The purpose of the lexicon below is to help provide a ready reference to the common terms used daily here at Biospherical Instruments. Note that often these terms are used in discussions about optics in aquatic research, so you may perceive a specialized focus to terms rather than a broad technical definition.

Those interested in pursuing The Truth may consult a number of excellent references, such as Curt Mobley's Light and Water (1994), Academic Press, New York; J.T.O. Kirk's Light and Photosynthesis in Aquatic Ecosystems, 2nd ed. (1994), University Press, Cambridge; the Optical Society of America's Handbook of Optics; and the AMS Glossary of Meteorology.

- **Actinic flux.** The spherically integrated radiation flux in Earth's atmosphere that originates from the Sun, including the direct beam and any scattered components. This radiation is responsible for initiating the chemistry of the atmosphere.
- **Attenuation coefficient** . The diffuse attenuation coefficient (abbreviated $K_d(\lambda)$) quantifies the rate of decrease of sunlight underwater in a narrow spectral band. It is often calculated from vertical profiles of irradiance; this rate of decrease is typically logarithmic.

- **Cast.** Cast is a vertical profile of data collected at a single location. It is often divided up into segments such as the downcast, the upcast, and the dark segment. In addition, multiple casts per station may be made.
- **Cosine collector**. An optical collector with a cosine response to measure irradiance .
- **Dark voltage or dark segment**. The “Dark Offset” or “Dark Voltage” or “Dark Current” or “The Dark” is the baseline reading from the instrument when there is no light. Dark voltages are almost always a function of instrument temperature. Dark voltages are almost always small. Dark voltages may be the opposite polarity from the reading in light. A dark segment is an interval of readings in a profile that indicate the values to use as darks when applying calibration values to the profile.
- **Directional response.** The sensitivity of a light sensor as a function of the angle of incidence of the light. For example, a cosine collector has a directional response that varies in proportion with the cosine of the zenith angle of incidence. This means the signal will have a maximum responsivity to light from directly overhead (local zenith) and should have no responsivity to photons coming directly from the side or below.
- **Dynamic range .** The ratio between the largest and smallest measurable value is called the dynamic range. Because it is an expression in power, those with an engineering bent often express dynamic range in decibels (db), although it is also convenient to use the resolution of

the associated analog-to-digital electronics. Thus, you may see dynamic range expressed in bits (e.g., 16 or 20 bits). To be truly useful, wide dynamic range requires more than just extra bits—high-quality, low-noise electronics are also needed to ensure that any extra bit depth is well used.

- **Einstein**. A mole (6.02×10^{23}) of quanta. See also Units , below.
- **Filter-photodetector radiometer.** This is a light sensor that measures a selective waveband of broadband sunlight where the spectral selection is performed using a combination of an optical filter and a photodetector. The waveband may be either narrowband (e.g., 10 nm FWHM) or broadband (e.g., PAR). Filter-photodetectors may be designed with combinations of filters to achieve very high resistance to spectral leakage.

- **FWHM**. Abbreviation for full-width at half-maximum. An expression of the spectral width of a detector or filter. The width is reported as the difference between the lower and upper wavelengths of the spectrum where the value of the response is equal to one-half the maximum value.
- **Irradiance detector** is a sensor that measures the radiative power per surface area. For example, the irradiance of bright day light is about 1000 W/m ^{2}, meaning that 1000 W of power are absorbed by one square meter of horizontal surface. Spectral irradiance is abbreviated E(λ) where λ is the center wavelength of the detector. Calibration units common for our irradiance sensors are μW $\cdot$ cm $^{-2}$ $\cdot$ nm $^{-1}$ for narrow bandwidth detectors, or either Q $\cdot$ m $^{-2}$ $\cdot$ s $^{-1}$ (quanta) or μE $\cdot$ m $^{-2}$ $\cdot$ s $^{-1}$ (microEinstein) for broadband sensors such as PAR (400–700 nm). The SI unit for spectral irradiance is W $\cdot$ m $^{-2}$.

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- **Irradiance detector, cosine** is a plane (vector) irradiance sensor with a directional response proportional to the cosine of the relative zenith angle of incidence. Cosine spectral irradiance is abbreviated $E_d(\lambda)$ or $E_u(\lambda)$ for downwelling or upwelling orientation. Cosine collectors often look like diffusing flat plates with sloping sides.

- **Irradiance detector, scalar** is an irradiance sensor with equal sensitivity to light from all directions. If the sensor is exposed to sunlight, scalar irradiance is often referred to as actinic flux
. Scalar spectral irradiance is abbreviated $E_o(\lambda)$. Scalar irradiance collectors often look like spheres. Chloroplasts frequently resemble small scalar collectors, and researchers concerned with photosynthesis or phytoplankton ecology often measure irradiance with scalar sensors. An above-water irradiance reference sensor equipped with a scalar collector often features a plate-like cutoff to help eliminate surface reflection. These sensors are called "hemispherical scalar collectors." Also see kPAR
for the "special" properties of the attenuation coefficient of PAR.

