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Report of the Working Group on Synchrotron Radiation Nomenclature – brightness, spectral brightness or brilliance?

1. Background information

There is nearly unanimous agreement across the synchrotron radiation community that a measure of the number of photons emitted per second per bandwidth per unit solid angle and unit area of the source[1] is the proper way to characterize the radiation properties of third-generation sources. What has not gained such uniform acceptance is the nomenclature for this quantity. This is most likely due to the fact that scientists from various disciplines and countries have contributed to this relatively new, but rapidly growing, field. Paging through the literature, one is likely to come across the words brilliance, brightness, spectral brightness *etc.* for this measure of this source property. Although there seems to be little correlation between nomenclature and geographical location, some correlation is found between the nomenclature and the generation of the source. Third-generation sources are more likely to call this quantity brilliance, if data taken from the facility's web sites can be considered indicative of the facility management's preference. However, even this observation is not fully consistent across all third-generation facilities. A quick search of 'spectral brightness' on the internet yields many hits from sites associated with both lasers and synchrotron radiation sources, while a search of 'spectral brilliance' leads to many fewer hits and from sites almost exclusively dealing with synchrotron radiation.

Given this inconsistency within the synchrotron radiation community, looking at other (related) fields, such as classical optics and accelerator physics, may provide some insight. The National Institute of Standards and Technology in the US defines brightness as '... the radiated power per unit solid angle per unit area normal to the direction ...' and spectral brightness as '... the brightness per unit frequency, the spectral radiance'. Spectral brightness has also found acceptance in the (visible light) laser community as a term to characterize the properties of laser light sources. In the accelerator physics community the generally accepted terminology (as no field seems to be fully consistent) for the particle density in phase space is brightness, *i.e.* the number of particles divided by the six-dimensional phase space.

2. Units

The current default standard units for this source characteristic are photons s^{-1} mm^{-2} $mrad^{-2}$ (0.1% bandwidth)$^{-1}$. In strict accordance with Système International (SI) units, one should perhaps use photons s^{-1} m^{-2} rad^{-2} (100% bandwidth)$^{-1}$. Discussions with colleagues in the field have also suggested the 'practical' units of photons s^{-1} μm^{-2} μrad^{-2} (0.1% bandwidth)$^{-1}$, as micrometres and microradians are convenient units of source size and source divergence, respectively.

3. Conclusions

The conclusion reached is that the term *spectral brightness* best describes this quantity. Brightness maintains the generally accepted concept of intensity per unit source size and divergence, while the adjective *spectral* conveys the scientific importance of the number of photons in a given bandwidth, particularly for experiments such as inelastic and/or nuclear resonant scattering.

Concerning units, it seems best to maintain the units of photons s^{-1} mm^{-2} $mrad^{-2}$ (0.1% bandwidth)$^{-1}$ since they are so ensconced in the literature that a drive to change this would only lead to more confusion rather than more clarity in the descriptions of synchrotron radiation sources.

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[1] Source size and divergence throughout this report implies the size and divergence of the photon beam, which may, in some cases, be considerably different than the size and divergence of the particle beam generating the photons.

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