogadro project, some further detailed study is necessary. The CIPM invited Dr Inglis and Dr Tanaka to assess the possibility of advancing the project in the way proposed.

### **13.3 BIPM summer school**

Dr Quinn presented the idea of holding a summer school in metrology at the BIPM. The idea sprang from the very successful series of Enrico Fermi schools organized by the Italian Physical Society. The most recent was held in Varenna and was co-directed by Dr Quinn and Prof. Leschiutta. Dr Quinn proposed that two-week school be held at the BIPM in 2003, specifically for young scientists from NMIs, with lectures held in the Pavillon du Mail, meals provided at the BIPM, and hotel accommodation organized in the close vicinity. This would be the first such metrology Summer School specifically directed at young people from national metrology institutes. He said that his experience of the three Italian Schools at which he had participated, those in 1976, 1986 and 2000, was that many long-lasting friendships were made among the students and that such events are excellent ways of building networks between researchers that are so essential to the success of the subject. For this reason he is proposing that we organize a Metrology Summer School for young people from NMIs at the BIPM.

On the question of finance, Dr Quinn confirmed that the BIPM would pay for the cost of the school, adding that the lecturers would not be paid and no subsidies for students would be available.

The CIPM approved the principle and Dr Quinn confirmed that, once the dates were fixed, the details would be publicized on the BIPM website. Prof. Leschiutta told the Committee that the Italian Physical Society hoped to hold its next school in 2006 and would be pleased to collaborate in the BIPM project. (Note: The dates of the BIPM Summer School are now fixed as the last two weeks in July 2003, namely 21 July – 1 August).

#### **13.4 BIPM website**

Dr Quinn presented two new services on the BIPM website: an extension of the much-used “Useful links page” and a new search engine allowing a simultaneous search over all the web pages of the NMIs of Member States of the Metre Convention and Associates of the CGPM. The Committee agreed that this provided a very useful service.

#### **14 DATE OF NEXT MEETING**

Prof. Kovalevsky had to leave the meeting shortly before the end and the Vice-President, Dr VanKoughnett, took his place as chairman and concluded the other business. He thanked all participants for their contributions, and reminded the Committee that the 91st meeting would be a four-day event held at the Pavillon de Breteuil from 8-11 October 2002.

## RECOMMENDATION ADOPTED BY THE INTERNATIONAL COMMITTEE FOR WEIGHTS AND MEASURES

### RECOMMENDATION 1 (CI-2001):

#### The neper and the bel

The International Committee for Weights and Measures,

#### considering that

- the natural logarithm is used for expressing the values of logarithmic decrement, field level and power level in the system of quantities on which the International System (SI) is based,
- quantities and quantity equations become simplified when the natural logarithm (logarithm to the base  $e$ ) is used, rather than logarithms to other bases,
- in particular, for complex quantities the only useful logarithm is the natural logarithm,
- with the use of the natural logarithm for complex quantities, the radian and neper become analogous units and should thus be given the same status in the SI,
- the 20th General Conference (1995, Resolution 8), decided to interpret the then supplementary units in the SI, namely the radian and steradian, as dimensionless derived units and consequently to eliminate the class of supplementary units as a separate class in the SI,
- the International Committee, through the SI brochure, 7th edition (1998), has accepted for use with the SI the neper, symbol  $Np$ , as a special name for the coherent SI unit number one, for expressing the values of logarithmic quantities defined using natural logarithms, and also the non-coherent unit, the bel, symbol  $B$ , as a unit for expressing the values of logarithmic quantities defined using logarithms to the base ten, and has emphasized the importance of stating the reference level,
- there is a need to complete the internal consistency of the SI by formally adopting the special name neper with symbol  $Np$  for the coherent SI unit “one”, for expressing the values of logarithmic quantities in areas such as signal decay, electrotechnology, and acoustics,

**confirms** the decision of the International Committee to accept for use with the SI the unit bel, symbol B, and its commonly used submultiple the decibel, symbol dB, when using logarithms to the base ten, and

**recommends** that the special name neper with symbol Np be adopted for the number one as the SI dimensionless derived unit for expressing the values of logarithmic quantities such as logarithmic decrement, field level, or power level defined using natural logarithms.

