Modifications to the Draft of the ninth SI Brochure dated 16 September 2016 recommended by the CCPR to the CCU via the CCPR president Takashi Usuda, Wednesday 14 December 2016.

The text in black is a selection of paragraphs from the brochure with the section title for indication. The sentences to be modified appear in red.

2.1 Definition of the SI

Like for any value of a quantity, the value of a fundamental constant can be expressed as the product of a number and a unit as $Q = \{Q\}\,[Q]$.

The definitions below specify the exact numerical value of each constant when its value is expressed in the corresponding SI unit. By fixing the exact numerical value the unit becomes defined, since the product of the ***numerical value* {*Q*}** and the ***unit* [*Q*]** has to equal the ***value Q*** of the constant, which is postulated to be invariant.

The seven constants are chosen in such a way that any unit of the SI can be written either through a defining constant itself or through products or ratios of defining constants.

The International System of Units, the SI, is the system of units in which

- **the unperturbed ground state hyperfine splitting frequency of the caesium 133 atom $\Delta\nu_{Cs}$ is 9 192 631 770 Hz,**
- **the speed of light in vacuum *c* is 299 792 458 m/s,**
- **the Planck constant *h* is 6.626 070 040 $\times 10^{-34}$ J s,**
- **the elementary charge *e* is 1.602 176 620 8 $\times 10^{-19}$ C,**
- **the Boltzmann constant *k* is 1.380 648 52 $\times 10^{-23}$ J/K,**
- **the Avogadro constant N_A is 6.022 140 857 $\times 10^{23}$ mol^{-1},**
- **the luminous efficacy of monochromatic radiation of frequency 540 $\times 10^{12}$ hertz K_{cd} is 683 lm/W.**

2.1.1 The nature of the seven defining constants

The luminous efficacy K_{cd} is a technical constant that gives an exact numerical relationship between the purely physical characteristics of the radiant power stimulating the human eye (W) and its photobiological response defined by the luminous flux due to the spectral responsivity of a standard observer (lm) at a frequency of 540×10^{12} hertz.

2.2.1 Base units

- **The candela, symbol cd, is the SI unit of luminous intensity in a given direction. It is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency 540 ×10^{12} Hz, K_{cd}, to be 683 when expressed in the unit lm W^{-1}, which is equal to cd sr W^{-1}, or cd sr kg^{-1} m^{-2} s^{3} , where the kilogram, metre and second are defined in terms of *h*, *c* and $\Delta\nu_{Cs}$.**

This definition implies the exact relation K_{cd} = 683 cd sr kg^{-1} m^{-2} s^{3} for monochromatic radiation of frequency ν = 540 ×10^{12} Hz. Inverting this relation gives an exact expression for the candela in terms of the defining constants K_{cd}, *h* and $\Delta\nu_{Cs}$:

$$\text{cd} = \left(\frac{K_{cd}}{683}\right) \text{kg m}^2\ \text{s}^{-3}\ \text{sr}^{-1} \ = \ 2.614\,830... \times 10^{10}\ (\Delta\nu_{Cs})^2\ h\ K_{cd}.$$

The effect of this definition is that one candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 ×10^{12} Hz and has a radiant intensity in that direction of (1/683) W/sr. The definition of the steradian is given under Table 4, below. To obtain the luminous efficacy function at other frequencies (wavelengths) in the visible spectral range, K_{cd} is weighted by the spectral luminous efficiency function for the specified photometric condition of a standardized CIE photometric observer, divided by its value at the frequency (wavelength) in the definition of the candela [see SI brochure, Appendix 2, *Mise en pratique* for the definition of the candela and associated derived units].

2.2.5 Units for quantities that describe biological and physiological effects

Four of the SI units listed in tables 2 and 4 include physiological weighing factors: candela, lumen, lux, and sievert.

Lumen (lm) and lux (lx) are derived from the base unit candela, where lm = cd sr and lx = cd sr m^{-2} . Like the candela they are units for quantities that carry information about how different geometrical characteristics of optical radiation stimulate the human visual system. The candela was established as a base unit in 1954, acknowledging the importance of light in daily life.

It is important to note that the photometric units are applicable under all photometric conditions (i.e. corresponding to different states of visual adaptation: photopic, scotopic and mesopic or to different size and position of the source in the visual field). However, the candela and other photometric units shall only be used for human vision related quantities and are not to be used for photochemical and photobiological quantities. In this latter case, the radiometric unit of the corresponding radiometric quantity is to be used. For further advice on the units and conventions to be used for defining photochemical and photobiological quantities, consult Appendix 3 of the SI brochure which is available in the on-line version [provide link].

Part 3 Historical perspective on the base units

Unit of luminous intensity, candela

The units of luminous intensity based on flame or incandescent filament standards in use in various countries before 1948 were replaced initially by the “new candle” based on the luminance of a Planckian radiator (a black body) at the temperature of freezing platinum. This modification had been prepared by the International Commission on Illumination (CIE) and by the CIPM before 1937, and the decision was promulgated by the CIPM in 1946. It was then ratified in 1948 by the 9th CGPM which adopted a new international name for this unit, the *candela*, symbol cd; in 1954 the 10th CGPM established the candela as a base unit; in 1967 the 13th CGPM (Resolution 5, CR, 104 and *Metrologia*, 1968, **4**, 43-44) gave an amended version of this definition.