- **Natural Fluorescence**: "**LuChl**" is the sunlight-stimulated fluorescence of chlorophyll in the ocean. This is normally measured by our instruments as a radiance measurement. Please see this article for details.
- **NIST**, is the United State's National Institute of Standards and Technology. This is the national agency in the United States responsible for maintaining national standards, such as calibration references and procedures.

- **PAR -** Photosynthetically Active Radiation (sometimes called photosynthetically available radiation). A PAR sensor is an irradiance or scalar irradiance sensor that is equally sensitive to photons between 400 and 700 nm and insensitive to photons outside this region. In terms of collector geometry, a PAR sensor is usually equipped with either a scalar or cos
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collector. At BSI, the most common units of calibration for broadband PAR are either Q
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m
-2.
s
-1
(quanta) or µE
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m
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(microEinstein). PAR may also be calculated by integrating the weighted visible channels from a multiwavelength instrument such as a PRR.

- **PPFD - the Photosynthetic Photon Flux Density** is defined as number of photons in the 400–700 nm wavelength interval incident per unit time on a unit surface. See also PAR.

- **Radiance** is spectral radiance integrated over wavelength.
- **Reflectance, irradiance**. For the purposes of our instrumentation, the spectral irradiance reflectance is the ratio of the upwelling irradiance to the downwelling irradiance: $E_u(\lambda)/E_d(\lambda)$.

- **Reflectance, radiance**. For the purposes of our instrumentation, the spectral radiance reflectance is the ratio of the upwelling radiance to the downwelling irradiance: $L_u(\lambda)/E_d(\lambda)$.

- **Response, spectral** . The spectral response of a sensor is the magnitude of the signal from a sensor as a function of wavelength of the incident radiation. Spectral response is sometimes denoted "spectral response function."
- **Response time**. The amount of time needed for a sensor and associated circuitry to respond to a change in condition. This time constant is one of the items used in optimizing the design elements of a sensor. In most of our sensors, 0.1 seconds is the typical value. If we abbreviate the response time constant as "t" then a full step change in input signal will change the output to 63% of its final value in t seconds, and will settle to within 1% of the final value in 5*t seconds, 0.1% of the final value in 7*t seconds, and 0.01% of the final value in 9*t seconds. In addition, a step change in input signal will change from 10% to 90% of its starting and ending values in 2.2*t seconds. As a practical matter in the field, sensors are not called upon to respond to large step-like changes, and thus, field data is not normally limited by the response time constant.
- **RMA - Return Material Authorization**. An RMA number is assigned to each return to aid the manufacturing team at Biospherical to coordinate and schedule repairs. This RMA number must be clearly marked on the outside of each package for instrument systems being returned to the factory for repair. Request RMA here .
- **Scalar irradiance.** See "irradiance detector, scalar" .
- **Spectral leakage**. Spectral leakage is the erroneous reporting of light energy within a band that actually originates from wavelengths outside the band.
- **Spectral radiance** is the radiant energy per time interval, per wavelength interval, per area, and per solid angle that is received by a detector oriented normal to the source of radiation. Spectral radiance is abbreviated $L(\lambda)$, where λ is the center wavelength of the detector. Submersible radiance sensors are normally oriented to measure the nadir (upwelling)

spectral radiance, abbreviated $L_u(\lambda)$. The calibration unit of spectral radiance used in our radiance sensors is $\mu W \cdot cm^{-2} \cdot nm^{-1} \cdot sr^{-1}$ although nE $\cdot m^{-2} \cdot s^{-1} \cdot sr^{-1}$ (where nE is nanoEinstein) is used to measure natural fluorescence (L_u(chl)). Note that the SI unit for spectral radiance is $W \cdot m^{-2} \cdot nm^{-1} \cdot sr^{-1}$.

- **Steradians** is the unit used to quantify a solid angle in three-dimensional space. It is analogous to the use of "radian" to quantify an angle in two-dimensional space. A sphere subtends 4π (pi) steradians, a hemisphere subtends 2π steradians.
- **Units, photometric**. Visible radiation is often described with units such as lumens, lux, phots, stibs, nits, footcandles, candelas, and lamberts. These all refer to a detector with a spectral response that mimics the visual response of the "Standard Observer." When expressed in radiometric terms, this means: 1) a wavelength of maximum response at 550 nm; and 2) a sharply sloping spectral response (0.41% response at 700 nm relative to the peak, 0.12% at 400 nm). It is possible to convert from radiometric units to photometric units only if the complete spectral distribution is known.
- **Units, radiometric.** Units used to describe electromagnetic radiation such as Watt, Joule, Quanta, and Einstein . Sometimes you want to convert from one unit to another — if so, consult this Excel spreadsheet . "For marine atmospheres with Sun altitudes above 22°, the quanta/Watt ratio for the region

400–700nm is 2.77 x 10
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quanta/s/Watt to an accuracy of plus or minus a few percent." This quote and a further discussion of the relationship of quanta to Watts in the water column can be found in Smith and Morel (1974)
Limnol. Oceanogr.,
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(4), 591–600.

- **Vertical Profile.** A vertical profile is obtained by moving an instrument vertically through the water while recording data as a function of depth. For measurements of light, it is not generally relevant whether or not the data are recorded when the instrument is raised (the "upcast") or lowered (the "downcast").