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Radiant exitance

In radiometry, **radiant exitance** or **radiant emittance** is the radiant flux emitted by a surface per unit area, whereas **spectral exitance** or **spectral emittance** is the radiant exitance of a surface per unit frequency or wavelength, depending on whether the spectrum is taken as a function of frequency or of wavelength. This is the emitted component of radiosity. The SI unit of radiant exitance is the watt per square metre (W/m^2), while that of spectral exitance in frequency is the watt per square metre per hertz ($W{\cdot}m^{-2}{\cdot}Hz^{-1}$) and that of spectral exitance in wavelength is the watt per square metre per metre ($W{\cdot}m^{-3}$)—commonly the watt per square metre per nanometre ($W{\cdot}m^{-2}{\cdot}nm^{-1}$). The CGS unit erg per square centimeter per second ($erg{\cdot}cm^{-2}{\cdot}s^{-1}$) is often used in astronomy. Radiant exitance is often called "intensity" in branches of physics other than radiometry, but in radiometry this usage leads to confusion with radiant intensity.

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Radiant exitance

Radiant exitance of a *surface*, denoted M_e ("e" for "energetic", to avoid confusion with photometric quantities), is defined as[1]

$$M_\mathrm{e} = \frac{\partial \Phi_\mathrm{e}}{\partial A},$$

where

- ∂ is the partial derivative symbol;
- Φ_e is the radiant flux *emitted*;
- A is the area.

If we want to talk about the radiant flux *received* by a surface, we speak of irradiance.

The radiant exitance of a black surface, according to the Stefan–Boltzmann law, is equal to:

$$M_\mathrm{e}^\circ = \sigma T^4,$$

where

- σ is the Stefan–Boltzmann constant;

- T is the temperature of that surface,

so for a real surface, the radiant exitance is equal to:

$$M_\mathrm{e} = \varepsilon M_\mathrm{e}^\circ = \varepsilon \sigma T^4,$$

where ε is the emissivity of that surface.

Spectral exitance

Spectral exitance in frequency of a *surface*, denoted $M_{e,\nu}$, is defined as[1]

$$M_{\mathrm{e},\nu} = \frac{\partial M_\mathrm{e}}{\partial \nu},$$

where ν is the frequency.

Spectral exitance in wavelength of a *surface*, denoted $M_{e,\lambda}$, is defined as[1]

$$M_{\mathrm{e},\lambda} = \frac{\partial M_\mathrm{e}}{\partial \lambda},$$

where λ is the wavelength.

The spectral exitance of a black surface around a given frequency or wavelength, according to the Lambert's cosine law and the Planck's law, is equal to:

$$M_{\mathrm{e},\nu}^\circ = \pi L_{\mathrm{e},\Omega,\nu}^\circ = \frac{2\pi \mathrm{h} \nu^3}{c^2} \frac{1}{e^{\frac{\mathrm{h}\nu}{\mathrm{k}T}} - 1},$$
$$M_{\mathrm{e},\lambda}^\circ = \pi L_{\mathrm{e},\Omega,\lambda}^\circ = \frac{2\pi \mathrm{h} c^2}{\lambda^5} \frac{1}{e^{\frac{\mathrm{h}c}{\lambda \mathrm{k}T}} - 1},$$

where

- h is the Planck constant;
- ν is the frequency;
- λ is the wavelength;
- k is the Boltzmann constant;
- c is the speed of light in the medium;
- T is the temperature of that surface,

so for a real surface, the spectral exitance is equal to:

$$M_{\mathrm{e},\nu} = \varepsilon M_{\mathrm{e},\nu}^\circ = \frac{2\pi \mathrm{h} \varepsilon \nu^3}{c^2} \frac{1}{e^{\frac{\mathrm{h}\nu}{\mathrm{k}T}} - 1},$$
$$M_{\mathrm{e},\lambda} = \varepsilon M_{\mathrm{e},\lambda}^\circ = \frac{2\pi \mathrm{h} \varepsilon c^2}{\lambda^5} \frac{1}{e^{\frac{\mathrm{h}c}{\lambda \mathrm{k}T}} - 1}.$$

