



# Report to CCU, April 2024

## KEY SCIENTIFIC QUESTIONS IN THE DEFINITION OF THE SI UNIT OF LUMINOUS INTENSITY, THE CANDELA

With the revision of the International System of Units, SI, approved by the 26<sup>th</sup> CGPM in 2018 and officially adopted on 20 May 2019, the SI unit of luminous intensity, the candela, has been consistently reformulated by fixing the numerical value of the so-called “defining constant” for photometry,  $K_{cd}$  (luminous efficacy of monochromatic radiation of frequency  $540 \times 10^{12}$  Hz).

$K_{cd}$  enables a direct link between photometric and radiometric quantities for monochromatic radiation of frequency 540 THz, together with the spectral luminous efficiency functions, therefore contributing to the establishment of a metrologically consistent system. The definition and standardization of these functions fall under the responsibility of the CIE, as agreed in the formal agreement signed with the CIPM in 2007. These provide agreed representations of the relative spectral sensitivity of the human visual system under defined conditions and are normalized to unity at the wavelength of peak sensitivity. The most important of these visual functions is the photopic (daylight conditions) luminous efficiency function for the light-adapted eye,  $V(\lambda)$ , with its first version adopted hundred years ago in 1924.

Much progress has been done since that time, leading to a much better understanding of the luminous perception via the human eyes, and the introduction of so-called *cone fundamentals*, which are functions describing colour vision mechanisms. A framework based on cone fundamentals was proposed in several CIE publications to establish a new photometric system, with new spectral luminous efficiency functions and colour-matching functions. Adoption of such a framework would imply revisiting the link between photometry and radiometry. This link and its nature are the key scientific challenges in the definition of the candela for the next future. This could have a significant impact on measurement devices, manufacturers, regulations and standardization that are based on the present definition of the candela (2018) with a defining constant  $K_{cd}$ .

To start the discussion on these issues, the CCPR is organising a one-day workshop with the CIE on cone-fundamentals, Monday 3 June 2024, and will invite further discussion on the possible impact on the definition of the candela during a special session of its working group on strategy, Tuesday 4 June 2024.

The [CCPR and CIE joint Workshop '100 Years of  \$V\(\lambda\)\$  and the Future of Photometry'](#) will commemorate 100<sup>th</sup> anniversary of  $V(\lambda)$ , overview the history of spectral luminous efficiency functions and CIE colorimetry, and introduce the cone fundamentals published by CIE (2006, 2015), then will discuss the future of photometry and colorimetry with cone-fundamental-based spectral luminous efficiency functions and colour-matching functions. It is intended for researchers,

engineers, and stakeholders in academia, industry, national metrology institutes, testing and calibration laboratories, lighting manufacturers, instrument manufacturers, who are engaged in photometry and colorimetry. CCU members are also welcome to register ([registration form](#)).

This will be followed by a half-day workshop during the 2024 CCPR week to discuss the future of the candela and have deep conversations on the current proposals on the definition of the candela, from no changes to the current definition to the removal of the candela from the 7 base SI units. CCPR delegates are invited to defend one of the positions below in order to foster constructive brainstorming:

- No changes to the current definition of the candela
- Adopt Cone Fundamentals to the  $K_{cd}$  definition.
- Adopt a set of  $K_{cd}$  values, each value corresponding to a given standardised Illumination/observer condition.
- Go back to the definition using a source like a blackbody instead of the spectral responsivity of the human eye.
- Photon-based candela
- Removing the candela from the 7 base SI units

The outcomes of both workshops will be discussed during the plenary session of the CCPR (6-7 June 2024) and summarised in the report of that session. A more detailed report will be proposed to the next CCU meeting.