## LIST OF ACRONYMS USED IN THE PRESENT VOLUME

### 1 Acronyms for laboratories, committees and conferences

AGAL	Australian Government Analytical Laboratories, Sydney, Melbourne and Perth (Australia)
AIST*	National Institute of Advanced Industrial Science and Technology, see NMIJ/AIST
APMP	Asia/Pacific Metrology Programme
BIML	Bureau International de Métrologie Légale
BIPM	International Bureau of Weights and Measures/Bureau International des Poids et Mesures
BNM	Bureau National de Métrologie, Paris (France)
BNM-INM	Bureau National de Métrologie, Institut National de Métrologie, Paris (France)
BNM-LPTF	Bureau National de Métrologie, Laboratoire Primaire du Temps et des Fréquences, Paris (France)
CC	Consultative Committee of the CIPM
CCAUV	Consultative Committee for Acoustics, Ultrasound and Vibration/Comité Consultatif de l'Acoustique, des Ultrasons et des Vibrations
CCDM*	Consultative Committee for the Definition of the Metre/Comité Consultatif pour la Définition du Mètre, see CCL
CCDS*	Consultative Committee for the Definition of the Second/Comité Consultatif pour la Définition de la Seconde, see CCTF
CCE*	Consultative Committee for Electricity/Comité Consultatif d'Électricité, see CCEM
CCEM	(formerly the CCE) Consultative Committee for Electricity and Magnetism/Comité Consultatif d'Électricité et Magnétisme
CCEMRI*	Consultative Committee for Standards of Ionizing Radiation/Comité Consultatif pour les Étalons de Mesure des Rayonnements Ionisants, see CCRI
CCL	(formerly the CCDM) Consultative Committee for Length/Comité Consultatif des Longueurs

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\* Organizations marked with an asterisk either no longer exist or operate under a different acronym.

CCM	Consultative Committee for Mass and Related Quantities/ Comité Consultatif pour la Masse et les Grandeurs Apparentées
CCPR	Consultative Committee for Photometry and Radiometry/ Comité Consultatif de Photométrie et Radiométrie
CCQM	Consultative Committee for Amount of Substance/Comité Consultatif pour la Quantité de Matière
CCRI	(formerly the CCEMRI) Consultative Committee for Ionizing Radiation/Comité Consultatif des Rayonnements Ionisants
CCT	Consultative Committee for Thermometry/Comité Consultatif de Thermométrie
CCTF	(formerly the CCDS) Consultative Committee for Time and Frequency/Comité Consultatif du Temps et des Fréquences
CCU	Consultative Committee for Units/Comité Consultatif des Unités
CEM	Centro Español de Metrología, Madrid (Spain)
CGPM	General Conference on Weights and Measures/Conférence Générale des Poids et Mesures
CIPM	International Committee for Weights and Measures/Comité International des Poids et Mesures
CMI	Český Metrologický Institut/Czech Metrological Institute, Prague and Brno (Czech Rep.)
CNAM	Conservatoire National des Arts et Métiers, Paris (France)
COOMET	Cooperation in Metrology among the Central European Countries
CRL*	Communications Research Laboratory, Tokyo (Japan), see NMIJ/AIST
CSIR-NML	Council for Scientific and Industrial Research, National Metrology Laboratory, Pretoria (South Africa)
CSIRO*	see NML CSIRO
EU	European Union
EUROMET	European Collaboration in Measurement Standards
GT-RF	CCEM Working Group on Radiofrequency Quantities/ Groupe de Travail du CCEM pour les Grandeurs aux Radiofréquences
IAEA	International Atomic Energy Agency
ICAG	International Conference of Absolute Gravimeters
ICRU	International Commission on Radiation Units and Measurements
IEC	International Electrotechnical Commission