SI radiometry units

SI radiometry units

Quantity		Unit		Dimension	Notes
Name	Symbol[nb 1]	Name	Symbol	Symbol	
Radiant energy	Q_e[nb 2]	joule	J	$\mathbf{M}\cdot\mathbf{L}^2\cdot\mathbf{T}^{-2}$	Energy of electromagnetic radiation.
Radiant energy density	w_e	joule per cubic metre	J/m^3	$\mathbf{M}\cdot\mathbf{L}^{-1}\cdot\mathbf{T}^{-2}$	Radiant energy per unit volume.
Radiant flux	Φ_e[nb 2]	watt	W = J/s	$\mathbf{M}\cdot\mathbf{L}^2\cdot\mathbf{T}^{-3}$	Radiant energy emitted, reflected, transmitted or received, per unit time. This is sometimes also called "radiant power".
Spectral flux	$\Phi_{e,\nu}$[nb 3] *or* $\Phi_{e,\lambda}$[nb 4]	watt per hertz *or* watt per metre	W/Hz *or* W/m	$\mathbf{M}\cdot\mathbf{L}^2\cdot\mathbf{T}^{-2}$ *or* $\mathbf{M}\cdot\mathbf{L}\cdot\mathbf{T}^{-3}$	Radiant flux per unit frequency or wavelength. The latter is commonly measured in $W\cdot nm^{-1}$.
Radiant intensity	$I_{e,\Omega}$[nb 5]	watt per steradian	W/sr	$\mathbf{M}\cdot\mathbf{L}^2\cdot\mathbf{T}^{-3}$	Radiant flux emitted, reflected, transmitted or received, per unit solid angle. This is a *directional* quantity.
Spectral intensity	$I_{e,\Omega,\nu}$[nb 3] *or* $I_{e,\Omega,\lambda}$[nb 4]	watt per steradian per hertz *or* watt per steradian per metre	$W\cdot sr^{-1}\cdot Hz^{-1}$ *or* $W\cdot sr^{-1}\cdot m^{-1}$	$\mathbf{M}\cdot\mathbf{L}^2\cdot\mathbf{T}^{-2}$ *or* $\mathbf{M}\cdot\mathbf{L}\cdot\mathbf{T}^{-3}$	Radiant intensity per unit frequency or wavelength. The latter is commonly measured in $W\cdot sr^{-1}\cdot nm^{-1}$. This is a *directional* quantity.
Radiance	$L_{e,\Omega}$[nb 5]	watt per steradian per square metre	$W\cdot sr^{-1}\cdot m^{-2}$	$\mathbf{M}\cdot\mathbf{T}^{-3}$	Radiant flux emitted, reflected, transmitted or received by a *surface*, per unit solid angle per unit projected area. This is a *directional* quantity. This is sometimes also confusingly called "intensity".
Spectral radiance	$L_{e,\Omega,\nu}$[nb 3] *or* $L_{e,\Omega,\lambda}$[nb 4]	watt per steradian per square metre per hertz *or* watt per steradian	$W\cdot sr^{-1}\cdot m^{-2}\cdot Hz^{-1}$ *or* $W\cdot sr^{-1}\cdot m^{-3}$	$\mathbf{M}\cdot\mathbf{T}^{-2}$ *or* $\mathbf{M}\cdot\mathbf{L}^{-1}\cdot\mathbf{T}^{-3}$	Radiance of a *surface* per unit frequency or wavelength. The latter is commonly measured in

