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PAR Light Sensors

Sea-Bird has several application notes dealing with PAR sensors from various manufacturers; this application note provides an overview of PAR measurements and units, and is applicable to all PAR sensors.

PAR is an abbreviation for **P**hotosynthetically **A**vailable **R**adiation (also called **P**hotosynthetically **A**ctive **R**adiation). Solar radiation reaching the Earth's surface comprises a mixture of ultraviolet light, visible light, and near-visible infrared radiation. All of this radiation conveys heat; the portion between approximately 400 nm and 700 nm wavelength can be captured and used by photo-autotrophs (organisms that are capable of obtaining their energy directly from sunlight), and is called PAR.

Irradiance is the flux of solar radiation incident on a surface per unit time per unit area and is reported in units of energy content (Watts/m^2) or photon content (quanta/m^2 sec or µEinsteins/m^2 sec). Conversion from energy to photon content can be made with Planck's equation, provided that the light wavelength is known. The energy of a photon is related to its wavelength as follows:

$$\mathbf{E = hc / \lambda}$$

where

h = Planck's constant (6.626×10^{-34} Joules/sec)

c = speed of light (2.998×10^{8} m/sec)

λ = wavelength (m)

This equation provides the energy for a single wavelength. For a broad spectrum PAR sensor, a wavelength of approximately 550 nm (550×10^{-9} m) is typically used for the conversion.

> "For marine atmospheres with sun altitudes above 22 degrees, the quanta/watt ratio for the region 400 to 700 nm is 2.77×10^{18} quanta/sec/Watt to an accuracy of plus or minus a few percent." This quote and further discussion of the relationship of quanta to Watts in the water column is found in Smith and Morel (1974) Limnol. Oceanogr. 19(4):591-600.

> **E (at 550 nm) = hc / λ =** (6.626×10^{-34} Joules/sec) * (2.998×10^{8} m/sec) / (550×10^{-9} m) = 3.61×10^{-19} Joules
> (Note: $1 / 3.61 \times 10^{-19} = 2.77 \times 10^{18}$ quanta/sec/Watt, the value quoted in the above reference.)

Application notes for underwater PAR sensors (**11Chelsea, 11Licor, 11QSP-L, and 11QSP-PD**) and surface PAR sensors (**11S and 47**) describe how to enter coefficients from the manufacturer's calibration in the CTD configuration (.con) file to provide SEASOFT output in µEinsteins/m^2•sec. To calculate irradiance in other units:

To convert to:	For *Underwater* PAR Sensors, set Multiplier to:	For *Surface* PAR Sensors, multiply calculated Conversion factor by:
µEinsteins/m^2•sec	**1.0**	
µEinsteins/cm^2•sec	(1.0) / (100 cm/m)^2 = **1×10^{-4}**	
Einsteins/m^2•sec	(1.0) / (1×10^{6} µEinsteins/Einstein) = **1×10^{-6}**	
Einsteins/cm^2•sec	(1×10^{-6}) / (100 cm/m)^2 = **1×10^{-10}**	
quanta/m^2•sec	(1×10^{-6}) * (6.022×10^{23} quanta/Einstein) = **6.022×10^{17}**	
quanta/cm^2•sec	(6.022×10^{17}) / (100 cm/m)^2 = **6.022×10^{13}**	
Watts/m^2	(6.022×10^{17}) / (2.77×10^{18} quanta/sec/Watt) = **0.2174**	
Watts/cm^2	(0.2174) / (100 cm/m)^2 = **2.174×10^{-5}**	
µWatts/m^2	(0.2174) * (1×10^{6} µWatts/Watt) = **2.174×10^{5}**	

Note: 1 Einstein = 1 mole (6.022×10^{23}) of photons 1 Watt = 2.77×10^{18} quanta/sec

Notes:

- In our SEASOFT-Win32 suite of programs, edit the CTD configuration (.con) file using the Configure Inputs menu in SEASAVE V7 (real-time data acquisition software) or the Configure menu in SBE Data Processing (data processing software).
- Multiplier can also be used to scale output for comparing the shape of data sets taken at disparate light levels. For example, a multiplier of 10 would make a 10 µEinsteins/m^2•sec light level plot as 100 µEinsteins/m^2•sec.