CCL report to the 2019 meeting of the CCU

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Highlights from CCL

- Publication of « Mise en pratique »
  - Primary methods for the practical realization of the metre
  - Secondary methods for the practical realization of the metre in the domain of dimensional nanometrology

- ISO/TC 213 approved the creation of new external liaisons with the CCL and appointed a CCL delegate as the Liaison Officer.

- CCL published the strategic document, its summary and guidance documents for CMCs after the last meeting held in 2018.

"Mise en pratique"

The "Mise en pratique" for the definition of the metre in the SI is now published in the Appendix 2 of the SI Brochure.

Practical realizations of the definitions of some important units

Appendix 2: *Mises en pratique* | SI Brochure (9th edition)

→ **Appendix 2 of the SI Brochure**

The *mises en pratique* are prepared by the relevant Consultative Committees and are then published in electronic form here on the BIPM website, where they may be revised more frequently than if they were printed in the SI Brochure.

- **second**
  - *Mise en pratique* for the definition of the second in the SI (20 May 2019)
  - Recommended values of standard frequencies (last updated 30 November 2018)
- **metre**
  - *Mise en pratique* for the definition of the metre in the SI (20 May 2019)
  - Guidance document CCL-GD-MeP-1
  - Guidance document CCL-GD-MeP-2
  - Guidance document CCL-GD-MeP-3
  - Recommended values of standard frequencies (last updated 30 November 2018)
- **kilogram**
  - *Mise en pratique* for the definition of the kilogram in the SI (20 May 2019)
  - Note on the impact of the redefinition of the kilogram on BIPM mass calibration uncertainties
- **ampere**
  - *Mise en pratique* for the definition of the ampere and other electric units in the SI (20 May 2019)
  - CCEM Guidelines for Implementation of the Revised SI
- **kelvin**
  - *Mise en pratique* for the definition of the kelvin in the SI (20 May 2019)
  - Temperatures scales and the kelvin
- **mole**
  - *Mise en pratique* for the definition of the mole in the SI (20 May 2019)
- **candela**
  - *Mise en pratique* for the definition of the candela in the SI (20 May 2019)
  - Principles governing photometry (2019)

Mise en pratique for the definition of the metre in the SI

Consultative Committee for Length

1. Introduction

The purpose of this *Mise en Pratique*, prepared by the Consultative Committee for Length (CCL) of the International Committee for Weights and Measures (CIPM), is to indicate how the definition of the SI base unit, the metre, symbol m, may be realized in practice.

In general, the term 'to realize a unit' is interpreted to mean the establishment of the value and associated uncertainty of a quantity of the same kind as the unit that is consistent with the definition of the unit. A primary method of realizing a unit is a method having the highest metrological properties; whose operation can be completely described and understood; for which a complete uncertainty statement can be written down in terms of SI units; and which does not require a reference standard of the same quantity.

This document starts with the definition of the metre as agreed at the 26th meeting of the Conférence Générale des poids et Mesures (CGPM) in November 2018. This is followed by a description of the methods by which the definition of the metre may be realized in practice, both primary realisations related to the speed of light (as implied in the definition) and secondary methods as used in specific fields of metrology. Annexes describe the theory underpinning the various realization techniques, together with details of their limitations.

2. Definition of the metre

The definition of the metre, SI base unit of length, is as follows [2.1]:

> **The metre, symbol m, is the SI unit of length. It is defined by taking the fixed numerical value of the speed of light in vacuum *c* to be 299 792 458 when expressed in the unit m s^{-1}, where the second is defined in terms of the caesium frequency $\Delta\nu_{Cs}$.**

This definition implies that *'The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second'*, as it was stated in the previous definition of the metre, which was in place since 1983 [2.2], thus ensuring the continuity of the SI unit of length with the previous definition.

The second is defined by an exact value of the hyperfine transition frequency $\Delta\nu_{Cs}$ of the caesium 133 atom.