		per square metre, per metre			$W \cdot sr^{-1} \cdot m^{-2} \cdot nm^{-1}$. This is a *directional* quantity. This is sometimes also confusingly called "spectral intensity".
Irradiance Flux density	E_e[nb 2]	watt per square metre	W/m^2	$\mathbf{M} \cdot \mathbf{T}^{-3}$	Radiant flux *received* by a *surface* per unit area. This is sometimes also confusingly called "intensity".
Spectral irradiance Spectral flux density	$E_{e,\nu}$[nb 3] *or* $E_{e,\lambda}$[nb 4]	watt per square metre per hertz *or* watt per square metre, per metre	$W \cdot m^{-2} \cdot Hz^{-1}$ *or* W/m^3	$\mathbf{M} \cdot \mathbf{T}^{-2}$ *or* $\mathbf{M} \cdot \mathbf{L}^{-1} \cdot \mathbf{T}^{-3}$	Irradiance of a *surface* per unit frequency or wavelength. This is sometimes also confusingly called "spectral intensity". Non-SI units of spectral flux density include jansky (1 Jy = 10^{-26} $W \cdot m^{-2} \cdot Hz^{-1}$) and solar flux unit (1 sfu = 10^{-22} $W \cdot m^{-2} \cdot Hz^{-1}$ = 10^4 Jy).
Radiosity	J_e[nb 2]	watt per square metre	W/m^2	$\mathbf{M} \cdot \mathbf{T}^{-3}$	Radiant flux *leaving* (emitted, reflected and transmitted by) a *surface* per unit area. This is sometimes also confusingly called "intensity".
Spectral radiosity	$J_{e,\nu}$[nb 3] *or* $J_{e,\lambda}$[nb 4]	watt per square metre per hertz *or* watt per square metre, per metre	$W \cdot m^{-2} \cdot Hz^{-1}$ *or* W/m^3	$\mathbf{M} \cdot \mathbf{T}^{-2}$ *or* $\mathbf{M} \cdot \mathbf{L}^{-1} \cdot \mathbf{T}^{-3}$	Radiosity of a *surface* per unit frequency or wavelength. The latter is commonly measured in $W \cdot m^{-2} \cdot nm^{-1}$. This is sometimes also confusingly called "spectral intensity".
Radiant exitance	M_e[nb 2]	watt per square metre	W/m^2	$\mathbf{M} \cdot \mathbf{T}^{-3}$	Radiant flux *emitted* by a *surface* per unit area. This is the emitted component of radiosity. "Radiant emittance" is an old term for this quantity. This is sometimes also confusingly called "intensity".
Spectral exitance		watt per square			Radiant exitance of

	$M_{e,\nu}$[nb 3] *or* $M_{e,\lambda}$[nb 4]	metre per hertz *or* watt per square metre, per metre	$W \cdot m^{-2} \cdot Hz^{-1}$ *or* W/m^3	$\mathbf{M} \cdot \mathbf{T}^{-2}$ *or* $\mathbf{M} \cdot \mathbf{L}^{-1} \cdot \mathbf{T}^{-3}$	a *surface* per unit frequency or wavelength. The latter is commonly measured in $W \cdot m^{-2} \cdot nm^{-1}$. "Spectral emittance" is an old term for this quantity. This is sometimes also confusingly called "spectral intensity".
Radiant exposure	H_e	joule per square metre	J/m^2	$\mathbf{M} \cdot \mathbf{T}^{-2}$	Radiant energy received by a *surface* per unit area, or equivalently irradiance of a *surface* integrated over time of irradiation. This is sometimes also called "radiant fluence".
Spectral exposure	$H_{e,\nu}$[nb 3] *or* $H_{e,\lambda}$[nb 4]	joule per square metre per hertz *or* joule per square metre, per metre	$J \cdot m^{-2} \cdot Hz^{-1}$ *or* J/m^3	$\mathbf{M} \cdot \mathbf{T}^{-1}$ *or* $\mathbf{M} \cdot \mathbf{L}^{-1} \cdot \mathbf{T}^{-2}$	Radiant exposure of a *surface* per unit frequency or wavelength. The latter is commonly measured in $J \cdot m^{-2} \cdot nm^{-1}$. This is sometimes also called "spectral fluence".
Hemispherical emissivity	ε			**1**	Radiant exitance of a *surface*, divided by that of a *black body* at the same temperature as that surface.
Spectral hemispherical emissivity	ε_ν *or* ε_λ			**1**	Spectral exitance of a *surface*, divided by that of a *black body* at the same temperature as that surface.
Directional emissivity	ε_Ω			**1**	Radiance *emitted* by a *surface*, divided by that emitted by a *black body* at the same temperature as that surface.
Spectral directional emissivity	$\varepsilon_{\Omega,\nu}$ *or* $\varepsilon_{\Omega,\lambda}$			**1**	Spectral radiance *emitted* by a *surface*, divided by that of a *black body* at the same