IEN	Istituto Elettrotecnico Nazionale Galileo Ferraris, Turin (Italy)
IFCC	International Federation of Clinical Chemistry and Laboratory Medicine
IGS	International GPS Service for Geodynamics
ILAC	International Laboratory Accreditation Conference
IMEKO	International Measurement Confederation
IMGC	Istituto di Metrologia G. Colonnetti, Turin (Italy)
IMGC-CNR	Istituto di Metrologia G. Colonnetti, Consiglio Nazionale delle Ricerche, Turin (Italy)
INM*	Institut National de Métrologie, Paris (France), see BNM-INM
INTI	Instituto Nacional de Tecnología Industrial, Buenos Aires (Argentina)
IOMP	International Organization for Medical Physics
IRMM	Institute for Reference Materials and Measurements, European Commission
IRPA	International Radioprotection Association
ISO	International Organization for Standardization
ISO CASCO	International Organization for Standardization, Conformity Assessment Committee
ISO REMCO	International Organization for Standardization, Committee on Reference Materials
ITU	International Telecommunication Union
JCGM	Joint Committee for Guides in Metrology
JCRB	Joint Committee of the Regional Metrology Organizations and the BIPM
JCTLM	Joint Committee on Traceability in Laboratory Medicine
JILA	Joint Institute for Laboratory Astrophysics, Boulder CO (United States)
LGC	Laboratory of the Government Chemist, Teddington (United Kingdom)
LPTF*	Laboratoire Primaire du Temps et des Fréquences, Paris (France), see BNM-LPTF
MENAMET	Middle East Metrology Organization
METAS	(formerly the OFMET) Office Fédéral de Métrologie et d'Accréditation, Wabern (Switzerland)
MIKES	Mittatekniiikan Keskus, Helsinki (Finland)
MOU	Memorandum of Understanding
MRA	Mutual Recognition Arrangement
NCM	National Centre of Metrology, Sofia (Bulgaria)

NEWRAD	New Developments and Applications in Optical Radiometry Conference
NIM	National Institute of Metrology, Beijing (China)
NIST	National Institute of Standards and Technology, Gaithersburg MD (United States)
NMI	National Metrology Institute
NMi VSL	Nederlands Meetinstituut, Van Swinden Laboratorium, Delft (The Netherlands)
NMIJ/AIST	National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology, Tsukuba (Japan)
NML CSIRO	National Measurement Laboratory, CSIRO, Pretoria (Australia)
NML	see CSIR
NORAMET	North American Metrology Cooperation
NPL	National Physical Laboratory, Teddington (United Kingdom)
NPL-DTI	National Physical Laboratory, Department of Trade and Industry, Teddington (United Kingdom)
NRC	National Research Council of Canada, Ottawa (Canada)
NRLM*	National Research Laboratory of Metrology, Tsukuba (Japan), see NMIJ/AIST
OFMET*	Office Fédéral de Métrologie/Eidgenössisches Amt für Messwesen, Wabern (Switzerland), see METAS
OIML	Organisation Internationale de Métrologie Légale
OMH	Országos Mérésügyi Hivatal, Budapest (Hungary)
OP	Observatoire de Paris (France)
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig and Berlin (Germany)
RMO	Regional Metrology Organization
SADCMET	Southern African Development Community Cooperation in Measurement Traceability
SIM	Sistema Interamericano de Metrología
SURAMET	South American Metrology Cooperation (Argentina, Brazil, Chile, Paraguay and Uruguay)
TempMeko	International Symposium on Temperature and Thermal Measurements in Industry and Science
UME	Ulusal Metroloji Enstitüsü/National Metrology Institute, Marmara Research Centre, Gebze-Kocaeli (Turkey)
UNIDO	United Nations Industrial Development Organization
USNO	U.S. Naval Observatory, Washington DC (United States)

VNIIM	D.I. Mendeleyev Institute for Metrology, Gosstandart of Russia, St Petersburg (Russian Fed.)
VNIIMS	Russian Research Institute for Metrological Service of Gosstandart of Russia, Moscow (Russian Fed.)
VSL*	Van Swinden Laboratorium, Delft (The Netherlands), see NMi VSL
WG	Working Group of a Consultative Committee
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization
WTO-TBT	World Trade Organization, Committee for Technical Barriers to Trade

## 2 Acronyms for scientific terms

AUV	Acoustics, Ultrasound and Vibration
CMC	Calibration and Measurement Capabilities
CRM	Certified Reference Material
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IT	Information Technology
ITS-90	International Temperature Scale of 1990
KCDB	BIPM Key Comparison Database
KCRV	Key Comparison Reference value
QHE	Quantum Hall Effect
QHR	Quantum Hall Resistance
SI	International System of Units
SIR	International Reference System for gamma-ray emitting radionuclides
SPRT	Standard Platinum Resistance Thermometer
TAI	International Atomic Time
UTC	Coordinated Universal Time
VIM	International Vocabulary of Basic and General Terms in Metrology