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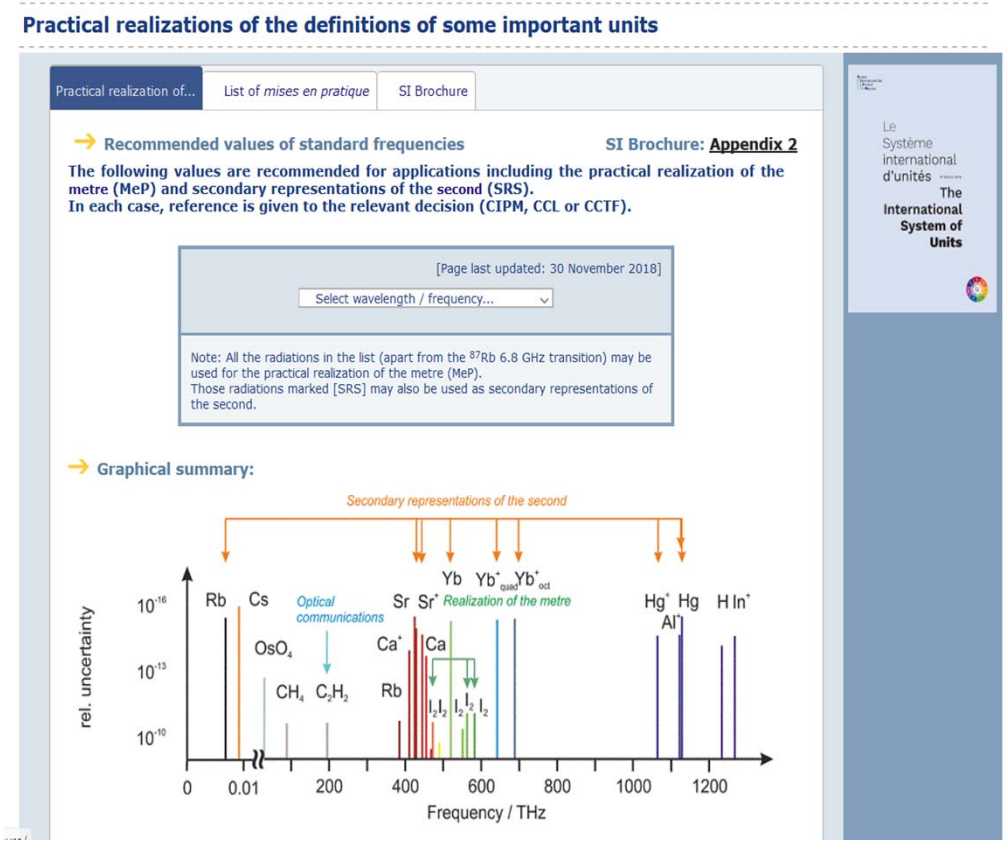
Primary methods

In BIPM website the "**recommended values of standard frequencies for applications including the practical realization of the metre and secondary representations of the second**" are published.

The realization of the metre is obtained by one of these atomic transitions, whose frequency has been measured with high accuracy and reliability



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Secondary methods - 1

For dimensional nanometrology the first method is inconvenient due to the uncertainty related to the techniques used to bridge from the standards frequencies to nano scale.

To ensure the traceability chain to SI for the nanometrology an alternate route to the nanometre and subnanometre scale is envisageable.

The availability of the very high purity crystalline silicon, the success of the semiconductor industry and prevalence of silicon-based technology has lead to **silicon** being one of the most thoroughly studied materials in nature.

Secondary methods - 2

There are several examples of how a traceability pathway through the **silicon lattice spacing** (Si d_{220} lattice parameter is quoted in CODATA) is relevant for dimensional metrology at nano scale.

Three of these examples are described in the guidelines published with the « Mise en Pratique ».

Realization of the SI metre:

- X-ray interferometry for displecement metrology
- using silicon lattice and Transmission Electron Microscopy for Dimensional Nanometrology
- using height of monoatomic steps of crystalline silicon surfaces

Thank you very much

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