					temperature as that surface.
Hemispherical absorptance	A			**1**	Radiant flux *absorbed* by a *surface*, divided by that received by that surface. This should not be confused with "absorbance".
Spectral hemispherical absorptance	A_ν *or* A_λ			**1**	Spectral flux *absorbed* by a *surface*, divided by that received by that surface. This should not be confused with "spectral absorbance".
Directional absorptance	A_Ω			**1**	Radiance *absorbed* by a *surface*, divided by the radiance incident onto that surface. This should not be confused with "absorbance".
Spectral directional absorptance	$A_{\Omega,\nu}$ *or* $A_{\Omega,\lambda}$			**1**	Spectral radiance *absorbed* by a *surface*, divided by the spectral radiance incident onto that surface. This should not be confused with "spectral absorbance".
Hemispherical reflectance	R			**1**	Radiant flux *reflected* by a *surface*, divided by that received by that surface.
Spectral hemispherical reflectance	R_ν *or* R_λ			**1**	Spectral flux *reflected* by a *surface*, divided by that received by that surface.
Directional reflectance	R_Ω			**1**	Radiance *reflected* by a *surface*, divided by that received by that surface.
Spectral directional reflectance	$R_{\Omega,\nu}$ *or* $R_{\Omega,\lambda}$			**1**	Spectral radiance *reflected* by a *surface*, divided by that received by that surface.
Hemispherical	T			**1**	Radiant flux

transmittance					*transmitted* by a *surface*, divided by that received by that surface.
Spectral hemispherical transmittance	T_ν *or* T_λ			**1**	Spectral flux *transmitted* by a *surface*, divided by that received by that surface.
Directional transmittance	T_Ω			**1**	Radiance *transmitted* by a *surface*, divided by that received by that surface.
Spectral directional transmittance	$T_{\Omega,\nu}$ *or* $T_{\Omega,\lambda}$			**1**	Spectral radiance *transmitted* by a *surface*, divided by that received by that surface.
Hemispherical attenuation coefficient	μ	reciprocal metre	m^{-1}	$\mathbf{L}^{-1}$	Radiant flux *absorbed* and *scattered* by a *volume* per unit length, divided by that received by that volume.
Spectral hemispherical attenuation coefficient	μ_ν *or* μ_λ	reciprocal metre	m^{-1}	$\mathbf{L}^{-1}$	Spectral radiant flux *absorbed* and *scattered* by a *volume* per unit length, divided by that received by that volume.
Directional attenuation coefficient	μ_Ω	reciprocal metre	m^{-1}	$\mathbf{L}^{-1}$	Radiance *absorbed* and *scattered* by a *volume* per unit length, divided by that received by that volume.
Spectral directional attenuation coefficient	$\mu_{\Omega,\nu}$ *or* $\mu_{\Omega,\lambda}$	reciprocal metre	m^{-1}	$\mathbf{L}^{-1}$	Spectral radiance *absorbed* and *scattered* by a *volume* per unit length, divided by that received by that volume.

See also: SI · Radiometry · Photometry

1. Standards organizations recommend that radiometric quantities should be denoted with suffix "e" (for "energetic") to avoid confusion with photometric or photon quantities.
2. Alternative symbols sometimes seen: *W* or *E* for radiant energy, *P* or *F* for radiant flux, *I* for irradiance, *W* for radiant exitance.
3. Spectral quantities given per unit frequency are denoted with suffix "ν" (Greek)—not to be confused with suffix "v" (for "visual") indicating a photometric quantity.
4. Spectral quantities given per unit wavelength are denoted with suffix "λ" (Greek).
5. Directional quantities are denoted with suffix "Ω" (Greek).